

RCMINS
14th CONGRESS
Regional Committee on Mediterranean Neogene Stratigraphy
8-12 September 2013 Istanbul, TURKEY

**Neogene to Quaternary
Geological Evolution of
Mediterranean, Paratethys and Black Sea**

BOOK of ABSTRACTS



Book of Abstracts of the RCMNS 2013

Publisher : Istanbul Technical University
ISBN : 978-975-561-438-0
Editors : Namık ÇAĞATAY
Cengiz ZABCI
Printing Layout : Tolga KOÇ
Cover Design : Ayşenur AYTAÇ
Composition : ARBER Professional Congress Services / www.arber.com.tr

Printed by
General Directorate of Mineral Research and Exploration (MTA)



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PREFACE

It gives me great pleasure to welcome you to the scientific programme of the 14th Congress of the Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS) held in Istanbul, Turkey from 8th to 12th of September 2013. The main theme of the congress this year is “Neogene to Quaternary Geological Evolution of Mediterranean, Paratethys and Black Sea”, which fits suitably with the venue of the Congress on the Sea of Marmara that is commonly regarded to be the main gateway between the Mediterranean and Paratethys (and the Black Sea). This gateway started forming during the Neogene along the North Anatolian Fault (NAF), a major continental transform boundary between the Eurasian and Anatolian plates.

The congress includes three keynote lectures by A.M. Celal Şengör on “The importance of the Neogene in Turkey”, by William B.F. Ryan on “Steps towards a comprehensive understanding of the Messinian Salinity Crisis”, and by Wout Krijgsman on “TNTS2012”. These keynotes lead the way to the technical programme with 124 oral and 79 poster presentations initially organized under 12 sessions: 1) Neogene tectonics and sedimentary evolution of peri-Mediterranean areas, 2) Geological evolution of the Sea of Marmara, 3) Mediterranean-Atlantic exchange: causes and consequences, 4) Mediterranean- Paratethys gateways and connections during Neogene, 5) Response of the Paratethys to the Messinian Salinity Crisis, 6) Mediterranean-Black Sea connections during Quaternary, 7) Recent developments in the Messinian Salinity Crisis, 8) Advances in Mediterranean Paleoceanography, 9) Recent Developments in Mediterranean Paleoclimatology, 10) Neogene mammalian successions and dispersals, 11) Hominid evolution and climate, 12). Quaternary researches: geomorphology, environment and geoarchaeology. Sessions 3 and 7 and Sessions 8 and 9 have been merged on requests from the related sessions’ conveners.

I believe that the Congress will advance our knowledge of the various aspects of the Neogene to Quaternary evolution of the Mediterranean regions by providing a platform for exchange of ideas and international collaborations.

I wish you all a very pleasant time in İstanbul and a successful Congress.

Prof. Dr. M. Namık Çağatay
Chair, 14th RCMNS Congress
İstanbul Technical University

TECHNICAL PROGRAMME AT A GLANCE

September 8, 2013 Sunday	September 9, 2013 Monday			September 10, 2013 Tuesday	September 11, 2013 Wednesday			September 12, 2013 Thursday	
Registration (12:30-15:00) Opening Ceremony (15:00 - 15:45) Coffee Break (15:45-16:00) Keynote Lecture 1 (16:00 - 16:45) Keynote Lecture 2 (16:45-17:30) Keynote Lecture 3 (17:30-18:15)	Hall A Session 12	Hall B Session 1	Hall C Session 11	MID-CONGRESS FIELD TRIP	Hall A Session 8 & 9	Hall B Session 12	Hall C Session 2	Hall A Session 3&7	Hall B Session 10
	Coffee Break				Coffee Break				
	Session 12	Session 1	Session 11		Session 8 & 9	Session 4	Session 2	Session 3&7	Session 10
	Lunch				Lunch				
	Session 12	Session 1			Session 8 & 9	Session 4	Session 6	Session 3&7	Session 10
	Coffee Break				Coffee Break				
	Session 12	Session 1	Session 5		Session 8 & 9	Session 4	Session 6	Session 3&7	Session 10
						Gala Dinner			Closing Remarks

Table of Contents

KEYNOTE LECTURES

187 - The Importance of the Neogene in Turkey	
<i>A. M. C. Şengör</i>	3
113 - Steps towards a Comprehensive Understanding of the Messinian Salinity Crisis	
<i>William B. F. RYAN</i>	4
244 - ATNTS2012	
<i>Frits Hilgen, Luc Lourens, Jan van Dam, Alan Beu, Andrew Boyes, Roger Cooper, Wout Krijgsman, James Ogg, Werner Piller, Doug Wilson</i>	5

SESSION 1

39 - Late tortonian Paleotectonic Restoration of the Gibraltar Arc Orogenic System: The Denouement of Its Geodynamic Evolution	
<i>Ana Crespo-Blanc, Menchu Comas, Juan Carlos Balanyá</i>	9
127 - Scenes from the Tectonic Evolution of the Alboran Sea Basin: Structural Framework and Role of Tectonic Heritage	
<i>Menchu Comas, Ana Crespo-Blanc, Juan Carlos Balanyá</i>	10
231 - 3D Structure and Tectonic Evolution of The Sorbas Basin: An inverted Asymmetric Graben Impacted by The Messinian Salinity Crisis	
<i>Damien Do Couto, Charles Gumiaux, Romain Augier, Noémie Lebrete, Nicolas Folcher, Gwenaél Jouannic, Laurent Jolivet, Jean-Pierre Suc, Christian Gorini</i>	11
134 - The Orbitally Tuned (400ky-Eccentricity) Decontra Section (Maiella, Central Apennines, Italy) as a Stratigraphic Reference for Shallow Marine Carbonate Successions in the Oligocene-Miocene Mediterranean	
<i>Werner E. Piller, Gerald Auer, Markus Reuter, Mathias Harzhauser, Marco Brandano</i>	12
219 - The Possibility of Using Pyroclastic Levels for Correlation of Continental and Marine Miocene Deposits in Poland	
<i>Krzysztof Bukowski, Marian Wagner, Jacek Kasiński, Krzysztof Dudek, Michał Stefaniuk</i>	13
121 - Paleogeography of The Pannonian Basin during The Late Miocene and Early Pliocene: Stratigraphic Implications	
<i>Imre Magyar</i>	14
242 - New Results on the Upper Miocene Turbidite Systems of the Transylvanian Basin, Lake Pannon	
<i>Lilla Tőkés, István Róbert Bartha, Lóránd Silye, Csaba Krézsek, Orsolya Sztanó</i>	15
98 - Evolution of the Danube Deep-sea Fan since The Last Glacial Maximum	
<i>A. M. Constantinescu, S. Toucanne, B. Dennielou, S. Jorry, N. Panin, G. Lericolais</i>	16
12 - The Northeast Ionian Margin: A Continuous Sedimentation Laboratory into The Quaternary and a Wealth of Hydrocarbon Prospects in The upper Cenozoic Sediments!	
<i>George Anastasakis, David J.W.Piper</i>	17
170 - Stratigraphy and Evolution of Miocene Pleistocene Intermountain Basins of Eastern Albania	
<i>Pandeli Pashko, Vesel Hoxha, Ibrahim Milushi</i>	18
22 - Karaburun Region's Cenozoic Structural History, NW Turkey	
<i>A. Gizem Say, Boris A. Natal'in</i>	19
238 - Tectonic, Stratigraphic and Volcanic Evolution of the Ne-Sw-Trending Neogene Basins of Western Anatolia	
<i>Cahit Helvacı, E. Yalçın Ersoy</i>	20
33 - The Varied Development and Regional Implications of Late Serravalian Erosional Unconformity in The Peri-mediterranean Basins of Southern Turkey	
<i>Ayhan Ilgar, Wojciech Nemec, Aynur Hakyemez, Tolga Esirtgen, Carlo Messina, Banu Türkmen, Attila Çiner</i>	21

103 - The Adana Basin (Southern Turkey): A Neogene Tectono-Stratigraphic Archive of The Eastern Mediterranean	
<i>Giuditta Radeff, Domenico Cosentino, Taylor F. Schildgen, Manfred R. Strecker, Paola Cipollari, Guldemir Darbaş, Kemal Gürbüz.....</i>	22
32 - Messinian Forced Regressions in the Adana Basin: A Near-Coincidence of Tectonic and Eustatic Forcing	
<i>Ayhan Ilgar, Wojciech Nemec, Aynur Hakyemez, Erhan Karakuş</i>	23
229 - Complex Tectono-Stratigraphic Evolution of the Frontier Northern Levant Basin (Offshore Lebanon)	
<i>Nicolas Hawie, Christian Gorini, Remy Deschamps, Fadi H. Nader, Lucien Montadert, Didier Granjeon, François Baudin</i>	24
58 - Environmental Reconstruction in The South Caspian Sea Basin Using Statistical Analyses of A Palynological Dataset from The Neogene Productive Series in Azerbaijan	
<i>Lourdes López-Merino, Suzanne A.G. Leroy, Keith Richards, Simon F. Grant</i>	25
237 - Mineralogical and Geochemical Studies on the Pliocene Clay Deposits, North Sinai, Egypt: Using Reomte Sensing Data	
<i>Talaat M. Ramadan, Safaa M. Hassan</i>	26
212 - New Datation of the Tafna Basin (Algeria): A Combination between Biochronological and Magnetostratigraphical Data	
<i>Salamet Mahboubi, Mouloud Benammi, Jean- Jacques Jaeger</i>	27
174 - Influence of the Recent Strike-Slip Tectonics on Dyking in the Urumieh-dokhtar Volcanic Belt, Tafresh Area, Iran	
<i>Zeinab Davoodi, Farkhondeh Khademi, Abbas Asiabanha</i>	28
SESSION 2	
81 - The Impact of the Messinian Salinity Crisis in the Region of the Marmara Sea	
<i>Jean-Pierre Suc, Gunay Çifci, Cagil Karakas, Rolando Armijo, Robin Lacassin, Seda Okay, Burcu Barin, Mihaela Carmen Melinte-Dobrinescu, Christian Gorini, Jean-Loup Rubino, M. Namık Çağatay, Gwenaél Jouannic, Speranta-Maria Popescu, Ziyadin Çakır</i>	31
169 - Evolution of Tectonic Structures under the Sea of Marmara from Middle Miocene to Present	
<i>Naci Görür, Şebnem Elbek</i>	32
105 - Modeling Basin Subsidence History in the Sea of Marmara	
<i>Pierre Henry, Celine Grall</i>	33
203 - Evidences of Gas Accumulation in Western High, Sea of Marmara in Light of 2d High Resolution Seismic Method	
<i>Hakan Sarıtaş, Günay Çifçi, Céline Grall, Pierre Henry, Yannick Thomas, Bruno Marsset, Louis Géli, Christopher Sorlien, Orhan Atgın.....</i>	34
180 - Steady Quaternary Deformation along the North Anatolian Fault System in Marmara Sea, Turkey	
<i>Christopher C Sorlien, Leonardo Seeber, Hülya Kurt , Donna J Shillington, Michael S Steckler, Günay Çifçi, Seda Okay, Burcu Barin, Orhan Atgın, Derman Dondurur, Marie-Helene Cormier, Cecilia M McHugh.....</i>	35
202 - Evolution of the Sedimentation and the Deformation on the Western High of the Sea of Marmara According to High Resolution Seismic Data	
<i>Céline Grall, Hakan Sarıtaş, Pierre Henry, A. M. Celâl Şengör, Christopher Sorlien, Yannick Thomas, Bruno Marsset, Günay Çifçi, Louis Géli</i>	36
28 - Fault Segmentation and Earthquake Recurrence Times from Earthquake Sedimentary Records in the Sea of Marmara	
<i>M. N. Çağatay, D. Biletkin, L. Erel, P. Henry, L. Gasperini, C. M. McHugh, Ü. Sancar, C. Grall, L. N. Güngör, E. Güngör, Bellucci, A. Polonia.....</i>	37

SESSION 3&7

82 - Improved Chronostratigraphy of The Messinian Salinity Crisis <i>Jean-Pierre Suc, François Bache, Speranta-Maria Popescu, Damien Do Couto, Mihaela Carmen Melinte-Dobrinescu, Nadia Barhoun</i>	41
137 - Reconstruction of Mediterranean Outflow Water in the Gulf of Cadiz over the Miocene-Pliocene Boundary <i>Marlies van der Schee, F. J. Sierro, J. A. Flores, M. Gutjahr, R. Flecker, F. J. Jimenez-Espejo, D. Hodell, F. J. Hernández-Molina, D.A.V Stow, C. Alvarez-Zarikian, IODP Expedition Scientists</i>	42
173 - Precession-Driven Cyclicity in the Northern Part of the Guadalquivir Basin (Sw Spain) during the Messinian Salinity Crisis <i>Bastiaan C.J. van den Berg, F. J. Sierro, J. A. Flores, J. Civis, J. A. González-Delgado, , P. Mata, J. C. Larrasoña</i>	43
197 - The onset of The Mediterranean Salinity Crisis Was Triggered by Prolonged Times of Dryness in The Northeast Atlantic and Mediterranean Climate <i>Francisco J. Sierro, S. Ledesma, J. A. Flores</i>	44
17 - Impact of Orbital forcing on Simulated Mediterranean-Atlantic Dynamics in The Late Miocene <i>Alice Marzocchi, Dan Lunt, Rachel Flecker, Rupert Gladstone, Catherine Bradshaw, Ruza Ivanovic</i>	45
129 - Sr Isotope Record from the Rifian Corridor <i>Rachel Flecker, Sevi Modestu, Ruza Ivanovic, Rob Ellam</i>	46
143 - Evolution of Ne Atlantic Mediterranean Outflow Water during the Messinian Salinity Crisis <i>Sevasti Modestou, Marcus Gutjahr, Ángel Rodés, Jan Fietzke, Martin Frank, Susana Bolhão Muiños, Rob Ellam, Rachel Flecker</i>	47
211 - Erosion of the Mediterranean Margins during the Messinian Salinity Crisis <i>D. Garcia-Castellanos, J. Lofi, J. Babault, R. Urgelès</i>	48
210 - Mio-Pliocene Evolution of the Western End of the Rifian Corridor, Rharrb Basin, offshore Morocco <i>Evelina Dmitrieva</i>	49
206 - Interest of Microfauna and Microflora in Reconstructing Marine Environments in the Rifian Corridor (Morocco) during the Late Miocene <i>N. Barhoun, N. Bachiri Taoufiq, J.-P.Suc, M.Z.Yousfi</i>	50
95 - Mineral Magnetic Properties of Late Miocene Marine Sediments from the Huelva-1 and Montemayor-1 Boreholes (Guadalquivir Basin, Sw Spain); Preliminary Results and Paleoenvironmental Implications <i>Juan C. Larrasoña, Qingsong Liu, Pengxiang Hu, Pilar Mata, José N. Pérez-Asensio</i>	51
16 - Upper Miocene Paleoenvironments of Bivalves from Tafna Basin (North-Western of Algeria) <i>L. Satour, L. Belkebir, B. Mansour, M. Bessedik</i>	52
138 - Precession-Driven Salinity and Sr Ratio Fluctuations in Marginal Basins during the Messinian Salinity Crisis <i>R.P.M. Topper, P. Th. Meijer, S. Lugli, V. Manzi, M. Roveri</i>	53
230 - The Messinian Salinity Crisis in the Alboran Sea: Morphology of the Messinian Erosional Surface from Land to Sea <i>Damien Do Couto, Christian Gorini, Ferran Estrada , Speranta-Maria Popescu, Jean-Pierre Suc, Nadia Barhoun, Mihaela Carmen Melinte-Dobrinescu, Jean-Luc Auxietre, Jean-Loup Rubino</i>	54
154 - Late Neogene Marine Records from Western Mediterranean: Insights into the Messinian Salinity Crisis <i>Diana Ochoa, Francisco J. Sierro, Johanna Lofi, Agnes Maillard, Jose-Abel Flores</i>	55
94 - Pseudo-Sarmatian Mollusc Assemblages from the Early Messinian of Sicily (Italy) <i>Mathias Harzhauser, Markus Reuter, Oleg Mandic, Simon Schneider, Werner E. Piller, Marco Brandano</i>	56

145 - Paleocceanographic and Paleoenvironmental Changes in the Red Sea during the Messinian/Zanclean: New Data from Site 225 <i>Antonio Caruso, Maria Bianca Cita, Maria Marino, Patrizia Maiorano, Giovanna Scopelliti, Marie-Madeleine Blanc-Valleron</i>	57
124 - The Record of the Messinian Salinity Crisis in Mobile Belts: Insights from the Molise Allochthonous Units (Southern Apennines, Italy) <i>Domenico Cosentino, V. Bracone, P. Cipollari, C. D'Amico, D. Esu, V. Frezza, E. Gliozzi, F. Grossi, P. Guerrieri, A. Iadanza, T. Kotsakis</i>	58
123 - New Palaeoenvironmental Implications for the Messinian Salinity Crisis: Insights from the Primary Lower Gypsum Unit of the Piedmont Basin (Nw Italy) <i>Marcello Natalicchio, Francesco Dela Pierre, Pierangelo Clari</i>	59
215 - Scientific Drilling in the Mediterranean Sea: Where and Why? <i>Marina Rabineau, Angelo Camerlenghi</i>	60
SESSION 4	
204 - Neogene-Quaternary Paratethyan-Pontocaspian Gateways and the Role of Anatolia in the Evolution of Pontocaspian Biota <i>Frank P. Wesselingh, Yesim Büyükmeric Islamoğlu, Hülya Alçiçek, Mehmet Cihat Alçiçek, Vitaliy Anistratenko, Tamara Yanina</i>	63
79 - New Palynological Studies from the Mio-Pliocene Palaeo-Volga Delta and the Present-day (Holocene) Volga Delta in the Caspian Sea: Similarities and Differences <i>Keith Richards</i>	64
55 - Salinity Crisis and Tethys-paratethys Connection during the Oligocene-miocene interval in the Eastern Carpathians <i>Mihaela C. Melinte-Dobrinescu, Marius Stoica</i>	65
8 - Neogene-Quaternary Sediments in Western Part of Caspian Sea in Iran <i>M. Jamil Andalibi</i>	66
59 - The Early Gulf of Corinth: A Conduit for Paratethyan Species Migration? <i>Thomas Wigley, Gerald Roberts, Charles Underwood, Marcelle K. BouDagher-Fadel</i>	67
132 - Lago Mare Events in the Mediterranean <i>Speranta-Maria Popescu, Mihaela Carmen Melinte-Dobrinescu, Bipo Barhoun, Maria-Angela Bassetti, Romain Pellen, Damien Do Couto-, Jean-Pierre Suc, Christian Gorini, Marina Rabineau</i>	68
119 - Biostratigraphic and Paleoenvironmental Contributions of Calcareous Nannofossil Study from Upper Miocene to Pliocene Deposits of Chelif Basin (NW Algeria) <i>Mohamed El Habib Mansouri, Mostefa Bessedik, Lahcene Belkebir, Bouhameur Mansour</i>	69
216 - Chronologic Constraints on High-Resolution Records of the Sedimentary and Biotic Response to the Badenian Salinity Crisis of the Central Paratethys <i>Arjan de Leeuw, Krzysztof Bukowski, Wout Krijgsman, Klaudia F. Kuiper, Oleg Mandic, Marius Stoica, Grzegorz Czapowski, Andrzej Gasiewicz</i>	70
163 - The Burdigalian Seaway: New insights into one of the Main Mediterranean/Paratethys Faunal Migration Routes of the Early Miocene <i>Patrick Grunert, Mathias Harzhauser, Werner E. Piller</i>	71
190 - Nannoplankton Assemblages Response to Environmental Changes during the Miocene in the Eastern Paratethys (Southern Russia) <i>Larisa Golovina</i>	72
40 - Eastern Paratethys Stratigraphic Scale of Neogene: Correlation Possibilities <i>S. V. Popov, N. Yu. Filippova, L. A. Golovina, I. A. Goncharova, E. P. Radionova, A. S. Tesakov, V. M. Trubikhin</i>	73
207 - Sr-isotope Compositions of Paratethys Mollusks and Barnacles - Stratigraphy, Taphonomy and Regional Deviations <i>Oleg Mandic, Fritz F. Steininger, Mathias Harzhauser, Susanna Scharbert</i>	74

50 - The Badenian Fish Fauna of St. Margarethen, Eistenstadt-sopron Basin, Burgenland, Central Paratethys: Stratigraphy, Paleoecology and Paleobiogeography	
<i>Giorgio Carnevale, Mathias Harzhauser</i>	75
SESSION 5	
213 - Paratethys Response to the Messinian Salinity Crisis	
<i>W. Krijgsman, M. Stoica, A. de Leeuw, I. Vasiliev, A. Grothe, C.G.C. Van Baak, F. Sangiorgi</i>	79
232 - Dacian Basin during the Messinian Salinity Crisis	
<i>M. Stoica, W. Krijgsman, I. Lazar, A. Floroiu, I. Vasiliev; C.G.C. Van Baak</i>	80
130 - The Evolution of the Eastern Paratethys during the Messinian Salinity Crisis	
<i>A. Grothe, F. Sangiorgi F, W. Krijgsman , I. Vasiliev, G-J. Reichart, M. Stoica, H. Brinkhuis</i>	81
192 - Insights from Isotopes Analysis on Biomarkers on Black Sea Hydrology at the End of Miocen	
<i>Iuliana Vasiliev, Gert-Jan Reichart, Arjen Grothe, Johan Weijers, Jaap-Sinninghe Daamstee, Wout Krijgsman, Francesca Sangiorgi, Yannick R. Mulders, Linda van Roij</i>	82
220 - Stratigraphic Re-Evaluation of the Desiccation of the Black Sea Basin and the Climate of the Khersonian Regional Substage	
<i>Madelaine Böhme</i>	83
152 - New Insights on Messinian Events in the Caspian Sea	
<i>Christaan G. C. Van Baak, A. Grothe, E. Aliyeva, K. F. Kuiper, M. Stoica, W. Krijgsman, </i>	84
SESSION 6	
89 - Massive Meltwater Discharge into the Black Sea Euxine Lake	
<i>Wiliam B. F. Ryan, Anastasia Yanchilina, Elizabeth Matamoros, Timothy Kenna</i>	87
75 - Freshening of the Marmara Sea prior to its post-glacial reconnection to the Mediterranean	
<i>G. Aloisi, G. Delaygue, P. Henry, K. Wallmann, R. Sauvestre, G. Soulet, C. Lecuyer, E. Bard</i>	88
73 - Isotopes Confirm the Mediterranean derivation of the Holocene transgression across the Black Sea shelf	
<i>Anastasia G. Yanchilina, William B.F. Ryan</i>	89
115 - Forcing Factors on Caspian Sea Level Changes in the Late Pleistocene and Early Holocene: Contribution of Palynology	
<i>S. Leroy, A. Kakroodi -, F. Chalié, A. Tudryn, S. Kroonenberg, H. Lahijani, K. Arpe</i>	90
20 - Holocene Salinity Changes in the Romanian Black Sea Shelf Mirrored by Microfaunal, Microfloral and Nannofloral Fluctuation	
<i>Mihaela C. Melinte-Dobrinescu, Gabriel Ion</i>	91
24 - Fluctuations in Holocene Ostracod Assemblages from the NW Black Sea Shelf	
<i>Andrei Briceag, Gabriel Ion, Gheorghe Oaie, Marius Stoica</i>	92
241 - Pronounced Millennial Scale Variability in the Black Sea Lake during Marine Isotope Stage 3	
<i>Helge W. Arz, Lyudmila Shumilovskikh, Antje Wegwerth, Olaf Dellwig, Jérôme Kaiser, Norbert R. Nowaczyk, Birgit Plessen, Mathias Prange, Guillemette Ménot, Edouard Bard, Hermann Behling, Dominik Fleitmann</i>	93
SESSION 8&9	
165 - Paleoclimatic and Paleoceanographic Changes during the Last 2K in the North Aegean Sea (northeastern Mediterranean)	
<i>A. Gogou, M.V. Triantaphyllou, I. Bouloubassi, C.S. Parinos, M.D. Dimiza, K. Kouli, G. Rousakis, E. Kaberi, M. Athanasiou, V. Lykousis</i>	97
144 - Carbonate Accumulation in Lake Iznik from Late Pleistocene to the Holocene	
<i>Patricia Angelika Roeser, Sven Oliver Franz, Thomas Litt</i>	98
114 - Late Quaternary Climate Changes As Reconstructed from Terrestrial Carbonates	
<i>Adele Bertini, Marianna Ricci</i>	99

92 - Late Quaternary through Recent Paleoenvironmental Change in the Sierra Nevada, Southern Spain <i>R. Scott Anderson Gonzalo Jiménez-Moreno Antonio García-Alix Francisco J. Jiménez Espejo Jaime L. Toney Jose S. Carrión Carmen Pérez-Martínez María Dolores Hernández-Corbalán</i>	100
236 - Different Ecosystems in the Late Neogene of Anatolia (Turkey) <i>Lars W. van den Hoek Ostende, Lysanne van Bennekom, Alison Murray, James Gardner, Flemming Diepenveen, M. Cihat Alçiçek</i>	101
7 - Sedimentological, Microscopic and Stable Isotope Constraints from Spring-fed Pınarbaşı Tufas (E Kayseri) Related to Late Pliocene Climate in Central Anatolia <i>Faruk Ocakoğlu, İsmail Ö. Yılmaz</i>	102
61 - Continental Climate and Vegetation Gradients on Both Sides of the North Atlantic before and After the Closure of the Central American Seaway – A Comparison Based on New Miocene and Pliocene Proxy Data <i>T. Utescher, M. Böhme, T. Hickler, Mosbrugger, F. Portmann</i>	103
83 - Vegetation Belts in Peri-mediterranean Massifs during the Late Miocene and Early Pliocene <i>Jean-Pierre Suc, Séverine Fauquette, Speranta-Maria Popescu, Gonzalo Jiménez-Moreno, Naima Bachiri Taoufiq, Demet Biltekin</i>	104
35 - Implications for Mediterranean Isolation and Climate via Sea Surface Temperature Reconstructions through the Miocene – Pliocene <i>Alexandrina Tzanova, Timothy D. Herbert, Laura Peterson</i>	105
91 - Late Miocene Vegetation and Climate Dynamics in the Sandanski Basin, Southwest Bulgaria <i>Dimitar Ivanov</i>	106
52 - Did Global Sea Level Drop Triggered the onset of the Messinian Salinity Crisis? <i>Gonzalo Jiménez-Moreno, José N. Pérez-Asensio, Juan C. Larrasoana, Julio Aguirre, Jorge Civis, María R. Rivas-Carballo, María F. Valle-Hernández, José A. González-Delgado</i>	107
133 - The “Brecciated Seep Limestones” Related to the Messinian Drawdown of the Mediterranean Sea and Possible Link to the Late Messinian Climate Shift <i>A. Iadanza, P. Cipollari, D. Cosentino, G. Sempalmieri, M. Mola</i>	108
243 - Density Banding in Corals: Barcodes of Past and Current Climate Change <i>T. C. Brachert, M. Reuter, S. Krüger, A. Böcker, H. Lohmann, R. Mertz-Kraus, C. Fassoulas</i>	109
208 - Astronomical Dating of the Badenian (Late Langhian to Early Serravallian) Succession in the Southern Pannonian Basin <i>Oleg Mandic, Karin Sant, Wout Krijgsman, Patrick Grunert, Arjan De Leeuw, Dörte Theobalt</i>	110
45 - Stratigraphy and facies analysis of the Langhian Dağpazarı reef complex (Mut Basin, Southern Turkey) <i>Alessandro Vescogni, Francesca R. Bosellini, Anna Cipriani, Gonca Gürler, Ayhan Ilgar, Emanuele Paganelli, Irene Chiossi</i>	111
126 - Burdigalian-Langhian Paleoclimatic Reconstruction of Middle and upper Globigerina Limestone (Malta Island, Central Mediterranean) <i>Luca Maria Foresi, Fabrizio Lirer, Niccolò Baldassini, Agata Di Stefano, Leonardo Sagnotti, Chira Caricchi, Luciana Ferraro, Nicola Pelosi, Roberto Mazzei, Gianfranco Salvatorini, Marina Verducci</i>	112
139 - High-resolution Paleoeological and Time-series Analyses of an upper Burdigalian upwelling Site in the North Alpine foreland Basin <i>Gerald Auer, Werner E. Piller, Mathias Harzhauser</i>	113
161 - Paratethys-southern Ocean Teleconnection in the Mid-Burdigalian: European Climate on the Verge to the Miocene Climate Optimum <i>Patrick Grunert, Alexandrina Tzanova, Mathias Harzhauser, Werner E. Piller</i>	114
56 - The Discovery of Lower Miocene Loess in Europe: A New Document for the Global Aridity <i>Davor Pavelić, Marijan Kovačić, Darko Tibljaš, Frane Marković, Kristina Pikelj, Alan Vranjković, Gonzalo Jiménez-Moreno</i>	115

162 - Neogene Planktonic Foraminiferal Turnover in the Mediterranean Area <i>Fabrizio Lirer , Luca Maria Foresi , Silvia Iaccarino, Nicola Pelosi</i>	116
19 - Freshwater Gastropods of the European Neogene – Setup of a New Database <i>Thomas A. Neubauer, Mathias Harzhauser, Oleg Mandic, Elisavet Georgopoulou, Andreas Kroh ..</i>	117
128 - Towards an Understanding of the Mechanism of Cyclic Sedimentation in the Mediterranean Basin Using a Mathematical Model of Overturning Circulation <i>Paul Meijer</i>	118
57 - Model study of the circulation of the Miocene Mediterranean Sea and Paratethys: Closure of the Indian Gateway <i>A. de la Vara, P. Th. Meijer, M.J.R. Wortel</i>	119
SESSION 10	
74 - The Vallesian Rodent Record from the Vallès-Penedès Basin (Catalonia, Spain): Biostratigraphy, Diversity and Structure <i>Isaac Casanovas-Vilar, Israel García-Paredes, Jan Van Dam</i>	123
106 - Two New Late Miocene Fossil Localities (Yiğitler and Hirfanlı) from Kırşehir in Central Anatolia <i>Ahmet Cem Erkman, Şakir Önder Özkurt, Nuretdin Kaymakçı, Cesur Pehlevan, Yarenkür Alkan, Ferhat Kaya</i>	124
49 - The Abrupt Collapse of a Diversity Hotspot? Reconsidering Vallesian (Late Miocene) Diversity in its Type Area <i>P. Anneke Madern, Isaac Casanovas-Vilar, David M. Alba, Daniel DeMiguel, Josep M. Robles, Lars W. van den Hoek Ostende, Salvador Moyà-Solà.....</i>	125
199 - Vertebrate Communities from Khersonian Sediments of Küçükçekmece Area, Turkey <i>Davit Vasilyan, Madelaine Böhme, Jérôme Prieto</i>	126
131 - Vallesian Gliridae from the Vallès-Penedès Basin (Catalonia, Spain) and How were They Affected by the 'Vallesian Crisis' <i>Israel García-Paredes, Isaac Casanovas-Villar</i>	127
136 - Pikermi; New Excavations at a Classical Locality <i>G. Theodorou, S. Roussiakis, A. Athanassiou, V. Mitsopoulou, Ch. Solomos, A. Lychounas.....</i>	128
164 - New Cranial Material of Hipparion Ssensu Lato (perissodactyla, Mammalia) from the Classical Locality of Pikermi, Greece <i>V. Mitsopoulou, S. Roussiakis, A. Athanassiou, G. Lazaridis, G. Theodorou.....</i>	129
48 - Paleontology, Biochronology and Palaeoecology of the Greek Hipparionine Horses <i>Theodora D. Vlachou, George D. Koufos</i>	130
38 - The Late Miocene Proboscideans of Greece: Taxonomy, Biochronology, Palaeoecology <i>George E. Konidaris, George D. Koufos.....</i>	131
63 - The Insectivores (Lipotyphla, Mammalia) from Hayranlı and Düzyayla (Sivas Basin, Central Anatolia): A Contribution to the Miocene Biostratigraphy from Turkey <i>Marc Furió, Jan van Dam, Ferhat Kaya</i>	132
88 - Late Miocene Terrestrial Biotic Record in the Northern Caucasus <i>V. V. Titov, A. S. Tesakov, E. V. Syromyatnikova, A. N. Simakova, M. V. Sotnikova, P. D. Frolov</i>	133
182 - Murids of the Genus <i>Hansdebruijnina</i> in Late Miocene of the Peri-Black Sea <i>A.S. Tesakov.....</i>	134
221 - Staniantzi – An exceptional Vertebrate Locality from the Miocene-pliocene Transition of Western Bulgaria <i>Madelaine Böhme, M. Aiglstorfer, L. Bullmann, M. Dolezych, P. Havlik, L. Hristova, A. Ilg, G. Markov, N. Ognjanova, J. Prieto, D. Uhl, D. Vasilyan, N. Spassov.....</i>	135
72 - Paleobiogeographical Implications of Fossil Mammals from Piedmont (NW Italy) during the Latest Messinian	

<i>Simone Colombero, David M. Alba, Giorgio Carnevale, Massimo Delfino, Paul Mazza, Giulio Pavia, Marco Pavia, Gianni Repetto</i>	136
42 - The Italian Late Miocene Continental Vertebrates, a Bridge between Western and Eastern Europe	
<i>G. Carnevale, S. Colombero, M. Delfino, F. Masini, P. Mazza, E. Patacca, G. Pavia, M. Pavia, G. Repetto, A. Savorelli, P. Scandone</i>	137
149 - New Data on the Neogene Turtles of European Russia	
<i>E. V. Syromyatnikova, I. G. Danilov, V. V. Titov, A. S. Tesakov</i>	138
186 - Fossil Otters from the Early-Middle Pleistocene of Italy: New Insights into the Mediterranean Lutrinae Evolutionary History	
<i>Marco Cherin, Luca Bellucci, Dawid A. Iurino, Lorenzo Rook, Raffaele Sardella, Gerard Willemsen</i>	139
30 - Mammalian Faunal Stability and Change in the Middle and Late Miocene Siwaliks of Pakistan: Time-Slice Analysis	
<i>M.E.Morgan, J.C. Barry, L.J. Flynn, D. Pilbeam, C. Badgley, M.S. Domingo, A.K. Behrensmeyer</i>	140
SESSION 11	
185 - A New Interpretation of Relationships among Euraisan and African Late Miocene Hominids	
<i>David R. Begun</i>	143
53 - Stable Isotope Ecology of Miocene Bovids from Hominid- and Cercopithecoid-bearing Sites from Northern Greece and the Ape/Monkey Turnover in the Balkans	
<i>Gildas Merceron, Louis de Bonis, George D. Koufos, Christophe Lecuyer, Dimitris S. Kostopoulos</i>	144
69 - The End of the Miocene Hominoid Experiment in Europe. Still a lot to be Explained	
<i>Isaac Casanovas-Vilar, David M. Alba, Josep M. Marmi, Salvador Moyà-Solà</i>	145
97 - Nature, Timing, and Dynamics of Green Sahara Periods Back to the Late Miocene: Implications for Hominin Evolution	
<i>Juan C. Larrasoña, Andrew P. Roberts, Eelco J. Rohling</i>	146
93 - Climate Dynamics and Early Human Dispersal Out of Africa	
<i>Jordi Agustí, Hugues-Alexandre Blain</i>	147
15 - Early Pleistocene Environment of Early Humans in Southern Caucasus - High-resolution Reconstruction of Climate and Vegetation in Armenia during Mis 31	
<i>Angela A. Bruch, Ivan Gabrielyan, Steffen Scharrer, Uwe Kirscher, Valerian Bachtadse, Klaudia Kuiper, Vasilis Teodoridis</i>	148
235 - The Forensic Anthropological Analysis of First Homo erectus from Turkey	
<i>Mehmet Görgülü, M. Cihat Alçiçek, Fatih Tepgeç, Uğur Genç, Seher Başaran</i>	149
196 - Persistence of Plesiomorphic Human Populations in the Middle Pleistocene of the Italian Peninsula: Deconstructing the Role of Climate Changes, Vegetation and Faunal Dynamics	
<i>Giorgio Manzi, Donatella Magri, Maria Rita Palombo</i>	150
SESSION 12	
84 - Evidence of Orbital- and Sub-Orbital-Driven Climate Change in the Near East-600.000 Years of Environmental Conditions Captured in Lake Van's Subsurface	
<i>Mona Stockhecke, Flavio S. Anselmetti, Ola Kwiecien, Mike Sturm, and PALEOVAN scientific party</i>	153
18 - Revealing Lake Level and Sedimentary History of Lake Van, Eastern Turkey, during the Past ~580 ka: Seismic, Hydroacoustic, and Lithological Evidence	
<i>Deniz Cukur, Sebastian Krastel, Hans Ulrich Schmincke, Mari Sumita, Daniel Winkelmann, M. Namık Çağatay, Emre Damcı, Aysegül Feray Meydan, Mona Stockhecke and PaleoVan Scientific Team</i>	154
102 - Paleomagnetic and Rock Magnetic Studies from Lake Van Sediments: Implications for Chronology and Paleoenvironment since 350 Ka	
<i>L. Vigliotti, J.E.T Channell, M. Stockhecke</i>	155

68 - Multivariate Statistics and Cyclostratigraphy Based on Downhole Logging in the ICDP Project Paleovan	
<i>H. Baumgarten, T. Wonik</i>	156
87 - Environmental Context of Neolithic Birth, Development and Diffusion in Anatolia, from 12 to 7 Ka Cal BP: The Evidence from Newly Studied Buried Sites in Anatolia	
<i>Catherine Kuzucuoglu</i>	157
191 - The East Caucasian Forelands during the Quaternary: Deposits and Environments	
<i>Nataliya Bolikhovskaya, Stanislav Faustov, Anastasia Markova</i>	158
43 - Palaeovegetational Comparison between Sediments of the 7000 BP and 6 Century in the Ancient Harbor of the Yenikapı-İstanbul Based on the Palynological Data	
<i>Funda Akgün, Doğan Perinçek, Mine Sezgül Kayseri-Özer, Mustafa Bozcu</i>	159
155 - Toward a Better Knowledge of <i>Elephas Tiliensis</i> Skeletal Proportions and Morphology	
<i>E. Theodorou, V. Mitsopoulou, T. Vasilopoulos, C. Provatidis, S. Roussiakis</i>	160
80 - Ancient Irrigation Canals Detection in Pharaonic Deir El-Hagar Playa, Western Desert, Egypt, Using Egyptsat-1 Data	
<i>S. M. Hassan, E. A. Zaghloul, A. Bahay El-Dein</i>	161
26 - Effects of Natural and Anthropogenic Processes on a Coastal Environment during Holocene: Maritsa (Maritsa) Delta Area, NE Aegean Region, Turkey	
<i>M. Namık Çağatay, T. Levent Erel, Mehmet Sakınç, Andrey Tchapyga</i>	162
13 - The Evolving Geometry of upper Quaternary Coastal Outbuilding in the East Saronikos Gulf	
<i>Panagiotis Foutrakis, George Anastasakis</i>	163
147 - Geochronology of Quaternary Coastal Deposits of Evoikos Gulf / Greece by Means of Luminescence Dating	
<i>Maria Kazantzaki, Constantin Athanassas, Theodora Rondoyanni, Yannis Bassiakos</i>	164
150 - Deciphering the Paleoenvironmental Framework of Southeast Cyprus over the Late Quaternary through Luminescence Dating of Coastal Deposits	
<i>Evangelos Tsakalos, Constantin Athanassas, Yannis Bassiakos</i>	165
227 - Geological-Stratigraphic Criteria, Remote Sensing Data and Gis Techniques for Mapping out the Old Seashore Line. Evidence from Different Area of Greece	
<i>Chryssanthi Ioakim, Dimitrios Galanakis, Charalambos Georgiou, Georgios Vougioukalakis, Konstantinos Nikolakopoulos, Dimitrios Mitropoulos</i>	166
11 - The Record of upper Quaternary Explosive and Effusive Volcanism in the Marine Realm on the Eastern Margin of the Nisyros-yali Volcanic Islands	
<i>Vassileios Anagnostopoulos, George Anastasakis</i>	167
41 - New Tephrostratigraphic Data from South-western Turkey: insights for Regional inter-archive Correlation and Volcanic Ash Dispersal	
<i>Roberto Sulpizio., M. Cihat Alçiçek, G. Zanchetta</i>	168
104 - Interpretation of Late Pleistocene Terrace Staircases along the Mudurnu River Valley (NW Anatolia) in Terms of Fluival Response to Climate Change and Natural Hazards	
<i>M. Korhan Erturaç, Sumiko Tsukamoto, Edwige Pons-Branchu, Gürsel Sunal, Pınar Gutsuz, Ayşe Atalay Dutucu, Cercis İkiel</i>	169
90 - Pollen and Non-pollen Palynomorphs as Environmental Indicators in Holocene Sediments of the North Anatolian Fault	
<i>Nurdan Yavuz</i>	170
234 - Late Quaternary Slip Rates of the Ecemiş Fault Inferred From Cosmogenic ³⁶ Cl Dating	
<i>M. Akif Sarıkaya, Cengiz Yıldırım, Attila Çiner</i>	171
6 - First High-Resolution Marinopalynological Stratigraphy of Late Quaternary Sediments from the Central Part of the Bulgarian Black Sea Area	
<i>Mariana Filipova-Marinova, Danail Pavlov, Marco Coolen, Liviu Giosan</i>	172

14 - Lateral Variability in Stratal Architecture and Quaternary Sedimentary Evolution of the NW Cyclades Plateau	
<i>George Kontogonis, George Anastasakis</i>	173
107 - Chemo-Stratigraphical Characterization of Lake Van Sediments: Implications for Holocene Ecology and Environment in Eastern Anatolia	
<i>Özlem Bulkan, M. Namık Çağatay, Özlem Makaroğlu, Naci Orbay</i>	174
176 - Quaternary Sediments Characteristic of Urmia Lake by 100 Meters Cores	
<i>Razyeh Lak, Javad Darvishi Khatooni, Ali Mohammadi</i>	175

POSTERS

SESSION 1

34 - Middle Miocene Relative Sea-level Changes in the Peri-pontide Branch of Eastern Paratethys: An interplay of Eustasy and Terminal Orogen Tectonics	
<i>Ayhan Ilgar, Yeşim İslamoğlu, Serap Demirkaya</i>	181
64 - "Sequential Analysis of Burdigalian-badenian Gypsum from Cernesti (Romania, Prahova County)	
<i>Dumitru Frunzescu</i>	182
171 - Geological Evolution and Deep Structure of the Pacific Mobil Belt (The Comparison with Tethys Area)	
<i>A. G. Rodnikov, N. A. Sergeyeva, L. P. Zabarinskaya</i>	183
151 - Late Miocene Model of the Area between Vardar and Middle Struma Rivers	
<i>Tzanko Tzankov, Nikolay Spassov, Krasimir Stoyanov, Denis Geraads</i>	184
175 - Marine Habitat Mapping and Sea-Floor Surface Structures Using Side Scan Sonar and Visual Data: Northern Cyprus Shelf Survey	
<i>Tarık İlhan, Barış Akçalı, Müge Atalar, Muhammet Duman</i>	185
178 - Stratigraphy and Structural Features of the Neogene Sequence in the Bozüyük (Bilecik) - Kizilinler (Eskisehir) Area	
<i>Elif Apaydin Poşluk, Hayrettin Koral</i>	186
179 - An Updated, Geo-Referenced 1:250.000 Scale Geological Map of the Betics	
<i>Ana Crespo-Blanc, Balanyá, J.C. Barcos, L. Díaz-Azpiroz, M. Expósito, I. Jiménez-Bonilla, A. Luján, M. Suades, E., Ana Retuerta</i>	187
188 - Expression and Importance of Alpine Phase in the Tadjerouna Region (Laghout. Central Saharan Atlas)	
<i>Abdellah Bettahar</i>	188
209 - New Proboscidean Site from the High Karst Dinarides in Southern Bosnia and Herzegovina	
<i>Oleg Mandic, Ursula B. Göhlich, Hazim Hrvatović, Jadranka Mauch Lenardić, Božena Čvorović, Goran Glamuzina, Denis Radoš</i>	189
228 - Biostratigraphy of the Neogene Southwestern Alboran Basin (Western Mediterranean, Nador Offshore, Morocco)	
<i>M. Z. Yousfi, N. Barhoun</i>	190
239 - Stratigraphic and Structural Interpretation of Regional Seismic Sections from the Pannonian Basin	
<i>A. Balázs, I. Magyar, F. Horváth</i>	191

SESSION 3&7

10 - Result of Messinian Crisis Impact on the Territory of Azerbaijan and Ps Paleobasin Formation	
<i>Malahat Afandiyeva, Ulvi Vahabov</i>	195
21 - The Neogene Basins in Ne Morocco: Impact of the Messinian on Groundwater Salinization on the Mediterranean Littoral Plains	
<i>El mandour Abdennabi, Elgettafi Mohammed, EL Yaouti Fouzia, Samia Rochdane, Himi Mahjoub, Benavente José, Casas Albert</i>	196

46 - Messinian Erosional Surface around the Levantine Basin: Geodynamic Implications <i>L. Mocochain, C. Gorini, G. Clauzon, J.-P. Suc, C. Blanpied, J. L. Rubino, A. Al Abdala, F. Azki.</i>	197
71 - Recovery of Molluscan Fauna in the Eastern Mediterranean (Crete, Greece) After the Messinian Salinity Crisis <i>Efterpi Koskeridou, Christina Giamali, Bruno Delrieu</i>	198
112 - Biostratigraphy and Palaeoecological Implications of the Tortonian – Messinian Transition of Faneromeni Section, Sitia Basin, Eastern Crete <i>A. Antonarakou, H. Drinia, E. Koskeridou, E. Manoutsoglou, P. Moissette, J.-J. Cornee, V. Karakitsios</i>	199
148 - The Role of Biotic and Abiotic Processes in the Origin of Messinian Evaporite-Associated Carbonates (Southern Italy) <i>E. Perri, A. Caruso, M. Cefalà, L. Gindre-Chanu, G. Scopelliti</i>	200
160 - The Effect of Contourite Deposition in the Gulf of Cádiz on Late Pleistocene Assemblages of Benthic Foraminifera <i>Vera Schrempf, Patrick Grunert, Werner E. Piller, Craig Sloss, Emmanuelle Ducassou, Carlos Alvarez-Zarikian, F. Javier Hernández-Molina, Dorrik A.V. Stow</i>	201
181 - Mineralogy, Geochemistry and Genesis of Plio-Quaternary Evaporites in Seyfe Lake (Kırşehir, Central Anatolia) Turkey <i>Nergis Önalgil, Selahattin Kadir, Tacit Külah, Muhsin Eren, Ali Gürel</i>	202
217 - "Mean Annual Air Temperature (Mat) in Sorbas Basin during Messinian Pre-evaporite Period: Glycerol Dialkyl Glycerol Tetraether Lipids as Temperature Proxy <i>C. C. Martins, J. P. Mayser, R. Flecker, F. J. Sierro, R. D. Pancost</i>	203
226 - Geochemical Features of Messinian Evaporites of the Adana Basin <i>Erhan Karakuş, Erdoğan Tekin, Ayhan Ilgar</i>	204
SESSION 4	
23 - Stratigraphy of the Middle Miocene Salt Deposit Tetima near Tuzla (the Central Paratethys, North Bosnia) <i>Sejfudin Vrabac, Stjepan Ćorić, Zijad Ferhatbegović, Izudin Đulović</i>	207
31 - Cimmerian Gastropod Fauna in Abkhazia (Eastern Paratethys) with Special Reference to Relations of Some Groups <i>Vitaliy V. Anistratenko, Frank P. Wesselingh, Olga Yu. Anistratenko</i>	208
47 - Characteristics of the Uppermost Lower–Lowermost Middle Miocene (Tarkhanian) in Aklıman, Northern Sinop, Turkey <i>I.A. Goncharova, M.E. Bylinskaya, Yu.V. Rostovtseva, A.L. Tchepalyga</i>	209
54 - Late Messinian Lago-mare Deposits of the Island of Mallorca (Western Mediterranean). Implications on the MSC Events <i>G. Mas-Gornals, J.J. Fornós</i>	210
117 - Mediterranean-Paratethys Connections during the Miocene: Shrimp's Point of View <i>Matúš Hyžný</i>	211
146 - Biomarker-Based Reconstruction of Salinity and Temperature during the Lead-in to the Messinian Evaporite Crisis (sorbas Section, Spain) <i>Jan Peter Mayser, Cesar Martins, Rachel Flecker, Rich D. Pancost</i>	212
177 - Effects of the Tethys Seaway Closure on Palaeoceanography of the Miocene Mediterranean Sea and Paratethys: Regional Ocean Model Study <i>M.P. Karami</i>	213
189 - The Paleogene–Neogene Boundary in the Northern Caucasus and Ciscaucasus <i>N. Yu. Filippova, L. A. Golovina, E. V. Beluzhenko</i>	214
193 - How dry was the Messinian Salinity Crisis? - A Molecular Study of the Eraclea Minoa Section (Sicily) <i>I. Vasiliev, E. M. Mezger, S. Lugli, M. Roveri, V. Manzi, G. J. Reichart, F. Sangiorgi, W.</i>	215

<i>Krijgsman</i>	
233 - Rapid Paleoenvironmental Change during the Late Maeotian -Early Pontian (6.6 Ma-5.9 Ma) in the Eastern Paratethys (Taman Peninsula)	
<i>Elenora Radionova, Larisa Golovina</i>	216
SESSION 6	
120 - Episodes of Isolation from the Mediterranean and Brief Lowstands of the Black Sea Lake	
<i>William B. F. Ryan, Anastasia G. Yanchilina</i>	219
159 - Ultra-High Resolution Paleoceanography and Paleoclimatology during Sapropel S1 Deposition in the NE Aegean Sea (South Limnos Basin): Evidence of Black Sea Inflow Establishment	
<i>Maria Triantaphyllou, A. Gogou, S. Kostopoulou, M. Dimiza, I. Bouloubassi, G. Rousakis, C. Parinos, M. Geraga, An. Diamantopoulou, V. Lykousis</i>	220
SESSION 8&9	
36 - High Climatic Resolution during the Last 13,000 Cal Years BP Inferred from A Charcoal Record from Lake Ifrah (Middle Atlas, Morocco) West Mediterranean Region	
<i>Brahim Damnati, Hanane Reddad</i>	223
108 - Eastern Mediterranean foraminiferal Palaeoecological Responses to Late Pliocene Environmental Changes	
<i>H. Drinia, A. Antonarakou, G. Kontakiotis, E. Tsiolakis</i>	224
135 - First Colonization of the Genus <i>Amphistegina</i> and Other Alien Benthic Foraminifera in the Pelagian Islands and in the South-Eastern Sicily (Central Mediterranean Sea)	
<i>Antonio Caruso, Claudia Cosentino</i>	225
140 - Benthic Foraminiferal Assemblages from the St. Peter's Pool Section (South Eastern Malta Island)	
<i>B. Russo, L. Ferraro, F. Lirer, L. Foresi, M. Verducci, N. Baldassini, R. Mazzei, G. Salvatorini</i>	226
141 - Approximating the Autecology of Endemic Lake Pannon Ostracods by High-Resolution Sampling (Late Miocene; Styrian Basin, Austria)	
<i>Frank Gitter, Martin Gross, Werner E. Piller</i>	227
153 - Late Interglacial to Holocene Paleoenvironmental Evolution of Western Cyclades Plateau (SW Aegean Sea)	
<i>G. Rousakis, M. Ratopoulou, M. Triantaphyllou, I. Bouloubassi, M. Dimiza, A. Gogou, , K. Parinos, K. Kouli, V. Kapsimalis, V. Lykousis</i>	228
166 - Foraminiferal Mg/Ca-Paleothermometry in the Mediterranean Sea: Constraints and Implications	
<i>S. Boussetta, N. Kallel , F. Bassinot, J. Nouet, N. Caillon, H. Rebaubier, L. Labeyrie</i>	229
200 - First Evidence of Palms in the Island of Crete, Southern Greece	
<i>D. Velitzelos, M. Dermitzakis, A. Antonarakou, T. Denk, G. Kontakiotis</i>	230
205 - Climate Variability in Lebanon during the Last Four Climate Cycles: A Multiproxy Approach	
<i>Laurence Vidal, Françoise Gasse, Elise Van Campo, François Demory, Kazuyo Tachikawa, Anne-Lise Develle, Noelle Buchet, Marta Garcia, Corinne Sonzogni, Edouard Bard, Nicolas Thouveny ..</i>	231
240 - Potential of Lipid Biomarkers and High Resolution Holocene to Last Glacial Archives from the Gulf of Genoa, Ligurian Sea (NW Mediterranean Sea)	
<i>Jérôme Kaiser , Helge W. Arz , Nicoletta Ruggieri, Jens Hefter, Herbert Siegel, Gesine Mollenhauer, Frank Lamy</i>	232
SESSION 10	
9 - Chinese Neogene Mammalian Succession and Biostratigraphy	
<i>Tao Deng, Sukuan Hou</i>	235
27 - Origin of the Elements of the Endemic “Terre Rosse” Fauna (Gargano, South-Eastern Italy).	
<i>Andrea Savorelli, Federico Masini</i>	236

44 - Hoplitomerycidae, a Possible Example of Giantism among Insular Ruminants	
<i>Paul P.A. Mazza, Maria Adelaide Rossi, Silvano Agostini</i>	237
51 - Anisodon (Chalicotheriidae, Perissodactyla) from China and the Phylogenetic Relationships of the Genus	
<i>Shao-kun Chen, , Tao Deng</i>	238
60 - Comparison of Miocene Xerini (Sciuridae, Mammalia) from Central Spain and Germany	
<i>Jérôme Prieto, Verónica Hernández-Ballarín, Adriana Oliver, Pablo Peláez-Campomanes</i>	239
62 - Cricetodontini from the Calatayud-daroca Basin (Miocene, Spain)	
<i>P. López-Guerrero, I. García-Paredes, M. A. Álvarez-Sierra, P. Peláez-Campomanes</i>	240
65 - Parasorex Depereti (Crochet, 1986) (Lipotyphla, Mammalia), from the Upper Maessinian (MN13) Fissure Filling of Brisighella (Faenza, Northern Apennine, Italy)	
<i>Federico Masini, Flaviano Fanfani, Andrea Savorelli</i>	241
67 - New Data on the Late Turolian Carnivora of Southern Russia	
<i>M.V. Sotnikova</i>	242
70 - Biostratigraphy of the Upper Miocene to Lowest Pleistocene Deposits of the Guadix Basin (Spain) Based on Small Mammals	
<i>Raef Minwer-Barakat, Antonio García-Alix, Elvira Martín Suárez, Matthijs Freudenthal, César Viseras</i>	243
77 - Biochronology and Historical Biogeography: Testing Symmetric Versus Asymmetric Time Models	
<i>M. Ángeles Álvarez-Sierra, Israel García-Paredes, Verónica Hernández-Ballarín, Lars W. van den Hoek Ostende, Kees Hordijk, Paloma López-Guerrero, Albert J. van der Meulen, Adriana Oliver, Pablo Peláez-Campomanes</i>	244
78 - Carnivore Biodiversity Changes among Neogene, Quaternary and Present Time Period in Turkey	
<i>Sakir Önder Özkurt</i>	245
85 - Paleoenvironmental Reconstructions Based on Small Mammals (Isotopic vs. Faunistic Data)	
<i>Antonio García-Alix, Antonio Delgado Huertas, Elvira Martín Suárez, Matthijs Freudenthal</i>	246
86 - Paleo-humidity Parameters in Fossil Rodents (Mammalia): Isotopic vs. Morphological Approach	
<i>Antonio García-Alix, Matthijs Freudenthal, María Rios, Francisco Ruiz-Sánchez, Elvira Martín-Suárez, Antonio Delgado Huertas</i>	247
100 - New Finds of Rodents from the upper Miocene Sediments of Danube Basin (Slovakia)	
<i>Peter Joniak</i>	248
99 - Lower to Middle Miocene Small Mammal Faunas from the Tudela Formation (Bardenas Reales Natural Park, N Iberian Peninsula); Biostratigraphic Implications	
<i>Oier Suarez-Hernando, Xabier Murelaga, Juan C. Larrasoña, Francisco J. Ruiz-Sánchez, Matthijs Freudenthal, Miguel Garcés</i>	249
116 - The Fossil Record of the Genus Vasseuromys (Mammalia, Gliridae) in Europe and Asia and Its Relation with the Climatic Conditions in the Late Oligocene-Late Miocene Period	
<i>Francisco J. Ruiz-Sánchez, Oier Suarez-Hernando, Xabier Murelaga, Juan C. Larrasoña, Matthijs Freudenthal, Miguel Garcés</i>	250
118 - The Insectivores from Hasznos (Middle Miocene, Hungary, Nógrad County)	
<i>Jérôme Prieto, , Lars W. van den Hoek Ostende, János Hír</i>	251
142 - New Small Mammal Faunas of Early Miocene Age (mn4-mn4/5) from the Magro and Ribesalbes-Alcora Basins (E. Spain)	
<i>Vicente D. Crespo, Francisco J. Ruiz-Sánchez, Samuel Mansino, Matthijs Freudenthal, Plinio Montoya, Marc Furió, Oier Suarez-Hernando, Xabier Murelaga, Juan C. Larrasoña, Miguel Garcés</i>	252
195 - Large Mammal Dispersal and Faunal Dynamics in Southern Europe during the Quaternary	
<i>Maria Rita Palombo</i>	253

214 - Paleogene Rodents from S.E. Serbia	
<i>W. Wessels, Z. Marković, H. de Bruijn</i>	254
222 - <i>Hystrix Primigenia</i> from the Staniantsi Locality (Miocene-Pliocene Transition) in Western Bulgaria	
<i>L. Bullmann, M. Böhme, J. Prieto, N. Spassov</i>	255
223 - A Rich Desman Record (Mammalia, Talpidae) from Staniantsi (Miocene-Pliocene Transition, Western Bulgaria)	
<i>J. Prieto, M. Böhme, D. Vasilyan</i>	256
224 - Small Mammals (Rodentia, Lipotyphla, Chiroptera) from Staniantsi (Miocene-Pliocene Transition, Western Bulgaria) – An Overview	
<i>J. Prieto, M. Böhme, J. Bullmann, D. Vasilyan</i>	257
225 - First Vallesian Small Vertebrate Fauna from Bulgaria	
<i>J. Prieto, M. Böhme, N. Spassov, L. Hristova</i>	258
SESSION 11	
29 - Small Mammals from Acheulean cave site Sel'-Ungur (The Fergana Valley, Uzbekistan)	
<i>Anastasia Markova</i>	261
101 - Ecology of European Hipparionines and the Diversity of Late Miocene Hominids in Western Eurasia	
<i>Scott R.S., Clavel J. DeMiguel D., Kaya T., Kostopoulos D.S., Mayda S., Merceron G.</i>	262
198 - First Results of a Pollen Record from Lake Iznik (NW Turkey) Encompassing the Last C. 30,000 years	
<i>Andrea Miebach, Patricia Angelika Roeser, Thomas Litt</i>	263
SESSION 12	
4 - An Evaluation of Several Representative Geoarcheological Sites from the Black Sea Coast	
<i>Dr. Frînculeasa Mădălina Nicoleta, Dr. Murărescu Ovidiu, Dr. Murătoreanu George, Dr. Țurloiu Rareș</i>	267
66 - Past Seismic Activity in Eastern Anatolia Recorded in the Sediments of Lake Van over Six Glacial/interglacial Cycles	
<i>Mona Stockhecke, Flavio S. Anselmetti, Kaspar Gaeggeler, Aysegül F. Meydan</i>	268
96 - Reconstruction of Vegetation and Climate during the Last Glacial/Interglacial Cycle at Lake Van (Eastern Anatolia, Turkey)	
<i>Nadine Pickarski, Thomas Litt</i>	269
110 - Preliminary Results of the Palaeontological Investigations of the Late Early Pleistocene Somssich Hill 2 Locality (South Hungary)	
<i>Piroska Pazonyi, Lukács Mészáros, Zoltán Szentesi, Mihály Gasparik, Attila Virág</i>	270
122 - Geomorphological, Environmental and Geoarcheological Structure of Akbuk Gulf	
<i>Şuheda Edremit</i>	271
172 - Recent Fluvial Clastic Input and Sedimentary Climate Records in Eastern Part of Lake Van, Eastern Turkey: Implications for Interpretation of Lacustrine Climate Records	
<i>Ayşegül Feray Meydan, M. Namık Çağatay, Sefer Örcen</i>	272
194 - New Early Middle Pleistocene Locality of Small Mammals (Lower Dniester) and Its Position in Early Middle Pleistocene Mammal Sequence	
<i>Anastasia K. Markova</i>	273
201 - Chemo-Stratigraphical Characterization of Lake Van sediments: Implications for Holocene Ecology and Environment in Eastern Anatolia	
<i>Bulkan Özlem, Çağatay M. Namık, Makaroğlu Özlem, Orbay Naci</i>	274
218 - A Pleistocene Freshwater Community and Rodents from the Pasinler Basin (Erzurum Province, North-Eastern Turkey)	
<i>Davit Vasilyan, Simon Schneider, Sevket Sen, Salih Bayraktutan</i>	275

Keynote Lectures

The Importance of the Neogene in Turkey

A. M. C. Sengör

İTÜ Maden Fakültesi, Jeoloji Müh. Bölümü
and Avrasya Yerbilimleri Enstitüsü,
Ayazağa 34469 Istanbul, Turkey. sengor@itu.edu.tr

Neogene, i.e. the time period from about 23 Ma to 2.6 Ma is a crucial time not only for Turkey, but the whole world: It is the time in which the equatorial circum-global current was annihilated by the closure of the isthmuses of Panama, Gibraltar and SE Turkey. This triggered the last great ice age.

In Turkey, the closure of the SE Turkish seaway was finally accomplished during the Serravallian, but deep-sea connection between the Indian Ocean and the Mediterranean had already been lost by the end of the Oligocene. The loss of the final connection triggered the Messinian Salinity Crisis in the Mediterranean Basin.

In Turkey, the shortening in the east caused by the terminal collision led to the development of the Anatolian Scholle bound by the North and the East Anatolian Faults. The Anatolian Scholle began its westward motion with respect to Eurasia during the Tortonian, helped massively by the trench pull along the Hellenic subduction zone. Since the Tortonian, Turkey as a whole remained out of water, but while its eastern part was rising to create the Turkish-Iranian High Plateau, its western part was being stretched and lowered.

The main question concerning the Neogene tectonics of Turkey is how much mantle motions have been contributing to the picture we see at the surface today. It is clear that the mantle lithosphere beneath much of Turkey is absent, but it is unclear how it was removed, except in the case of eastern Turkey.

Keywords: Neogene, Tectonics, SE Turkish seaway, Messinian Salinity Crisis, Panama Isthmus, Gibraltar Isthmus.

Steps towards a Comprehensive Understanding of the Messinian Salinity Crisis

William B. F. Ryan

Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA, billr@ldeo.columbia.edu

There are several observations that must be reconciled when trying to decode the Messinian Salinity Crisis.

- The salinity of the Mediterranean increased before the onset of the first evaporite bed.
- The initial gypsum appeared within the same precession cycle in all marginal settings and in continuity with underlying clays.
- All first cycle beds, comprising selenite layers 1 through 16, were deposited in a subaqueous environment without emersion. The accommodation space was never filled.
- An erosion surface that extends across the shelf to beneath the edge of the mobile salt layer on all passive margins.
- Detrital wedges at the base of the slope pass beneath and into the mobile layer. The wedge volume is less than the amount of sediment eroded from the margin.
- The mobile layer displays internal stratification seaward of river deltas, and is transparent in distal settings, suggesting substantial detritus within this layer at proximal locations.
- The volume of the mobile salt layer is approximately one-quarter the volume of the pre-MSC Mediterranean.
- The Lago-Mare sediments in the deep-sea drill cores contain shallow-water fauna and flora requiring sunlight. For Lago-Mare sediments to be present also in margin settings, there had to be large and rapid variations of water thickness.
- The thick “M” reflectors that conformably cap the mobile salt layer in the western basins are not present in the east. Instead, the top of the salt layer is significantly eroded, and this layer is overlain by Trubi-equivalent marls with room only for a thin Lago-Mare interval.
- In both the western and eastern basins, the mobile salt layer originally overlapped the slope. The mobile layer has since flowed basinward and its edge has become detached in slivers.
- Mobile salt movement occurs before the accumulation of significant overburden.

A scenario to account for these observations begins with restriction of the inlet from the Atlantic. As its sill shoaled, salinity within the Mediterranean increased. Once the brine reached concentration to initiate sulfate precipitation, the first selenite bed began to grow in all marginal areas. During the wetter part of each subsequent precession cycle, salinity decreased and selenite growth gave way to carbonate sedimentation. The increasing density of the brine, thickest above the basin floors, induced a load on the lithosphere, causing basin centers to subside and peripheral bulges to emerge. The bulges further restricted the entry of Atlantic water, thus concentrating the brine towards halite saturation. The concentration added to the brine load so that eventually a combination of peripheral uplift and eustasy closed or severely restricted the inlet. Evaporative drawdown of the brine accelerated halite precipitation.

Drawdown during halite precipitation accounts for the timing of the emergence of the shelves after the first cycle gypsum, onset of massive erosion, delivery of detritus into the salt layer, the observed increase in the thickness of the salt layer with greater depth below today's sealevel and the total volume of salt. Formation of the mobile salt layer ceased when the brine had mostly evaporated. The only remaining sources of water were rivers and spillage from the Paratethys. Gypsum and halite on the exposed margins were eroded or dissolved and re-deposited as clastics, as well as re-precipitated to form the “M” reflectors with the second cycle evaporates. The load of mobile layer, when combined with the weight of the returning Pliocene water, further depressed the basin centers so that the accumulated salt flowed towards its depocenter under its own weight. This phenomenon explains the early mobility.

ATNTS2012

Frits Hilgen¹, Luc Lourens¹, Jan van Dam², Alan Beu³, Andrew Boyes³, Roger Cooper³, Wout Krijgsman⁴, James Ogg⁵, Werner Piller⁶ and Doug Wilson⁷

¹Institute of Paleoenvironments and Paleoclimate Utrecht, Budapestlaan 4, 3584 CD Utrecht, The Netherlands. e-mail: fhilgen@geo.uu.nl.

²Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands

³GNS Science, Lower Hutt 5040, New Zealand

⁴Paleomagnetic Laboratory Fort Hoofddijk Faculty of Earth Sciences, Utrecht University
Budapestlaan, 17, 3584 CD Utrecht, The Netherlands, e-mail: krijgsma@geo.uu.nl

⁵Purdue University Department of Earth and Atmospheric Sciences, West Lafayette, Indiana 47907-1397
USA

⁶Institut für Erdwissenschaften, Bereich Geologie und Paläontologie, Universität Graz, Heinrichstrasse 26,
A-8010 Graz, Austria

⁷Department of Geological Sciences and Marine Science Institute, University of California, Santa Barbara
CA 93016-9630, USA.

ATNTS2012 is presented in the Neogene chapter of GTS2012, which just appeared as a two volume book published by Elsevier. It is the successor of ATNTS2004. The changes with respect to ATNTS2004 are relatively minor as might be expected from a time scale that is largely based on astronomical tuning. The Serravallian Global Stratotype Section and Point (GSSP) has been defined at the boundary between the Globigerina Limestone and Blue Clay Formations in the Ras-il-Pellegrin section on Malta and coincides with the termination of the Mi3b isotope shift; ongoing studies are further directed to define the Langhian GSSP close to the C5Cn/C5Br boundary and the Burdigalian GSSP in a deep marine core in the open ocean. In addition to the global chronostratigraphic scale, regional subdivisions for New Zealand and the Paratethys have been added, and detailed mammal-based chronological units and calcareous plankton, dinoflagellate and radiolarian biozonal schemes are included.

The age calibration of ATNTS2012 is based on astronomical tuning for the interval younger than 15 Ma, whereby reversal ages of the marine Monte Corvi section replace ages based on the continental Orera section. For the interval between 15 and 23 Ma, age calibration is still based on interpolation of spreading rates from 5 high spreading rate plate pairs in the Pacific, but these will likely be replaced in the future by tuned ages coming from ongoing studies of deep-sea cores from (I)ODP Legs. Important issues are further the proposed use of unit stratotypes instead of GSSPs (only), and the application of Milankovitch cycles as chronozones, i.e. formal chronostratigraphic units of a smaller scale than (sub)stages.

SESSION 1

**NEOGENE TECTONICS AND SEDIMENTARY EVOLUTION
OF PERI-MEDITERRANEAN AREAS**

**CONVENER
IMRE MAGYAR**

Late tortonian Paleotectonic Restoration of the Gibraltar Arc Orogenic System: The Denouement of Its Geodynamic Evolution

Ana Crespo-Blanc^{1,2}, Menchu Comas^{2,1}, Juan Carlos Balanyá³

¹Departamento de Geodinámica, Facultad de Ciencias, Universidad de Granada, Fuentenueva s/n, 18071 Granada – Spain. acrespo@ugr.es

²Instituto Andaluz Ciencias de la Tierra, Consejo Superior de Investigación Científica- Universidad de Granada, Avenida de las Palmeras 4, 18100 Armilla (Granada - Spain). mcomas@ugr.es

³Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Ctra. de Utrera km. 1, 41013 Sevilla – Spain. jcbalrou@upo.es

The Gibraltar Arc System (GAS) closes the Alpine-Mediterranean orogenic system to the west and includes the Betic-Rif orogenic belt, the Alboran and Argelian-Balearic basins and the accretionary prism present in the Cadiz Gulf. Since at least two decades, the geodynamic evolution of the GAS has been a matter of debate and a huge number of models, so many as working groups, have been proposed. In most of these models, generally at scale equivalent to 1:10.000.000 or even smaller, the external boundary of the Betic-Rif orogenic wedge, initially N-S directed, sweeps from east to west the Gibraltar Arc area, acquiring his arcuate geometry during this westward movement. Moreover, they are frequently based on 2D schematic cross-sections from which a model for the whole arc is deduced. This fact under evaluates not only the mass movements oblique to the selected cross-section plane, but also the diachronism of the deformation, in turn expected in a so closed arc.

In this communication, we want to zoom on the Gibraltar Arc area, to draw a detailed Late Tortonian paleotectonic restoration and to highlight the consequence of this reconstruction on the final evolution of the westernmost Mediterranean. Our approach is based on: 1) the identification and characterization of structural domains of the Gibraltar Arc orogenic system and the transfer fault zones that separate them, 2) an accurate dating of the superposed events of deformations for each one of these domains, 3) the restoration of vertical axis-rotations of some of these structural domains (evidenced by paleomagnetic data), and 4) the quantification of Miocene shortening in the External zones. This exercise makes us to put all together the results of twenty years of research of our teams on this natural case-study, mainly with field and marine geology techniques, and to test it through the revision of an extensive bibliography.

It will be shown that the proposed reconstruction permit to simplify most the kinematics models proposed at the moment. Although some key points are still problematic, this paleotectonic restoration may solve more problems than arise them.

Keywords: Gibraltar Arc orogenic system, paleotectonic restoration, Upper Tortonian

Acknowledgements:

This study was supported by grants RNM-3713, RNM-215, CGL2008-03474 E/BTE, CTM2009-07715/MAR and CGL2009-11384.

Scenes from the Tectonic Evolution of the Alboran Sea Basin: Structural Framework and Role of Tectonic Heritage

Menchu Comas¹, Ana Crespo-Blanc^{1,2}, Juan Carlos Balanya³

¹Instituto Andaluz Ciencias de la Tierra, CSIC and University of Granada, 18100 Granada (Spain), mcomas@ugr.es

²Departamento de Geodinámica, Facultad de Ciencias, University of Granada, 18071 Granada (Spain), acrespo@ugr.es

³Departamento de Sistemas Físicos, Químicos y Naturales, Pablo Olavide University, 41013 Sevilla (Spain), jcbalrou@upo.es

The Alboran Basin provides clues to decipher tectonic and sedimentary processes occurred during the tectonic evolution of the Gibraltar Arc System (GAS), which besides the Alboran and Algerian back-arc basins comprises the tight Betic-Rifean orogenic arc and its forefront accretionary prism. It is now accepted that the GAS formed through the Neogene from the westward moving of the crustal Alboran Domain (the Betic-Rifean hinterland) within a tectonic context of continental collision between Eurasia and Africa plates. This contribution focuses in getting new clues on our understanding of the complex structure and tectonic history beneath the Alboran Sea and at its transition to the neighboring Algeria Basin. On the basis of multichannel reflection seismic profiles and mapping from these basins we document their seismic stratigraphy, shallow-crustal structures, different structural domains, and the sequence of major deformation events. Furthermore we discuss the impact of inherited structures on the tectonic evolution of the basin and resulting tectonic framework.

The West Alboran basin reveals events of ENE-WSW directed extensional deformation (from about 16 to 8.5 Ma, late Burdigalian to late Tortonian) that affected tectonic elements from the Alboran Domain hinterland and the overlying Miocene sedimentary units. The mid to late Miocene extension resulted in major low angle normal faults, and NNW-SSE trending grabens connected by ENE-WSW transtensional transfer faults, both occurring in concomitance with the westward migration (around 200 km) of the crustal Alboran Domain. The geometry of extensional structures constrains the manner, timing and amount of the coeval crustal thinning. Calkalkaline major volcanic events occurred along this extensional period. In the late Tortonian (about 8.5 Ma) a dominant N-S directed compressional event caused basinwide inversions of extensional faults, discrete folding, and strike-slip faulting. This compressional event triggered the spectacular West Alboran shale-diapirism from the basal units seen in the Alboran basin. At the South and Eastern Alboran and at the transition of the Alboran Basin to the Algeria basins to the E, a pervasive period of compressional deformation (from about 7 Ma onwards) is patent. The long lasting compressional conditions since the late Tortonian resulted in a contractive reorganization of the basin, including significant development of the shale-tectonics and subsequent mud volcanism. In fact, thrusts and oblique strike-slip fault-zones limit the deformation partitioning, bound the actual structural domains, and exemplify the nature of the crustal boundaries between the Alboran and Algeria basins.

The tightening of the Gibraltar Arc, the bending of former extensional structures, the development of main wrench-fault systems and thrusting, as well as the rotated segments of the basin-margins are expressive of a late Miocene to Present dramatic reorganization of the basin caused by the coeval NNW-SSE plate-tectonic convergence. The spatial and temporary evolution of the tectonic deformation documented here by geological and geophysical observables provides, among others, new insights into the critical role of tectonic inheritances and major transfer fault-zones in the geodynamic history of the GAS.

Keywords: Alboran Sea, Neogene, Tectonic evolution, Structural inheritance, Reflection seismic

Acknowledgements:

This study was supported by projects RNM-3713, RNM-215, CSD2006-00041, CGL2008-03474 E/BTE, CTM2009-07715 and CGL2009-11384 (MINECO, Junta Andalucía, and Feder funds, Spain).

3D Structure and Tectonic Evolution of The Sorbas Basin: An inverted Asymmetric Graben Impacted by The Messinian Salinity Crisis

Damien Do Couto^{1,2,3}, **Charles Gumiaux**^{4,5,6}, **Romain Augier**^{4,5,6}, **Noémie Lebreton**^{4,5,6}, **Nicolas Folcher**⁷, **Gwenaél Jouannic**⁸, **Laurent Jolivet**^{4,5,6}, **Jean-Pierre Suc**^{2,3}, **Christian Gorini**^{2,3}

¹Total S.A., 2 Place De La Coupole, 92078 Paris La Défense Cedex, France,
docoutodamien@gmail.com

²UPMC Université Paris 6, UMR 7193, ISTEP, 75005, Paris, France

³CNRS, UMR 7193, ISTEP, F-75005, Paris, France, jeanpierre.suc@gmail.com,
christian.gorini@gmail.com

⁴Université d'Orléans, ISTO, UMR 7327, 45071, Orléans, France, charles.gumiaux@univ-orleans.fr,
noemie.lebreton@univ-orleans.fr, romain.augier@univ-orleans.fr, laurent.jolivet@univ-orleans.fr

⁵CNRS/INSU, ISTO, UMR 7327, 45071 Orléans, France

⁶BRGM, ISTO, UMR 7327, BP 36009, 45060 Orléans, France

⁷PPME (EA n° 3325), Université de la Nouvelle-Calédonie, BP R4 98851 Nouméa Cedex, Nouvelle-Calédonie, nicolas.folcher@univ-nc.nc

⁸IDES (UMR 8148), Université Paris-Sud, 91405 Orsay Cedex, France, gwenael.jouannic@gmail.com

Since the Early Miocene, the formation of sedimentary basins in the Alboran domain, and more specially in the Betic Cordillera, is related to the exhumation of metamorphic rocks (Meijninger and Vissers, 2006; Augier *et al.*, in press). While their mechanisms of formation are still debated, their history extends over a ca. 15 Ma period through a transition from regional late-orogenic extension to compression (Weijermars *et al.*, 1985; Martínez-Martínez *et al.*, 1997; Comas *et al.*, 1999; Jolivet *et al.*, 2006). An integrated study coupling field work and gravity data acquisition was performed in the Sorbas basin located in the southeastern Betic Cordillera. These two independent datasets are integrated in a 3D geomodeling software to better constrain the deep geometry of the basin.

We show that the sediment/basement rock interface displays a marked asymmetry consistent with an inverted Late Serravallian-Early Tortonian half-graben depocenter. The cumulative shortening calculated from its initial geometry is estimated at 9% with maximum shortening rate of 1mm/yr during the Late Tortonian, absorbing 15% of the Africa/Eurasia convergence. A particular attention has been paid to the geometry of Messinian deposits and associated erosional surfaces in the Sorbas Basin, considered as a reference basin to study the Messinian Salinity Crisis (MSC). The 3D model confirms the erosional character of the Messinian/Pliocene boundary, thereby called the Messinian Erosional Surface, and we tentatively show that the fluvial system developed during the peak of the MSC should have exited the basin toward the south.

The new geometrical model, showing a perfect internal consistency, can be used as a basis for interpretations of the Neogene tectonic history of the southeastern Betics and the Messinian Salinity Crisis. Based on this integrated study we explore a new evolutionary scenario.

Keywords: Alboran domain, Sorbas Basin, geodynamic evolution, Messinian Salinity Crisis

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The Orbitally Tuned (400ky-Eccentricity) Deontra Section (Maiella, Central Apennines, Italy) as a Stratigraphic Reference for Shallow Marine Carbonate Successions in the Oligocene-Miocene Mediterranean

Werner E. Piller¹, Gerald Auer¹, Markus Reuter¹, Mathias Harzhauser², Marco Brandano³

¹Institute for Earth Sciences, University of Graz, Heinrichstrasse 26, 8010 Graz, Austria;
werner.piller@uni-graz.at

²Geological-Paleontological Department, Natural History Museum Vienna, Burgring 7, 1010 Wien, Austria

³Dipartimento di Scienze della Terra, Università di Roma “La Sapienza”, P. Aldo Moro 5, 00185 Roma, Italy

The Oligocene–Miocene transition is of particular interest for the development of the Mediterranean Sea. At this time, the convergence of Africa and Eurasia impacted the Circum-Mediterranean region by a complex pattern of changing seaways and landbridges and caused the reorganization of oceanic current patterns. These geodynamic changes were amplified by drastic climate changes in the course of the stepwise long-term global cooling trend. Shallow marine sediment records have the strong potential to display sensitive environmental changes in sedimentary geometries and skeletal content. However, the time resolution of most neritic carbonates is not high enough to allow a correlation with climatic events as recorded in the deep sea sediment archives. In order to resolve the paleoceanographic and paleoclimatic changes during the Oligocene–Miocene transition in the Mediterranean shallow water carbonate systems with the best possible time resolution, we re-evaluated the Deontra section on the Maiella Platform (central Apennines, Italy), which acts as a reference for the correlation of Oligocene–Miocene shallow water deposits in the Mediterranean region. The widely continuous carbonate succession is composed of Larger benthic foraminiferan, bryozoan and corallinacean limestones interlayered with distinct planktonic foraminiferal carbonates representing a mostly outer neritic setting. Integrated multi-proxy and facies analyses indicate that CaCO_3 and total organic carbon contents as well as gamma-ray display only local to regional processes on the carbonate platform and are not suited for stratigraphic correlation on a wider scale. In contrast, new biostratigraphic data correlate the Deontra stable carbon isotope record to the global deep sea carbon isotope record. This links relative sea level fluctuations, which are reflected by facies and magnetic susceptibility changes, to third-order eustatic cycles. The new integrated bio-, chemo-, and sequence stratigraphic framework enables a more precise timing of environmental changes within the studied time interval.

In addition, observed low frequency cycles in the magnetic susceptibility record were used to orbitally tune the Deontra section with the 400ky-eccentricity cycles provided by the La2004 equation. The age model constructed by tuning the section to the 400ky-eccentricity orbital metronome correlates well with the ages defined by both bio- and sequence stratigraphy.

Additionally, time series analyses of gamma ray data indicate that the 400ky-eccentricity cycle is only preserved in this proxy during the interval between ~17 and 13.5 Ma which equals the well-known “Monterey event”. Gamma radiation is a direct proxy for raised precipitation of autogenic Uranium caused by increased burial of organic carbon in this section and thus follow the same long-term orbital pacing as observed within deep-sea carbon and oxygen isotope records. The observed 400ky gamma ray beat is thus assumed to correlate with the carbon isotope maxima observed during the “Monterey event”.

The cyclicities detected in both magnetic susceptibility and gamma ray data allow, within a well constrained bio-, sequence and isotope stratigraphic framework, a much more precise correlation of the Deontra section with deep sea records from the Mediterranean region but also on a global scale and designate Deontra as a key locality for Oligo/Miocene stratigraphy.

This is a contribution to FWF project P 23492-B17.

Keywords: Stratigraphy, Mediterranean, Oligocene-Miocene, Orbital tuning

The Possibility of Using Pyroclastic Levels for Correlation of Continental and Marine Miocene Deposits in Poland

Krzysztof Bukowski¹, Marian Wagner¹, Jacek Kasiński², Krzysztof Dudek¹, Michał Stefaniuk¹

¹ Faculty of Geology, Geophysics and Environmental Protection, AGH - University of Science and Technology, A. Mickiewicza 30, 30-059 Krakow, Poland, buk@agh.edu.pl; wagner@geol.agh.edu.pl; kadudek@agh.edu.pl; stefan@geolog.geol.agh.edu.pl

² Polish Geological Institute-National Research Institute, Rakowiecka 4, 00-975, Warsaw, Poland, jacek.kasinski@pgi.gov.pl

Numerous Miocene sequences in Poland contain intercalations of pyroclastic materials. These are most often tuffites, as well as tuffs, bentonitized tuffites, bentonites, and tonsteins. Such sediments were reported from the Polish Lowlands, the Upper Silesian part of the Carpathian Foredeep, Bochnia-Wieliczka part of the Forecarpathians, southern margin of the Holy Cross Mountains, as well as from boreholes from the eastern part of the Carpathian Foredeep.

The term ‘tuffites’ was used for materials of the volcanic origin, which settled in the sedimentary basin parallel to the ‘normal’ sedimentation processes. This way tuffite, being a sedimentary rock, volcanogenic, may contain terrigenous material (up to 50%) and cement. On account of the aqueous sedimentation environment, often encountered features of tuffites are bedding characteristic for flowing waters, gradation of grains, and lamination.

The tonsteins are known exclusively from coal deposits. They are kaolinitized tuffs transformed in an acid (peat) sedimentary environment. For the Neogene sediments of this type the term ‘paratonsteins’ has been used, as for a rock poorly diagenized, of distinct primary tuffite character. In the Polish Lowland, within the lower and middle Miocene sediments at least seven pyroclastic levels were encountered (mainly in deposits of brown coal), in the Carpathian Foredeep – at least ten ones, and another one in the Orava-Nowy Targ Intramontane Basin. They appear in sediments of diversified genesis: marine, brackish, and continental. Hence, different local profiles exist for these regions, which are difficult for the lithostratigraphical correlation.

Individual pyroclastic levels are different as to the chemical composition of the glass, participation of basic plagioclases, sizes of individual grain elements, or presence of characteristic rock-forming minerals (e.g.: hornblende, biotite, pyroclastic quartz, or potassium feldspars). These differences proved to be distinct enough to have used the tuffite levels for correlation of the Miocene sediments.

There exists a real possibility of working out an uniform profile for the continental and marine Miocene on the basis of lithostratigraphical correlation between these neighbouring regions, considering mineralogical and petrological features of the pyroclastic isochronous levels, and their ages: absolute (radiometric) and relative, based on their closest environment.

Paleogeography of The Pannonian Basin during The Late Miocene and Early Pliocene: Stratigraphic Implications

Imre Magyar¹

¹MOL Hungarian Oil and Gas Plc. & Research Group for Paleontology, Hungarian Academy of Sciences
MOL Nyrt., Oktober 23. u. 18., H-1117 Budapest, Hungary
immagyar@mol.hu

During the Late Miocene and Early Pliocene, the paleo-Danube and other rivers filled the deep Pannonian Basin System with sediments, creating one of the thickest Neogene non-marine depositional sequences in Europe. The basin of giant Lake Pannon was filled by forward accretion of sediment packages. Successive positions of the shelf-margin are represented by a series of clinoforms in seismic profiles. The height of the clinoforms, and thus the minimum (undecompact) paleo water depth is 200-600 m in the successions, and the width of the slope, as measured from the shelf-break down to the toe of slope, varies between 5 and 15 km.

The most significant agent of the shelf growth was the sediment dispersal system of the paleo-Danube: about 2/3 of the basin's area was filled by sediment transport systems supplying sediments from the NW, from the Alps and Western Carpathians. After quickly filling the shallow Vienna Basin, the paleo-Danube started to build a morphological shelf into the deeper water of the Kisalföld/Danube sub-basin at about 10 Ma ago. The main control on shelf-margin growth was the regional subsidence of the basin, and the dominant direction of progradation was NW to SE. Basement morphology only locally and moderately influenced the shelf advance. Progradation above the relatively uplifted but flooded (sublacustrine) basement highs, such as the Transdanubian Range, was especially fast as a consequence of low accommodation.

By 8.6 Ma, the northwestern part of the basin system had been turned into shelf areas and alluvial plains by the paleo-Danube and its tributaries, and a similar process took place in the northeastern part, where the paleo-Tisza system supplied sediments from the Northeastern and Eastern Carpathians. The two, almost perpendicularly striking systems coalesced, and formed a uniform shelf along the northern perimeter of the lake. The paleo-Danube system, however, remained the dominant agent, and it formed the youngest shelf margin of the Pannonian Basin in the southeastern corner of the basin system. This margin has an estimated age of about 4 Ma, and it lies 400 km to the southeast of the oldest paleo-Danube shelf margin. Additional local systems carried sediments from E to W along the eastern margin and S to N along the southern margin of the Pannonian Basin, respectively.

In spite of the recognition of extended clinoform successions, the shelf break is still commonly interpreted as a chronostratigraphic boundary, either between the Lower and Upper Pannonian, as in Hungary, or between the Lower and Upper Pontian, as in Slovenia, Croatia, and Serbia, or between the Pontian and Dacian, as in Romania. Apart from the different national nomenclatures, these interpretations are seemingly supported by the significant and usually sharp change in both lithology and fossil content across the shelf break. Shales with remains of deepwater animals, such as thin-shelled molluscs, are common below this boundary, whereas more sandy deltaic deposits with shallow water fauna occur above. The shelf break, however, cannot be considered a chronostratigraphic boundary, because the age difference along this lithological boundary across the entire Pannonian Basin, as discussed above, may amount 6 million years.

Seismic stratigraphic investigations, including shelf margin trajectory analysis, revealed climate and subsidence controlled base level changes during the Late Miocene and Early Pliocene. Evidence of a significant late Messinian lake level drop in Lake Pannon, however, has not been found so far.

Keywords: Pannonian Basin, Neogene, paleogeography, stratigraphy

New Results on the Upper Miocene Turbidite Systems of the Transylvanian Basin, Lake Pannon

Lilla Tőkés¹, István Róbert Bartha², Lóránd Silye², Csaba Krézsek³, Orsolya Sztanó¹

¹Eötvös Loránd University, Department of Physical and Applied Geology, Budapest, Hungary

²Babeş-Bolyai University, Department of Geology, Cluj Napoca, Romania

³OMV-Petrom S.A., Bucharest, Romania

The Transylvanian Basin was an embayment of Lake Pannon in the Late Miocene. Deepwater sedimentation was widespread in Lake Pannon; thick turbidite sequences developed. These are buried in much part of the Pannonian Basin. However, Upper Miocene deepwater sediments crop out in wide areas in the Transylvanian Basin. This provides a unique opportunity to understand their depositional setting as most probably good analogs of their subsurface counterparts.

Many lacustrine turbidite outcrops from the Southwestern part of the basin have not yet been studied in detail. The aim of our work was to set up a detailed environmental reconstruction. In addition, we did gamma-ray logging in the studied outcrops to aid in subsurface gamma-ray log interpretation.

In six outcrops detailed facies analysis was carried out. The sedimentary records of different sediment gravity flows were observed: high density gravelly and sandy as well as low density turbidity currents alternated with settling of mud. The exposures allowed detailed description of the turbidite system's architectural elements. Consequently we did gamma-ray logging on channel, levee, overbank deposits and lobe elements. The gamma-ray logs do reflect the facies associations which are characteristic for the architectural elements.

Erosional channels, aggradational channel-levee systems, isolated meandering channel-levee systems, lobes with distributary channel and lobes build up the turbidite system of the Transylvanian Basin. It is possible that these architectural elements developed in a stream wise direction. However, based on their characteristics, they belong to two different turbidite systems: a sand-rich and a mud/sand-rich turbidite system. The sand-rich system was presumably sourced from the South (~Southern Carpathians), while the mud/sand-rich from the East (~Apuseni Mountains). Thus, it implies that the Apuseni Mountains supplied finer grained sediments to the basin than the Southern Carpathians.

Acknowledgements:

The study was supported by the Papp Simon Foundation, the Koch Antal Geological Society and the Hungarian Research Fund (81530).

Keywords: Transylvanian Basin, Lake Pannon, Upper Miocene, turbidites, sedimentology

Evolution of the Danube Deep-sea Fan since the Last Glacial Maximum

A. M. Constantinescu^{1,2}, S. Toucanne², B. Dennielou², S. Jorry², N. Panin¹, G. Lericolais²

¹GeoEcoMar Bucharest, 23-25 Str. Dimitrie Onciul, Sector 2, 70318, Bucharest, Romania,
adriana.c@geoecomar.ro

²IFREMER, Unité de Recherche Géosciences Marines, Laboratoire Environnements Sédimentaires,
CS10070, 29280 Plouzané

The Danube deep-sea fan is one of the most extensive deep-sea sedimentary systems in Europe. It lies in the base of slope of the north-western margin of the Black Sea. The work of Popescu (Popescu *et al.*, 2001, Popescu, 2002) has opened the way to better understand the morphology and architecture of the fan. First results evidenced that during lowstand periods, the fan was fed by the Viteaz Canyon, which was directly connected to the Danube River. The fan has developed an impressive channel-levees network which is characterized by at least six major channel avulsions (Popescu, 2002; Lericolais *et al.*, 2013).

Despite the numerous sedimentary cores retrieved during the Blason (1998, 2002) and Assemblage (2004) oceanographic cruises, the details of the factors controlling the turbiditic activity of the Danube deep-sea fan still remained largely unknown. The purpose of our study is to improve the chronology of Danube deep-sea fan and to tie the expected results to the recent findings obtained by Soulet *et al.* (2011) regarding the chronostratigraphy and environmental changes in the Black Sea since the Last Glacial Maximum (~26-19 kyr before present).

Six küllenberg cores, retrieved from along the Viteaz Canyon and the deep depositional system, were analysed through detailed visual description, X-ray radiographs, spectrophotometry and X-Ray Fluorescence (XRF) scanner analysis. These analyses allow core-to-core correlation and the recognition of the well-known sedimentary units of Degens and Ross (1972; lacustrine and marine units) and Major *et al.* (2002; Red Layers), while using the revisited chronology of Soulet *et al.* (2011).

Sediment accumulation rates and turbidite frequency were then determined, revealing a shift in the sedimentation activity from the Southern channel-levee system (Unit 3; Lericolais *et al.*, 2013) to the Northern channel-levee system (Unit 6; Lericolais *et al.*, 2013) after the deposition of the so-called Red Layers 15,700 +/-300 cal yr BP and before the onset of the Bölling-Alleröd (14,700 cal yr BP). The feeding of the Northern channel-levee system continued until the marine invasion ca 9,000 yr ago, while no turbidite activity in the Danube deep-sea fan and the Viteaz canyon is observed thereafter. These results are of primary importance to understand sediment transfer from source (Danube River) to sink (Danube deep-sea fan) in Central Europe since the last glacial period, and we will discuss our results in the light of recent reconstructions of past terrestrial environmental (Soulet *et al.*, 2013) and sea-level changes in the Black Sea region (Lericolais *et al.*, 2009).

Keywords: Black Sea, Danube Deep-Sea Fan, turbidite, channel-levee, Last Glacial Maximum

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The Northeast Ionian Margin: A Continuous Sedimentation Laboratory into The Quaternary and a Wealth of Hydrocarbon Prospects in The upper Cenozoic Sediments!

George Anastasakis¹, David J.W.Piper²,

¹Faculty of Geology and Geoenvironment, University of Athens, Panepistimiopolis, Athens 15784, Greece,
anastasakis@geol.uoa.gr

²Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography, P.O.Box 1006, Dartmouth,
Nova Scotia, B2Y 4A2, Canada, dipper@nrcan.gc.ca

The continental margin offshore northwest Greece borders the northern Ionian Sea and hosts the well-defined western limit of the Ionian thrust belt that is encountered on the Greek islands from Zakynthos to Kerkira (Corfu) and extends offshore in the marine region between the islands. The post Lower Miocene sedimentary succession is exposed on the islands and shows quasi-continuous sedimentation throughout the Miocene into the Pliocene. A transition from carbonate to clastic-marly sedimentation occurred in this pre-Apulian zone in early Langhian, well exposed on Kefallinia and Levkas islands. Messinian gypsum, both of shelf facies and basinal turbidites, is well exposed on Zakynthos island, overlain by a major erosion surface. Several major strike-slip zones striking NNW-SSE are present on land and parallel structures are present offshore. They have created several pull-apart basins both in the marine and emerged sections of the islands and West Greece.

The pre-Apulian zone, on the west shelf of the Ionian Islands, constitutes the least deformed zone of the Greek peninsula and is a continuous marine sedimentation laboratory throughout the Neogene and Quaternary. Upper Cenozoic marine sedimentary depocenters formed both landwards and seawards of the Ionian thrust belt and include several basins with amazingly undeformed and continuous thick sedimentary strata.

Multichannel marine seismic reflection data delineate the seaward limit of the Ionian thrust belt that appears as an overthrust-folded zone. Seaward of the last shallow thrust is a continental slope that leads into deep trough shaped basins with thick, generally conformable sub-parallel reflectors to the limit of seismic penetration at 5 secs. The Messinian sequence is up to 1.2 sec thick and starts with a slightly unconformable surface that laterally passes into pinnacle buildups. At places the buildups form above a well pronounced erosional surface that cuts into parallel reflectors of Tortonian age. Within the basin strong reflectors attributed to Messinian evaporites are present. The basins are partly filled with gravity flow deposits, mostly turbidites and the top of the Messinian sequence contains erosive channels and other evidence of lowering of the base levels causing widespread erosion. On the continental slope in the Messinian, steep clinoforms developed with their inflection points gradually rising through time. Whether this is due to outer shelf subsidence or changes in base-level is at present uncertain. The top of the Messinian clinoforms are eroded out by a Messinian unconformity that is continuous along the entire slope as an erosional or bypassing zone laterally equivalent to the topmost part of the Messinian in the basin. The Pliocene-Quaternary sediments are 1.4–0.6 sec thick and generally are sub-parallel reflectors that along the slope contain several transgressive surfaces and locally fan deltas. Immediately above the Messinian, 0.2–0.4 sec of acoustically transparent sediment onlapping the slope probably corresponds to Zanclean hemipelagic sedimentation.

The basins that form on the shelf landwards of the Ionian thrust belt generally display a thinner Messinian sequence, mostly 0.6–0.3 sec thick that contains several erosive surfaces and locally thinner evaporites. The Langhian-Tortonian sequence below the Messinian is locally present, overlying folded Alpine sedimentary rocks of the Ionian thrust belt. The Pliocene–Quaternary sediments are up to 1.5 sec thick and contain several sea-level related clinoform packages and transgressive surfaces.

The NW Ionian margin hosts extensive post Middle Miocene organic rich source beds and a wealth of structural and stratigraphic traps within a little deformed extensive area of Upper Cenozoic sediments. Sandy turbidites and Messinian reef structures are potential reservoir rocks and inter-turbidite shales, evaporites, and Zanclean hemipelagic deposits, all of which onlap against the continental slope, are potential seals.

Keywords: Messinian, Ionian Margin, Greece, offshore, oil prospects

Stratigraphy and Evolution of Miocene Pleistocene Intermountain Basins of Eastern Albania

Pandeli Pashko¹, Vesel Hoxha¹ & Ibrahim Milushi¹

¹Institute of Geosciences, Energy, Water and Environment, Polytechnic University of Tirana.
Rruga "Don Bosko", No. 60, Tirana, Albania

The stratigraphy for the Messinian evaporite of the Pre – Adriatic Basin (PAB) is presented here. The PAB is a foreland basin filled by a thick Neogene-Quaternary sedimentary succession that starts with transgressive Serravalian formations and ends with the marine Pliocene (Zanclean) and Quaternary formations. The Kavaje Messinian sequence comprises the most complete sedimentary succession from Late Tortonian (Mengaj formation) up to marine Pliocene formations.

The up to 750 m thick Messinian sedimentary succession of PAB consists dominantly of marls with the oligotypical foraminifera assemblages and extinction of mollusks and can be divided into following units.

a. Pre-Evaporitic Mengaj Formation up to 320 m thick, consists dominantly of cyclic alternation of marine blue-grayish marls, and minor layers of fine-grained sandstone rich in marine benthic and plankton foraminifers and mollusks. The 90-97 m thick below the first massive gypsum body composed of clays and marls yielded oligotypical foraminifera assemblages. This strong environmental change shows the onset of Messinian salinity crisis.

b. Lower gypsum horizon of Gips-Sharri village consists of 286 m thick cyclic successions of clays, marls with crystalline selenite gypsum and sandstone beds. There are totally up to 9-12 gypsum beds of which 3-5 which are thickest occur in lower part of the unit. The first basal gypsum bed, 60 m thick, laterally splits into 2-3 beds. In the lower half this massive gypsum consists of twins of big grey-brown large sized crystals and upwards of massive, white selenitic gypsum. Fine-grained dolomites, 0.25-0.30 m thick occur within this gypsum. Gypsum beds are lens-layered and are intercalated with thin (few millimeter thick) gypsum and clay layers. The halite horizons, 16 to 30 m thick, occupy the upper part. There are no outcrop of the halite in the area, but it is confirmed by drillings and mining works.

c. Inter-Gypsum Marls, 281 m thick, overly erosion surface which separates it by the Lower Gypsum and Halite unit. The erosion surface is represented by a 1.0–1.5 m thick conglomerate, an important intra-Messinian subareal erosion surface. Inter-Gypsum Marls consists mainly of the rhythmic alternation of the grey clays and marls with scarce thin fine-grained sandstone layers, 5-12 up to 0.30 m thick, but two of sandstone bodies are 12.8 m and 14.0 m thick, respectively.

d. Upper gypsum horizon of Mushnik village is represented by a chain - like lens of massive selenite bodies, rich in fine grained clastic materials which frequently laterally pass in gypsum/mudstone, 1-2 up to 4 m in thickness.

e. Post-Evaporitic Marls (Lago Mare) consists of an 82 m thick sequence of the regular, alternation of grey marls and clays with thin sandstone layers, often very frequent grading to a rhythmic, cyclic succession and contains the small nodules of white carbonaceous sands.

The Pliocene formations are represented by 10-12 m thick sandstones and gravel-conglomerates, followed by thick grayish-blue marls-clays with marine mollusks and foraminifers (Acme *Sphaeroidinellopsis*) (Zanclean).

Marginal Basins

In the marginal basins, the Lower gypsum horizon is cut, on the top, by an important erosion surface. At their extension towards the north, (Durrës) the Messinian evaporite (270 m thick) consists of two gypsum bodies, 15 m and 4-5 m thick, whereas, towards the south (Vlorë), the Messinian Evaporites about 190 m thick, consists of three beds mainly macro-crystalline gypsum. From south of Kavaja to the north of Vlora the Messinian is represented by a thick silica-clastic fluvial-deltaic unit with silicified woods.

Keywords: Foreland basin, evaporite, gypsum, halite.

Karaburun Region's Cenozoic Structural History, NW Turkey

A. Gizem Say¹, Boris A. Natal'in¹

¹Istanbul Technical University, Department of Geology, 34469 Istanbul, Turkey

The Cenozoic stratigraphic succession of the Karaburun Peninsula starts with the Eocene Soğucak Formation of massive reef limestone showing facial changes to medium to thickly bedded biomicritic limestone or carbonate sedimentary breccia. Contrary to former statements (Oktay *et al.* 1992), stratigraphic relations with younger Oligocene rhythmically bedded carbonaceous shale, fine-grained sandstone, and marl of the Ceylan Formation are not exposed because of faulting. However, it seems that they are conformable according to data collected in the neighboring regions and our reconstruction of tectonic evolution. The upper lying Ceylan rocks made up of two facies: 1) Coarse grained sandstone and diamictites containing pebbles of volcanic rocks (up to 32m) and 2) Medium bedded limestone, limestone breccia with slump horizons (more than 80m). Miocene coal-bearing claystone, sand, and silt (>37m thick) are exposed to the east of Karaburun. They are unconformably overlain the Upper Miocene Çukurçeşme Formation consisting of red or variegated fluvial conglomerate and sand. The Eocene-Miocene rocks record a succession of structural events including the Eocene - Oligocene NE-SW extension, Oligocene NE-SW compression, and Miocene NE-SW extension. The earliest structures are represented by NE-dipping normal brittle faults cutting the Soğucak Formation. A few synsedimentary faults of the same kinematics have been also observed in the lower part of the Ceylan Formation. Numerous dominantly NW-striking clastic dykes in the lower deep water part of the Ceylan Formation confirm extensional nature of processes related disruption and subsidence of the extensive Eocene carbonate platform existed in the Istanbul area and at least in the southern part of the Thrace Basin (e.g. Turgut and Eseller, 2000). Unusual aspect of this event is oblique orientation of normal faults to the Black Sea coast and its narrow shelf. Conjugated tight recumbent syncline-anticline couple marks the transition to compression. The width of these folds is 200-250m. They have W-NW strike deviating to the north in off shore areas. The folds show northeastern vergence and their geometry is unique over a wide area because the Ceylan Formation is gently dipping there. The formation of these folds was synchronous with shallowing of the sedimentary basin as it is evidenced from facies changes from deep marine turbiditic sediments to shallow marine sandstone/diamictite and limestone (mostly packed medium to thickly bedded biomicrite) with wavy bedding surfaces. This compressional event provoked extensive submarine sliding that is well manifested along the Black Sea coast to the west of Karaburun for 2.5 km and also in cliffs along the southern coast of Terkos Lake (at least 8 km). There are several slump horizons in the upper part of the Ceylan Formation varying in thickness from 6 (the lowest) to 3 m. Block imbrications in the slumps and fragments of asymmetric folds indicates westerly motions of the slumps away from the growing northeast-vergent folds. Fluid overpressure caused by folding created mud diapirs in the lower part of the Ceylan Formation, which are shaved by the slumps. Clastic dykes have not been observed in the slump deposits. However, their concentration is maximal along the southwestern margin of the tight folds. Scattering of clastic dyke orientations can be related to the rotation of stress field from the NE-SW extension to NE-SW compression. After the Oligocene compression, the Karaburun region was again affected by extension. It formed small amplitude (0.5-1.5 m) NW-trending normal fault cutting all above mentioned structures as well as the Miocene coal-bearing sediments. Southward regional tilting of the Çukurçeşme Formation was a last structural event in the Karaburun region.

Keywords: Oligocene stratigraphy, tectonic evolution, NW Turkey, Black Sea

Tectonic, Stratigraphic and Volcanic Evolution of the Ne-Sw-Trending Neogene Basins of Western Anatolia

Cahit Helvacı¹, E. Yalçın Ersoy¹

¹Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Jeoloji Mühendisliği Bölümü, TR-35160 İzmir, Turkey

The geometry, stratigraphy, tectonics and volcanic components of the Neogene basins in western Anatolia offer some key knowledge and points on the relationship between the basin evolution and mode of extension in this intensely and chaotically deformed and extended area. With present-day configurations, two main types of Neogene basins are recognized in the western Anatolia: (a) NE–SW- and (b) ~E–W-trending basins. Detailed stratigraphy and tectonic features of the NE-SW-trending basins reveal that their evolution was more complex than previously thought. The E–W-trending basins are typical grabens which are still deformed under ~N–S-extension.

The NE–SW-trending basins which occur on the northern side of the Menderes Core Complex (MCC), are Demirci, Selendi, Uşak-Güre and Emet basins. The basins, formed on the MCC were evolved as successive supra-detachment basins and include two main sedimentary sequences: the early Miocene Hacıbekir Group and the early-middle Miocene _nay Group. These units represent two-stage low-angle detachment faulting of the MCC, and were formed in response of successive detachment, and following mainly strike- and oblique slip faulting in the course of extension.

There are also NE–SW-trending basins developed along the İzmir-Balıkesir Transfer zone (İBTZ) (e.g., Bigadiç and Gördes basins). The sedimentary infill of the basins developed on the İBTZ show distinct sequences and is controlled by mainly strike-slip and subsidiary normal faults.

In this study, stratigraphic (volcanostratigraphy successions), tectonic and volcanic geochemical evolutions of the NE–SW-trending basins of the MCC and İBTZ are summarized and compared to test the models proposed for the late Cenozoic extension in the western Anatolia.

Keywords: NE-SW-trending basins, Neogene stratigraphy, extensional tectonics, supra-detachment basins, Menderes Core Complex, Western Anatolia

The Varied Development and Regional Implications of Late Serravalian Erosional Unconformity in The Peri-mediterranean Basins of Southern Turkey

Ayhan Ilgar¹, Wojciech Nemec², Aynur Hakyemez¹, Tolga Esirtgen¹, Carlo Messina³, Banu Türkmen¹, Attila Çiner⁴

¹Department of Geological Research, General Directorate of Mineral Research and Exploration (MTA),
06800 Ankara, Turkey, ayhan_ilgar@yahoo.com

²Department of Earth Science, University of Bergen, 5007 Bergen, Norway

³Statoil Gulf Services LLC, Research and Development, 77042, Houston USA

⁴Department of Geological Engineering, University of Hacettepe, 06800 Ankara, Turkey

A late Serravalian forced-regressive unconformity is recognizable in the Adana, Mut, Ermenek and Antalya basins of southern Turkey. In the Antalya Basin to the west, the unconformity is marked by an erosional advance of gravelly fan deltas over the lower shoreface to offshore-transition heterolithic deposits. The correlative unconformity is less apparent in the Ermenek, Mut and Adana basins to the east, where it separates two successive platforms of marine reefal limestones and is manifested mainly by isolated incised fluvial palaeovalleys filled with mixed calci-siliciclastic deposits. In the Ermenek Basin, the local incised valley was filled by a bayhead Gilbert-type delta and further by a shoal-water delta and beach/lagoon deposits. In the Mut Basin, the incised valley-fill comprises basal fluvial deposits overlain by lagoonal and shoal-water bayhead delta deposits. Two coeval incised palaeovalleys have been recognized in the Adana Basin to the east, in the Tarsus and Kuzgun areas. The Tarsus incised valley-fill represents a classical wave-dominated microtidal estuary with a bayhead river delta, tidal flats, central lagoon and a barrier island with tidal-inlet delta. The Kuzgun valley-fill comprises basal alluvium overlain by tidal estuarine deposits passing upwards into offshore-transition mudstones and regressive shoreface sandstones. Planktonic foraminiferal biostratigraphy indicates that the latest deposits preserved below the erosional surface of forced regression represent biozone MMi7 (*Paragloborotalia partimlabiata* interval zone), which means a time interval between 12.77 and 11.78 Ma BP. The valley-fill deposits correspond to the zonal interval MMi8–MMi9 (*Neogloboquadrina atlantica-praeatlantica* and *Paragloborotalia siakensis* interval zones), spanning the time from 11.78 to 11.19 Ma BP. The regionally correlative surface of forced regression can thus be attributed to the end-Serravalian eustatic fall in sea level (Ser4/Tor1), recognized also in many other peri-Mediterranean areas. The varied regional development of the forced-regression unconformity is attributed to the differences in the subsidence history of the individual basins, not necessarily related to their differing tectonic regimes. The Antalya Basin was an orogen-collapse depression formed on the southern flank of the Tauride belt, where the eustatic sea-level fall coincided with the late Miocene period of relatively high subsidence. Fluvial incision there was thus limited to the hinterland area. The Ermenek Basin was an intra-Tauride pull-apart depression formed by strike-slip tectonics, where the sea-level fall coincided with relatively low subsidence and the basin's over-filled state of littoral carbonate platform expansion. A similar state of low subsidence and over-filling by carbonate platforms was met by the regression in the adjacent Mut and Adana basins to the east, although the first resembled tectonically the Antalya Basin and the second was a late-stage foreland syncline. The deficit of accommodation in over-filled basins caused incision of basin-crossing fluvial valleys. The depth of valley incision and their infilling pattern depended again on the local subsidence rate, as well as on the local rate of terrestrial sediment supply.

Keywords: forced regression, incised valley, eustatic sea-level change, bayhead delta, estuary, basin subsidence

The Adana Basin (Southern Turkey): A Neogene Tectono-Stratigraphic Archive of the Eastern Mediterranean

Giuditta Radeff^{1,2}, Domenico Cosentino^{1,3}, Taylor F. Schildgen², Manfred R. Strecker², Paola Cipollari^{1,3}, Guldemin Darbaş⁴, Kemal Gürbüz⁵

¹Dipartimento di Scienze Geologiche, Università degli Studi Roma Tre, Italy. gradeff@uniroma3.it

²Institut für Erd- und Umweltwissenschaften, Universität Potsdam, Germany

³Istituto di Geologia Ambientale e Geoingegneria, CNR-Roma, Italy

⁴Jeoloji Mühendisliği Bölümü, Kahramanmaraş Sütçü İmam Üniversitesi, Turkey

⁵Jeoloji Mühendisliği Bölümü, Çukurova Üniversitesi, Turkey

The Adana Basin of southern Turkey is a sedimentary basin with a stratigraphic record spanning the Late Oligocene and Quaternary. The basin is located in a crucial area that experienced at least three major tectonic events: (1) the collision between the African and Eurasian plates associated with the Tauride fold-and-thrust-belt; (2) the collision of the Arabian and Eurasian plates, leading to the extrusion of the Aegean-Anatolian microplate along the North Anatolian and the East Anatolian faults; and (3) the surface uplift of the southern margin of the Central Anatolian Plateau.

Being located immediately to the south of the southern flank of the Central Anatolian Plateau and the Central-Eastern Tauride mountains, the Adana Basin is in an ideal location to record tectonic and sedimentologic changes in the Mediterranean realm and to identify the catchment areas of the fluvial networks that have been transporting sediments from the orogen to the marine environment.

We studied the Adana Basin sedimentary sequences and the structural setting along the basin margins to identify the structural styles and the overall tectonic processes that generated sedimentary accommodation space and the record of the main events that occurred in the area.

In light of the recently refined stratigraphy of the Adana Basin, we re-interpreted more than 600 km of onshore seismic reflection profiles provided by the Turkish Petroleum Corporation (TPAO). We interpreted 34 seismic profiles, identifying 4 regional erosional surfaces and distinguishing five different seismostratigraphic units. We generated an isopach map for each seismic unit and estimated their volumes.

Combined with our seismic interpretations, we measured fault planes and kinematic indicators of different structures along the NW and the SE margins of the basin to define the structural setting along the basin margins.

Based on our results, we conclude that the Adana Basin records all the main regional tectonic and sedimentary events in the region. These include (a) evidence for the collision between the Arabian and Eurasian plates coupled with a major sea-level drop, which is expressed by a late Serravallian basin-wide unconformity; (b) structural evidence for a transcurrent or transtensional component of faulting along the NW basin margin that may be related to the activation of the East Anatolian Fault and the uplift of the Central Anatolian Plateau; and (c) evidence for plateau margin uplift represented by an up to 1700-m-thick sedimentary sequence of conglomerates and marls bearing a brackish-water Paratethyan fauna, attributed to the latest stage of the Messinian Salinity Crisis of the Mediterranean (the Messinian late Lago-Mare event; 5.45 – 5.33 Ma).

Finally, the NW and SE margins of the Adana Basin record two different main deformation styles. This observation, coupled with the architecture of the basin fill suggests that the tectonics which generated the accommodation space in the Adana Basin may not be attributed to one single event.

Keywords: Neogene stratigraphy, tectonic, accommodation space, surface uplift, southern Turkey.

Messinian Forced Regressions in the Adana Basin: A Near-Coincidence of Tectonic and Eustatic Forcing

Ayhan Ilgar¹, Wojciech Nemec², Aynur Hakyemez¹, Erhan Karakuş¹

¹Department of Geological Research, General Directorate of Mineral Research and Exploration (MTA),
06800Ankara, Turkey, ayhan_ilgar@yahoo.com

²Department of Earth Science, University of Bergen, 5007 Bergen, Norway

This sedimentological and sequence-stratigraphic study focuses on the late Miocene deposits in one of the largest peri-Mediterranean basins of southern Turkey, the Adana Basin, which formed as a Tauride foreland depression accumulating molasse deposits. The Tortonian–Messinian shallow-marine Handere Formation, previously interpreted as a regressive succession, appears to have recorded several relative sea-level changes. The formation base recorded a forced regression attributed to the end-Serravalian (Tor-1) eustatic fall in sea level. The lower to middle part of the formation is transgressive, culminating in offshore mudstones. The upper part is regressive and its three isolated conglomeratic members represent sharp-based Gilbert-type deltas with incised fluvial valley-fill deposits, recording a forced regression followed by marine reflooding. The time of this regression is biostratigraphically constrained to ~7.8 to 6.4 Ma BP on the basis of planktonic foraminifera in delta bottomset deposits. The regression is attributed to the tectonic conversion of the Adana foreland shelf into a piggyback basin, as indicated by seismic sections and compressional basin-margin deformation. The reflooding of the basin ~6.4 Ma BP. is ascribed to a post-thrusting flexural subsidence of the foreland under increased crustal load. The marine transgression brought an almost immediate evaporitic sedimentation, which suggests invasion of hypersaline Mediterranean water. The basin was subsequently emerged and its gypsiferous deposits were extensively eroded due to a second Messinian forced regression, attributed to the early evaporative drawdown in the Mediterranean Sea (~6 Ma b.p.). The post-orogenic isostatic uplift of the Taurides had meanwhile elevated the basin enough to prevent its reflooding by the Zanclean regional transgression.

Stratigraphic comparison with coeval peri-Mediterranean basins to the west demonstrates that inter-basinal correlations are difficult and that a superficial linking of comparable events may be quite misleading. The local timing of the late Miocene relative sea-level changes and also the landward extent of the Zancleanflooding were apparently determined by the combination of eustasy, tectonics, basin topography and sediment supply, whereby the eustatic signal was modulated and often obscured by local conditions. However, the individual basin-fill successions bear a high-resolution record of local events and give unique insights into the local role of tectonics, sediment yield and sea-level changes.

Keywords: sedimentology, sequence stratigraphy, Taurides, piggyback basin, Gilbert-type delta, incised valley-fill, Messinian salinity crisis, stratigraphic correlation

Complex Tectono-Stratigraphic Evolution of the Frontier Northern Levant Basin (Offshore Lebanon)

**Nicolas Hawie^{1,2,3}, Christian Gorini^{1,2}, Remy Deschamps³, Fadi H. Nader³, Lucien Montadert⁴,
Didier Granjeon³, François Baudin¹**

¹UMR 7193 Institut des Sciences de la Terre de Paris, Université Pierre et Marie Curie/ Univ. Paris 06, case 117. 4, place Jussieu 75252 Paris Cedex 05, France, nicolas.hawie@upmc.fr, christian.gorini@upmc.fr, francois.baudin@upmc.fr

²iSTEP, UMR 7193, CNRS, F-75005, Paris, France

³IFP Energies nouvelles, 1-4 avenue du Bois Préau 92852 Rueil Malmaison Cedex, France, remy.deschamps@ifpen.fr, fadi-henri.nader@ifpen.fr, didier.granjeon@ifpen.fr

⁴Beicip Franlab, 232 Av. Napoléon Bonaparte, 95502 Rueil-Malmaison, France, lucien.montadert@beicip.com,

The application of seismic stratigraphic concepts supported by seismic facies analysis is a powerful tool that can be used in order to assess the tectono-stratigraphic evolution of complex frontier margins. The seismic interpretation constrained by a detailed assessment of the Levant paleogeography allowed to subdivide the sedimentary infill of the northern Levant Basin (offshore Lebanon) in eight major seismic packages delimited by nine horizons. Fifteen main seismic facies have been identified presenting distinctive characteristics. The Levant Basin architecture is affected by a Late Paleozoic/Early Mesozoic rift that led to the formation of a passive margin setting characterized by a duality between aggrading carbonate platforms on the Levant margin and deepwater settings in the basin. The collision of Afro-Arabia with Eurasia and the overthrusting of the Latakia Ridge onto the Levant Basin led to the formation of a flexural basin in the northernmost Lebanese offshore section since the Late Cretaceous. A southward migration of this flexural depocenter in the Oligo-Miocene is hindered by the change in the stress field along the Latakia Ridge leading to the development of a transpressive system favored by the westward escape of the Anatolian micro-Plate in Late Miocene and Pliocene times. Interplay between major geodynamic events as well as sea level fluctuations in the Mesozoic and Cenozoic led to important marginal uplifts and emersion. The huge quantities of sediments sourced from the erosion of Nubian siliciclastic material and from the exposed granitic Red Sea rift shoulders and Arabian Shield, are driven into the Levant Basin. The diversity of sediment sources, the mechanisms of sediment transport through varied pathways (i.e., the Levant margin canyons, the Latakia region and the Nile Delta deep sea cone) should be accounted for in the hydrocarbon exploration risking process as it strongly impacts the reservoir characteristics and prospectivity of the northern Levant Basin.

Environmental Reconstruction in The South Caspian Sea Basin Using Statistical Analyses of A Palynological Dataset from The Neogene Productive Series in Azerbaijan

Lourdes López-Merino¹, Suzanne A.G. Leroy¹, Keith Richards², Simon F. Grant³

¹Institute for the Environment, Brunel University, Uxbridge, London, Middlesex UB8 3PH (UK);
Suzanne.Leroy@brunel.ac.uk

²KrA Stratigraphic, Deganwy, Conwy LL31 9YY (UK);

³BP Exploration Operating Company Ltd., Sunbury-on-Thames, Middlesex TW16 7LN (UK).

The South Caspian Sea Basin (SCSB) has been a very important oil and gas producing region since the late 19th century. The Early Pliocene strata, part of the Neogene Productive Series, are the principal reservoirs. The onset of the deposition of the Productive Series is correlated as approximately synchronous with the Messinian salinity crisis, which meant a water-level drop and the disconnection of the Caspian Sea from the general oceanic system. From a palynological point of view, the Pliocene in the SCSB has been the focus of detailed studies during the last decade (Lowe & Richards 2001, Richards 2010, Vincent *et al.* 2010). However, the published data is fragmented and does not show a continuous environmental reconstruction for the Productive Series. To fill this gap we present sixteen palynological records located onshore and offshore of the Apsheron Peninsula, covering the intervals from the Pontian (Late Miocene) to the Sabunchi Suites (Late Pliocene). Owing to a high volume of data (1376 samples, 79 taxa) we have used Principal Components Analysis (PCA) to reduce the dimensionality and to describe the main features of the palynological record. PCA analysis has been applied to: 1) the regional dataset (hinterland pollen) that has been a valuable tool for inferring temperature changes, and is in broad agreement with the oxygen stable isotopic record of the global ocean; and 2) the local dataset (aquatic pollen, spores, dinocysts and algae) that has been helpful for inferring lake level changes and other processes such as erosion, river input and water salinity changes. All these results combine to offer an exceptional opportunity to infer the environmental conditions in which the Productive Series was deposited and understand the complex system of the Caspian Sea during the Late Neogene.

Keywords: Caspian Sea, Pliocene Productive Series, palynology, statistical analysis

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Mineralogical and Geochemical Studies on the Pliocene Clay Deposits, North Sinai, Egypt: Using Remote Sensing Data

Talaat M. Ramadan¹, Safaa M. Hassan¹

¹National Authority for Remote Sensing and Space Sciences (NARSS), Cairo, Egypt

In north Sinai Peninsula, clay deposits are found as alternating beds within thick sandstone succession in the Pliocene sediments (Kafr El Sheik Fm).

Spectral characteristic analysis (SCA) followed by band ratio analysis of the nine ASTER bands enabled selection of appropriate band combination, band ratio for discriminating the exposed rock units associated with clay deposits throughout the study area.

The Pliocene deposits are recorded in several localities, e.g. east Gabal Libni, east Wadi El Hema and southwest Gabal Risan Eniza. These deposits are quarried in some localities for the cement industry at Gabal Lebni.

In the present work, 4 samples from The Pliocene deposits (Kafr El Sheik Fm) east Gabal Lebni were analyzed using X-Ray Diffraction (XRD) analysis. These analyses revealed the samples are composed of the following minerals in a decreasing order of their abundance: quartz, montmorillonite, kaolinite and calcite.

The chemical analyses for the studied samples using XRF analysis indicate that SiO₂ ranging from 54.06 to 55.75 and %, Al₂O₃ ranging from 15.84 to 20.82%.

This new method helped to update the geological map of the study area and discriminate the Pliocene clay deposits much better than the previous published maps.

Keywords: Pliocene clay deposits, chemical analyses, geological map, remote Sensing data

New Datation of the Tafna Basin (Algeria): A Combination between Biochronological and Magnetostratigraphical Data

Salamat Mahboubi¹, Mouloud Benammi¹, Jean- Jacques Jaeger¹

¹Institut de Paléoprimatologie et Paléontologie humaine: Evolution et Paléoenvironnements – iPHEP CNRS
UMR 7262- Université de Poitiers 6 rue Michel Brunet F-86022 Poitiers , France.

The Tafna basin corresponds to the lowlands which extend below the Tlemcen mountains and in front of Tessala and Traras ranges. This basin displays a complete sedimentary cycle dominated by lagoonal-marine deposits. The continental deposits are mainly composed of alternating sandstones and clays to which an early Late Miocene age has been attributed on the basis of correlations with marine deposits. Paleontological investigations led to the discovery of three different rodent species from a single locality at the bottom of these deposits, which indicate a late Vallesian age. In addition, 64 oriented samples have been collected for a magnetostratigraphic study along a 92 meters thick section. Rock magnetic investigations indicate the presence of both high- and low-coercivity minerals. Specimens subjected to progressive thermal demagnetization procedures show that the samples exhibit high-temperature magnetization component characterized by a normal polarity. Correlation with the geomagnetic polarity time scale is based on biostratigraphic data obtained from the rodent study, and the Tafna section can be correlated with polarity Chron C4n.2n with an age of 8.5 to 8.1 Ma.

Keywords: Algeria, Tafna, rodents, late Miocene, magnetostratigraphy.

Influence of the Recent Strike-Slip Tectonics on Dyking in the Urumieh-dokhtar Volcanic Belt, Tafresh Area, Iran

Zeinab Davoodi¹, Farkhondeh Khademi¹, Abbas Asiabanha¹

¹Department of Geology, Faculty of Basic Science, Imam Khomeini International University, Qazvin, Iran.
Davoodi.zeinab@gmail.com

Urumieh-Dokhtar volcanic arc trending NW-SE is part of Alpian-Himalyan orogenic belt that extends from the Anatolian Fault in Turkey to the Oman line in southern Iran. Urumieh-Dokhtar belt represents an Andean type magmatic arc formed by subduction along the active continental margin of the central Iran plate during the Alpine Zagros orogeny. This belt are transversely cross cut by a set of strike-slip fault zones during the Late Alpine Zagros orogeny that oriented NNW-SSE and shows right- lateral strike- slip movement such as the Floojerd-Rahjerd (introduce at the first time in this article), Bidhand and Qom-Zefreh fault zones from the west to the east. Tafresh area that located in the middle part of the Urumieh-Dokhtar volcanic belt shows a close relationship between magmatism and strike-slip tectonic regime. The volcanic sequence of the study area consists of the pyroclastic deposits, basic lava flows, hypabyssal rokes and basic dykes. The good relation between the dyke trends and the major stike-slip fault zones in this area suggests that the latest magmatic activities occurred in association with the recent tectonic events. According to the left-lateral en-echelon arrangement of the Floojerd-Rahjerd (FR) and Bidhand (BH) strike-slip faults and also their right-lateral strike-slip movements, it can be stated that influence of the dykes were accord within the restraining zones between the faults synchronously with continental collision of the Arabian Plate and central Iran and closure of central paratethys.

Keywords: Urumieh-Dokhtar volcanic arc, Strike-slip tectonic, Floojerd-Rahjerd strike-slip fault, Influence of dyke, Tafresh.

SESSION 2

GEOLOGICAL EVOLUTION OF THE SEA OF MARMARA

CONVENERS

NACİ GÖRÜR AND PIERRE HENRY

The Impact of the Messinian Salinity Crisis in the Region of the Marmara Sea

Jean-Pierre Suc¹, Gunay Cifci², Cagil Karakas³, Rolando Armijo³, Robin Lacassin³, Seda Okay², Burcu Barin², Mihaela Carmen Melinte-Dobrinescu⁴, Christian Gorini¹, Jean-Loup Rubino⁵, M. Namık Çağatay⁶, Gwenaél Jouannic⁷, Speranta-Maria Popescu⁸, Ziyadin Çakır⁶

¹Université P. & M. Curie, ISTEP, CNRS, UMR 7193, 75005 Paris, France. jeanpierre.suc@gmail.com, christian.gorini@gmail.com

²Institute of Marine Science and Technology, Dokuz Eylul University, 10 Inciralti, 35340 Izmir, Turkey. gunay.cifci@deu.edu.tr, seda.okay@deu.edu.tr, barin_burcu@windowslive.com

³Laboratoire de Tectonique, Institut de Physique du Globe de Paris (UMR 7154 CNRS), 75252 Paris Cedex, France. karakas@ipgp.fr, armijo@ipgp.fr, lacassin@ipgp.fr

⁴National Institute of Marine Geology and Geoecology, 23-25 Dimitrie Onciul street, P.O. Box 34-51, 70318 Bucharest, Romania, melinte@geoecomar.ro

⁵TOTAL, TG/ISS, CSTTF, Avenue Laribeau, 64018 Pau Cedex, France. Jean-Loup.Rubino@total.com

⁶Istanbul Technical University, School of Mines and Eurasia Institute of Earth Sciences, Maslak, 34469 Istanbul, Turkey, cagatay@itu.edu.tr, ziyadin.cakir@itu.edu.tr

⁷Université Paris-Sud, IDES, UMR 8148, 91405 Orsay, France, gwenaél.jouannic@gmail.com

⁸GeoBioStratData.Consulting, 385 route du Mas Rillier, 69140 Rillieux la Pape, France, speranta.popescu@gmail.com

The impact of the Messinian Salinity Crisis is now definitely demonstrated in the area of the Dardanelles Strait using unambiguous calcareous nannoplankton biostratigraphy. The strait is superimposed, for its eastern part, on a Messinian fluvial valley (Melinte-Dobrinescu *et al.*, 2009). Extensive field investigations and analyses of the nannoplankton show that the Messinian Erosional Surface is overlain by Zanclean Gilbert-type fan deltas. In interfluvial locations, the Messinian Discontinuity is marked by rubefacted clays, overlain by Zanclean marine sediments (Melinte-Dobrinescu *et al.*, 2009).

The same approach has been extended throughout around the Marmara Sea and several sites located along its southern shoreline have provided well-preserved evidence of Messinian fluvial erosion followed by the Zanclean marine transgression.

Several sets of seismic profiles acquired in different regions of the Marmara Sea with different degree of penetration and resolution suggest that Messinian fluvial erosion has occurred at the base of all the main sub-basins, implying that the bulk of the subsidence and sedimentation processes in the tectonically controlled Sea of Marmara pull-apart basin has started after the Messinian Salinity Crisis.

Keywords: Messinian fluvial valleys, Zanclean Gilbert-type fan deltas, Biostratigraphy, Paleogeography

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Evolution of Tectonic Structures under the Sea of Marmara from Middle Miocene to Present

Naci Görür¹, Şebnem Elbek²

¹ITU Faculty of Mines, Department of Geological Engineering

²COMU Faculty of Engineering, Department of Geophysical Engineering

The Marmara Region is an area where several basins are nested on top of one another as a result of complex series of tectonic processes. These processes are related to the evolution of the Thrace Basin (s.l.), western portion of the North Anatolian Shear Zone and the Sea of Marmara. The Thrace Basin (s.l.) evolved during the Eocene to Oligocene as a forearc basin along the active margin of the Strandja/Istanbul Zones. Mainly turbidites accumulated in the basin interiors with shallow marine and terrestrial deposition near the basin margins. The basin seems to have been affected from two collisional events during its evolution. The first one occurred during the Middle Eocene in the neighbouring areas to the east where the Istanbul and Sakarya Zones collided along the Intra-Pontide Suture. This collision resulted in a great erosion of its sedimentary content. The second collision took place at the end of the Oligocene when the Strandja and the Sakarya Zones were juxtaposed as the western remnant of the Intra-Pontide Ocean closed. Following the collision, the Thrace Basin (s.l.) lost its deep basin character and underwent erosion throughout the Early Miocene under a limited convergence. Contrary to the extensive erosion, the deformation of this last terminal closure was not very intense as shown by both the present-day existence of the Thrace Basin (s.l.) and its post-collisional tectonic structures. There are two reasons why the basin was not totally obliterated. One was probably the diachronous elimination of the already narrowed western part of the Intra-Pontide Ocean along a thick accretionary mélange at the trench side of the basin. The other one was the successive strike-slip tectonics that may have prevented further intra-continental compression to be exerted on the basin (Görür and Okay, 1996).

The Thrace Basin (s.l.) was overlain by a more extensive and much shallower dextral shear zone during the Middle to Late Miocene. This zone constitutes the westernmost part of the North Anatolian Shear Zone developed in relation to the escape tectonics of Turkey. Its evolution began in the Middle Miocene and still continues with various tectonic structures, representing the pre-peak, peak, post-peak and pre-residual stages defined on the basis of the stress-displacement behaviour and structures in the Riedel Experiment (Tchalenko, 1970; Şengör, 2005). The Sea of Marmara probably resulted from the development of the NASZ during the Late Pliocene to Pleistocene along a variety of Riedel, anti-Riedel and P-shears of the post-peak and pre-residual structure stages.

This study concludes that the formation and evolution of the Sea of Marmara are much more complicated than it is thought. It developed in a region of complex plate convergence, continental collision and strike-slip activities each of which created a number of superimposed basins and tectonic structures in a complex overprinting relationships. The Sea of Marmara is the result of the last tectonic event. Therefore, in order to understand fully its geological evolution, the older tectonic processes and their products cannot be omitted.

Keywords: Sea of Marmara, tectonics, North Anatolian Shear Zone, North Anatolian Fault, Middle Miocene

Modeling Basin Subsidence History in the Sea of Marmara

Pierre Henry¹, Celine Grall¹

¹CEREGE, CNRS and Aix-Marseille Université, Aix-en-Provence, France. henry@cerege.fr

The history of subsidence in strike-slip basins is a key to constrain the evolution of the fault network geometry and of fault slip rates with time, as subsidence rates computed from mechanical or kinematic models with assumed fault geometries may be compared with observed subsidence patterns. Recent studies constrained the subsidence in the Sea of Marmara basins over the last 330.000 to 540.000 years with stratigraphic models correlated to the glacial-interglacial cycles. Variations of subsidence over longer time scales are recorded in the sedimentary structure of the basins and can be deciphered with a modeling approach, taking into account compaction and using measured heat flow as an additional constrain. The subsidence history of the Central Basin has been reconstructed with this approach and imply a progressive change of active fault kinematics over the last 2 Ma to 330.000 years (Grall *et al.*, 2012). When the same approach is applied to the Cinarcik Basin, the present day subsidence pattern appear even harder to reconcile with the heat flow data, acquired on three N-S heat flow profiles across the Basin. In general agreement with the asymmetric fault bend basin model, an earlier onset of subsidence is found in the western part of the basin. However, consideration of basement geometry suggests that the subsidence pattern has changed in the Eastern part of the basin from symmetric subsidence between two faults to asymmetric tilting toward the northern fault. The timing of this transition could not be precisely constrained with thermal modeling because of a trade off between basement heat flow and sedimentation rate. A reflector at the base of an onlap sequence is correlated across the basin and, considering the very high subsidence rates (exceeding 7 mm/yr; Seeber *et al.*, 2006) inferred at the Eastern end of the Cinarcik Basin, could mark the beginning of the last interglacial period (MIS-5). However, this interpretation would imply a high crustal heat flow in this part of the basin, of the order of 110 mW/m², almost twice the background value and the crustal heat flow calculated for the Central Basin. We wonder whether this high heat flow could be reasonably accounted for by local crustal extension.

Evidences of Gas Accumulation in Western High, Sea of Marmara in Light of 2d High Resolution Seismic Method

Hakan Sarıtaş¹, Günay Cifçi¹, Céline Grall², Pierre Henry², Yannick Thomas³, Bruno Marsset³, Louis Géli³, Christopher Sorlien⁴, Orhan Atgın¹

¹Institute of Marine Science and Technology, Dokuz Eylül University, Inciralti-Izmir, Turkey

²CEREGE, CNRS-Aix Marseille Univ., Marseille, France

³Marine Geosciences, Ifremer, Brest, France

⁴University of California Santa Barbara, CA, United States

Sea of Marmara comprises three deep basins which are Çınarcık, Central and Tekirdağ Basins and two major ridges which are Central and Western High. The Western High is one region of geological interest where evidence of gas and fluid escapes have been observed during previous scientific cruises, notably in the area close to the North Anatolian Fault (NAF). The Eocene-Oligocene Thrace Basin, where gas and petroleum reservoirs of industrial importance are exploited, extends off shore below the Tekirdağ basin and the Western High. During MARNAUT-2009 cruise, gravity cores which sampled gas hydrate were taken on the Western High, close to Erkan Gökaşan mud volcano area. The chemical analysis of gas components between Thrace Basin reservoirs and Western High gas hydrates in Sea of Marmara are comparable (Bourry *et al.*, 2009). These gas signatures indicate a thermogenic component

In 2009 December, 3D multichannel seismic reflection (MCS) data was collected by Le Suroit R.V.(Ifremer) in this area. After that in 2010 June, a 2D MCS PirMarmara cruise was carried out by K.Piri Reis R.V (D.E.U) covering Western High to study the geological structure of this area and understand strain related to dextral strike slip NAF. We here focus on a mud volcano area located close to NAF and observation of gas accumulation in the sediment. According to 3D MCS data acquired on the Western High, there is gas accumulation within an anticline extending east-west along the southern side of the NAF. However, the study of 2D seismic data, shows that gas accumulations in the Western High sediments are more widespread north of the NAF, and likely amounts to larger volumes. The source rock presumably lie in an extension of the Thrace Basin under the Western High, where upward gas migration is favored along the NAF as well as secondary faults. However, lateral migration along faults and other pathways may also be envisioned.

In conclusion, Western High is a complex area where active folding occurs in association with slip along the NAF and other fault segments. Gas trapping in anticlines is observed, but also leakage along active strike-slip and normal faults, which makes economical assessment of gas and gas hydrates resources uncertain.

Keywords: Western High, gas accumulation, 2D Seismic reflection

Steady Quaternary Deformation along the North Anatolian Fault System in Marmara Sea, Turkey

Christopher C Sorlien¹, Leonardo Seeber², Hulya Kurt³, Donna J Shillington², Michael S Steckler², Günay Çifçi⁴, Seda Okay⁴, Burcu Barin⁴, Orhan Atgin⁴, Derman Dondurur⁴, Marie-Helene Cormier⁵, Cecilia M McHugh^{6,2}

¹University of California Santa Barbara, Santa Barbara, CA, United States.

²Lamont Doherty Earth Observatory, Columbia Univ., Palisades, NY, United States.

³Istanbul Technical University, Istanbul, Turkey.

⁴Dokuz Eylül Üniversitesi, İzmir, Turkey.

⁵University of Missouri, Columbia, MO, United States.

⁶Queens College CUNY, New York, NY, United States.

The North Anatolian Fault system (NAF) bifurcates westward into three major branches in northwest Turkey. Right-lateral motion on the Northern Branch (NAF-N), closest to Istanbul, has driven formation of transtensional basins across releasing segments of fault strands, and more locally, formation of thrust-related folding across restraining geometries. The Central Branch is confined to a relatively narrow zone in Gemlik Gulf in the east, but splays dramatically in a west-diverging fan pattern.

Our stratigraphic age model back to 540 ka, based in part of glacial-period shelf edge deltas, has been correlated along high-resolution multichannel seismic reflection profiles between basins across much of Marmara Sea. Growth of the vertical component of slip on widely distributed fault strands across the southern continental shelf and the upper slope has been steady with little change in pattern or rate for at least the last 540 ka. Part of the vertical component of displacement is by folding including tilting along the southern upper slope fault and also the NAF-N.

The deepest bathymetric and Quaternary sedimentary basins are along the NAF-N. They subside on one side of the NAF-N with the most rapid subsidence and initial sedimentation in the west for the western (Tekirdag) basin, and in the east at a pronounced fault bend for the eastern (Cinarcik) basin. Basin strata are obliquely tilted towards the fault, down to the west and south for Tekirdag basin and to the east and north for Cinarcik basin. This tilting focuses active turbiditic deposition towards respectively the southwest and east corners of the basins. The older sediment is successively buried and transported by right-lateral motion relative to the stable footwall side of the NAF-N. The onlap point for successively older strata gives the total displacement. Total displacement during the current phase of basin formation is at least 30 km, and could be 40 km in Cinarcik Basin. Subsidence rates have exceeded 6 mm/yr. in eastern Cinarcik basin for the last 540 ka, and oblique-right-normal motion in that area logically could produce tsunamis. Depocenter migration for the last half million years is 18.5 mm/yr., with errors for displacement estimated at 1 km, and the age error is one 100 ka glacial cycle.

Eurasian-Anatolian plate motion is now ~23 mm/yr. near Istanbul. If 18.5 mm/yr right-lateral slip is accommodated on NAF-N, 4.5 mm/yr. is distributed on the other strands including faults south of Marmara Sea. Our age resolution is 100 ka, and we cannot rule out variations in slip rates on the different faults at shorter time scales.

Evolution of the Sedimentation and the Deformation on the Western High of the Sea of Marmara According to High Resolution Seismic Data

Céline Grall¹, Hakan Sarıtaş², Pierre Henry¹, A. M. Celâl Şengör³, Christopher Sorlien⁴, Yannick Thomas⁵, Bruno Marsset⁵, Günay Çifçi², Louis Géli⁵

¹CEREGE, CNRS, Aix-Marseille University, Marseille, France

²Institute of Marine Sciences and Technology, Dokuz Eylül University, Izmir, Turkey

³Istanbul Technical University, Istanbul, Turkey

⁴University of California Santa Barbara, CA, United States

⁵Marine Geosciences, Ifremer, Brest, France

The Sea of Marmara is a strike-slip basin within an active continental dextral fault boundary, the North Anatolian fault system. In the Western part of the Sea, it has been shown that the northern part of the present day main fault trace is likely the zone of maximum strain since the last 2.5-1.5 Ma (Grall *et al.*, 2012) and that the present day fault system which includes a main E-W strike slip fault which accommodates most of the inter-plate deformation did not significantly evolve since 330 ± 100 ka (Grall *et al.*, 2013). It is inferred that the deformation evolved from a more distributed system to a main E-W strike-slip fault segment between 2.5 Ma and 330 ka, but the evolution in time of the distribution of strain remains poorly constrained. In order to bring insights about this subject, we examine the evolution of the sedimentation on the Western High, according to high resolution 3D and 2D seismic data. High resolution stratigraphic sequences are correlated to the 100 ka glacial/interglacial periodicity, at least over the last 450 ka. Stratigraphic sequences consist of the alternation of draped low-stand sea/lake units with high-stand sea/marine basin filling units laterally correlative with either condensed sections or hiatuses on the slopes and topographic highs. We here propose to extend this model over the last 600-800 ka, recognizing older sequences on a basin of the Western High, which extends mainly south of the present day main fault trace. Numerous N130°E transtensive faults occur within the basin, in agreement with a right-lateral oblique divergence strain field. Variations of layer thicknesses indicate that rapid changes in deformation and subsidence are recorded within this basin. Our preliminary results show that the western part of the basin has been uplifted around 330-250 ka, despite its eastern part remained still active. This change of subsidence pattern may result from vertical axis clockwise rotation of a fold, which, at least at its western end, ceased growing about 450-540 ka. Over this period, Mass Transport Deposit occurrence increased within the basin. These changes of deformation pattern presumably indicate that the distribution of strain at shallow depth ranges evolved over this time scale, in this area.

Fault Segmentation and Earthquake Recurrence Times from Earthquake Sedimentary Records in the Sea of Marmara

M. N. Çağatay¹, D. Biltekin¹, L. Erel², P. Henry³, L. Gasperini⁴, C. M. McHugh⁵, Ü. Sancar¹, C. Grall³, L. N. Güngör⁶, E. Güngör⁶, Bellucci⁴, A. Polonia⁴

¹İTÜ, EMCOL, Faculty of Mining, Ayazağa, 34469 İstanbul, Turkey, cagatay@itu.edu.tr

²İÜ, Faculty of Education, Vefa, İstanbul, Turkey

³CNRS, Aix-en-Provence, France

⁴Institute of Marine Geology, ISMAR, Bologna, Italy

⁵Queens College, City University of New York, USA

⁶TAEK, Çekmece Nuclear Research Centre, İstanbul Turkey

A systematic study of the sedimentological, physical and geochemical properties of 24 cores recovered from the different Marmara basins and highs along the strands of North Anatolian Fault (NAF) was carried out, using high resolution digital X-Ray Radiography and XRF Core Scanner, MSCL physical properties and grain-size analyses. The chronology was determined using AMS radiocarbon and radionuclide methods.

Turbidite-homogenite deposits (TH) triggered by earthquakes are commonly characterized by multiple sand-silt laminae above a sharp and often erosional base and a homogeneous mud at the top. However, in shallow basins (<100-120) such as Gölcük and Gemlik, the mass flow units consists of red brown coarse to medium silt unit having a sharp basal boundary. The basal TH parts have high density and magnetic susceptibility, and are often enriched in one or more of elements, such as Si, Zr, Ca, Ti, K and Fe, indicative of coarse detrital input.

Radionuclide and radiocarbon dated TH units in different basins of the Sea of Marmara can be confidently correlated with historical earthquake records. The sedimentary records provide average earthquake recurrence time between 220 and 300 years measured over the last 5000 years for the various segments of northern branch, and 1000 years for the middle branch of the NAF in the Gemlik Gulf. These results are compatible with GPS velocities and geological slip rates. However, the intervals between two consecutive events vary widely between 90 to 1500 years for the different northern NAF segments.

The last earthquake event in the Gölcük and Karamürsel basins is the 1999; on Prince Islands segment in the Çınarcık Basin the 1794; in the Central High and Central Basin the 1963; in Western High and Tekirdağ Basin the 1912; and Gemlik Gulf is the 1855 earthquakes. The only earthquake recorded on the sediment covered Central High segment for the last 15 ka is a faint, far-field expression of the 1963 event having an assigned epicentre in the southern Çınarcık Basin. This suggests that the Central High segment SW of İstanbul has been creeping, and the rupture of the 1963 earthquake may have extended to the Central Basin from the south of the Çınarcık Basin and the Central High.

Keywords: Sea of Marmara, earthquake records, fault segmentation, recurrence time, radiocarbon dating, radionuclides

SESSION 3&7

**MEDITERRANEAN-ATLANTIC EXCHANGE: CAUSES AND
CONSEQUENCES**

&

**TOWARDS NEW UNDERSTANDING OF LATE MIOCENE
MESSINIAN SALINITY CRISIS**

CONVENERS

**RACHEL FLECKER AND FRANCISCO SIERRO
CHRISTIAN GORINI AND ANTONIO CARUSO**

Improved Chronostratigraphy of the Messinian Salinity Crisis

Jean-Pierre Suc¹, François Bache², Speranta-Maria Popescu³, Damien Do Couto^{1,4}, Mihaela Carmen Melinte-Dobrinescu⁵, Nadia Barhoun⁶

¹Université P. & M. Curie, ISTEP, CNRS, UMR 7193, 75005 Paris, France, jeanpierre.suc@gmail.com, docoutodamien@gmail.com

²GNS Science, Ocean Exploration Section, P.O. BOX 30368, Lower Hutt 5040, New Zealand, fbache@gmail.com

³GeoBioStratData.Consulting, 385 route du Mas Rillier, 69140 Rillieux la Pape, France, speranta.popescu@gmail.com

⁴TOTAL, 2 place Jean Millier, 92400 La Défense, Paris, France

⁵National Institute of Marine Geology and Geoecology, 23-25 Dimitrie Onciul street, P.O. Box 34-51, 70318 Bucharest, Romania, melinte@geoecomar.ro

⁶University Hassan II-Mohammedia, Faculty of Sciences Ben M'Sik, BP 7955 Sidi Othmane, Casablanca, Morocco, nbarhoun@yahoo.fr

The Messinian Salinity Crisis (MSC) is now defined to start at 5.971 Ma and usually accepted to end at 5.332 Ma at the Zanclean GSSP (Manzi *et al.*, 2013). Its peak is estimated to start at 5.600 Ma and would be interrupted by the Lago Mare event, the beginning of which being estimated at 5.420 Ma (Manzi *et al.*, 2013). Such a chronology has been established considering that deposition of the turbiditic p-ev₁ Unit in the Apennine Foredeep followed that of evaporites in the central Mediterranean basins (Roveri *et al.*, 2008). On contrary, we interpret both the central evaporites and p-ev₁ Unit as deposited contemporaneously, considering the Apennine Foredeep as a perched basin during the peak of the MSC, isolated by the Pelagosa Sill (Clauzon *et al.*, 2005; Popescu *et al.*, 2007; Bache *et al.*, 2012).

It has been shown in many places that the post-MSC marine reflooding significantly preceded the Zanclean GSSP (Cavazza and DeCelles, 1998; Cornée *et al.*, 2006; Popescu *et al.*, 2007; Melinte-Dobrinescu *et al.*, 2009; Clauzon *et al.*, revised; Do Couto *et al.*, submitted). The marine reflooding is thus proposed to have occurred at 5.460 Ma (Bache *et al.*, 2012).

In addition, we evidenced three successive Lago Mare (LM) events: LM1 (directly overlying peripheral evaporites) and LM3 (overlying the Messinian Erosional Surface in the peripheral basins and linked to the marine reflooding) are exchange episodes between the Mediterranean and Paratethys at high sea level; LM2 only concerns central basins (directly overlying evaporites) and needs more investigation and clarification (Clauzon *et al.*, 2005; Popescu *et al.*, 2009).

On these aspects, chronostratigraphy must be re-visited.

Keywords: Chronostratigraphy, Marine reflooding, Lago Mare events

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Reconstruction of Mediterranean Outflow Water in the Gulf of Cadiz over the Miocene-Pliocene Boundary

Marlies van der Schee¹, F. J. Sierro¹, J. A. Flores¹, M. Gutjahr², R. Flecker³, F. J. Jimenez-Espejo⁴, D. Hodell⁵, F. J. Hernández-Molina⁶, D.A.V Stow⁷, C. Alvarez-Zarikian⁸, and IODP Expedition 339 Scientists^{*}.

¹Dept. de Geologia, Universidad de Salamanca, Salamanca, Spain.

²GEOMAR Helmholtz Centre for Ocean Research, Kiel, Germany.

³BRIDGE, School of Geographical Sciences, Bristol University, UK.

⁴Dept. of Earth and Planetary Sciences, Nagoya University, Nagoya, Japan.

⁵Dept. of Earth Sciences and Godwin, Laboratory for Palaeoclimate Research, University of Cambridge, Cambridge, UK.

⁶Facultad de Ciencias del Mar, Universidad de Vigo, Vigo, Spain.

⁷Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, UK.

⁸Dept. of Oceanography, Texas A&M University, College Station, USA.

^{*}IODP Expedition 339 Scientists: Acton, G., Alvarez-Zarikian, C., Bahr, A., Balestra, B., Ducassou E., Flood, R., Flores, J.A., Furota, S., Jimenez-Espejo, F., Grunert, P., Hernández-Molina, J. Hodell, D., Kim, J. K., Krissek, L., Kuroda, J., Li, B., Llave, E., Lofi, J., Lourens, L., Miller, M., Nanayama, F., Nishida, N., Richter, C., Roque, C., Sanchez Goñi, M.F., Singh, A., Sierro, F.J., Sloss, C., Stow, D., Takashimizu, Y., Tzanova, A., Voelker, A., Williams, T., Xuan, C.

IODP Expedition 339 recovered key sections to investigate the onset and development of Mediterranean Outflow Water (MOW) during and after the Messinian Salinity Crisis (MSC). Site U1387 in the Gulf of Cadiz is located on the middle slope of the Iberian Peninsula at a current water depth of 559 m and covers today's Upper MOW that flows from the Strait of Gibraltar northwards between 500 and 800 m water depth. The Mediterranean experienced extreme salinity fluctuations during the Late-Miocene and MOW is thought to have been reduced or stopped. After this, the Gibraltar Straits is thought to be opened at the Mio-Pliocene boundary.

In order to investigate what happened in the Atlantic side of the Gibraltar Strait at that time the Late Messinian-Early Pliocene time interval was studied in Hole U1387C in order to reconstruct early changes in regional water-masses circulation through the Gibraltar Straits.

A cyclostratigraphic approach based on regular alternations in sedimentary and geochemical properties together with high-resolution biostratigraphic analyses are used to establish an age model and to locate the Messinian-Pliocene boundary.

Here, preliminary results are presented of stable and radiogenic isotopic analyses. Oxygen and carbon isotopes were measured on *Cibicidoides* spp. and *Globigerina obliquus* to reconstruct changes in sea surface and deep-water physical-chemical water properties. Nd and Pb isotope analyses were performed on planktonic and benthonic foraminifera, fish fragments and bulk sediment leachates on several samples of Late Messinian to the Early Pliocene age. These results were compared with radiogenic isotope data from Modern and Last Glacial compositions in order to trace past changes of the source of MOW. The results of the bulk leachates and fish fragments are highly comparable with each other. Known paleo-isotope ratios and today's MOW closely match the new obtained data.

Precession-Driven Cyclicity in the Northern Part of the Guadalquivir Basin (Sw Spain) during the Messinian Salinity Crisis

Bastiaan C.J. van den Berg¹, F. J. Sierro¹, J. A. Flores¹, J. Civis², J. A. González-Delgado,¹ P. Mata², J. C. Larrasoaña³

¹Departamento de Geología, Universidad de Salamanca, Salamanca, Spain, bvandenber@usal.es

²Instituto Geológico y Minero de España. Ríos Rosas 23, Madrid, Spain.

³Instituto Geológico y Minero de España, Unidad Zaragoza, Zaragoza, Spain.

The volume of evaporite deposits in the Mediterranean during the Messinian Salinity Crisis (MSC) requires an on-going supply of sea water from the Atlantic. The location of the connecting corridor(s) at this time however remains elusive. One possibility is that the Guadalquivir Basin at the western end of the Betic Strait linked the Atlantic and Mediterranean during the MSC. The Messinian sediments deposited here are largely preserved in the sub-surface, but recent results based on paleobathymetric data from two boreholes indicate that this region accumulated deep water sediments continuously right up until the Mio-Pliocene boundary (Pérez-Asensio *et al.*, 2012). These boreholes, located at the north-western margin of the Guadalquivir basin, have been dated in a low resolution chronostratigraphic framework using magneto- and biostratigraphy (Larrasoña *et al.*, 2008) or correlated to global, obliquity-driven glacial records (Pérez-Asensio *et al.*, 2012b).

We hereby present a high-resolution chronostratigraphic framework for the Montemayor borehole using cyclostratigraphy and additional bio-events. Cyclostratigraphic results were obtained by tuning patterns in the elemental composition of the sediments to the astronomical solution using high resolution XRF data. From these results we have interpreted that the cyclic sedimentary features are the result of oscillations in carbonate input forced by precession. Besides, we can accurately locate the position of the Mio-Pliocene boundary within this borehole, and relate changes in sedimentation rate to major events within the Mediterranean basin (e.g. Halite deposition).

This study will provide a high resolution chronostratigraphic framework for further research on these boreholes, e.g. geochemical analyses, which will hopefully result in a better understanding of the flow of water masses through at least a part of this potential corridor.

Keywords:Betic Corridor, Guadalquivir basin, Cyclostratigraphy, XRF, Messinian Salinity Crisis.

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The onset of The Mediterranean Salinity Crisis Was Triggered by Prolonged Times of Dryness in The Northeast Atlantic and Mediterranean Climate

Francisco J. Sierro¹, S. Ledesma², J. A. Flores¹

¹Department of Geology, University of Salamanca, Salamanca, Spain.

²Gas Natural SDG, S.A. Av. San Luis 77, Madrid

Deposition of the lower evaporites in the marginal basins at 5.97 Myr has been traditionally considered as the onset of the Messinian salinity crisis, however, this was only the culmination of a series of events that were progressively changing the chemistry of Mediterranean waters towards a highly hypersaline Sea as the Atlantic Mediterranean sill was progressively closing.

The Atlantic Gateway was probably very narrow between 6.3 and 5.97 Myr, immediately prior to the onset of the lower evaporites probably as a result of tectonic uplift in the Betic-Riffian orogene. The longer residence time of Mediterranean water and the subsequent increase in salinity made the Mediterranean very sensitive to regional climate changes, especially to variations in its hydrologic budget. The total disappearance of planktonic foraminifers at times of minimum northern Hemisphere summer insolation strongly suggest high salinity of surface waters that reached values above the maximum tolerance of these planktonic organisms. This was probably the result of higher water deficit in the Mediterranean at times of lower annual rainfall.

Simultaneously, the precessionally-driven climate changes were also recorded on the Atlantic side of Spain. Cyclical changes in average annual rainfall were recorded as cyclical silt/mud deposits into the Guadalquivir basin. Several petroleum exploration wells drilled in this basin, present cyclical oscillations in gamma ray, sonic or resistivity values in the logs. Such that the time-periods with lower annual rainfall in the Atlantic side of Spain coincide with those with higher salinities in the Mediterranean and with the onset of gypsum deposition. These astronomically-driven climate changes were superimposed on the long-term tectonic narrowing of the Gateway.

Impact of Orbital forcing on Simulated Mediterranean-Atlantic Dynamics in The Late Miocene

Alice Marzocchi (a) Dan Lunt (a) Rachel Flecker (a) Rupert Gladstone (b) Catherine Bradshaw (a) Ruza Ivanovic (a)

(a) School of Geographical sciences, University of Bristol (UK)

(b) Arctic Centre, University of Lapland (Finland)

In the Late Miocene (8-5 Ma) the Mediterranean Sea was connected to the Atlantic Ocean by two marine corridors through northern Morocco, and southern Spain. The progressive closure of these gateways led to catastrophic changes in Mediterranean sea-level and salinity and ~6% of the world's sea salt precipitated in evaporite deposits across the Mediterranean. This event is known as the Messinian Salinity Crisis (MSC), which ended with the opening of the Straits of Gibraltar (Zanclean Flood, 5.33 Ma). This refilled the Mediterranean basin, and restored Mediterranean-Atlantic exchange.

Despite decades of research, the exact timing of closure, the geometry of the corridors and the patterns of exchange through them, remains uncertain. The MSC represents an extreme event and a perfect case study for palaeoclimate modelling to investigate variations in the Mediterranean-Atlantic exchange, and their impact on ocean circulation.

Changes in the orbital configuration influence the Mediterranean's hydrologic budget (river discharge plus precipitation minus evaporation). Such variations produced the pronounced cyclicity found in the Mediterranean's sedimentary record both before and after the MSC.

Here, we investigate the impact of orbital forcing on the Mediterranean's Late Miocene hydrologic budget using the Hadley Centre Global General Circulation Models. Simulations resulting in an amplified seasonal cycle for the Northern Hemisphere (i.e. warmer summers) exhibit higher sea surface temperatures, extreme intensification of rainfall across northern Africa, and increased river discharge from all the catchments draining into the Mediterranean Sea. The larger quantity of fresh water being fed into the basin could create a cap at the surface, triggering changes in the stratification of the water column, local circulation patterns, and potentially global circulation.

Sr Isotope Record from the Rifian Corridor

Rachel Flecker¹, Sevi Modestu², Ruza Ivanovic¹, Rob Ellam²

¹BRIDGE, School of Geographical Sciences, University of Bristol, UK

²SUERC, Rankine Avenue, East Kilbride, Glasgow, UK

Sr isotopes measured on foraminifera are typically used for dating purposes. However, in restricted, evaporative basins, Sr isotope records can also be used to quantify the riverine and marine contributions to the basin's hydrologic budget. This approach has been applied to Late Miocene Mediterranean sequences and indicates that some marginal Mediterranean sub-basins were dominated by river water several million years before the onset of the Messinian Salinity Crisis. This observation is consistent with dating of the closure of the two marine corridors that linked the Mediterranean and Atlantic during the Late Miocene which also predate the first evaporites.

Here, we measure Sr isotopes on samples from one of those corridors, the Rifian Strait in northern Morocco. We use the Sr isotope records of both foraminifera and bulk sediment to explore the nature and timing of corridor restriction. Astronomical tuning of sections at both the eastern and western end of the corridor permit bed-by-bed correlation and precise age dating. Consequently the records can be interpreted within the context of major Mediterranean events, providing insight into the palaeogeographic evolution of the corridor area and its control on the hydrologic budget of the Mediterranean before and during the MSC.

Evolution of NE Atlantic Mediterranean Outflow Water during the Messinian Salinity Crisis

Sevasti Modestou¹, Marcus Gutjahr², Ángel Rodés¹, Jan Fietzke², Martin Frank², Susana Bolhão Muiños³, Rob Ellam¹, Rachel Flecker⁴

¹ Scottish Universities Environmental Research Centre, East Kilbride, UK, sevasti.modestou@glasgow.ac.uk

² Helmholtz Centre for Ocean Research, GEOMAR, Kiel, Germany

³ Divisão de Geologia e Georecursos Marinhos, Instituto Português do Mar e da Atmosfera, Lisboa, Portugal

⁴ School of Geographical Sciences, University of Bristol, Bristol, UK

Before the opening of the Gibraltar Straits two corridors linked the Atlantic and Mediterranean, one in southern Spain and one in northern Morocco. Restriction and closure of these corridors led to the deposition of more than 1.5 km of evaporites across the Mediterranean, an event known as the Messinian Salinity Crisis (MSC), spanning approximately 5.97 to 5.33 Ma (Manzi *et al.*, 2013). While the Mediterranean response to the MSC is documented in great detail, key information such as the timing of restriction and the flow patterns within the corridors are poorly constrained. Due to the geologically short time scale, records with high temporal resolution are required to resolve perturbations in flow dynamics between the Atlantic and Mediterranean in order to make causative links between events in the corridors and their consequences.

High temporal resolution isotope records allow reconstruction of the presence and physical properties of Mediterranean Outflow Water (MOW) in the Atlantic before, during and after the MSC. Radiogenic isotopes of Pb are sensitive water mass tracers ideal for examining changes in local sedimentary and hydrologic inputs. Ferromanganese (FeMn) crusts are excellent archives of heavy metal isotopes and have been used extensively to study water mass paleocirculation. Published coarse time resolution data for a crust from the NE Atlantic Lion Seamount (3514-6) at a location currently bathed in MOW show little to no variation in Pb isotope compositions during the MSC (Muiños *et al.*, 2008). Here, this sample is reexamined for its Pb isotopic signatures using Laser Ablation (LA) MC-ICP-MS. The resolution of this approach is defined by LA spot size and sample growth rate. The spot size used here (15 µm) provides a temporal resolution of less than 20 ky, allowing for the production of a significantly improved Northeast Atlantic intermediate water/MOW provenance signal. Along with additional ¹⁰Be-based ages for this FeMn crust, our data provide new information on the evolution of Pb isotope signatures of MOW for the MSC, allowing for future work to test hypotheses regarding paleogateway flow patterns and closure.

Keywords: Messinian Salinity Crisis, Mediterranean Outflow Water, ferromanganese crust, radiogenic isotopes, laser ablation

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Erosion of the Mediterranean Margins during the Messinian Salinity Crisis

D. Garcia-Castellanos¹, J. Lofi², J. Babault³, R. Urgelés⁴

¹Instituto de Ciencias de la Tierra Jaume Almera, CSIC, Barcelona

²Géosciences Montpellier, Université de Montpellier

³Universitat Autònoma de Barcelona

⁴Instituto de Ciencias del Mar, CSIC, Barcelona

The main evidence supporting a large evaporative drawdown of the Mediterranean during the Messinian salinity crisis (MSC) is the widespread presence of erosional features over the entire sea, both on- and off-shore. The most remarkable among the on-shore features are the gorges excavated by rivers draining to the Mediterranean margins as the Nile and the Rhone rivers. Off-shore, seismic surveys have long revealed that these rivers also produced deep incisions into their own deltas, such as at the Ebro Delta. Computer models of river erosion have shown that the convex-up longitudinal river profiles inferred from those erosion valleys can be explained by a rapid, kilometric-scale lowering of the sea level. Here we compile geomorphic parameters of those erosional features in order to allow a quantitative assessment of the three main parameters controlling their evolution via numerical modelling, that are in turn three key unknowns of the MSC: drawdown duration, paleoclimate, and average rock erodability. For this purpose we use a stream-power-law, landscape-evolution model (the code named TISC) that calculates the erosion occurring along rivers as a function of local water discharge and slope. The modelling also accounts for the isostatic response of the crust to the removal of the water column and the accumulation of salt and sediment. The results will be tested against previous estimates of drawdown, Miocene climate, and rock erodability.

Mio-Pliocene Evolution of the Western End of the Rifian Corridor, Rharb Basin, offshore Morocco

Evelina Dmitrieva¹

¹Repsol, Madrid, Spain

Two ancient corridors, the Betic and Rifian, connected the Mediterranean and the Atlantic during the Late Miocene. During the Messinian however the Rifian (500 km long and up to 100 km wide) is considered to be the most important corridor as it closed after the Guadalhorce gateway, which is considered to be the only Messinian Betic strait.

This study focuses on the underexplored offshore Rharb Sub-Basin, which is part of the forland Rharb-Prerif Basin. The Rharb Sub-Basin is situated in northwestern Morocco and extends westward into the adjoining offshore area of the Atlantic Ocean. It represents the western end of the Rifian strait.

3D seismic covering ca. 2200 km² and four wells are utilized in order to reconstruct the Miocene-Pliocene evolution of the western end of the Rifian corridor. In addition interpretations are aided by a new biostratigraphic framework.

The western end of the Rifian corridor is associated with a series of satellite extensional mini-basins that are filled with thick Upper Miocene to Pleistocene clastics. These mini-basins formed at the late stages of the Rif-Betic orogeny due to the collapse of the accretionary wedge at Tortonian-Messinian times. Late Miocene gravitational normal faulting and related growth generated subsidence and sedimentation into the mini-basins.

This integrated study will help to understand better the geometry of the offshore Rharb basin and the tectonosedimentary evolution of the western end of the Rifian corridor. The results will be discussed in the framework of the Late Miocene structural and stratigraphic evolution of the Rifian corridor.

Interest of Microfauna and Microflora in Reconstructing Marine Environments in the Rifian Corridor (Morocco) during the Late Miocene

N. Barhoun¹, N. Bachiri Taoufiq¹, J.-P. Suc², M.Z. Yousfi³

¹ Department of Geology, Hassan II-Mohammed VI University, Faculty of Science Ben M'Sik, PO 7955, Casablanca, Morocco.

² ISTEP, UMR 7193 CNRS, Université P. & M. Curie, 75005 Paris, France

³ ONHYM, 34 Avenue Al Fadila, 10050-Rabat-Morocco

The Rifian Corridor is one of the ways connecting the Mediterranean Sea to the Atlantic Ocean during the Late Miocene and is an ideal place for understanding the onset of the Messinian Salinity Crisis.

In this work, we present the contribution of microfauna and microflora to reconstruct marine environments of the Rifian Corridor. Miocene deposits of the corridor have revealed the presence of a rich foraminifer and ostracod fauna, pollen, spores and dinoflagellate cyst assemblages. In addition to vegetation and climate reconstruction in the area, these microfossils contribute to (1) understand the evolution of water exchanges between the Atlantic and Mediterranean before the Messinian Salinity Crisis, and (2) characterize several paleoenvironments (Dayja *et al.*, 2003; Barhoun *et al.*, 2008).

The marine microfauna and microflora recorded in the southern Rifian Corridor are similar to those which already document the Atlantic coast at the same latitude as also the Mediterranean coast. This confirms that the water exchanges between the Atlantic Ocean and the Mediterranean Sea occurred through the southern Rifian Corridor during the mid- to late Tortonian and early Messinian. As other authors (Ivanovic *et al.*, 2013), we did not find any evidence supporting the siphon hypothesis.

These results on foraminifera, ostracods, pollen grains, spores and dinoflagellate cysts show that the marine environment was epicontinental and was influenced by important fluvial inputs. They also document the relative changes in sea level and allow to estimate temperature of surface waters. During the Tortonian, marine environment was neritic (external shelf) and evolved towards the middle internal shelf, that concerns more specifically the eastern side of the corridor. Since the Tortonian-Messinian boundary, the sudden loss of microfauna and microflora is referred to the rapid shrinking of the Rifian Corridor (Krijgsman *et al.*, 1999; Warny *et al.*, 2003; Van Assen *et al.*, 2006). Hydrographic changes during this period have also been reported in the recent work of Ivanovic *et al.* (2013).

Through this work, microfossils are confirmed to be essential tools for reconstructing marine environments in a tectonically unstable context and documenting the onset of the Messinian Salinity Crisis.

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Mineral Magnetic Properties of Late Miocene Marine Sediments from the Huelva-1 and Montemayor-1 Boreholes (Guadalquivir Basin, Sw Spain); Preliminary Results and Paleoenvironmental Implications

Juan C. Larrasoaña¹, Qingsong Liu², Pengxiang Hu², Pilar Mata³, José N. Pérez-Asensio⁴

¹Instituto Geológico y Minero de España, Unidad de Zaragoza. Zaragoza 50006, Spain. jc.larra@igme.es

²State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences. Beijing 100029, People's Republic of China. qslu@mail.iggcas.ac.cn; pxhu@mail.iggcas.ac.cn

³Instituto Geológico y Minero de España. Madrid 28760, Spain. p.mata@igme.es

⁴Departamento de Estratigrafía y Paleontología, Facultad de Ciencias, Universidad de Granada. Granada 18002, Spain. jnoel@ugr.es

The Messinian salinity crisis (MSC; Late Miocene) represents a major paleoceanographic event since it involved the nearly complete desiccation of the Mediterranean Sea after the closure of its connection with the Atlantic Ocean. Despite of decades of research, several aspects regarding the causes (tectonics versus sea level changes) and climatic context and consequences of the MSC are still under debate partly due to the typical discontinuity of the Mediterranean Messinian sedimentary record.

In this study we present a preliminary environmental magnetic study of marine sediments recovered in the Guadalquivir Basin (N Spain) at Huelva-1 and Montemayor-1 boreholes, which have been dated as Tortonian to Early Pliocene by means of bio- and magnetostratigraphy. These sediments are continuous, and thus represent prime targets for studying paleoenvironmental variations in the Atlantic side of the Gibraltar Arch during the MSC and for providing new insights into its causes and environmental consequences.

Paleomagnetic and environmental magnetic data indicate that the dominant magnetic mineral in the studied sediments is magnetite. A high-coercivity mineral is also found. Hysteresis data indicate that the studied samples fall toward the finer grain-size range within the pseudo domain (PSD) field in the Day plot, and First Order Reversal Curves (FORCs) indicate that at least part of this magnetite is single domain (SD) and of biogenic origin. Given the location of the studied area near the North African margin, an eolian origin for the high-coercivity mineral is likely. The concentration of magnetite in the two studied cores drops dramatically near the onset of the MSC coinciding with a significant increase in mean accumulation rates, which suggests an important environmental shift in the Guadalquivir Basin and a sensitive response from magnetic minerals. Whether this responds to a decrease in the production of magnetite, to an increase in the dilution by terrigenous inputs, or to changes in redox conditions, needs to be further investigated. In any case, our study suggests that environmental magnetic techniques can provide a new perspective into paleoenvironmental changes associated to the MSC.

Keywords: Messinian salinity crisis; Guadalquivir Basin; environmental magnetism; magnetotactic bacteria; eolian dust.

Upper Miocene Paleoenvironments of Bivalves from Tafna Basin (North-Western of Algeria)

L. Satour¹, L. Belkebir¹, B. Mansour¹, M. Bessedik²

¹Laboratory of Stratigraphic paleontology and Paleoenvironment & Faculty of Earth Sciences and Geography, University of Oran, Algeria. satour.linda@univ-oran.dz

²Laboratory of Stratigraphic paleontology and Paleoenvironment & University of Hassiba Ben Bouali, Chlef, Algeria.

The Upper Miocene (Upper Tortonian and Messinian) deposits (marl, sandstone and limestone) of the Tafna basin revealed a relatively rich macrofauna of bivalves. Actually, the establishment of the neogene facies coincides with the introduction of the regressive Messinian stage well recorded in this basin.

Indeed, the spatio temporal evolution of mollusks bivalves contained in the several neogene studied facies shows that at the base of the series, the sandy marl deposits (Upper Tortonian- Lower Messinian), indicated an average depth mudflats environment which reflected the instauration of quiet hydrodynamic conditions. Furthermore, the decrease of the bathymetry in the messinian limestone deposits attests the installation of reef limestone, including quite diverse and quantitatively rich macrofauna (particularly Pectinidae and Veneridae).

Keywords: bivalves, mollusk, Upper Miocene, basin of Tafna, north western Algeria, paleoenvironment.

Precession-Driven Salinity and Sr Ratio Fluctuations in Marginal Basins during the Messinian Salinity Crisis

R.P.M. Topper¹, P. Th. Meijer¹, S. Lugli², V. Manzi³, M. Roveri³

¹Department of Earth Sciences, Utrecht University, Budapestlaan 4 3584CD Utrecht, The Netherlands

²Dipartimento di Scienze della Terra, Università degli Studi di Modena e Reggio Emilia, Piazza S. Eufemia 19, 41100 Modena, Italy

³Dipartimento di Fisica e Scienze della Terra, Università di Parma, Parco Area delle Scienze, 157/a, 43124 Parma, Italy

Based on $^{87}\text{Sr}/^{86}\text{Sr}$ data of the Primary Lower Gypsum (PLG) deposits in the Vena del Gesso basin, a marginal basin of the Mediterranean during the Messinian Salinity Crisis, a correlation between $^{87}\text{Sr}/^{86}\text{Sr}$ values and precessional forcing has recently been proposed. A sampling bias in the data towards the highest $^{87}\text{Sr}/^{86}\text{Sr}$ values expected in a precession cycle, due to sampling of only the gypsum layers, and a lack of sampling resolution have hitherto hindered the affirmation of the proposed correlation. We use measurements of $^{87}\text{Sr}/^{86}\text{Sr}$ and estimated minimum and maximum salinities from the PLG to constrain results of a simple box model which was set up to represent the Mediterranean deep basin and a connected marginal basin during the Messinian Salinity Crisis. In an extensive analysis with this model, we have assessed whether coeval $^{87}\text{Sr}/^{86}\text{Sr}$ and salinity fluctuations could have been forced by precession-driven changes in the fresh water budget. Furthermore, a comprehensive set of the controlling parameters has been examined to assess the uniqueness of the occurrence of precession-driven $^{87}\text{Sr}/^{86}\text{Sr}$ variations and determine the most likely setting for PLG formation.

Model results show that as long as the marginal basin is not severely restricted from the deep Mediterranean basin, precession-driven $^{87}\text{Sr}/^{86}\text{Sr}$ and salinity fluctuations are produced in settings within a large range of marginal basin sizes, riverine strontium characteristics, amplitudes of precessional river input and evaporation variation, and average fresh water budgets of both the marginal and deep basin. The most likely settings for PLG deposition occur when the Atlantic-Mediterranean connection is restricted and the average fresh water budget in the Mediterranean is significantly less negative, i.e. more river input, than at present-day. The amplitudes of precession-driven variations of river input and evaporation with which $^{87}\text{Sr}/^{86}\text{Sr}$ fluctuations are reproduced, are found to be well within the range of amplitudes found in climate model studies on orbital forcing.

Considering the large range of settings in which salinities and $^{87}\text{Sr}/^{86}\text{Sr}$ fluctuate on a precessional timescale, similar $^{87}\text{Sr}/^{86}\text{Sr}$ variations are expected to be present in PLG deposits in other marginal basins of the Mediterranean as well.

Another important finding in the model results is a systematic offset between the precession signal and the extrema in salinity and $^{87}\text{Sr}/^{86}\text{Sr}$. This result calls for a reconsideration of the link between evaporite deposits and the precession curve. Although the exact timing may vary dependent on the characteristics of the marginal basin, the middle of a gypsum layer deposited during a precession cycle cannot be correlated with a precession maximum. If the fresh water budget, size/volume and connectivity to the deep basin are known for a marginal basin of which deposits are used for cyclostratigraphic dating, the correlation between the precession signal and the deposits can be determined from our model results. In the more realistic case that these marginal basin characteristics are unknown, a delay in the range of 1 - 7 kyr (3-5 kyr being the most common) should be taken into account. Because of the even larger time interval in which gypsum saturation may be reached within a precession cycle, the bottom of a gypsum layer is even harder to date and hence not a suitable alternative for the use of the middle of a layer.

Keywords: Messinian Salinity Crisis, Primary Lower Gypsum, precession, phase lags, modelling

The Messinian Salinity Crisis in the Alboran Sea: Morphology of the Messinian Erosional Surface from Land to Sea

Damien Do Couto^{1,2,3}, Christian Gorini^{2,3}, Ferran Estrada⁴, Speranta-Maria Popescu⁵, Jean-Pierre Suc^{2,3}, Nadia Barhoun⁶, Mihaela Carmen Melinte-Dobrinescu⁷, Jean-Luc Auxietre¹, Jean-Loup Rubino⁸

¹TOTAL, 2 place Jean Millier, 92400 La Défense, Paris, France. damien.do-couto@total.com; jean-luc.auxietre@total.com

²UPMC, Université Pierre et Marie Curie, ISTEP, Institut des Sciences de la Terre de Paris, F-75005, Paris, France. christian.gorini@upmc.fr ; elia.dacremont@upmc.fr

³CNRS, Centre National de la Recherche Scientifique, UMR 7193, F-75005, Paris, France

⁴Instituto de Ciencias del Mar, CSIC. Passeig Marítim de la Barceloneta, 37-49, 08003 Barcelona, Spain. festrada@icm.csic.es

⁵GeoBioStratData.Consulting, 385 route du Mas Rillier, 69140 Rillieux la Pape, France speranta.popescu@gmail.com

⁶University Hassan II-Mohammedia, Faculty of Sciences Ben M'Sik, BP 7955 Sidi Othmane, Casablanca, Morocco nbarhoun@yahoo.fr

⁷National Institute of Marine Geology and Geocology, 23-25 Dimitrie Onciul street, P.O. Box 34-51, 70318 Bucharest, Romania, melinte@geoecomar.ro

⁸TOTAL, TG/ISS, CSTTF, Avenue Laribeau, 64018 Pau Cedex, France jean-loup.rubino@total.com

The Messinian Salinity Crisis (MSC), which affected the Mediterranean region during the latest Miocene, is mainly characterized by the deposition of thick evaporites in central basins and strong fluvial erosion of margins (Hsü *et al.*, 1973; Chumakov, 1973; Clauzon, 1973; Bertoni and Cartwright, 2006; Bache *et al.*, 2009). The fluvial erosion, known as the Messinian Erosional Surface (MES), is continuously followed from the Gulf of Lions up to 360 km from the present-day shoreline upstream the Rhône Valley (Clauzon *et al.*, 1990; Guennoc *et al.*, 2000; Lofi *et al.*, 2005; Bache *et al.*, 2009). Short drainage systems limited by high coastal mountain ranges, must have been significantly affected by the Messinian erosion.

The Alboran Sea is similarly characterized by a geographic context and was the first Mediterranean area concerned by connection-disconnection to the Atlantic Ocean during the last millions years. We have performed an extensive research of the MES in the Alboran region, both onshore and offshore, integrating outcrop descriptions, supported by new biostratigraphic data, and seismic profile analyses. This study leads to an up-to-date geological and morphological map displaying the actual contours and morphology of the MES in the whole Alboran domain.

Keywords: Alboran Sea, Messinian Salinity Crisis, Messinian Erosional Surface

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Late Neogene Marine Records from Western Mediterranean: Insights into the Messinian Salinity Crisis

Diana Ochoa¹, Francisco J. Sierro¹, Johanna Lofi², Agnes Maillard³, Jose-Abel Flores¹

¹Geology Department, University of Salamanca, Spain

²Geosciences Montpellier, Université de Montpellier 2, France

³Laboratoire de Dynamique des bassins sédimentaires, Université Paul Sabatier, Toulouse, France

The Messinian Salinity Crisis (MSC) was a major desiccation event affecting the entire Mediterranean basin during the latest Miocene. Thick evaporitic sequences with similar sedimentological patterns preserved in distant areas provide compelling evidence on the magnitude of this event. Although evaporitic sequences are well known in marginal basins onshore, a better knowledge of the late Miocene successions offshore is needed for better understanding the MSC in deeper settings.

In order to correlate shallower/continental sediments with those from more distal areas, data from several oil-industry wells are being revisited and integrated. All studied wells are located in the Valencia Basin and the Alicante area, and range from onshore to offshore environments. Lower Evaporites sequences up to ~100 m thick can be recognized in well-logging records. They display a stacking pattern similar to the one previously described for other marginal basins (i.e. Sorbas in Spain or Vena del Gesso in Italy). However, none of the deepest wells show these dense sequences, although traces of anhydrite/gypsum are commonly found as part of the lithology. To assess whether or not these deep-sea MSC records are coeval with the marginal Lower Evaporites, biostratigraphic analyses using planktonic foraminifera are being performed. A high-resolution chronological framework is being established to compare with other Messinian successions. In addition, changes in the benthic foraminifer assemblages will be used to shed new light on the paleobathymetry and paleoenvironments before and after the MSC. Finally, well-logging and micropaleontological data is being integrated with recently gathered 2D-seismic data, intentionally tied to some of our studied wells. By extending well information throughout the entire area, we expect to build a more robust geological model for the Valencia Basin that allows us to understand different evolutionary stages of the MSC.

Keywords: Valencia Basin, Messinian Salinity Crisis, Lower Evaporites, and Biostratigraphy.

Pseudo-Sarmatian Mollusc Assemblages from the Early Messinian of Sicily (Italy)

Mathias Harzhauser¹, Markus Reuter², Oleg Mandic¹, Simon Schneider³, Werner E. Piller², Marco Brandano⁴

¹Natural History Museum Vienna, Geological-Paleontological Department, Burgring 7, 1010 Vienna, Austria, mathias.harzhauser@nhm-wien.ac.at; oleg.mandic@nhm-wien.ac.at

²Institute for Earth Sciences, University of Graz, Heinrichstrasse 26, 8010 Graz, Austria; markus.reuter@uni-graz.at; werner.piller@uni-graz.at

³CASP, University of Cambridge, West Building, 181A Huntingdon Road, Cambridge, CB3 0DH, UK ; simon.schneider@casp.cam.ac.uk

⁴Dipartimento di Scienze della Terra, La Sapienza Università di Roma, P. A. Moro 5, 00185 Roma, Italy; marco.brandano@uniroma1.it

The coastal cliff at Faro Santa Croce at Augusta (SE Sicily) is formed by Late Miocene limestones of the Monte Carrubba Formation. A striking feature of this outcrop is the occurrence of dense venerid-cardiid coquinas in association with cross-bedded oolite deposits. Fuchs (1874) was the first to visit the locality and compared the assemblages with those of the Volhynian and Bessarabian (Upper Serravallian and Lower Tortonian) of Russia (now Ukraine and Moldova), which are also characterised by oolites and venerid-mactrid-cardiid coquinas. Due to very similar morphologies represented in the Sicilian assemblages, he concluded that the molluscs are conspecific with those from the Paratethyan assemblages. Consequently, the list given by Fuchs (1874) comprised 55% of Sarmatian Paratethyan species. Later workers reproduced the influential identifications, including even endemic Paratethyan/Euxinian cardiid genera such as *Obsoletiforma*, *Didacna* and *Euxinocardium*, although the Messinian age of these deposits was already known. Consequently, the oolite-associated assemblages in the Monte Carrubba Formation were interpreted as evidence for reduced (mesohaline) salinity.

Thus, the existing literature suggested a close (on the species level) Mediterranean–Paratethyan faunistic relation between 6.4 to 5.96 Ma comparable to the alleged Paratethyan influence during the Late Messinian Lago Mare phase. This, however, is in striking contrast to the age of the endemic Sarmatian assemblages, which developed roughly between 12 and 10 Ma.

After revising the fauna, not a single Paratethyan Sarmatian species was detected in the assemblage. Instead, all species represent typical Mediterranean species of which 20% are restricted to the Late Miocene. No indications for lowered salinities during the Messinian interval at Faro Santa Croce can be documented. Alleged brackish water taxa, such as *Didacna* and *Euxinocardium*, turned out to represent normal marine species of *Acanthocardia*.

This revision is a perfect example to demonstrate the importance of a proper taxonomy to avoid severe misinterpretations concerning paleogeography and biogeography, which tend to become “common knowledge” by uncritical repetition.

Keywords: Messinian, Mediterranean, Paratethys, Sarmatian

Paleoceanographic and Paleoenvironmental Changes in the Red Sea during the Messinian/Zanclean: New Data from Site 225

**Antonio Caruso¹, Maria Bianca Cita², Maria Marino³, Patrizia Maiorano³,
Giovanna Scopelliti¹, Marie-Madeleine Blanc-Valleron⁴**

¹Dipartimento di Scienze della Terra e del Mare – Università di Palermo

²Dipartimento di Scienze della Terra – Università di Milano

³Dipartimento di Scienze della Terra e Geoambientali– Università di Bari

⁴UMR 7207 CNRS, MNHN, Univ Paris 06, 57 rue Cuvier, CP48, F-75005, Paris, France

DSDP Leg 23 was the only drilling cruise in the Red Sea which found evaporites, below 170 metre-deep of hemipelagic sediments from the Plio-Pleistocene, two years later the discovery of Messinian Evaporites in the Mediterranean Basin. Six sites were drilled in the Red Sea. One of these (Site 225) was cored to a depth of 230 m (Whitmarsh *et al.*, 1974) ending with several metres of anhydrite overlying halite. A strong seismic reflecting horizon (Horizon S) separates the Late Miocene evaporites from the early Pliocene ooze. In the original report, no mention was made of a correlation with the Messinian Mediterranean Salinity Crisis (MSC), which later became the subject of considerable discussion in the scientific community. Over the last 40 years, more advanced research into biostratigraphy and biochronology have allowed the original geological dataset to be improved thereby making it more useful for paleoceanographic and paleoecological reconstructions. Thus, in order to establish whether if the evaporites found in the Red Sea are comparable with those of the MSC, a new analysis of the 30 samples collected from cores (26-10) of Site 225A has been carried out here. Results from this multidisciplinary study indicate that the cores studied span the interval from late Messinian to upper Pliocene. Samples from the late Messinian (cores 26-23) were characterized by strong variations in both on $\delta^{13}\text{C}$ and $\delta^{18}\text{O}$. In particular, samples from core 23 yielded the lowest values of $\delta^{18}\text{O}$ (-5.25‰; -4.95‰) and the presence of *Ammonia tepida* and *A. beccarii*. Similar assemblages, with low $\delta^{18}\text{O}$ values, typical of “Lago-Mare” conditions have been reported in several Mediterranean outcrops from the late Messinian. Furthermore, specimens of planktonic foraminifera were not found demonstrating that the Indian Ocean was not connected to the Red Sea during that period. In the lowermost part of the Pliocene (cores 22-20), planktonic foraminifera were not yet present, while benthic foraminiferal assemblages were typical of hypoxic conditions. Calcareous nannofossil assemblages contained *R. cisnerosii*, *C. acutus*, and *S. abies*. The improvement in the environmental conditions started in samples of core 19, demonstrated by the occurrence of *Candeina nitida*, *discoasterids*, *P. lacunosa*, *H. sellii*, and small *Geophyrocampa*. This drastic change in calcareous plankton and in their relative abundance coincides with more stable marine conditions with $\delta^{18}\text{O}$ values between -1.1 and 0.5‰. In the Pliocene, Mediterranean marine fossil records demonstrate that the species *C. nitida* have never been present there, while it is a species typical of the Indian Ocean. The newly obtained data indicates that during the late Messinian the Red Sea was connected to the Mediterranean Sea, with environments characterized by strong variations in salinity similar to those described in the “Lago-Mare” facies. Furthermore, the co-occurrence of *C. nitida*, the drastic increase in other species of calcareous plankton and more stable values of $\delta^{18}\text{O}$, suggest an inflow of water from the Indian Ocean into the Red Sea. Finally, during the lowermost part of the Piacenzian, the progressive phase of rifting of the Red Sea favoured seafloor spreading, opening a connection between the Red sea and the Indian Ocean.

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The Record of the Messinian Salinity Crisis in Mobile Belts: Insights from the Molise Allochthonous Units (Southern Apennines, Italy)

Domenico Cosentino^{1,2}, V. Bracone³, P. Cipollari^{1,2}, C. D'Amico⁴, D. Esu^{5,2}, V. Frezza^{4,5}, E. Gliozzi^{1,2}, F. Grossi^{1,4}, P. Guerrieri⁶, A. Iadanza¹, T. Kotsakis¹

¹Dipartimento di Scienze, Università degli Studi Roma Tre, Largo S. Leonardo Murialdo, 1, I-00146 Roma, Italy, domenico.cosentino@uniroma3.it; paola.cipollari@uniroma3.it; elsa.gliozzi@uniroma3.it; francesco.grossi@uniroma3.it; annalisa.iadanza@uniroma3.it; anastassios.kotsakis@uniroma3.it

²Istituto di Geologia Ambientale e Geoingegneria, CNR,

³GeoGIS Lab, Department of Biosciences and Territory, University of Molise, C.da Fonte Lappone, 86090 Pesche (Isernia), Italy, vito.bracone@unimol.it

⁴Informal Group of Micropaleontological and Malacological Researches, www.girmm.com, crmn.damico@gmail.com

⁵Dipartimento di Scienze della Terra, Università degli Studi "La Sapienza" di Roma, Piazzale A. Moro, 5, I-00185 Roma, Italy, daniela.esu@uniroma1.it; virgilio.frezza@uniroma1.it

⁶Saint-Gobain PPC Italia S.p.A, via Ettore Romagnoli 6, 20146, Milano, Italy, pietro.guerrieri@saint-gobain.com

The Mediterranean marginal basins recorded the Messinian salinity crisis (MSC) in various structural settings, including syn-rift, thrust-top, foredeep, and foreland basins. During the MSC, the Apennines of Italy were one of the mobile belts of the peri-Mediterranean Messinian chain. Starting from more hinterland areas, as a consequence of the main Apennine tectonic phases, allochthonous units of both the northern and southern Apennines migrated towards the Adriatic foreland, developing thrust-top sedimentary basins.

In the southern Apennine mobile belt, the Molise allochthonous units recorded the main steps of the MSC, starting with the deposition of the Lower Evaporites. In a gypsum quarry district near Guglionesi (Campobasso, Molise), a fluid migration event (i.e. methane release) is testified by the occurrence of conduits yielding flow-mobilized sediments, which cross-cut the Lower Evaporites and feed abraded mudgrade limestone buildups resting just above an erosional surface on top of the Lower Evaporites. This event can be connected with the Mediterranean drawdown responsible for the Messinian erosional surface (MES).

Marls with Paratethyan ostracods, pertaining to the *Loxocorniculina djafarovi* Zone, mollusc fauna that include Lymnecardiinae and Dreissenidae of Paratethyan origin (late Lago-Mare event), and abundant reworked planktonic foraminifera disconformably overlie the Lower Evaporites, with thin brecciated authigenic limestones in between. Above a second erosional surface, marls containing Paratethyan ostracods and molluscs unconformably overlie the Lower Evaporites or older marls pertaining to the late Lago-Mare event. In their lower part, the younger marls include a 30-cm thick dark layer consisting of black clays with a small-mammal assemblage containing *Prolagus* sp., Cricetidae, and Muridae. Paratethyan ostracod and mollusc assemblages of the late Lago-Mare event are still present in the dark layer. The occurrence of Hydrobiidae-rich levels at the top of the late Lago-Mare deposits points to decreasing salinity, with a trend similar to that recognized at the Montepetra and Maccarone sections (northern Apennines) (Grossi *et al.*, 2008).

A third erosional surface separates the late Messinian sediments containing Paratethyan fauna from fully marine Pliocene deposits, mainly sands and conglomerates with ostreid and pectinid molluscs. In the study area, the Pliocene deposits, which seem to be not older than late Zanclean, unconformably overlie the MSC succession.

The disconformity separating the Lower Evaporites and the late Lago-Mare deposits could be related to a late Messinian base level drop, whereas the younger angular unconformities affecting both the late Lago-Mare deposits and the fully marine Pliocene sediments might be related to two different phases of orogenic transport, which affected the Molise allochthonous units during their late Miocene-early Pliocene forelandward migration.

Keywords: Messinian salinity crisis; brecciated limestones; Lago-Mare deposits; Paratethyan fauna; southern Apennines

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New Palaeoenvironmental Implications for the Messinian Salinity Crisis: Insights from the Primary Lower Gypsum Unit of the Piedmont Basin (NW Italy)

Marcello Natalicchio¹, Francesco Dela Pierre¹, Pierangelo Clari¹

¹Earth Sciences Department, University of Torino

The Primary Lower Gypsum unit (PLG) unit accumulated during the first stage of the Messinian salinity crisis (5.97-5.60 Ma) and consists of up to 16 lithologic cycles composed of mudstone-gypsum intervals that were deposited under the control of precession-driven climate changes. A study, focused on the palaeobiological content of both mudstones and gypsum is in progress on the PLG unit of the Piedmont Basin (NW Italy), aimed to better constrain the environmental parameters governing its deposition. In the mudstone intervals, dm-thick laminated layers, rich in intrabasinal biotic components, have been found. These layers are interbedded to flood-transported mudstones and siltstones and are composed of the cyclic alternation of sub-mm thick terrigenous and carbonate-rich laminae. Two types of layers were distinguished on the basis of composition of the carbonate-rich laminae: i) peloidal layers, formed by faecal pellet and diatom-rich irregular aggregates; these layers are interpreted as flocculent beds, formed by deposition of marine snow at the sea bottom, during episodes of high productivity in the upper water column. ii) filament-bearing layers composed of a network of interwoven curved filaments, up to 150 µm in diameter and a few millimeters long, whose shape is often outlined by grains of sulphide minerals. These features are interpreted as remains of sulphide-oxidizing bacteria, like *Beggiatoa*, that formed dense microbial mats on temporarily anoxic sea bottoms. The studied gypsum beds (up to 30 m thick) are made up of bottom-grown twinned selenite crystals in which the alternation of sub-mm thick turbid and limpid laminae is clearly visible. As a rule, the basal portions of the turbid gypsum laminae enclose densely packed clay-rich aggregates, peloids and rare diatoms; conversely, the upper portions incorporate a loose network of curved filaments with the same dimensions of those observed in the mudstones. The limpid laminae are made up of gypsum almost devoid of solid inclusions. Remarkably the palaeobiological content of the turbid laminae closely resembles the one described for the laminated layers of the mudstone intervals. In particular, the sediments of their basal portion may correspond to marine snow whereas the filaments are definitely identical to the *Beggiatoa*-like remains; similar features (the “spaghetti-like” structures) were already described in many Mediterranean gypsum sequences and interpreted as fossilised cyanobacteria.

This study allows to better define the palaeoenvironmental conditions and the processes governing the deposition of the PLG unit. In particular:

- 1) The common occurrence of marine snow deposits suggests that conditions of high primary organic productivity in the upper water column persisted also during the phases of gypsum deposition;
- 2) The interpretation of the filaments trapped in the gypsum crystals as sulphide-oxidizing bacteria (and not as cyanobacteria) implies that gypsum not necessarily formed at shallow water depth within the photic zone; moreover it indicates the persistence of poorly oxygenated bottom conditions during gypsum deposition;
- 3) The occurrence of sulphide-oxidizing bacteria remains indicates that bacterially-mediated sulphur redox reactions effectively operated also during deposition of gypsum intervals. This raises the question whether these reactions may have contributed to the localized increase of sulphate concentration, promoting the nucleation of gypsum crystals.

Keywords: marine snow, bacterial mats, Messinian salinity crisis, Piedmont Basin

Scientific Drilling in the Mediterranean Sea: Where and Why?

Marina Rabineau¹, Angelo Camerlenghi² and the Gold and Dream scientific teams

¹Institut Universitaire Européen de la Mer, UMR6538, Domaines Océaniques, CNRS, 1 Place Nicolas Copernic, Plouzané, France, marina.rabineau@univ-brest.fr

²OGS, Trieste, Italy, acamerlenghi@ogs.trieste.it

In the recent years the Mediterranean Sea has become a unique natural laboratory to study both the evolution and interaction of deep processes and surficial processes. Moreover, about 6 million years ago the Mediterranean Sea was transformed into a giant saline basin, one of the largest in the Earth's history and surely the youngest. This event, commonly referred to as the Messinian Salinity Crisis (MSC), changed the chemistry of the global ocean and had a permanent impact on both the terrestrial and marine ecosystems but also on the vertical evolution of the margins related to widespread deposition of basinal and marginal evaporites and erosion of the surrounding margins.

An almost complete record of this episode, the events leading to it as well as its consequences, is preserved in the deep eastern and deep western Mediterranean. Some key issues and scientific questions remain hidden in these pre-salt series. A large scientific community is taking action in order to submit scientific proposals to IODP (International Ocean Discovery Program) in order to use the riser-drilling vessel Chikyu (JAMSTEC) in the Mediterranean Sea.

The Western Mediterranean Sea is characterized by an oceanic crust and conjugate passive margins system which took place during the Cenozoic. Drilling at the foot of the continental slope (GOLD site) (2400 m water depth) would enable to reconstruct the complete paleoclimatological and geodynamical high-resolution history of the last 30 Ma recorded in some 6 km of sedimentary archive, including the entire Messinian sequence, and to reach an area with undetermined crust which is essential for the understanding of margin formation and its consequences on margin evolution. The drilling will also represent a first-class opportunity to study the microbial communities and processes in extremely deep marine sediments.

Complementary multiple-site drilling (DREAM sites) are also envisioned in the Mediterranean (e.g. Levant margin) to fully resolve several open questions about the causes, processes, timing and consequence at local and planetary scale of the outstanding MSC case of natural environmental change.

Deep drilling through the complete series of sediments in Western and Eastern Mediterranean Sea is the only way to give answers to these crucial questions, this is the aim of the GOLD and DREAM initiatives.

SESSION 4

MEDITERRANEAN-PARATETHYS GATEWAYS AND CONNECTIONS DURING THE NEOGENE

CONVENERS

MATHIAS HARZHAUSER AND SPERANTA POPESCU

Neogene-Quaternary Paratethyan-Pontocaspian Gateways and the Role of Anatolia in the Evolution of Pontocaspian Biota

Frank P. Wesselingh¹, Yesim Büyükmeric Islamoğlu², Hülya Alçıçek³, Mehmet Cihat Alçıçek³, Vitaliy Anistratenko⁴, Tamara Yanina⁵

¹Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, The Netherlands, frank.wesselingh@naturalis.nl

²General Directorate of Mineral Research and Exploration (MTA), TR-06520 Ankara, Turkey, yesimislamoglu@yahoo.com

³Pamukkale University, Department of Geology 20070 Denizli, Turkey, halcicek@pau.edu.tr, alcicek@pau.edu.tr

⁴I. I. Schmalhausen Institute of Zoology, National Academy of Sciences of the Ukraine, B. Khmelnytsky Str., 15, UA-01601, Kiev, Ukraine, anistrat@izan.kiev.ua

⁵Moscow State University, Faculty of Geography, Moscow, Russia, didacna@mail.ru

The Pontocaspian fauna is an anomalohaline fauna dominated by endemic neritid and hydrobiid gastropod species and lymnecardiine and dreissenid bivalve species living in the Black Sea, Caspian Sea and formerly Aral Sea Basin. Some Anatolian lakes also include Pontocaspian species¹. The fauna is experiencing severe decline. In the Black Sea basin the development of coastal wetlands and pollution diminish suitable habitat², possibly aggravated by introduced species. The intended as well as unintentional introduction of Mediterranean species in the Caspian Sea since the 1930ties has dramatically changed the formerly endemic communities^{3,4}. Possibly a major extinction has occurred in the past century especially in poorly understood endemic groups such as hydrobiid snails. The desiccation of most of Lake Aral too has resulted in the decline of the Pontocaspian fauna there.

The Pontocaspian fauna has experienced severe turnover events in its geological past. The modern fauna assembled in the middle Quaternary in the Black Sea and Caspian Sea basins. Several of the taxa (mostly genera) that now typify the Pontocaspian fauna derived from paratethyan lake systems such as the Pontian-Dacian system (several of the hydrobiid and dreissenid lineages^{1,5}, from rivers in the Pontocaspian drainage basin (possibly neritine and dreissenid lineages), but several derived from Neogene Anatolian lake systems (some hydrobiid and two lymnecardiine lineages^{6,7}). We present new data that indicate faunal exchange between the Pontocaspian domain and the Anatolian lake systems during the Quaternary.

By documenting successive Pontocaspian faunas in the different basins, the documentation of turnover events and studying their paleogeographic, environmental and climatic context we aim to elucidate the resilience of the fauna in past adverse conditions. A comparison with the modern, human-mediated Pontocaspian biodiversity crisis is made.

Keywords: Mediterranean - Paratethys gateways, Pontocaspian, Mollusca, turnover, paleogeography

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New Palynological Studies from the Mio-Pliocene Palaeo-Volga Delta and the Present-day (Holocene) Volga Delta in the Caspian Sea: Similarities and Differences

Keith Richards¹

¹Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, 1090 GE, (The Netherlands)
KrA Stratigraphic, Deganwy, Conwy, LL31 9YY (UK), kr@paly.co.uk

New palynological data are presented from the modern (Holocene) Volga delta and from the Mio-Pliocene palaeo-Volga of the Caspian Sea (CS). The modern Volga delta is a low-gradient, mud-dominated delta with numerous distributaries and more than 800 outlets, and is a partial analogue for the palaeo-Volga (Kroonenberg *et al.* 2005), a major hydrocarbon play in the Productive Series (PS) of the South Caspian basin. The palaeo-Volga was much larger than the modern delta, depositing over 6km of sediment in c.2.6 Ma (Abdullayev *et al.* 2011). Much of the palaeo-Volga deposition occurred in the Central and South Caspian basins, approximately 500 km to the south of the present delta. During the Late Miocene (Pontian), the CS was connected to the para-tethyan oceans (Reynolds *et al.* 1998) and this connection is visible in a palynological record from onshore Azerbaijan. There is no present day connection between the CS and world oceans, the last connections having occurred in the late Pleistocene. The Messinian dessication affected the Mediterranean, Black Sea and also the CS, where a major lowering of CS level, to c.1500m below present day levels, incised the palaeo-Volga canyon. The South Caspian basin was gradually re-filled with fluvio-lacustrine sediments during the latest Miocene to Pliocene, initially with the Lower Productive Series [Kalin, PK, Kirmaky, NKP and NKG], and then the Upper Productive Series [Fasila, Balakhany, Sabunchi and Surakhany] (Green *et al.* 2009). The Fasila is the main reservoir unit, formed by increased fluvial discharge, flushing out of sands from incised valleys into the CS. Although direct analogies cannot be made, there are broad similarities between many of these PS units and the Holocene delta. The Messinian lowering of the CS may be broadly analogous to the Mangyshlak lowstand, present at much smaller scale in the early Holocene delta, where palynology shows extensive reworking in channel deposits, overlain by aeolian dunes, lakes and lagoons of the Baer Hills. A short-lived aridification with very abundant Chenopodiaceae pollen in the early Holocene (c.8240-8400 cal. years BP) occurs as a thin drape across a wide area of the modern delta, and shows some similarities with the NKG (red-bed) unit. There is no exact analogy for the Fasila reservoir sand in the modern delta, however, channel sands do occur and contain frequent reworked palynomorphs. Both deltas were deposited in closed lacustrine basins, not directly affected by marine influences, with sedimentation controlled by climate, fluvial discharge and base level. The modern delta supports largely cold temperate and semi-arid plant communities, whereas the Pliocene delta shows good pollen evidence for the presence of warm temperate and swamp communities. River margin trees present during the Pliocene included frequent Taxodiaceae (swamp cypress), a niche that is filled by Salix (willow) in the modern delta.

Keywords: Palynology, Caspian Sea, Volga delta, Miocene, Pliocene, Holocene, Productive Series

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Salinity Crisis and Tethys-paratethys Connection during the Oligocene-miocene interval in the Eastern Carpathians

Mihaela C. Melinte-Dobrinescu¹, Marius Stoica²

¹ National Institute of Marine Geology and Geoecology Bucharest, Romania, 23-25 Dimitrie Onciul, RO-024053 Bucharest, Romania, melinte@geoecomar.ro

² University of Bucharest, Faculty of Geology and Geophysics, 1 Nicolae Bălcescu., RO-010041, Bucharest, Romania, marius.stoica@g.unibuc.ro

Since the first isolation of the Paratethys Domain from the Tethys during the Early Oligocene (Báldi, 1980; Rusu, 1988), fluctuations in salinity mirrored by modification of the biotic assemblages took place, linked to the palaeogeographic changes (Rögl, 1998). Repeated salinity crises, including the instauration of a brackish setting, but also of a hypersaline regime, affected the Carpathian area, part of the Paratethys (Piller *et al.*, 2007). The main aim of this paper is to present fluctuations in microfaunas and nannofloras related to repeated connections and isolations of the Paratethys during the Oligocene-Miocene interval.

The first isolation of the Paratethys in the Early Oligocene led to a strong decrease of the salinity, together with the instauration of an anoxic regime. This change allowed the occurrence of endemic nannofloras (Melinte, 2005), accompanied by blooms of *Braarudosphaera bigelowii*. Toward the upper part of the Oligocene, the reconnection with the Mediterranean is mirrored by the presence of cosmopolitan calcareous nannofossil assemblages. The anoxic sedimentation lasted, in the Romanian Carpathians, until the base of the Miocene. Afterwards, in the Eastern Carpathians salt deposits occurred in the Late Aquitanian (i.e., Egerian/Eggenburgian boundary interval), in the outer structures of the Eastern Carpathians, synchronous with the deposition of gypsum deposits in the inner structures. The evaporitic sedimentation lasted, in the Eastern Carpathians, until the Burdigalian (Early Eggenburgian). Another interval in which evaporate sediments occur in the Eastern Carpathians is the Middle Miocene, i.e., the Badenian Paratethyan stage. Gypsum and salt formations are widespread in the outer nappes along the all chain of the Eastern Carpathians. Nannofloras are entirely cosmopolitan, but high frequency of *Braarudosphaera bigelowii*, species that tolerates significant salinity fluctuations, was observed. The ostracod faunas of this interval are dominated by shallow water species, while the most frequent benthonic foraminifers encountered are the Elphidium, *Uvigerina* and *Biasterigerina* taxa. The youngest Miocene salinity crisis in the Romanian Carpathians corresponds to the Paratethyan Early Pontian (Odessian) interval and is possibly linked to the Messinian crisis of the Mediterranean (Stoica *et al.*, 2013). The earliest Pliocene, i.e., Zanclean (=Middle Pontian, respectively Bosphorian substage in the Eastern Paratethys that includes also the Eastern Carpathian region) transgression is marked by the occurrence in the Eastern Carpathians of planktonic foraminifers, diversified marine ostracod assemblages and calcareous nannofossil assemblages containing the species *Ceratolithus acutus*.

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Neogene-Quaternary Sediments in Western Part of Caspian Sea in Iran

M. Jamil Andalibi¹

¹Research Institute of Earth Sciences, Tehran, Iran

Some important observations have been made regarding the age and classification of Quaternary sediments with respect to their lithology, thickness, lower and upper boundaries and facies variation in relation to Eastern Paratethys in the Dasht-e-Moghan area in west of the Caspian Basin. Upper Pliocene-Lower Pleistocene of the Caspian Basin in Azerbaijan (former USSR) is represented by the Akchaglian and Apsheronian stages (oil bearing). The same lithotypes and corresponding stage names are also recognized in the stratigraphy of Iran. Based on a study of 9 sections in the Dasht-e-Moghan area using tectonostratigraphic and lithostratigraphic criteria, keybeds of volcanic tuff and peat as well as paleontological evidence, it is concluded that:

1. Sediments which have been hitherto termed Akchaglyian in the stratigraphy of Iran are actually younger and have an Apsheronian age (Lower Pleistocene).
2. Due to strong post-Miocene, pre-Upper Pliocene tectonic movements (Late Alpine) sedimentation did not occur in the Akchaglyian times. As a result, Lower Quaternary (Apsheronian) sediments rest with angular unconformity over older, Upper Miocene (Pontian-Sarmatian) sediments. The thickness of the Quaternary sediments in this area is estimated between 550-600 meters.
3. Volcanic phases which occurred concurrently with the Quaternary tectonic activities can be inferred from the well-defined horizons of volcanic tuff and other acid volcanic at various levels. Although the volcanoclastics and their derivations of this area contained at least 60% SiO₂, and the presence of abundant silica could have given rise to diatoms, there is no evidence of diatoms in the sediments of this area.

The Early Gulf of Corinth: A Conduit for Paratethyan Species Migration?

Thomas Wigley¹, Gerald Roberts¹, Charles Underwood¹, Marcelle K. BouDagher-Fadel²

¹Department of Earth and Planetary Sciences, Birkbeck College, University of London. Malet Street, Bloomsbury, London WC1E 7HX

²Department of Earth Sciences, University College London, Gower Street, London WC1E 6BT

We present new data regarding the age and palaeoenvironments of the earliest extensional phase in the Gulf of Corinth rift, a major branching structure of the Aegean extensional province. The dates and palaeontology strongly suggest a Messinian age, with typical paratethyan-type faunas.

The Gulf of Corinth is an asymmetric rift graben in central Greece, separating Hellas to the north from Peloponnesus to the south. The rift is extending in the back-arc region of the Hellenic subduction zone, though its age is uncertain, with various workers proposing dates ranging from Miocene to Pleistocene for rift initiation (though most recent workers favour a Plio-Pleistocene age). We have been able to date at least some of the syn-rift sediments in the eastern Gulf using micropalaeontology to the late Miocene. The Gulf's location at the edge of the Aegean extensional province means the age is important with regards to our understanding of Paratethyan-Mediterranean connections.

The dated Miocene sediments can be correlated with a number of outliers across the Perachora peninsula in the Eastern Gulf, most of which are known not to contain age diagnostic fossils. The undatable sediments include coarse prograding deltaics as well as fine silts probably deposited in deep lakes. Numerous beds have yielded diverse ostracod faunas containing cryprideids, loxoconchids and tyrrhenocytherids amongst others. There are also horizons of well developed *Lithophyllum* patch reefs ~10m high. Furthermore, field investigation has yielded numerous sites of extensive shell beds containing typical paratethyan-associated Lymnocytherids and other molluscs.

The age of the fossils and their paratethyan affinity supports the idea that the Gulf played a role in the migration of Paratethyan faunas into the Mediterranean, though what its role was is uncertain. One possibility is that the Gulf was an early conduit for Paratethyan species, cutting through the Hellenides orogen and linking the early Aegean and Ionian seas; thereby facilitating the development of the abundant Lymnocytherid populations elsewhere, such as in northern Italy. Another more likely hypothesis is that the earliest Gulf did not form a continuous seaway, but rather a region of numerous periodically isolated fault controlled basins. Such an environment would have promoted the rapid allopatric diversification of mollusc/ostracod faunas due to periodic tectono-eustatic controlled isolation and reconnection – especially during the Messinian.

Keywords: Aegean, Messinian, Biostratigraphy, Corinth Rift.

Lago Mare Events in the Mediterranean

Speranta-Maria Popescu¹, Mihaela Carmen Melinte-Dobrinescu², Bipo Barhoun³, Maria-Angela Bassetti⁴, Romain Pellen⁵, Damien Do Couto⁶⁻⁷, Jean-Pierre Suc⁶, Christian Gorini⁶, Marina Rabineau⁵

¹GeoBioStratData.Consulting, 385 route du Mas Rillier, 69140 Rillieux la Pape, France. speranta.popescu@gmail.com

²National Institute of Marine Geology and Geoecology, 23-25 Dimitrie Onciul street, P.O. Box 34-51, 70318 Bucharest, Romania. melinte@geoecomar.ro

³University Hassan II-Mohammedia, Faculty of Sciences Ben M'Sik, BP 7955 Sidi Othmane, Casablanca, Morocco. nbarhoun@yahoo.fr

⁴CEFREM (UMR 5110), University of Perpignan, 52 avenue Paul Alduy, 66860 Perpignan Cedex, France maria-angela.bassetti@univ-perp.fr

⁵Domaines Océaniques (UMR 6538 CNRS), IUEM, place Copernic, 29280 Plouzané, France romin.pellen@gmail.com, marina.rabineau@univ-brest.fr

⁶ISTEP (UMR 7193 CNRS), Université P. et M. Curie, case 117, 4 place Jussieu, 75252 Paris Cedex 05, France. docoutodamien@gmail.com, jeanpierre.suc@gmail.com, christian.gorini@gmail.com

⁷TOTAL, 2 place Jean Millier, 92400 La Défense, Paris, France

In the Mediterranean, deposits rich in Paratethyan organisms (bivalvia: dreissenids and lymnocyprids; ostracods; dinoflagellate cysts) are linked to the Messinian Salinity Crisis (MSC). They are usually grouped within a single chronostratigraphic unit preceding the Messinian – Zanclean boundary, the so-called “Lago Mare” (Cita and Colombo, 1979; Orszag-Sperber, 2006; Manzi *et al.*, 2013), which is supposed to represent temporary low salinity conditions.

However, the evidence of three successive Lago Mare (LM) events (Clauzon *et al.*, 2005; Popescu *et al.*, 2007, 2009) led to an extensive micropaleontological research in the Mediterranean sections, both exposed onland (peripheral basins) and DSDP/ODP holes (central basins).

Some exposed sections display such peculiar deposits enriched in fossils originated from the former Paratethys which belong to:

LM1 (ending evaporitic sedimentation in peripheral basins) for example at Cava Serredi and Eraclea Minoa; LM3 (post-MSC reflooding) for example at Sorbas, Níjar, Malaga, Maccarone, Civitella del Tronto, Eraclea Minoa).

Some DSDP/ODP Sites display such deposits which successively belong to LM2 (ending evaporitic deposition in central basins) and LM3.

It appears that LM1 and LM2 illustrate high sea-level conditions with a temporary connection between the Mediterranean and Paratethys. Origin of the LM2 event is still enigmatic.

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Biostratigraphic and Paleoenvironmental Contributions of Calcareous Nannofossil Study from Upper Miocene to Pliocene Deposits of Chelif Basin (NW Algeria)

Mohamed El Habib Mansouri¹, Mostefa Bessedik¹, Lahcene Belkebir¹ and Bouhameur Mansour¹

¹Université d'Oran, Département des Sciences de la Terre, Laboratoire de Paléontologie Stratigraphique et Paléoenvironnement, B.P. 1524, 31000 Oran (Algeria). Mansouri_habib@hotmail.com

Fifty four calcareous nannofossil species were listed in the upper Miocene to Pliocene deposits of the Northern Chelif Basin (Dahra, Meni section). The frequency of some of them (*Discoaster loeblichii*, *D. quinqueringus*, *Amaurolithus primus*, *A. amplificus*, *Ceratolithus rugosus*, *Discoaster asymmetricus* and *D. tamalis*) suggests the presence of various zones and subzones (NN10b, NN11a, NN11b, NN11c, NN11d, NN13, NN14, NN15a, NN15b) which are assigned to the Tortonian, Messinian and Zanclean stages. The Tortonian-Messinian boundary is pointed out at the sample 15 of the section and characterized by the first occurrence (FO) of *Amaurolithus delicatus* and *Reticulofenestra rotaria* on the one hand and *Globorotalia mediterranea* on the other hand. The assemblage analysis and relative abundance fluctuations of *Coccolithus pelagicus* and *Reticulofenestra pseudoumbilicus* show evidence of seven successive phases which are characterized, alternately, by cold and hot water marine masses, light intensity variations and nutriment availability.

Keywords: Calcareous nannofossils, Upper Miocene-Pliocene, biostratigraphy, paleoecology, NW Algeria

Chronologic Constraints on High-Resolution Records of the Sedimentary and Biotic Response to the Badenian Salinity Crisis of the Central Paratethys

Arjan de Leeuw¹, Krzysztof Bukowski², Wout Krijgsman³, Klaudia F. Kuiper⁴, Oleg Mandic⁵, Marius Stoica⁶, Grzegorz Czapowski⁷, Andrzej Gasiewicz⁷

¹CASP, West Building, 181A Huntingdon Road, Cambridge, CB3 0DH, United Kingdom,
arjan.deleeuw@casp.cam.ac.uk

²Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, A. Mickiewicza 30,
30-059 Krakow, Poland, buk@agh.edu.pl

³Paleomagnetic Laboratory 'Fort Hoofddijk', Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands, w.krijgsman@uu.nl

⁴Isotope Geochemistry, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081 HV Amsterdam, the Netherlands, klaudia.kuiper@falw.vu.nl

⁵Department of Geology & Palaeontology, Natural History Museum Vienna, Burgring 7, 1010 Wien, Austria, oleg.mandic@nhm-wien.ac.at

⁶Bucharest University, Department of Geology and Paleontology, Balcescu Bd. 1, 010041 Bucharest, Romania, marius.stoica@g.unibuc.ro

⁷Polish Geological Institute-National Research Institute, Rakowiecka 4, 00-975, Warsaw, Poland, grzegorz.czapowski@pgi.gov.pl

Hydrological changes had a profound influence on environmental conditions within the Paratethys. The silled nature of the basins that constituted Paratethys made them particularly sensitive to eustatic changes and tectonism leading to frequent isolation. This brought about large fluctuations in water chemistry, which led to a number of regional extinction events, multiple expansions of highly endemic faunas, and the deposition of world-class source rocks. A base-level drop and subsequent strong increase in salinity during the regional Badenian stage led to the extinction of a large number of species and triggered deposition of up to 300 m of evaporites in large parts of the Central Paratethys. This so-called Badenian Salinity Crisis (BSC) was arguably one of the most severe environmental catastrophes striking this aquatic ecosystem. A lack of rigorous age control on tell-tale sedimentary records throughout southeastern Europe nevertheless hampered its thorough understanding.

Recently obtained radio-isotopic ($^{40}\text{Ar}/^{39}\text{Ar}$), magnetostratigraphic and cyclo-stratigraphic age constraints and an enhanced biostratigraphic control on sections spanning the BSC interval in southern Poland, Romania, Bosnia-Herzegovina and Austria allow for high-resolution correlation of the BSC deposits in different parts of the basin. Detailed descriptions of the sedimentary and biotic response apparent in these stratigraphically calibrated sections elucidate the progression and basin-wide impact of the BSC. The constructed chronostratigraphic framework furthermore allows the placement of this benchmark event in a regional as well as global context, and the discussion of its potential forcing mechanisms.

The Burdigalian Seaway: New insights into one of the Main Mediterranean/Paratethys Faunal Migration Routes of the Early Miocene

Patrick Grunert¹, Mathias Harzhauser², Werner E. Piller¹

¹Institute for Earth Sciences, University of Graz, Heinrichstraße 26, A-8010 Graz, Austria;
patrick.grunert@uni-graz.at

²Geological-Paleontological Department, Natural History Museum Vienna, Burgring 7, A-1030 Vienna, Austria

The Burdigalian Seaway provided the main route for faunal migration between the Central Paratethys and the Western Mediterranean during the early and middle Burdigalian. The opening of this gateway was promoted through a major eustatic rise in sea-level at c. 20.44 Ma when transgressions via the Rhône Basin in the west and via the North Alpine Foreland Basin (NAFB) in the east connected the Paratethys and Mediterranean seas. The fossil record of the Central Paratethys bears clear evidence for the immigration of e.g. echinoids and bryozoans from the Mediterranean once the Burdigalian Seaway was properly established. Closure of the gateway occurred at c. 18 Ma due to increasing sediment input from the Alpine hinterland.

For a long time the stratigraphic framework for the Burdigalian Seaway was poorly developed, and it hampered the evaluation of migrational events considerably. Only recently new results from outcrops and drill-sites in the NAFB of Upper Austria (e.g., Grunert *et al.*, 2011; 2012; 2013) and Bavaria (e.g., Pippèrr and Reichenbacher, 2009; Pippèrr, 2011) have provided new stratigraphic constraints for the marine deposits of the Burdigalian Seaway. The revealed sequence stratigraphic framework is linked to global 3rd-order sequences Bur 1-3, and integrated bio- and magnetostratigraphic data further improve the age model for the study area. Current research efforts attempt to integrate the stratigraphic model in the east with available bio-, sequence- and magnetostratigraphic data from Switzerland and the Rhône Basin in the west. The ultimate goal will be an age model for the Burdigalian Seaway that reflects its complex history marked by the interplay of eustatic sea-level, Alpine tectonics, and variable sediment discharge, and that will allow a more precise dating and evaluation of migrational events between the Mediterranean and Paratethys seas.

Keywords: Burdigalian Seaway; faunal migration; Central Paratethys; Mediterranean

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Nannoplankton Assemblages Response to Environmental Changes during the Miocene in the Eastern Paratethys (Southern Russia)

Larisa Golovina¹

¹Geological Institute RAS, Pyzhevskiy per. 7, 119017, Moscow, Russia, golovina@ginras.ru

The succession of calcareous nannoplankton assemblages are very sensitive to palaeoenvironmental conditions (fluctuations of the salinity, temperature, nutrients). The distribution pattern of the nannofossils reflects the peculiar bionomic conditions during the Miocene of the Eastern Paratethys. Thus, the nannoplankton zonal subdivision of most sections in the Eastern Paratethys remains still problematic because the impoverished nannofossil assemblages include cosmopolitan species and lack stratigraphically significant taxa.

The association with a predominance of *Cyclicargolithus floridanus* was identified in the Alkunian Formation (Central Caucasus, Karamurzinsky section on the Kuban River) and in North Ossetia, central part of the Northern Slope of the Greater Caucasus; sections Fiagdon and Mayramadag (Filippova, Beluzhenko, Golovina 2012; 2013). Nannoplankton assemblages contain: *Coccolithus pelagicus*, *Coronocyclus nitescens*, *Cyclicargolithus floridanus*, rare *Cyclicargolithus abisectus*, *Helicosphaera euphratis* *Helicosphaera* sp., *Pontosphaera multipora*, *Pontosphaera* sp., *Reticulofenestra* cf. *haqi*, *Reticulofenestra* sp., *Sphenolithus conicus*, *Thoracosphaera* sp., *Triquetrorhabdulus carinatus*, *Tr. milowii*, *Umbilicosphaera* sp., very rare *Discoaster* aff. *deflandrei*.

The association with a predominance of *Sphenolithus heteromorphus* was identified in the Tarkhanian key sections (Yaman Dzhalga, Ust Nevinka - Kuban River; Starokuvinski aul - Bolshoi Zelenchuk River, Northern Caucasus, Russia; Kop-Takyl and Malyi Kamyshlak, Crimea, Ukraine; Rubas-chai River, Dagestan; Perekishkyul - Sumgait River, Azerbaijan) (Goncharova, Golovina, 2003; Golovina, Goncharova, Rostovtseva, 2004; Popov *et al.*, 2008; Golovina 2012). The calcareous nannoplankton assemblages contain abundant *Braarudosphaera bigelowii*, *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Helicosphaera carteri*, *H. waltrans*, *H. mediterranea*, *Rhabdosphaera* sp., *Reticulofenestra pseudoumbilica*, *Sphenolithus heteromorphus*. The assemblages are represented by high number of helicoliths (*Helicosphaera carteri* and *H. waltrans*; however *H. ampliaperta* is not found). The most diverse and abundant nannoplankton there are in the upper part of Kuvinian Beds, in the Terskian Beds (Tarkhanian marl), at the base of Argunian Beds. Then assemblages rapidly impoverished in the lower-middle part of Argunian Beds.

Sphenolithus heteromorphus occurs within the NN4-NN5 Zones. At the same time *Helicosphaera waltrans* is an important additional marker and was recorded in many areas of Central Paratethys (described by Theodoridis, 1984 from Gozo, Italy) within nannoplankton zone NN5 and was used for the subdivision of Langhian sediments in the Mediterranean (Theodoridis 1984; Fornaciari *et al.* 1996). Stratigraphic significance of *Helicosphaera waltrans* discussed by many authors (Andreeva-Grigorovich *et al.*, 2000; Švábenská, 2002; Rögl, Spezzaferri, 2003; Ćorić, Švábenská, 2004, Bartol, 2009). Biohorizon with *H. waltrans* are related to the Lower Badenian transgressive phase (Ćorić, Švábenská, Rögl, Petrova, 2007).

The association with a predominance of *Reticulofenestra pseudoumbilica* was identified in the Konkian key sections of the south of Russia (Zelensky Mountain anticline, Taman Peninsula; Belaya River, Fars River and Pshekha River, Northern Caucasus). The assemblage characterized by the presence of *Braarudosphaera bigelowii*, *Coccolithus pelagicus*, *Cricolithus jonesi*, *Reticulofenestra pseudoumbilica*, *Rhabdosphaera sicca*, *R. poculi*, *R. pannonica*, *Helicosphaera carteri*, *Sphenolithus moriformis*, *Discoaster* sp., *Helicosphaera* sp., *Sphenolithus* sp., *Thoracosphaera* sp. and well correlated with the nannofossil associations from the Upper Badenian (Kosovian) sediments (NN6/NN7 zones). The upper part of this horizon is characterized by a peculiar conditions bionomic association with the development of monospecific *Reticulofenestra pseudoumbilica* (Veselyanian Beds).

The association with a predominance of *Braarudosphaera bigelowii* and *Lithostromation perdurum* was identified in the Upper Maeotian-Lower Pontian ("Transitional Strata") (Popov Kamen, Taman, Zheleznyi Rog and Kholodnaya Dolina Sections, Taman Peninsula, Russia). The assemblage are represented with dominance *Braarudosphaera bigelowii*, whereas *Lithostromation perdurum*, *Coccolithus pelagicus*, *Discoaster* sp., *Reticulofenestra* sp., *Rhabdosphaera* sp., *Syracosphaera pulchra*, *Syracosphaera* sp., and *T. thoracosphaera* sp. are found rarely. Some specimens *Discoaster intercalaris* are found in the Upper Maeotian deposits (Popov Kamen section). The distribution pattern of the nannofossils reflects the peculiar bionomic conditions during the accumulation of "Transitional Strata" - the period of indirect Mediterranean water invasion into the Eastern Paratethys basin (Radionova, Golovina, 2011; Radionova *et al.*, 2012).

Keywords: Eastern Paratethys, Miocene, biostratigraphy, palaeoenvironmental conditions, nannoplankton

Eastern Paratethys Stratigraphic Scale of Neogene: Correlation Possibilities

S. V. Popov¹, N. Yu. Filippova², L. A. Golovina², I. A. Goncharova¹, E. P. Radionova², A. S. Tesakov, V. M. Trubikhin²

¹Paleontological Institute RAS, Profsoyuznaya 123, Moscow, 117997 Russia, serg.pop@mail.ru

²Geological Institute RAS, Pyzhevskiy per. 7, 119017, Moscow, Russia

Next stratigraphic levels, which are helpful for correlation with Central Paratethys and Mediterranean, have been recorded in Eastern Paratethys (see stratigraphic scheme):

1. Upper Akchagilian (=Upper Kujalnician) has reversed polarity and is correlateable with C2r Chron and Gelasian of Mediterranean. Mammals of MN17 were found directly in marine deposits of this age.

2. Lower Akchagilian (Lower Kujalnician) is magnetized mainly normally and corresponded to Gauss (C2An) and Piacenzian (Trubikhin, 1977, 1989; Pevzner, 1986).

3. *Ceratolithus acutus* (FO-5.4 Ma, according to Ogg *et al.*, 2008) was found in the Lower Kimmerian (Lyulieva, 1989).

4. Pontian is correlated mainly with Chron C3r of Upper Messinian, but it is longer than the latter, according to paleomagnetic data, mollusks succession, *Galeacysta etrusca* appearance in dinocyst assemblage.

5. The upper part of Maeotian and base of Pontian is corresponded to terminal Lower Messinian, what is based on marine nannoplankton presence and oceanic *Thalassiosira convexa* FO 6.6 Ma and *Th. oestrupii* FO 5.8 Ma (Radionova, Golovina data).

6. Lower / Upper Maeotian boundary is close to C3Ar/C3An one (6.6 Ma, Filippova, Trubikhin, Pilipenko, 2010).

7. The lower part of Maeotian has reversed polarity (C3Ar, C3Br chrons - Trubikhin, 1989) and is correlated with the uppermost Tortonian according to findings of oceanic diatoms *Thalassiosira burkiana* (LO 7.9 Ma) and *Th. grunowii* (LO 7.8 Ma - Radionova *et al.*, 2012). Mammals of MN11 are known in Khersonian-Maeotian transition in South Ukraine.

8. Base of Khersonian is corresponded to Upper Tortonian too, what is based on *Thalassiosira burkiana* findings (FO 8.9 Ma Radionova *et al.*, 2012).

9. Konkian deposits contain rich mollusk and foraminifer assemblages, nannoplankton of NN6-7. That is why Konkian is correlated with Upper Badenian (Kosovian) and Middle Serravalian.

10. Transitional MN5/MN6 mammal association in the upper Lower Chokrakian (Belomechetka – Gabunia, Bendukidze, 1984, Lopatin, 2004) make it possible to correlate Chokrakian with Lower Badenian (Moravian) and Upper Langhian.

11. Mammal remains of MN4/MN5 zones in Kazakhstan (North Usturt, Lopatin, 2004) are correlatable with Karpatian – Lower Badenian of the Western Paratethys and Upper Burdigalian - Lower Langhian of the Mediterranean.

12. Tarkhanian is dated by Lower-Middle Miocene because of the presence of NN5 zone nannoplankton and mollusks similar to the Karpatian ones, with marine association and *Rzehakia dubiosa* in basal Kuvinian layers.

13. Kozachurian of stratotypic area (Central Georgia) contains brackish mollusks, including *Rzehakia dubiosa*, common with Upper Otnangian. Correlation with Ciscaucasian Riza suite is carried out on the base of lowered salinity assemblages: mollusk with *Rzehakia* and brackish lymnocyprids, foraminifers with *Saccammina zuramakensis*, euryhaline dinocysts.

14. List of Sakharaulian mollusks includes 30% species characteristic for the Western Paratethys Eggenburgian.

15. Stratigraphical position of lower Caucasian is controversial. From one side, lowest Alkun Suite of the Caucasian contains transitive Oligocene - Miocene associations of dinocysts and nannofossils in basal part and Miocene species, including characteristic for NN1 zone in the upper parts (Filippova, Golovina, 2010, 2013).

16. From other side, lower Caucasian mollusk association in parastratotype section includes *Cerastoderma prigorovskii*, which is characteristic species for the Upper Oligocene of Eastern Paratethys. Dinocysts contain *Chiropteridium partispinatum* and *Delandrea spinulosa*, more usual for Oligocene (Akhmetiev, Zaporozhec, 1996).

Sr-isotope Compositions of Paratethys Mollusks and Barnacles - Stratigraphy, Taphonomy and Regional Deviations

Oleg Mandic¹, Fritz F. Steininger², Mathias Harzhauser², Susanna Scharbert³

¹Geological-Paleontological Department, Natural History Museum, Burgring 7, 1010 Vienna, Austria.

oleg.mandic@nhm-wien.ac.at; mathias.harzhauser@nhm-wien.ac.at

²Krahuletz-Museum Eggenburg, Krahuletz-Platz 1, 3730 Eggenburg, Austria.

fritz.steininger@senckenberg.de

³Geologische Bundesanstalt, Neulinggasse 38, 1030 Vienna, Austria.

Strontium isotope stratigraphy (SIS) uses $^{87}\text{Sr}/^{86}\text{Sr}$ values of Sr dissolved in the world's oceans to date and correlate marine sedimentary rocks. The $^{87}\text{Sr}/^{86}\text{Sr}$ values in authigenic/biogenic minerals, which have been precipitated in marine waters at salinities above 20 psu, are used to obtain the numerical age of its formation based on the direct comparison with the calibrated, global $^{87}\text{Sr}/^{86}\text{Sr}$ record.

For the present study, measurements of $^{87}\text{Sr}/^{86}\text{Sr}$ in calcite and aragonite shells of marine bivalves, gastropods and barnacles have been processed for more than 170 samples from about 100 Western and Central Paratethys localities in the Alpine-Carpathian Foredeep and the Pannonian Basin System. Covering an area of almost 200,000 km² and including seven countries between Switzerland and Romania the samples span a time interval from ~27.3 Ma to ~11.6 Ma (Egerian to Sarmatian, Late Oligocene to Middle Miocene) characterized mostly by a significant (stratigraphically) upward increase of marine $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. The age control is provided by correlation with the Paratethyan chronostratigraphy. Most of the localities have been already dated by means of biostratigraphy or integrative stratigraphic methods.

The large data-set available, based largely on collection material, provides a very good insight into the strength and weaknesses of the method including indeed some highly promising results. The Sr-isotope concentrations captured in the Paratethyan biogenic material clearly coincides with the concentrations found in the global paleoceanographic records, despite its geographically semi-closed or even restricted epicontinental setting.

The stratigraphic resolution is in average about 1 m.y. but in some cases even more precise. The best results have been achieved in the Lower Miocene deposits, which is explained by the fact that the Sr curve is steepest i.e. shows the fastest change of $^{87}\text{Sr}/^{86}\text{Sr}$ during the early Miocene. In the Middle Miocene, after ~15 Ma when the curve starts to flatten, rough age estimations are still possible although at a much coarser scale because of significantly extended probability ranges.

Pectinid shells are usually preferred for this kind of studies as they provide an excellent biostratigraphic control. The present study, however, documents barnacles as best measuring target, due to their stable shell structure, which is less prone to leaching. Fully marine settings are not necessarily a guarantee for good results – also shells from estuaries can provide reliable dating, whereas shells from open marine conditions may turn out to be inappropriate for analysis. The influence of weathering of basement rocks, such as the granites of the Bohemian Massif, is not always overprinting the marine $^{87}\text{Sr}/^{86}\text{Sr}$ ratios. In contrast, the most crucial overprint parameter is taphonomy i.e. the shell preservation, although also even apparently well preserved shell material does not always provide excellent results. Therefore, additional stratigraphic control remains still crucial for the interpretation of numerical ages inferred through SIS analyses.

Keywords: Western and Central Paratethys, strontium isotope stratigraphy, Oligocene-Miocene

The Badenian Fish Fauna of St. Margarethen, Eisenstadt-sopron Basin, Burgenland, Central Paratethys: Stratigraphy, Paleoecology and Paleobiogeography

Giorgio Carnevale¹, Mathias Harzhauser²

¹Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso, 35 I-10125 Torino, Italia; giorgio.carnevale@unito.it

²Geologisch-Paläontologische Abteilung, Naturhistorisches Museum in Wien, Burgring 7 A-1010 Vienna, Austria; mathias.harzhauser@nhm-wien.ac.at

Exquisitely preserved articulated skeletal remains of teleost fishes from the Badenian coralline limestone exposed in the Eisenstadt-Sopron Basin, Austria are known since the first part of the XIX century thanks to the efforts of brilliant Austrian naturalists such as Johann Jakob Heckel and Rudolf Kner that described several specimens collected in a few outcrops located in the nearby of the village of St. Margarethen. A vast collection of extraordinarily well preserved fishes and invertebrates from the coralline limestone was recently accumulated during two large excavation campaigns carried out in the Kummer Quarry, about 2 km E of St. Margarethen village (47°48'01.76''N, 16°37'59.12''E). These fossils, primarily represented by skeletal remains of teleost fishes and subordinately by shark teeth, crustaceans, bryozoans, echinoids, molluscs and brachiopods, are preserved in finely laminated greenish-whitish calcarenitic marls that apparently originated in low-energy depressions of the floor surrounded by carbonate sand build-ups. The mass accumulations of fishes and the thanatocoenoses of autochthonous benthic invertebrates originated in response to repeated hypoxic events. The repeated and severe benthic hypoxic events were probably associated to blooms of *Coccolithus pelagicus* and some reticulofenestrads triggered by periodic increased input of nutrients.

The Late Badenian age of this konservat-lagerstätte has been estimated based on calcareous nannoplankton, which indicates zone NN5b, around the Langhian/Serravallian boundary, roughly between 14.0 and 13.5 Ma.

The excellent preservation of fish skeletal remains seems to be primarily related to the development of a microbial film that promoted the rapid mineralization of bones and other organic components. Slightly less than thousand fish specimens (sharks, batoids and teleosts) have been analyzed, among which 49 taxa belonging to 37 families have been identified. The round herring *Spratelloides* sp., the lanternfish *Diaphus* sp. and the scorpionfish *Scorpaena prior* sharply dominate the assemblage, represented by more than 50% of the recognized specimens. The comparative analysis of the ecological categories indicates that the assemblage primarily consists of benthic and demersal neritic (e.g., *Boops* aff. *roulei*, *Callionymus* sp., *Calotomus priesli*, *Chaetodon* cf. *ficheuri*, *Coris sigismundi*, “*Ctenolabrus*” agassizi, *Dentex* sp., *Epinephelus* cf. *casottii*, *Gaidropsarus pilleri*, *Lophius* sp., *Malacanthus* sp., *Miobothus weissi*, *Mullus* sp., *Nerophis zapfei*, *Palimphemus anceps*, *Priacanthus* cf. *croaticus*, *Scorpaena prior*, *Synodus* sp., *Trachinus* sp.) and coastal epipelagic taxa (e.g., *Belone* sp., *Sardinella* sp., *Scomber* sp., *Sphyræna* sp., *Spratelloides* sp., *Trachurus* sp.), with a relatively diverse contingent of migratory pelagic and oceanic taxa (*Bregmaceros* cf. *albyi*, *Cetorhinus parvus*, *Diaphus* sp., *Merluccius* aff. *errans*)

The paleoecological analysis of the fish assemblage suggests that the deposition of the finely laminated fossiliferous calcarenitic marls occurred not far from the coastline in a moderately shallow basin surrounded by rocky reefs and seagrass beds and remarkably influenced by the open sea. The highly heterogeneous composition of the assemblage, which is characterized by the co-occurrence of coastal, and opportunistic mesopelagic taxa, is consistent with the unstable eutrophic conditions indicated by the nearly monospecific or oligospecific blooms of *Coccolithus pelagicus* and reticulofenestrads that triggered the periodic hypoxic events.

From a paleobiogeographical point of view, the fish assemblage from St. Margarethen exhibits a clear Atlantic-Mediterranean configuration, but also includes several taxa today restricted to the tropical waters of the Indo-Pacific and Caribbean regions (e.g., *Aeoliscus*, *Calotomus*, *Chaetodon*, *Malacanthus*, *Pristis*), representing the heredity of the Tethyan biota.

Keywords: fossil fishes; Badenian; Central Paratethys; paleoecology; paleobiogeography

SESSION 5

**RESPONSE OF THE PARATETHYS TO THE MESSINIAN
SALINITY CRISIS**

**CONVENER
WOUT KRIJGSMAN, MARIUS STOICA AND M.CİHAT
ALÇİÇEK**

Paratethys Response to the Messinian Salinity Crisis

W. Krijgsman¹, M. Stoica², A. de Leeuw³, I. Vasiliev¹, A. Grothe⁴, C.G.C. Van Baak¹, F. Sangiorgi⁴

¹Paleomagnetic Laboratory Fort Hoofddijk, Department of Earth Sciences, Utrecht University, Budapestlaan 17, 3584 CD Utrecht, The Netherlands, W.Krijgsman@uu.nl; I.Vasiliev@uu.nl; C.G.C.vanBaak@uu.nl

²Department of Geology and Paleontology, Faculty of Geology and Geophysics, Bucharest University, Bălcescu Bd. 1, 010041, Romania, marius.stoica@g.unibuc.ro

³CASP, University of Cambridge, 181a Huntingdon Rd, Cambridge, CB3 0DH, UK
arjan.deleeuw@casp.cam.ac.uk

⁴Marine Palynology, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands, A.Grothe@uu.nl; F.Sangiorgi@uu.nl

Deep-sea drilling of the Black Sea basin revealed a peculiar sedimentary layer (Unit IVd of DSDP Site 380), which was interpreted as a sudden drastic (~1600 m) lowering of the Black Sea water-level. Unit IVd was proposed to be the result of the Messinian Salinity Crisis (MSC) event, mainly because “the MSC was the only unusual event that might be responsible for those unusual sediments”. The hypothesis of a Messinian desiccation event in the Black Sea was not generally accepted, and especially the timing was seriously questioned. Seismic profiles of the Black Sea basin show evidence of several major erosional surfaces, which are generally correlated to the MSC event, but chronostratigraphically meaningful data are still absent.

A major Messinian base level drop has furthermore been proposed for the Dacian Basin, the Pannonian Basin and the Caspian Sea, suggesting that the entire Paratethys domain was seriously affected by the Mediterranean MSC event. The timing, magnitude and, in some cases, even the sign of these sea or lake level changes are seriously questioned and subjected to ongoing controversy. Especially the common presence of brackish water fauna (ostracods and molluscs of Paratethyan affinity) in the post-evaporitic ‘Lago-Mare’ sediments of the Mediterranean suggest overspilling of Paratethyan waters into the Mediterranean and thus no widespread desiccation event in the Paratethys.

In this contribution, we discuss the most significant scientific data and arguments that deal with the question how the Paratethys basins were influenced by the Mediterranean MSC event.

Dacian Basin during the Messinian Salinity Crisis

M. Stoica¹, W. Krijgsman², I. Lazar¹, A. Floroiu¹, I. Vasiliev²; C.G.C. Van Baak²

¹Department of Geology, Faculty of Geology and Geophysics, Bucharest University, Bălcescu Bd. 1, 010041, Romania, marius.stoica@g.unibuc.ro; iuliana.lazar@g.unibuc.ro; floroiualina@yahoo.com

²Paleomagnetic Laboratory Fort Hoofddijk, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands, W.Krijgsman@uu.nl; I.Vasiliev@uu.nl; C.G.C.vanBaak@uu.nl

The evolution of the Dacian Basin is influenced by the evolution of the Eastern Paratethys and its connections in time with open marine basins, like the Mediterranean Sea or Indian Ocean. The Dacian Basin forms the connection between the Central Paratethys (Pannonian Basin) and Eastern Paratethys and all faunal migrations between these two important Paratethyan aquatic domains took place through it. The connection with the Eastern Paratethys took place along a shallow gateway, most probably situated north of the Dobrogea land. Base level oscillations during the Late Messinian are very prominent in sedimentary and faunal records of the Dacian Basin. Based on investigations of many sections from marginal areas of Dacian basin we discuss the evolution during the Pontian stage (6.04 - 4.7 Ma), which is the time-equivalent of the Messinian Salinity Crisis (MSC) and the Early Pliocene.

The Lower Pontian (Odessian) starts with a transgressive moment (dated at ~6.04 Ma) which affected all Eastern Paratethyan basins, including the Dacian basin. At this moment the base level rose possibly by several tens of meters up to 100m. This event can be observed over more than 2500 km in the Eastern Paratethys and produced a level with marine fauna (including foraminifers) which replaced the Upper Maeotian fresh water fauna. In the Lower Pontian, the Dacian Basin experienced high-stand conditions with a large development of fine-grained sediments (marls) and fauna dominated by brackish water mollusks and ostracods. During this time interval an important migration of Pannonian mollusk into the Dacian Basin and further into Eastern Paratethys can be observed. This shows that the transgressive event at the beginning of the Pontian led to the reconnection of the Pannonian Basin with the Eastern Paratethys through the Dacian Basin. The origin of this transgression in Paratethys is still disputed (Mediterranean Sea or Indian Ocean), but the onset of it coincides closely with the onset of the MSC (5.97 Ma) when the first evaporites formed in the Mediterranean basin.

In the Middle Pontian (Portaferrian) the base level dropped tens of meters and basinal areas turned to a more marginal setting (littoral, fluvial-lacustrine). Fauna reacted to the changed environment, brackish water mollusks and ostracods migrated to the central part of the basin and newly formed marginal areas were populated by fresh water taxa. In our opinion this is the main effect of MSC event in the Dacian Basin. The water level drop of tens of meters might reflect the amplitude of the gateway depth located north of Dobrogea land. Our data suggest that Dacian basin never completely desiccated during the MSC and no evaporites were formed, as some recent studies claimed.

The Upper Pontian (Bosphorian) started with another transgressive moment and water level rose again in the Dacian Basin (and throughout the Eastern Paratethys). The brackish basinal mollusk and ostracod fauna replaced the Middle Pontian fresh water ones developed in littoral and fluvial-lacustrine facies. This second transgressive event during the Pontian might be linked with the transgressive event at Miocene / Pliocene boundary in Mediterranean domain and the end of the MSC. Alternatively, a climatical change during the MSC interval towards more humid conditions, as observed after ~5.5 Ma, might have caused a positive water-budget in Paratethys and can also explain the return of brackish basinal conditions.

Keywords: Dacian Basin, Paratethys, Pontian, gateways

The Evolution of the Eastern Paratethys during the Messinian Salinity Crisis

A. Grothe¹, F. Sangiorgi F¹, W. Krijgsman², I. Vasiliev², G-J. Reichart^{3,5}, M. Stoica⁴, H. Brinkhuis^{1,5}

¹Utrecht University, Faculty of Geosciences, Department of Earth Sciences, Marine Palynology and Paleooceanography, Laboratory of Palaeobotany and Palynology, Budapestlaan 4, 3584 CD Utrecht, The Netherlands, a.grothe@uu.nl

²Utrecht University, Faculty of Geosciences, Department of Earth Sciences, Paleomagnetic Laboratory 'Fort Hoofddijk', Utrecht, The Netherlands

³Utrecht University, Faculty of Geosciences, Department of Earth Sciences, Geochemistry, Utrecht, The Netherlands

⁴Bucharest University, Faculty of Geology and Geophysics, Department of Paleontology, Bucharest, Romania

⁵Royal Netherlands Institute for Sea Research (NIOZ), Den Burg, The Netherlands

During the late Miocene, the connection(s) between the Mediterranean Basin and the Atlantic Ocean deteriorated, which ultimately culminated in thick evaporite deposits and a water level drop in the Mediterranean Basin during the so-called Messinian Salinity Crisis (MSC, 5.96–5.33 Ma). Several lines of evidence, including an anomalous breccia layer in the late Miocene deposits of Deep Sea Drilling Project (DSDP) Leg 42B Site 380a (Hsü and Giovanoli, 1980) and seismic profiles (Gillet *et al.*, 2007) suggest a synchronous desiccation event in the Black Sea. However, the timing and nature of this apparent desiccation event is still poorly understood.

Here we present new palynological data (dinoflagellate cysts and pollen) from the DSDP Site 380a and the Zheleznyi Rog section (Taman Peninsula, Russia), providing in combination with a magnetostratigraphic framework the unique opportunity to date this apparent desiccation event in the Black Sea. Moreover, our records allow for an evaluation of the climatic and environmental evolution of the Eastern Paratethys during the latest Miocene.

Keywords: dinocysts, Messinian Salinity Crisis, Black Sea, connectivity

Insights from Isotopes Analysis on Biomarkers on Black Sea Hydrology at the End of Miocen

Iuliana Vasiliev^{1,2}, Gert-Jan Reichart^{1,3,4}, Arjen Grothe⁵, Johan Weijers¹, Jaap-Sinninghe Daamstee^{1,3}, Wout Krijgsman², Francesca Sangiorgi⁵, Yannick R. Mulders⁵, Linda van Roij¹

¹Organic Geochemistry, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD, Utrecht, The Netherlands

²Paleomagnetic Laboratory 'Fort Hoofddijk', Department of Earth Sciences, Utrecht University, Budapestlaan 17, 3584 CD, Utrecht, The Netherlands

³Royal Netherlands Institute of Sea Research, P.O. Box 59, 1790AB, Den Burh, Texel, The Netherlands

⁴Alfred Wegener Institute for Polar and Marine Research, Biogeosciences, Am Handelshafen 12 (E), D-27570 Bremerhaven, Germany

⁵Marine Biogeosciences, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD, Utrecht, The Netherlands

During the Miocene and Pliocene, the Paratethys represented a large restricted basin extending from central Europe to inner Asia. Because of its latitudinal location and restriction to marine realm, the Paratethys was very sensitive to fluctuations in the hydrological cycle. However, until now these changes have been assessed mainly through the reconstruction of relative salinity and sea level. Here we present compound specific analyses of hydrogen isotope ratios (δD), measured on both terrestrial and aquatic biomarkers to investigate changes in the hydrological budget of the Paratethys during the Mio-Pliocene transition. Organic geochemistry analyses of the Mio-Pliocene succession in DSPD42B core 380A from the Black Sea, drilled in the mid seventies, revealed both long chain *n*-alkanes with a distinct odd over even predominance originating from terrestrial plants, and abundant long-chain alkenones originating from haptophyte algae. The δD analyses of these compounds together constrain precipitation and sea surface salinity. The δD of the alkenones from DSPD42B core 380A of the Black Sea shows a δD enrichment of $\sim 70\text{‰}$ at the end of the Miocene. The amplitude of these changes implies a major shift in sea water δD , either caused by a doubling of salinity or a switch in source water δD . The hydrogen isotope data are sustained by changes in palynological assemblages. The shift in δD may coincide with the Messinian Salinity Crisis in the Mediterranean when kilometer thick evaporites were deposited. Although the Paratethys did not reach the saturation level required to generate gypsum precipitation, the recorded deuterium enrichment suggests a negative water budget in the region with evaporation exceeding rainfall and runoff.

Stratigraphic Re-Evaluation of the Desiccation of the Black Sea Basin and the Climate of the Khersionian Regional Substage

Madelaine Böhme¹

¹Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

Sediment cores from DSDP leg 42b (sites 380A and 381) drilled in 1975 had provide first evidence of a significant sea-level lowering in the southern Black Sea (Hsü 1978), which was later supported by seismic reflection lines indicating an erosional surface offshore the Bosphorus (Gillet *et al.* 2007).

Already at the beginning of scientific investigations (Hsü 1978, Hsü & Giovanoli 1979) it has been claimed that the stratigraphic age of this erosional disconformity correlates to the latest Miocene (late Messinian), and consequently the Black Sea suffered a desiccation event simultaneously with the Mediterranean Sea (*Black Sea Messinian desiccation* hypothesis of Hsü & Giovanoli 1979). However, biostratigraphic data from cores 380A and 381 have been largely misinterpreted (Kojumdieva 1979). In the presentation I review the microfossil biostratigraphy of both cores based on foraminifers, mysids (Gheorgian 1978), and diatoms (Jousé & Mukhina 1978) in the light of recent stratigraphic subdivisions in the Eastern Paratethys. I will argue (in accordance to Kojumdieva 1979) that the erosional surface correlating to lithologic unit IVd at site 380 is of latest Khersionian age, corresponding to 8.6 or 8.2 Ma (Vasilyev *et al.* 2011).

In the second part of the presentation I will propose a model for the *Black Sea Khersionian desiccation*, which is largely based on the model presented by Kojumdieva (1983) supplemented by new precipitation estimates from the Khersionian substage of the Euxinian/Black Sea Basin.

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New Insights on Messinian Events in the Caspian Sea

Christaan G. C. Van Baak¹, A. Grothe¹, E. Aliyeva², K. F. Kuiper³, M. Stoica⁴, W. Krijgsman,¹

¹Paleomagnetic Laboratory “Fort Hoofddijk”, Utrecht University, Budapestlaan 17, 3584 CD, Utrecht, The Netherlands, C.G.C.vanBaak@uu.nl

²Geological Institute of Azerbaijan (GIA), H. Javid Pr. 29A, AZ 1143, Baku, Azerbaijan

³Faculty of Earth and Life Sciences, Vrije Universiteit Amsterdam, De Boelelaan 1085, 1081 HV, Amsterdam, The Netherlands

⁴Department of Geology, Faculty of Geology and Geophysics, University of Bucharest, Balcescu Bd. 1, 010041, Bucharest, Romania

The latest Miocene-earliest Pliocene of the Caspian Sea is marked by a sudden regression, which led to the deposition of the so-called “Productive Series”, the main reservoir unit for the South Caspian Basin oil province. In the formed depression, three major rivers (Volga, Kura and Amu Darya) deposited enormous amounts of clastic material. The basin-fill consists in the basin center of up to 7 kilometers of fluvial and deltaic deposits and is subdivided in nine units defined by regional flooding surfaces and sequence boundaries.

It has been suggested that the formation of the deltaic successions of the Productive Series is related to the peak sea level drop of the Messinian Salinity Crisis at 5.5 Ma. Other suggestions advocate large-scale plate tectonic causes, with high uplift rates in the Greater Caucasus Range initiating around 5 Ma and the onset of subduction in the South Caspian Basin.

To further improve knowledge, two important unknowns need to be solved, a) the water-depth prior to the sea-level drop (and the resulting maximum amount of sea-level drop) and b) a high-resolution age-model to correlate events to the Messinian Salinity Crisis events in the Mediterranean Sea.

We use an integrated stratigraphic approach to better constrain the age of this major sea-level drop in the Caspian Sea and determine the causal relationship. Since the regression phase itself is not known from sections in the SCB we constrain the age from the under- and overlying deposits in Azerbaijan. In addition to this, we focus on the underlying deposits to better describe the paleoenvironmental conditions prior to the sea-level drop.

Keywords: Caspian Sea, Messinian, sea-level drop, integrated stratigraphy

SESSION 6

**MEDITERRANEAN-BLACK SEA CONNECTIONS DURING
QUATERNARY**

CONVENERS

M. NAMIK ÇAĞATAY AND VALENTINA YANKO-HOMBACH

Massive Meltwater Discharge into the Black Sea Euxine Lake

William B. F. Ryan¹, Anastasia Yanchilina¹, Elizabeth Matamoros², and Timothy Kenna¹

¹Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA, billr@ldeo.columbia.edu, nyanchil@ldeo.columbia.edu, tkenna@ldeo.columbia.edu

²Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA, USA, elizabethmatamoros@college.harvard.edu

An abrupt shift in the color and composition of the Black Sea lacustrine sediment occurs at the end of the last glacial period. The change is from gray mud rich in smectite and manganese to reddish-brown mud with illite, kaolinite, iron and titanium. The compositions indicate a switch in watershed from Anatolia to Eurasia, and timing corresponds to the collapse of the Eurasian lobe of the Fennoscandian Ice Sheet (Major *et al.*, 2002; Ryan *et al.*, 2003). The reddish-brown sediment is present in >30 cores in the western Black Sea. This mud occurs in beds of finely laminated silt and clay (Bahr *et al.*, 2006; Soulet *et al.*, 2011; 2013). Strontium isotopes reveal an excursion to more radiogenic values in each reddish-brown bed (Major *et al.*, 2006). The layers are thickest on the outer shelf and slope and thinner on the basin floor. Titanium enrichment is attributed to abundant ilmenite and rutile in placer deposits within the Dnieper watershed. The area covered by the muds exceeds 60,000 km² and is equivalent to >20% of the total seafloor. The estimated volume approaches 100 km³. Dilution to the density of sediment-laden river water requires >50,000 km³ of water delivered through the Dnieper watershed in repetitive flooding events. The strontium isotopic excursions also imply that a substantial portion of the Euxine Lake was replaced with meltwater derived from pro-glacial lakes as suggested by similarity between the neodymium isotope composition of the mud and the Ukrainian Shield (Soulet *et al.*, 2013). The reddish-brown mud appears at 18,000 cal years BP (Bahr *et al.*, 2006; Ryan, 2007, Soulet *et al.*, 2011). Wiggle-matching of isotopic variations in Black Sea cores to the Greenland GRIP ice core (Ryan, 2007) and Hula Cave stalagmites (Soulet *et al.*, 2011) indicates that the ¹⁴C reservoir age of the Euxine Lake water dropped from 1600 years in the glacial mud below the reddish-brown mud to 200 years at its top. This decrease requires a vast volume of melt water with its dissolved ¹⁴C equilibrated with the atmosphere. The eastern Black Sea floor does not contain the reddish-brown mud.

Keywords: Meltwater discharge, Strontium isotopes, Clay minerals, Reddish-brown mud, Dnieper, Black Sea

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Freshening of the Marmara Sea prior to its post-glacial reconnection to the Mediterranean

G. Aloisi¹, G. Delaygue², P. Henry³, K. Wallmann⁴, R. Sauvestre, G. Soulet³, C. Lecuyer⁵, E. Bard⁵

¹LOCEAN, Université Pierre et Marie Curie - 4, Place Jussieu, 75005 Paris, France. galod@locean-ipsl.upmc.fr

²LGGE, Université Joseph-Fourier – 54, rue Molière BP96, 38402 Saint-Martin-d'Hères, France. delaygue@lgge.obs.ujf-grenoble.fr

³CEREGE – Avenue Louis Philibert, BP80, 13545 Aix en Provence, France. henry@cerege.fr, bard@cerege.fr

⁴GEOMAR, Wischhofstrasse, 1-3, 24148, Kiel, Germany. kwallmann@geomar.de

⁵Laboratoire de Géologie de Lyon – 2, rue Raphaël Dubois, 69622, Villeurbanne, France. christophe.lecuyer@univ-lyon1.fr

During the last glaciation the Marmara Sea was separated from the Mediterranean Sea because global sea level was below the depth of the Dardanelles sill. Prior to the postglacial reconnection to the Mediterranean (~ 14.5 cal kyr BP), the surface waters of the Marmara Sea were brackish (Marmara 'Lake'). Recent evidence suggests that freshening could have happened via spill-out of deglacial meltwater through the Bosphorous. This hypothesis has not been tested against alternative possibilities (flushing by river run-off and/or precipitation and freshwater input by cold seepage). Furthermore, it is not known if freshening was extended to Marmara Lake bottom waters, a possibility that would imply a relatively higher amount of flushing. Here we use the dissolved Cl⁻ and δ¹⁸O composition of Marmara Sea sediment pore waters to estimate the Cl⁻-δ¹⁸O_{H2O} composition of Marmara Lake bottom waters and to evaluate possible freshening scenarios. Our results show that the bottom waters of the Marmara Lake were brackish and had a variable salinity (7 – 19 ‰). Their Cl⁻-δ¹⁸O_{H2O} composition shows that they are a mixture of Mediterranean waters and Danube-like waters implying that the freshening occurred via flushing with glacial meltwaters. Box modeling of the salt budget in the Marmara Sea shows that freshening via Black Sea spill-out may have occurred on very rapid time scales (< 250 yr). Moreover, it shows that also river run-off and precipitation have the potential to freshen the Marmara Sea, even if on longer time scales (< 2000 years). Thus, in periods when the Marmara Sea is separated from the Mediterranean and the Black Sea level is lower than the Bosphorous sill depth, freshening can still take place via flushing with river run-off and precipitation. The seepage of poorly saline fluids that is taking place along the Main Marmara Fault, however, provides negligible amounts of water and can be discarded as a source of freshening.

Keywords: Freshening of the Marmara Sea, Deglaciation, Pore water chemistry, Transport-reaction modeling

Isotopes Confirm the Mediterranean derivation of the Holocene transgression across the Black Sea shelf

Anastasia G. Yanchilina¹, William B.F. Ryan¹

¹Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York 10964, USA,
nyanchil@ldeo.columbia.edu, billr@ldeo.columbia.edu

Sediment cores located landward of a Black Sea paleo-shoreline observed at ~95 m were collected from the Bulgarian, Romanian, and Ukrainian shelves, in the vicinity of the Danube, Dniepr, and Sakarya deltas, and south of the Kerch Strait. Samples from this array of cores are investigated to determine whether the Holocene transgression in the Black Sea was accomplished by fresh or marine water. Individual specimens of fresh (i.e., *Dreissina rostriformis*), brackish (i.e., *Dreissina polymorpha*, *Monodacna caspia*, *Turricaspia caspia*), and marine (i.e., *Cardium edule* and *Mytilus galloprovincialis*) mollusks are picked from the transgressive shell hash deposit in each core and are analyzed for stable isotopes, ⁸⁷Sr/⁸⁶Sr, and radiocarbon. The analyses clearly show that all of the intact and articulated specimens have a contribution from Mediterranean water to varying degrees, whereas stained, abraded, and polished shells all belong to a glacial interval older than 22,000 ¹⁴C years when the basin was filled with water of light $\delta^{18}\text{O}$ (<-6‰) and less radiogenic ⁸⁷Sr/⁸⁶Sr (< 0.7087) composition.

In the shell hash, *Dreissina rostriformis* specimens have $\delta^{18}\text{O}$ of -2‰, a ⁸⁷Sr/⁸⁶Sr of 0.70895, and range from 8700 to 8200 ¹⁴C years. *Dreissina polymorpha* and *Monodacna caspia* specimens have an $\delta^{18}\text{O}$ signature between -1 and 0‰, ⁸⁷Sr/⁸⁶Sr increasing from 0.70905 to 0.70910, and measured ¹⁴C ages between 8200 to 7500 ¹⁴C years. The first appearance of *Cardium edule* give values of 0 to 0.5‰ for $\delta^{18}\text{O}$, 0.70915 for ⁸⁷Sr/⁸⁶Sr, and an age no older than 7200 ¹⁴C years indicating the attainment of a composition equivalent to the global ocean. The observation that the dated mollusk specimens span a range of radiocarbon ages exceeding 1,500 years indicates that they were sampling water with a radiocarbon reservoir age evolving during the transgression. The increase of the ⁸⁷Sr/⁸⁶Sr and $\delta^{18}\text{O}$ also support this interpretation. The decreasing ages and increasing isotopic ratios are indicative of mixing between a reservoir of prior lake-water and new salt-water introduced from the Mediterranean through the Dardanelles-Marmara-Bosporus gateway.

Using core transects extending landward from the lowstand shoreline and reaching -20m below modern sea level, we observe a progressive increase of Mediterranean-derived water as the lake surface rose during the transgression. Upon its entry over the Bosporous sill, the ¹⁴C composition of the Mediterranean reached equilibration with the atmosphere. As a consequence, Mediterranean water of zero ¹⁴C age enters a lake whose ¹⁴C age had greatly increased due to the input of dead carbon derived from river water and methane seeps with inability to be exported to the external ocean. The decrease of the reservoir age following the introduction of Mediterranean water is also observed in slope and basin cores where the measured ¹⁴C age decreases by more than 1,200 years in a span of a few centimeters at the boundary where the marine dinoflagellates are replaced by marine species.

Keywords: Sr-Isotopes, radiocarbon dates, reservoir age, Mediterranean water, marine transgression, Black Sea shelf

Forcing Factors on Caspian Sea Level Changes in the Late Pleistocene and Early Holocene: Contribution of Palynology

S. Leroy¹, A. Kakroodi^{2,3}, F. Chalié⁴, A. Tudryn⁵, S. Kroonenberg², H. Lahijani⁶, K. Arpe¹⁻⁷

¹Institute for the Environment, Brunel University, Kingston Lane, Uxbridge UB8 3PH (London), UK.
suzanne.leroy@brunel.ac.uk

²Department of Geotechnology, Delft University of Technology, The Netherlands.
S.B.Kroonenberg@tudelft.nl

³Department of Remote Sensing, Faculty of Geography, University of Tehran, Tehran, Iran.
kakroodi_a@yahoo.com

⁴Aix-Marseille Université, CEREGE, UMR 7330 CNRS, UM34, Europôle de l'Arbois, BP80, 13545 Aix-en-Provence cedex 04, France. chalie@cerge.fr

⁵Laboratoire IDES UMR CNRS/UPSud 8148, Université Paris Sud, Bât. 504, 91405 Orsay cedex, France.
alina.tudryn@u-psud.fr

⁶Iranian National Institute for Oceanography (INIO), No. 3 Etamadzadeh St, Fatemi Avenue, Tehran 1411813389, Iran, lahijani@inio.ac.ir

⁷Max Plank Institute for Meteorology, Hamburg, Germany. klaus.arpe@zmaw.de

Three Late Pleistocene and Holocene sequences from the south (a deep sea one and a coastal one) and the middle (a deep-sea one) basins of the Caspian Sea (CS) have been studied for their palynological contents in order to reconstruct past vegetation (hence climate) and past water salinities (hence water levels).

It has been established that the Younger Dryas is well marked by a regional aridification of the climate, but sea level remained high and was still part of the Khvalynian highstand.

The Mangyshlak lowstand in the Early Holocene is characterised by the most brackish waters of the whole south basin deep sequence and a hiatus in the coastal one. No specific vegetation changes are observed. It is suggested that this water level lowering was due to a starvation of water inflow to the CS in response to hydrographic modifications of the main rivers - the Volga River and the Amu Darya - under a climate that has remained still very dry at the beginning of the Holocene.

The development of trees was delayed in the deep-sea cores and occurred not until 8.3 cal. ka BP, but hardly any delay was noticed in the coastal one that is located at the foot of the Elburz Mountains which were a refugium during glacial times.

The freshest waters are inferred between 8.3 and ≤ 4.0 cal. ka BP, linked to a connection of the CS with the Amu Darya, which was fed by the melting of glaciers on the Pamir Mountains.

A sharp drop of water level is finally reconstructed at 3.9 cal. ka BP, before the start of the Neocaspian period.

In conclusion, at present the CS levels are mainly forced by the summer precipitation on the Volga drainage basin. In the past, the drainage basin of the Amu Darya (flowing from the Pamir Mountains) must be considered to understand the CS hydrological budgets.

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Keywords: Younger Dryas, Holocene, Caspian Sea, water level, climate, vegetation, hydrology

Holocene Salinity Changes in the Romanian Black Sea Shelf Mirrored by Microfaunal, Microfloral and Nannofloral Fluctuation

Mihaela C. Melinte-Dobrinescu¹, Gabriel Ion¹

¹National Institute of Marine Geology and Geoecology Bucharest, Romania, 23-25 Dimitrie Onciul, RO-024053 Bucharest, Romania, e-mails: melinte@geoecomar.ro; gion@geoecomar.ro

The calcareous nannofloras represents a major component of oceanic phytoplankton. Nowadays, coccoliths are adapted to very high salinity fluctuations. For instance, the present day extremely cosmopolitan species *Emiliania huxleyi* lives in the Black Sea, at salinity below 20‰, but also in the Azov Sea, at 11‰ (Bukry, 1974). The last invasion of *Emiliania huxleyi* in the Black Sea, followed by its proliferation, indicating the instauration of a Late Holocene marine regime, similar to the present days, was approximated at 3,000 a BP (Bukry, 1974). The aim of this paper is to present fluctuation in nannofloral abundance during Holocene times in the NW Black Sea, mainly focused on *Emiliania huxleyi* distribution pattern, for deciphering salinity changes.

The studied 18 cores are situated in the N part of the Romanian Black Sea shelf, at various water depths, between 20 and 80 m. Some of the cores are placed in front of the Danube Delta, i.e. the Sulina branch. The drilled interval varies between 15 and 40 cm. A very detailed sampling, at 5 cm of sediment interval, has been achieved for nannofloral qualitative and quantitative analysis. Additionally, microfaunas and microfloras, including radiolarians, dinoflagellates and diatoms, have been analysed.

Emiliania huxleyi is the dominant nannofloral taxon in the identified assemblages; in the samples from the water/sediment interface, monospecific associations of this species were recorded. *Braarudosphaera bigelowii*, the other *in situ* species that is present in the Holocene sediments of the NW Black Sea (Giunta *et al.*, 2007), was encountered down from 10-15 cm sediment, always with a low frequency. In front of the Danube Delta, *Emiliania huxleyi* and *Braarudosphaera bigelowii* are missing in the whole drilled interval, due to the low salinity. As some of the studied cores are situated in the former Danube palaeodelta (Panin and Jipa, 2002), we may assume that the uppermost Holocene sediments were deposited in a fresh-water setting. The frequency of *Emiliania huxleyi* and abundance of *Braarudosphaera bigelowii* increases with the distance from the shoreline and water depth. A negative correlation was observed between *Emiliania huxleyi* and *Braarudosphaera bigelowii*. The frequency of the latter species increases in all cores below 20 cm depth, probably related to an increased salinity above 17 ‰ value that allows this taxon to survive. The silicoflagellates are generally rare in the studied samples. The dominant taxonomic group is *Distephanus* genus; rarely, species of the genus *Dictyocha* are also present. The most numerous dinoflagellates observed belong to the genera *Alexandrium*, *Ceratium*, *Dinophysis*, *Gymnodinium*, *Gyrodinium*, *Goniaulax*, *Peridinium*, *Prorocentrum*, *Protoperidinium*, and *Scrippsiella*, taxa that generally tolerate high salinity fluctuations. Concerning the diatoms, centric taxa (*Coscinodiscophyceae*), as well as pennate ones without a raphe (*Fragilariophyceae*) and with a raphe (*Bacillariophyceae*) were observed. The centric diatoms are prevailing in a very shallower setting, i.e., in front of the Danube Delta mouth, while in deeper waters, below 60 m depths, the pinnate diatoms are dominant.

Keywords: Holocene, Nannofossil, Microfauna, Microfauna, salinity, Black Sea

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Fluctuations in Holocene Ostracod Assemblages from the NW Black Sea Shelf

Andrei Briceag¹, Gabriel Ion¹, Gheorghe Oaie¹, Marius Stoica²

¹National Institute of Marine Geology and Geo-ecology, 23-25 Dimitrie Onciul Street, RO-024053 Bucharest, Romania, e- andrei.briceag@geoecomar.ro, gion@geoecomar.ro, goaie@geoecomar.ro

²University of Bucharest, Faculty of Geology and Geophysics, Bucharest, Romania, marius.stoica@g.unibuc.ro

During Holocene times, the Black Sea basin suffered a major shift from a fresh water environment to a brackish one, which is mirrored in the biotical turnover. In the deeper parts of the Black Sea basin, i.e., below 200 m water depth, Ross and Degens (1974) recorded three stratigraphic units (from young to old): Unit 1 (the microlaminated coccolith ooze, deposited under marine conditions), Unit 2 (the sapropel mud, corresponding to a brackish, anoxic phase), and Unit 3 (the lacustrine lutite deposited during the freshwater or oligohaline stage).

This study is focused on the fluctuations in composition and abundance of the ostracod assemblages encountered in five cores collected from the Romanian Black Sea shelf area. In the deepest analysed core, situated at 200 m water depth, two lithological units, Unit 1 (Coccolith Mud) and Unit 3 (Lacustrine lutite), were identified. Unit 2 is missing, either because water depth was not enough to sapropel development or it was naturally eroded. In this core, based on the ostracod associations, we identified two distinct assemblages: (1) in Unit 3, a low salinity lacustrine fauna with a relatively high diversity and low abundance, mainly containing Candonidae and Loxoconchidae taxa, that tolerate a salinity between 3-8 ‰; (2) and in Unit 1, a brackish ostracod assemblage, with low diversity and abundance. This latter interval is characterised by the presence of polyhaline ostracods that are Mediterranean in origin, such as *Hiltermannicythere rubra*, *Cytheroma variabilis* and *Palmoconcha granulata* (Boomer *et al.*, 2010; Ivanova *et al.*, 2012). The ostracods of Unit 1 tolerate salinities between 17-21 ‰, being related to a sub-littoral environment. The occurrence of this type of microfaunal association is indicative for the Late Holocene reconnection of the Black Sea with the Mediterranean.

Our studies were also focused on cores placed on the Romanian Black Sea inner shelf, at water depths between 17 and 78 m. These cores penetrated the Shallow Unit (Giunta *et al.*, 2007, Oaie and Melinte-Dobrinescu, 2012) 0.4 to 2 m bsf (below sea-floor). In these cores, we identified two distinct ostracod assemblages: (1) in the shallower cores located at 17.80-28.15 m water depths, the ostracods are represented by a mixture of Caspian and Mediterranean origin species, all assemblages yielding a relatively low abundance; (2) in cores located at 66.80 m to 78 m water depths, the Mediterranean type ostracods prevailed, having very high abundances. Based on qualitative and quantitative ostracod analysis of the cores, their fluctuation pattern is interpreted in term of environmental changes.

Keywords: Ostracod assemblages, Holocene, environmental changes, Romanian shelf, Black Sea

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Pronounced Millennial Scale Variability in the Black Sea Lake during Marine Isotope Stage 3

Helge W. Arz¹, Lyudmila Shumilovskikh², Antje Wegwerth¹, Olaf Dellwig¹, Jérôme Kaiser¹, Norbert R. Nowaczyk³, Birgit Plessen³, Mathias Prange⁴, Guillemette Ménot⁵, Edouard Bard⁵, Hermann Behling², Dominik Fleitmann⁶

¹Leibniz-Institute for Baltic Sea Research (IOW), Marine Geology, Rostock, Germany; jerome.kaiser@io-warnemunde.de;

² University of Göttingen, Department of Palynology and Climate Dynamics, Göttingen, Germany;

³ Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Climate Dynamics and Landscape Evolution, Potsdam, Germany;

⁴ MARUM – Centre for Marine Environmental Sciences, University of Bremen, Bremen, Germany;

⁵CEREGE, Aix-Marseille University, Collège de France, CNRS, IRD, Aix en Provence, France;

⁶University of Reading, Scientific Archaeology Research Group, Reading, UK

Here we present new results based on a sediment core retrieved from the Archangelsky Ridge in the south-eastern Black Sea which provides a first view into a complete and undisturbed section of the last glacial period, the MIS 2-4. Different independent stratigraphic approaches (radiocarbon dating, tephrochronology, paleomagnetism, tuning to the NGRIP ice core) lead to a highly constrained age model for the last glacial period. The multi-proxy approach reveals strong and immediate responses of the glacial Black Sea freshwater/brackish lake to the abrupt Dansgaard-Oeschger (D-O) climate oscillations of the last glacial period.

Bulk $\delta^{18}\text{O}$ values along with total organic carbon and carbonate reproduce the $\delta^{18}\text{O}$ -oscillations of the NGRIP ice core and of the nearby Sofular cave indicating the presence of milder DO-interstadials in the Black Sea region. Indeed, TEX₈₆ derived mean annual lake surface temperature (LST) suggest 3-4°C temperature increase. Furthermore, pollen assemblages and soil-derived lipid (br-GDGTs) concentrations evidence relatively humid conditions. Therefore, the Black Sea Lake water level may have been relatively high during DO events. The Heinrich events (or stadials) are characterised by high amounts of ice rafted debris originating from winter coastal ice formation. Annual mean LST were similar to the glacial mean temperature of ca. 6°C and dry conditions prevailed as shown by the pollen assemblages and br-GDGTs concentrations. Ostracod stable oxygen isotopes record the precipitation/runoff signal of the drainage basin, but show a strongly smoothed signal characteristic to a shifting mixing-time in the Black Sea related to general changes in the hydrological balance of the basin throughout the glacial. Our results provide an important step forward in the comprehension of abrupt glacial climate oscillations in the land-locked Black Sea Lake system and in south-eastern Europe during MIS 3.

Keywords: Black Sea; MIS 3; $\delta^{18}\text{O}$; TEX₈₆; pollen

SESSION 8&9

**ADVANCES IN MEDITERRANEAN PALEOCEANOGRAPHY
&
RECENT DEVELOPMENTS IN MEDITERRANEAN
PALEOCLOMATOLOGY**

CONVENERS

**MARIO SPROVIERI AND LAURENCE VIDAL
FABRIZIO LIRER AND GONZALO JIMENEZ-MORENO**

Paleoclimatic and Paleoceanographic Changes during the Last 2K in the North Aegean Sea (northeastern Mediterranean)

A. Gogou¹, M.V. Triantaphyllou², I. Bouloubassi³, C.S. Parinos¹, M.D. Dimiza², K. Kouli², G. Rousakis¹, E. Kaberi¹, M. Athanasiou², V. Lykousis¹

¹Hellenic Centre for Marine Research, Institute of Oceanography, 190 13 Anavyssos, Greece

²Faculty of Geology and Geoenvironment, University of Athens, Panepistimioupolis, 157 84, Athens, Greece

³Laboratoire d'Océanographie et du Climat, Expérimentation et Approche Numérique, Université Pierre et Marie Curie, Paris Cedex 05, France

Studies of proxy records from several paleoclimate archives worldwide (including tree rings, lake sediments, marine cores and speleothems) have enabled identification of five climatic periods, in terms of temperature and precipitation variability, during the last two millennia. These have been characterized as: the Roman Humid Period (RHP), the Dark Ages (DA), the Medieval Climate Anomaly (MCA), the Little Ice Age (LIA) and a subsequent period of warming, known as the Instrumental Period (IP).

In this study, we focus on the Eastern Mediterranean paleoclimate variability during the last 2K, using marine archives (multicores) retrieved from the North Aegean Sea. Multicores have been sectioned at 0.5 cm intervals and dated by ²¹⁰Pb and radiocarbon. Multi-geochemical and micropaleontological proxy-indices have been used, namely the alkenone-based U₃₇^kSea Surface Temperature (SST), coccolithophores, benthic foraminifera and pollen assemblages and related indices, which allowed to delineate climatic and oceanographic changes and their impacts on marine ecosystems.

During the Dark Ages (500-900 AD), higher values of *Florisphaera profunda* and *Braarudosphaera bigelowii* support the establishment of low-salinity, stratified waters and the onset of nutrient-rich environment in the deep photic zone. The MCA interval (~900-1300 AD) is characterized by increased upper photic zone productivity, associated with an increase in the abundance of coccolithophore placoliths. SSTs fluctuate with an average value of 17 °C. Pollen records display the occurrence of open vegetation on-land, while a decreasing trend of available humidity (H-index) is recorded in-between ~1050-1400 AD. Within the Little Ice Age (~1300 -1850 AD), several cold intervals are recorded in the North Aegean Sea, which reflect the presence of minimal solar activity periods (e.g., Oort, Wolf, Sporer, Maunder and Dalton minima) and consequent reduced surface productivity, all featured by minima in upper water column stratification and alkenone U₃₇^kSSTs. A marked warm period (SST max=19.5 °C) within the LIA from ~1632 to 1655 AD, is characterized by drastic changes in productivity, with the increase of both coccolithophore productivity proxies *F. profunda* and *Helicosphaera* spp, expressed by higher organic carbon contents along with a marked increase of all marine biomarkers during this time, pointing to enhanced productivity and organic matter preservation. In support to this, dysoxic benthic foraminifera although in low abundances, indicate slowing down of deep water formation processes. On-land, although the LIA period is generally characterized by open vegetation, marked short intervals of increased humidity (H-index) and deciduous woodland expansion are recorded. Finally, the Instrumental Period (1850 AD – present) is characterized by gradually rising SSTs of about 1 °C/100 yrs.

Keywords: last 2K, North Aegean, SST, productivity, stratification

Carbonate Accumulation in Lake Iznik from Late Pleistocene to the Holocene

Patricia Angelika Roeser¹, Sven Oliver Franz¹, Thomas Litt¹

¹Steinmann Institute for Geology, Mineralogy and Palaeontology, University of Bonn, Nussallee 8, 53115 Bonn, Germany, patricia.roeser@uni-bonn.de

Lake Iznik, situated in the Marmara region, is warm monomictic, with an eutrophic to mesotrophic character, with circa 310 km² in size and an average water depth of 50 m. Despite an outflow to the Sea of Marmara, the lake was subject to closed moments and lower lake levels during historical times. The modern lake has a low salinity of about 0.5 to 1 mg/L, contributed by the ionic composition as follows: for the cations Na>Mg>K>Ca, and anions CO₃>>Cl>SO₄. The distinctive water chemistry and a pH~8.8 induce primary aragonite precipitation in the water column. Aragonite needles are well preserved in the sedimentary record. For the modern lake, historical sedimentation and during the Holocene, higher total inorganic carbon has been associated to drier periods (Franz *et al.*, 2006; Ülgen *et al.*, 2012; Viehberg *et al.*, 2012). Also for longer time frames the carbonate accumulation is expected to reflect environmental conditions, as confirmed by our investigations.

Undisturbed sediments were recovered in 2009 from a sedimentary ridge in the center of the lake. Correlation to the Holocene record generates a cored composite depth of 18 meters. First investigations on this profile, based on magnetic susceptibility as reflection of clastic input, and Ca/Ti as a record for calcium carbonate accumulation, extended the interpretation of Ülgen *et al.* (2012), allowing a first insight into the lakes' history since the late Pleistocene (Roeser *et al.*, 2012). An updated age model adding novel radiocarbon determinations gives the sedimentary profile an age of 31 ka cal BP. New results on mineralogy and geochemistry, associated to variation in grain size composition, reveal a dynamic lake evolution. Changes in hydrochemistry are related to inversions in the predominant accumulating carbonate phase from aragonite to calcite. Such changes take place rapidly at 27 ka cal BP and 18 ka cal BP and are maintained in between this period. During the Pleistocene – Holocene transition a gradual increase in aragonite concentrations associated to punctual gypsum occurrences is related to coarser grain size deposition, culminating at the early Holocene. At 8.5 ka cal BP dilution takes place, as aragonite concentrations retreat. Furthermore, observed short term oscillations are related to increased aragonite accumulations, which can be correlated to Dansgaard/Oeschger events 3 and 4. Summarizing, together with geochemical and mineralogical variations, the carbonate accumulation within Lake Iznik is outlining long term environmental trends as well as short term climatic triggers that have affected the Marmara Region.

Keywords: calcite, aragonite, Dansgaard/Oeschger events

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Late Quaternary Climate Changes As Reconstructed from Terrestrial Carbonates

Adele Bertini¹, Marianna Ricci¹

¹Dipartimento di Scienze della Terra, Università di Firenze - via G. La Pira 4, 50121 Firenze (Italy),
adele.bertini@unifi.it; marianna.ricci@unifi.it

Palynological studies on both marine and continental successions of the peri-Mediterranean area have demonstrated that fossil pollen grains are a useful tool in the reconstruction of palaeoenvironmental changes occurred during the Neogene and Quaternary. Numerous analyses, especially, on organic-rich silty-clays strata from lacustrine sites, provided rich floristic and vegetational assemblages, whereas, as testified by the scanty literature, very few works deal with pollen in carbonates. However, travertines s.l. are potentially very useful deposits for the study of palaeoenvironment and palaeoclimate because of their strong sensitiveness to different environmental changes (e.g., external and deposition temperature, humidity and CO₂ partial pressure). Drawbacks concerning the use of travertines for palaeofloristic and palaeovegetational reconstructions by palynology, are mainly related to the generally accepted thought that they are not optimal for pollen preservation. The palynological analysis carried out on two late Quaternary travertine s.l. deposits (43°N 11°E) of central Italy, at Serre di Rapolano and Bagnoli, demonstrates that this is anything but a “mission impossible” (Ricci, 2011; Bertini *et al.*, submitted). 52526 pollen grains belonging to 118 pollen taxa, from local to extra-regional sources, have been counted by the analysis of 200 samples from different travertine and calcareous tufa lithofacies. The study was developed in two phases with the aim of improving: 1. our knowledge of the factors that affected the accumulation of the pollen grains, from when they dispersed to when they were recovered in thermal (i.e. travertine) and ambient temperature (i.e. calcareous tufa) terrestrial carbonates; 2. the reconstruction of the palaeoenvironmental and palaeoclimatic conditions during the time interval spanning the last 130 thousand years (including the Eemian).

The main lines of evidence for these two steps are:

Despite the significant number of barren samples and the generally low pollen concentrations, pollen is present, well preserved, in the different sedimentary carbonate facies. Such occurrence excludes that an alkaline environment is per se responsible for the pollen destruction or corrosion phenomena. In slope depositional areas the energy of the water is a further parameter for the low accumulation rate of pollen, diverted towards more distal flat areas. The median pollen concentration values show a progressive increase passing from travertine to calcareous tufa. Among the travertine, the higher concentrations are evident in low thermal depressions whereas the lowest concentrations in high thermal slope. Among the terrestrial carbonates apparently more significant for palaeoclimatic reconstruction by pollen are hierarchically calcareous tufa, low thermal travertine and finally high thermal travertine. Lithofacies and depositional systems are apparently independent (especially in travertine) by palaeoclimatic changes as attested by pollen assemblages. Different pollen inputs and components (e.g. local to extra-regional, water-borne and air-borne) are well represented in the different lithofacies; changes in pollen assemblages are therefore coherent to both palaeoenvironmental and palaeoclimatic changes. The careful tracking of fluctuations of the pollen curves with those of the stable isotope curves from the same samples as well as their comparison with independent palaeoclimatic records from key sections of the Mediterranean area elucidate upon the significance of terrestrial carbonate deposition in the context of climate changes.

Keywords: terrestrial carbonates, pollen analysis, palaeoenvironmental reconstructions, late Quaternary, central Italy

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Late Quaternary through Recent Paleoenvironmental Change in the Sierra Nevada, Southern Spain

R. Scott Anderson¹ Gonzalo Jiménez-Moreno² Antonio García-Alix³ Francisco J. Jiménez Espejo⁴ Jaime L. Toney⁵ Jose S. Carrión⁶ Carmen Pérez-Martínez⁷ María Dolores Hernández-Corbalán²

¹School of Earth Sciences & Environmental Sustainability, Northern Arizona University, Flagstaff, AZ, USA

²Departamento de Estratigrafía y Paleontología, Universidad de Granada, Granada, Spain

³Instituto Andaluz de Ciencias de la Tierra, CISC-UGR, Granada, Spain

⁴Department of Earth and Planetary Sciences, Nagoya University, Nagoya, Japan

⁵Geographical & Earth Sciences, University of Glasgow, Glasgow, UK

⁶Departamento de Biología Vegetal, Universidad de Murcia, Spain

⁷Departamento de Ecología, Universidad de Granada, Granada, Spain

The Sierra Nevada of southern Spain is a region with a rich biological and cultural heritage. Recent paleoenvironmental research in the range includes sedimentary records from several high elevation lakes and bogs (locally named borreguiles), spanning an elevational range of ca. 2500 m to over 3000 m elevation. Common research themes have centered around (1) the impact of climate change and human land use on the fragile alpine ecosystems, as well as (2) the record of more regional human impact on lower elevation landscapes surrounding the mountain range. The longest (~ 11,500-yr) record studied comes from the 3020 m asl Laguna de Río Seco^{8,9}, where paleobotanical, isotope geochemical and organic biomarker data suggest wet conditions prior to ~ 7.8 ka, and much drier climates after ~ 5.7 ka. These changes are confirmed from the 2945 m asl Borreguiles de la Virgen site^{10,11}, where an initial lake transitioned to the current bog between ~ 6.9 and 4.6 ka. Although each site documents sensitivity to long-term climate trends, the lower elevation bog and lake sites record additional centennial-scale climate change. Progressive aridification was punctuated by significant drought intervals throughout middle and early late Holocene at the Borreguiles de la Virgen site. These droughts were not noted in the higher elevation lake site record. Lake levels at the lowest site in the transect – 2497 m asl Laguna de la Mula¹² – increased during widespread Roman Humid Period, followed by more aridification.

Additional signals of human activity within the region and locally within the range are evident in the cores. For example, increases in lead concentrations within the Laguna de Río Seco record occur during the Early Bronze Age, ~ 3.9 ka⁹. Regionally, increases in charcoal deposition ~ 4.0 ka may result from these activities, rising population levels with changing land-use, or climatic factors. Increasing pollen of *Olea* after ~ 3.0 ka may signify the beginnings of olive cultivation at lowland sites, although major expansion of olive orchards are registered by high percentages only during the 20th century. Though the local occurrence of grazing animals – shown by concentrations of the dung fungus, *Sporormiella* – are periodic through the Holocene at Borreguiles de la Virgen, consistently abundant *Sporormiella* after ~ 3.0 ka suggest intensive pasturing around Laguna de Río Seco. Though pine (*Pinus*) was dominant during the early Holocene, it largely disappeared in the pollen record at about the same time, suggesting widespread tree-cutting may have occurred in the range. Only with the establishment of pine (*Pinus*) plantations during 20th century is does pine return to importance there.

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Different Ecosystems in the Late Neogene of Anatolia (Turkey)

**Lars W. van den Hoek Ostende¹, Lysanne van Bennekom¹, Alison Murray², James Gardner³,
Flemming Diepenveen¹, M. Cihat Alçiçek⁴**

¹Naturalis Biodiversity Centre, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands,
Lars.vandenHoekOstende@Naturalis.nl

²University of Alberta, Department of Biological Sciences, Edmonton, AB T6G 2E9, Canada,
alison.murray@ualberta.ca

³Royal Tyrrell Museum of Palaeontology, Box 7500, Drumheller, Alberta, Canada,
james.gardner@gov.ab.ca

⁴Dept. of Geology Pamukkale Univ. 20070 Denizli, Turkey, alcicek@pau.edu.tr

The presence of both dry and wet ecosystems in the Late Neogene of Anatolia was already suggested by Ünay & De Bruijn (1998), on the basis of a series of faunules. Two localities in the Çameli Basin that were studied in full by master students in Leiden now clearly confirm that indeed wet environments existed next to the typical steppe localities.

The locality of Bıçakçı yielded an extremely rich fauna of micromammals dominated by hamsters (*Cricetulus*, *Mesocricetus* and *Cricetus*) and voles. Overall, the fauna is typical for a steppe environment. In contrast the small assemblage of Ericek is dominated by murids and shrews, *Dolomys* being the only arvicolid. Whereas the locality is relatively poor in mammals, it yielded a rich assemblage of pharyngeal teeth of cyprinid fishes, including members of the genera *Barbus*, *Carassius*, *Chondrostoma* and *Tinca*. A remarkable find is a maxilla from a palaeobatrachid frog, the second find from Anatolia. The fish and frog remains of Ericek indicate the continuous presence of water, and the locality presumably represents marginal lake deposits.

Bıçakçı and Ericek differ considerably in age. The first is placed in the Early Pleistocene (MN 17), the latter is clearly a Pliocene locality (MN 15). However, other Pliocene localities such as Maritsa (De Bruijn *et al.* 1970) and Çalta (Sen 1977) show that a steppe ecosystem was already in place during the Pliocene. Therefore, Ericek represents a surprisingly wet ecosystem at a time that steppes were already formed in Anatolia. The future study of additional localities in the Çameli Basin and surrounding areas will give a more detailed picture on how the Late Neogene ecosystems of Anatolia evolved.

Sedimentological, Microscopic and Stable Isotope Constraints from Spring-fed Pınarbaşı Tufas (E Kayseri) Related to Late Pliocene Climate in Central Anatolia

Faruk Ocakoğlu¹, İsmail Ö. Yılmaz²

¹Eskişehir Osmangazi University, Department of Geological Engineering, Eskişehir, Turkey

²Middle East Technical University, Department of Geological Engineering, Ankara, Turkey

100 km-long, NE-running Pınarbaşı basin (Central Anatolia, E Kayseri) comprises sporadic, km-scale tufa deposits at its uppermost stratigraphic levels in vicinity of basin margin. Tufa deposits are covered by well-dated, extensive Valibaba tepe ignimbrite (2.52 Ma) following several meters thick fluvial sediments. Sedimentological, stable isotopic, microscopic and magnetic susceptibility (MS) data from tufa outcrops in vicinity of Samağır village at the north of basin provide important constraints for the Late Pliocene terrestrial climate of Central Anatolia.

The investigated 25 m thick carbonate succession which is interpreted as spring-fed tufa in a basin margin setting, consists of two architectural packages of laterally hundreds of meters persistence. First package is formed from phytoherm framestone, phytoherm boundstone and laterally and vertically interfingering minor coarse phytoclastic/intraclastic tufa. Phytoherm framestone facies consists of highly porous *in situ* carbonate-encrusted reeds and spherical aquatic plants. Phytoherm boundstone facies is whitish, laminated or massive and quite dense. Second building package consists of 80-100 cm thick yellow fine-grained phytoclastic tufa. It contains ellipsoidal oncoids and horizontal tubular remains, as well as cross bedding and reactivation surfaces all explaining an agitated environment. These two architectural elements abruptly overly each other, forming couplets. Phytoherm boundstones display bacterial dendrites and filaments under microscope and in SEM studies. In between the filaments, silt/sand sized grains of similar texture and origin are observed. In phytoherm framestone facies, reeds and other aquatic elements are found within a pelletic and micritic matrix. Phytoclastic/intraclastic facies comprises abundant carbonate clasts as well as ostracod and Charophyte fragments in a pelletic and micritic matrix.

Through the section, there is strong positive correlation between ¹⁸O and ¹³C stable isotopes. Based on changes in ¹⁸O concentrations, the section is divided into 3 larger cycles each with about 10 m thick. Magnitude of the cycles is about 2-2.5 ‰. The lowermost larger cycle comprises nested smaller cycles of about 2 m thick whose magnitude in turn is in the order of 1-2 ‰. More negative ¹⁸O concentrations generally match with detrital tufa facies. Additionally, MS measurements carried out at laboratory using highly sensitive MS2B sensor display generally positive correlation with ¹³C concentrations. SEM investigations show that higher MS-value intervals have more probably airborne fine grains captured within algal/bacterial filaments.

The findings show that the hierarchical cycles would correspond to Milankovitch bands of 100 ka and 21 ka respectively. The phytohermal facies that constitutes the bulk of the section is formed in hot periods while the phytoclastic/intraclastic intervals are developed in cool/dry periods when degradation/reworking of existing tufa facies dominate. Temperature difference estimates (4-10 °C) within cycles deduced from the magnitude of ¹⁸O curve implies that the glacial/deglacial cycles had been already under operation before late Pliocene in Central Anatolia.

Continental Climate and Vegetation Gradients on Both Sides of the North atlantic before and After the Closure of the Central American Seaway – A Comparison Based on New Miocene and Pliocene Proxy Data

T. Utescher^{1,2,3}, M. Böhme⁴, T. Hickler^{1,2}, Mosbrugger^{1,2}, F. Portmann^{1,2}

¹Senckenberg Research Institute and Natural History Museum, Senckenberganlage 25, 60325 Frankfurt/Main, Germany

²Biodiversity and Climate Research Centre (LOEWE BiK-F), Senckenberganlage 25, 60325 Frankfurt/Main, Germany

³Steinmann Institute, University of Bonn, Nußallee 8, 53115 Bonn, Germany

⁴Senckenberg Center for Human Evolution and Paleoecology (HEP), Institute for Geoscience, University of Tübingen, Sigwartstr. 10, 72076 Tübingen

At present, the Gulf Stream is responsible for a considerable warming of the middle and higher latitudes of Western Eurasia. As a result, a more thermophilous vegetation exists at present under the maritime climate of Western and Northwest Europe when compared to the vegetation growing in North America at the same latitude. Actually, discussions on the Gulf Stream evolution in the Past, and its intensity, are very active because past conditions can be used to assess anticipated changes. A slowing-down or even complete cessation of the thermohaline circulation in the North Atlantic would have severe consequences for the regional climate and vegetation of Western Eurasia. The evolution of the North Atlantic circulation pattern and Gulf Stream intensity are traditionally referred to the tectonic history of the Central American Seaway (CAS) and its final closure. The timing of this event is recently revisited and controversially debated, mainly based on studies on biotic interchange between both Americas.

Currently, we study Cenozoic palaeobotanical records from two transects in Western Eurasia and North America. We use quantitative techniques such as the Coexistence Approach, CLAMP and an approach of vegetation reconstruction employing diversity of plant functional types in order to obtain data sets for Past time slices. At the same time modelling studies are performed differing in boundary conditions such as prescribed Gulf Stream intensity in order to test the effects and to find the best fit with the proxy data. First results obtained for a Middle and a Late Miocene time slice pointed to milder conditions in Western Eurasia, and to a more thermophilous aspect of the arboreal component of the vegetation, even at times where a reduced intensity of the Gulf Stream activity is assumed. Now, a Pliocene data set, clearly representing the conditions of a closed CAS, can be presented and compared to the results obtained for the Miocene time slices.

[grant: DFG MI 926 / 8-1]

Vegetation Belts in Peri-mediterranean Massifs during the Late Miocene and Early Pliocene

**Jean-Pierre Suc¹, Séverine Fauquette², Speranta-Maria Popescu³, Gonzalo Jiménez-Moreno⁴,
Naima Bachiri Taoufiq⁵, Demet Biltekin⁶**

¹Université P. & M. Curie, ISTEP, CNRS, UMR 7193, 75005 Paris, France, jeanpierre.suc@gmail.com

²Institut des Sciences de l'Evolution de Montpellier, UMR CNRS 5554, case courrier 061, Université de Montpellier 2, Place Eugène Bataillon,
34 095 Montpellier cedex 05, France, severine.fauquette@univ-montp2.fr

³GeoBioStratData.Consulting, 385 route du Mas Rillier, 69140 Rillieux la Pape, France,
speranta.popescu@gmail.com

⁴Departamento de Estratigrafía y Paleontología, Universidad de Granada, Fuente Nueva S/N, 18002 Granada, Spain, gonzaloj@ugr.es

⁵University Hassan II-Mohammedia, Faculty of Sciences Ben M'Sik, BP 7955 Sidi Othmane, Casablanca, Morocco, bachinai@yahoo.fr

⁶Istanbul Technical University, Faculty of Mines, Eastern Mediterranean Centre for Oceanography and Limnology (EMCOL), Ayazaga Campus, 34469 Istanbul, Turkey, biltekin@itu.edu.tr

Estimation of palaeoaltitudes is essential for past climate modeling. The Mediterranean region is surrounded by important massifs which significantly uplifted during the Late Miocene and Early Pliocene. The Mediterranean and peripheral sedimentary basins are rich in pollen records, which, if they are properly processed from the botanical viewpoint, reliably inform on vegetation belts of their respective nearby massif.

These pollen records show that different coniferous taxa populated the highest altitudinal forest belt (Cathaya, Cedrus and Tsuga, Abies and Picea), according to temperature evolution along the time-interval 14 - 4 Ma and to latitude of the massifs.

The 'Climatic Amplitude Method' has been performed on the pollen data for quantifying climatic parameters (Fauquette *et al.*, 1998). At the same time, and because this method discriminates thermophilous plants from others, which may inhabit altitudinal places, it has also been applied for palaeoaltitude reconstructions (Fauquette *et al.*, 1999; Jiménez-Moreno *et al.*, 2008; Melinte-Dobrinescu *et al.*, 2009; Suc and Fauquette, 2012; Fauquette and Combourieu-Nebout, 2013).

An overview of altitudinal organization of vegetation is presented for the peri-Mediterranean massifs from the Serravallian to Zanclean with palaeoaltitude estimates.

Keywords: Pollen records, Vegetation belts, Transfer Function, Climate reconstructions, Palaeoaltitude

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Implications for Mediterranean Isolation and Climate via Sea Surface Temperature Reconstructions through the Miocene – Pliocene

Alexandrina Tzanova¹, Timothy D. Herbert¹, Laura Peterson²

¹Brown University, 324 Brook Street Box 1846, Providence, RI 02912, USA,
Alexandrina_Tzanova@brown.edu

²Luther College, 700 College Drive, Decorah, IA 52101, USA

Newly reconstructed sea surface temperatures spanning 13 Ma to 4 Ma from the Mediterranean have the ability to shed light on the climate of the Mediterranean preceding two important events in the region – the Messinian Salinity Crisis in the Late Miocene and Northern Hemisphere Glaciation in the Pliocene. The thick salt layers resulting from the isolation of the Mediterranean have so far been an obstacle to conventional drilling in obtaining a high-resolution, continuous record of the basin's conditions prior to ~6 Ma. While planktonic $d^{18}O$ records from uplifted marine sections do exist, they are hampered by the lack of independent temperature reconstruction in order to detangle the competing influence of both temperature and salinity on such data. The temperature record presented here is a ~20 kyr resolution dataset compiled from the Monte dei Corvi and Rosello land sections for the Late Miocene – Pliocene and in the Pliocene has been supplemented with data from ODP Site 969. Using alkenone paleothermometry we show that the Late Miocene Mediterranean Sea was notably warmer than present with SSTs equivalent and even higher than the warmest parts of the modern ocean. Between ~ 12.9 Ma to ~8.1 Ma temperatures hovered close to 28°C and possibly even higher. At ~8.1 Ma, concurrent with notable changes in the vegetation pattern of the area as well as globally, sea surface temperatures show a distinct cooling trend punctuated with a cold episode at ~7 Ma which coincides with the first appearance of desert conditions in the Sahara. The cooling trend continues up to the Messinian Salinity Crisis at which point marine sedimentation was interrupted at the sites, and then resumes after the basin was re-flooded at 5.3 Ma. Approaching ~4 Ma we observe sea surface temperatures to show ~2°C amplitude oscillations around stable conditions of ~5°C warmer than modern.

The reconstructed sea surface temperatures allow to reconstruct the paleosalinity of the Mediterranean approaching and following the Messinian Salinity Crisis. While uncorrected the published $d^{18}O$ planktonic records show a sharp enrichment at ~7.5 Ma, once corrected for temperature the residual salinity component shows a much more gradual change. Therefore, we suggest that the isolation of the basin was a gradual restriction. Following the re-establishment of a Mediterranean – Atlantic connection the salinity remains relatively stable with the usual for the Mediterranean sapropel pattern of warm temperatures accompanied with low salinity and high productivity.

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Late Miocene Vegetation and Climate Dynamics in the Sandanski Basin, Southwest Bulgaria

Dimiter Ivanov¹

¹Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., bl. 23; 1113 Sofia, Bulgaria, dimiter@bio.bas.bg

Lake and lake-and-marshy sediments are widely spread on the territory of South Bulgaria and often contain various plant fossils: carpoids, leaf imprints, cuticles, and spores and pollen. In the last years Neogene sediments from the Sandanski Basin have been palynologically studied and revealed new floristic data. The present report offers a quantitative palaeoclimate analysis of the fossil pollen flora. The analyzed palynomorphs originate from tree cores drilled in the southern part of the basin. The succession is represented by irregularly layered whitish, yellowish and grayish-green conglomerates, sandstones, siltstones, clays, and fine-grained coal interbeds. Based on finds of mammalian fauna the age of the sediments is estimated as Turolian (zones MN 11-12).

Palaeoecological analysis of pollen flora leads to inferences about the character of fossil vegetation. Swamp forests of Taxodiaceae contributed by *Alnus*, *Liquidambar*, *Myrica*, *Nyssa*, and *Itea* were widest distributed on permanently or temporary flooded terrains along the basin. Major role in the composition of mesophytic forest paleocoenoses played species of *Quercus*, *Castanea*, *Ulmus*, *Pterocarya*, and *Carya*, together with *Castanopsis*, *Juglans*, *Engelhardia*, and *Araliaceae*. These grew on the hilly and mountainous terrains situated relatively distant from the basin, forming an irregularly developed mesophytic forest belt. Some xerophytes (*Celtis*, *Pistacia*, *Berberis* and *Rubus*) evidenced existence of xeromesophilous shrub communities on the stony slopes and on drier habitats. The presence of *Chenopodiaceae*, *Artemisia*, *Centaurea*, *Asteroideae*, *Chichorioideae*, *Caryophyllaceae*, *Poaceae* and other herbs indicates distribution of herbaceous communities in the open riverine valleys and low-hill territories. Finds of Hipparion fauna related to open spaces and steppe (or savannah) communities corroborate this assumption.

The coexistence approach was applied to reconstruct palaeoclimate based on pollen record. Four climatic parameters are considered and discussed, namely mean annual temperature (MAT), mean temperature of the coldest month (MTCM), mean temperature of the warmest month (MTWM), and mean annual precipitation (MAP). The results show dynamic climatic conditions during the sedimentation process. Intervals for MAT are mainly in the range 15.6-18.4°C, winter temperatures in most cases are 5 to 9.4°C. Most common intervals for summer temperatures are 25.6-27.5°C (up to 28.1°C). The annual amount of precipitation is quite variable. Highest intervals are in the range 1187-1322 mm, while the lowest are 512-741 mm (in some cases even lower). Lower levels of rainfall probably reflect dry climate with seasonal distribution of rainfall. These values indicate that the climate was about 3-4 degrees warmer than today, and precipitation reached values exceeding more than twice contemporary level. Dynamics of climate variables in the sedimentary sequences revealed changes in climate conditions which are likely cyclic in nature, but fragmentarily presented.

Acknowledgements:

The author is thankful to the project BG051PO001/3.3.-05.001 "Science and Business", Operational Program "Human Resources Development" at the European Social Fund for financial support.

Did Global Sea Level Drop Triggered the onset of the Messinian Salinity Crisis?

Gonzalo Jiménez-Moreno¹, José N. Pérez-Asensio¹, Juan C. Larrasoña², Julio Aguirre¹, Jorge Civis³, María R. Rivas-Carballo³, María F. Valle-Hernández³, José A. González-Delgado³

¹Departamento de Estratigrafía y Paleontología, Facultad de Ciencias, Universidad de Granada. Avenida Fuente Nueva s/n, Granada 18002, Spain. gonzaloj@ugr.es; jnoel@ugr.es; jaguirre@ugr.es

²Instituto Geológico y Minero de España, Unidad de Zaragoza.C/ Manuel Lasala 44, 9B, Zaragoza 50006, Spain. jc.larra@igme.es

³Departamento de Geología, Universidad de Salamanca, Plaza de la Merced s/n, Salamanca 37008, Spain. civis@usal.es; crivas@usal.es; maruja@usal.es; angel@usal.es

The Messinian salinity crisis (late Miocene) is one of the most intriguing paleoceanographic events in the recent geological history of the Mediterranean Sea, defining a time when it partly or nearly completely dried out. Nevertheless, the relative roles of tectonic processes and sea-level changes, as triggers for restriction and isolation of the Mediterranean Sea from the open ocean, are still under debate. In this study, we present a detailed pollen, dinoflagellate cyst (dinocyst), benthic foraminiferal paleodepth, benthic and planktonic foraminiferal $\delta^{18}O$ stable isotopes and magnetic susceptibility analysis of a sequence of late Neogene (between ca. 7.3 and 5.2 Ma) marine sediments from the Montemayor-1 core (lower Guadalquivir Basin, SW Spain), which provides a continuous record of paleoenvironmental variations in the Atlantic side of the Betic corridors during the late Miocene. Our results show that significant paired vegetation and sea-level changes occurred during the Messinian, likely triggered by orbital-scale climate change. Important cooling events and corresponding glacio-eustatic sea-level drops are observed in this study at ca. 5.95 and 5.75 Ma, coinciding with the timing and duration of oxygen isotopic events TG32 and TG22–20 recorded in marine sediments worldwide. It is generally accepted that the onset of the Messinian salinity crisis began at ca. 5.96 ± 0.02 Ma. Therefore, this study suggests that the restriction of the Mediterranean could have been triggered, at least in part, by a strong glacio-eustatic sea-level drop linked to a climate cooling event occurring at the time of initiation of the Messinian salinity crisis.

The “Brecciated Seep Limestones” Related to the Messinian Drawdown of the Mediterranean Sea and Possible Link to A the Late Messinian Climate Shift

A. Iadanza¹, P. Cipollari^{1,2}, D. Cosentino^{1,2}, G. Sampalmieri, M. Mola²

¹Dipartimento di Scienze, Università degli Studi Roma Tre, Largo S. Leonardo Murialdo, 1, I-00146 Roma, Italy, annalisa.iadanza@uniroma3.it

²Istituto di Geologia Ambientale e Geoingegneria, CNR

The anaerobic oxidation of methane at seeps is a major sink for this greenhouse gas and is associated with the precipitation of carbonates. The geological record of seep carbonates thus provides insights into their potential role in the modeling of global carbon budgets and interpretation of past climates. Authigenic carbonate precipitation, accompanied by brecciation processes, took place during the Messinian Salinity Crisis (MSC) of the Mediterranean Sea. At that time, following the deposition of the Lower Evaporites, the isolation of the Mediterranean Sea from the Atlantic Ocean caused a major drop in Mediterranean sea level, which was responsible for the development of the Messinian Erosional Surface (MES) at the Mediterranean Basin margins. Above the MES, the postevaporitic phase is recorded first by Resedimented Lower Evaporites and brecciated carbonates, and then by Upper Evaporites and Lago-Mare facies.

In our study, we investigated the Messinian carbonate breccias by means of sedimentological, textural, and geochemical analyses, in correspondence with some key-sections that are located in central and southern Italy (Maiella foreland area, Molise basin, Rossano and Crotona forearc basins, and Caltanissetta thrust-top basin).

The Messinian carbonate breccias are bedding-retentive and occur at different stratigraphic levels. They are constituted by microbial mudstones and consist of patchy concretions and mud-grade carbonate mounds (massive or thick-stratified buildups). Their jigsaw texture (autobreccias), together with their scale- and lithology-independent fabric, point to *in situ* brecciation processes.

In correspondence with and below the brecciated bodies, we identified cemented chimneys, micropipes, and feeder channels with flow-mobilized sediments, representing fluid migration pathways that cross-cut the Lower Evaporites and the MES.

The geochemical signature of the carbonates is depleted in $\delta^{13}\text{C}$ (down to -43.7‰ PDB), pointing to the occurrence of hydrocarbon-charged fluids involved in microbially-triggered authigenesis. In detail the carbon isotopic composition is more complex and might represent the composite result of (1) originally mixed C sources involved in authigenesis, (2) variable fluid-rock interaction, (3) site-specific fluid composition (HC-charged vs saline), and (4) biodegradation of crude oil.

The Messinian autobreccias, associated with fluid migration pathways, are therefore constituted by authigenic hydrocarbon-derived limestones that depict a seep Messinian environment where brecciation was fluid-induced. Since the seeping features and the associated plumbing systems are sealed by deposits pertaining to the initial phase of the early postevaporitic phase of the MSC, the age of the fluid migration event is constrained to this phase, immediately following the development of the MES. The major drawdown of the Mediterranean represented an instantaneous unloading of water of at least 1.5 km that may have caused high depressurization of subsurface sediments and most likely favored a vigorous migration of overpressured fluids from below. Beside our study, evidence for gas venting from the Mediterranean seafloor as a consequence of the Messinian drawdown also comes from both the eastern (Levantine Basin) and central Mediterranean (Tertiary Piedmont Basin, SE Spain and Northern Morocco). This large scale methane release event, possibly even associated with a wholesale dissociation of gas hydrates, point to a regional extent of fluid discharge.

It has been suggested that the drawdown of the Mediterranean happened in correspondence with the TG12 glacial peak (~ 5.55 Ma). Thus a sudden release of methane towards the seafloor and eventually into the atmosphere at around 5.55 Ma could have played a role in the intra-MSC climate shift (arid vs. humid conditions).

Keywords: intra-MSC climate shift; seep limestones; Messinian drawdown

Density Banding in Corals: Barcodes of Past and Current Climate Change

T. C. Brachert¹, M. Reuter², S. Krüger¹, A. Böcker¹, H. Lohmann¹, R. Mertz-Kraus³, C. Fassoulas⁴

¹Institut für Geophysik und Geologie, Universität Leipzig, Talstrasse 35, 04103 Leipzig, Germany.
brachert@uni-leipzig.de

²Institut für Erdwissenschaften, Universität Graz, Heinrichstr. 26, 8010 Graz, Austria. markus.reuter@uni-graz.at

³Institut für Geowissenschaften, Universität Mainz, J.-J. Becher-Weg 21, 55099 Mainz, Germany.
mertzre@uni-mainz.de

⁴Natural History Museum, University of Crete, 71409 Iraklion, Greece. fassoulas@nhmc.uoc.gr

The predicted sea surface temperature (SST) rise over the next decades is likely hazardous to coral health because precipitation of the calcareous skeleton depends primarily on SST. Temperature modulates vertical growth and density of the skeleton with seasonal SST changes resulting in an alternation of high density and low density bands (HDB, LDB). Notably, growth rates and the timing of the HDBs and LDBs relative to the seasons differ on a global scale within geographic regions. In this contribution we use combined information of skeletal density and seasonally-resolved oxygen isotope SST estimates from massive *Porites* from a Late Miocene (9-10 Ma) reef in the eastern Mediterranean Sea (Crete, Greece) to understand reef vulnerability over short and geological periods of time. Three types of HDB–SST relationships have been found: (1) coincidence of HDB with summer, (2) winter, or (3) autumn and spring. The latter doubles HDBs in a year and implies maximum calcification is coupled to the taxon specific optimum SST during the transitional seasons and reduced at its respective critical winter and summer SSTs. Modelling with a non-linear temperature–calcification relationship reproduces the climate barcode of density bands. The model should be relevant for other poikilothermic carbonate producers in reefs and platforms, and has implications for judging geographic distributions and causes of extinctions of corals, benthic carbonate communities and entire carbonate systems. With regard to the causes underlying expansion and demise of carbonate platforms and reefs in geological history, we expect the model predictions to help for a deeper understanding of biotic responses during hyperthermals or coolings.

Astronomical Dating of the Badenian (Late Langhian to Early Serravallian) Succession in the Southern Pannonian Basin

Oleg Mandic¹, Karin Sant², Wout Krijgsman², Patrick Grunert³, Arjan De Leeuw⁴, Dörte Theobalt¹

¹Geological-Paleontological Department, Natural History Museum, Burgring 7, 1010 Vienna, Austria.
oleg.mandic@nhm-wien.ac.at

²Fort Hoofddijk, Paleomagnetic Laboratory, Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, The Netherlands. karin.sant@gmail.com, krijgsma@geo.uu.nl

³Institute for Earth Sciences, University of Graz, Heinrichstrasse 26, A-8010 Graz, Austria.
patrick.grunert@uni-graz.at

⁴CASP, West Building, 181A Huntingdon Road, Cambridge, CB3 0DH, United Kingdom.
arjan.deleeuw@casp.cam.ac.uk

Astronomical tuning of sedimentary, magnetic susceptibility and natural radioactivity logs has been carried out for one Middle Miocene (Badenian to Sarmatian), deep to shallow marine, ~140 m thick, succession, calibrated through magnetostratigraphic and biostratigraphic data. The studied section, in the coal mine Ugljevik in NE Bosnia-Herzegovina, provides the only currently known site where the latest open marine Central Paratethys depositional interval (Kosovian, late Badenian) completely outcrops. Based on magnetostratigraphic data, the basal marine ingressión is dated at ~14.2 Ma, while the top part of the section with an age of ~12.5 Ma extends well into the Sarmatian. This succession thus comprises the Middle Miocene Climate Transition, the final glaciation of Antarctica, the major glacio-eustatic sea-level fall at the Langhian/Serravallian boundary, the Wielician Salinity Crises in the Central Paratethys, the change from an estuarine to anti-estuarine circulation pattern in the Pannonian Basin and the Sarmatian endemic/restriction event.

The depositional architecture of the Ugljevik section comprises four major transgression-regression cycles apparently resulting from ~400-kyr-eccentricity forcing. The initial transgression is dominated by deep-water marls in its lower part grading into platform carbonates on top. The renewed sea level rise at the base of the second cycle coincided with the Serravallian transgression and reinstalled deep-water conditions. The corresponding deposits pass upward into an almost 20-m-thick interval of pteropod- and fish-remain-bearing finely laminated marls and diatomites indicative of high-stand conditions. The third cycle consists of monotonous marls that bear intervals of carbonate debris in their top and base and contain articulated deep water oysters and corbulid bivalves. This interval shows the lowest sediment accumulation rates, possibly reflecting the maximal depositional depth in the succession. The lower part of the topmost cycle is dominated by monotonous marls bearing carnivorous nassarid snails and deep water oysters. Its upper part is marked by siliceous sponge spicule accumulations and common lucinid and corbulid bivalves marking the low-oxic bottom conditions during the final highstand systems tract in the Badenian. The base of the Sarmatian is marked by an erosional disconformity. The Sarmatian succession overlies this disconformity transgressively and comprises clays, marls and sands with silicified trunks, reworked fauna from the Badenian strata and new endemic mollusks.

Keywords: Middle Miocene, Central Paratethys, cyclostratigraphy

Stratigraphy and facies analysis of the Langhian Dağpazarı reef complex (Mut Basin, Southern Turkey)

Alessandro Vescogni¹, Francesca R. Bosellini¹, Anna Cipriani¹, Gonca Gürler², Ayhan Ilgar², Emanuele Paganelli¹, Irene Chiossi¹

¹Dipartimento di Scienze Chimiche e Geologiche, Largo S. Eufemia 19, Modena, Italy.
alessandro.vescogni@unimore.it

²Department of Geological Research, General Directorate of Mineral Research and Exploration (MTA),
06800 Ankara, Turkey

During the Early/Middle Miocene, the eastern part of the Mediterranean region registered the narrowing, and the ultimate interruption of the connections with the Indian Ocean. This event represented one of the most important episodes in the Cenozoic evolution of the Mediterranean marine biota. For this reason, the study of Middle Miocene reefal communities from this area can offer an important contribution for the reconstruction of the palaeogeography and palaeoecological settings of the Mediterranean shallow-water, carbonate-producers. The primary aim of the present study is to provide a small-scale, detailed reconstruction of the stratigraphy and facies associations of a Langhian reef complex from the Mut Formation (Mut Basin, Southern Turkey). This study has been based on field observation and microfacies analysis, with a particular emphasis on the characterization of calcareous algae associations (both corallines and green codiacean) and coral fauna. The Dağpazarı reef represents a portion of a small, isolated carbonate platform located 12 Km north from the town of Mut. Its early Langhian age has been determined by ⁸⁷Sr/⁸⁶Sr isotope analyses performed on several well preserved oyster samples. Dağpazarı reef is represented by two main stratigraphic sequences separated by a major erosion surface. Only a few meters of lowermost sequences are exposed, while the upper one measures about 72 meters in thickness and is characterized by the superimposition of four different cycles. During the first cycle, the amplitude of the sea transgression allowed the growth of a massive coral framestone on the shelf-edge, associated to well developed slope deposits toward the basin. In particular, concentrations of small rhodoliths with large nuclei and laminar/columnar structure characterize the shallower part of the slope, while in the middle slope the presence of Halimeda bioherms indicates a palaeodepth of about 30/50 meters. The two subsequent cycles show the superimposition, on the shelf-edge, of two similar shallowing-upward sequences, each of them related to a small-scale, transgressive phase. In particular, each sequence exhibits at the base a coralline red algae bindstone, typical of low hydrodynamic conditions, made of thin, laminar/foliose crusts associated to discoidal/irregular rhodoliths. This facies is followed by Halimeda bioherms and biocalcarenite deposits, the latter characterized by the presence of abundant “hooked” and foliose coralline algae crusts associated to gastropods concentrations. The coexistence of the latter features within biocalcarenite deposits is considered a reliable marker of the presence of seagrass beds. Both sequences terminate with the occurrence of shallow-water, massive coral framestone on the top. The fourth Dağpazarı reef cycle developed on the shelf-edge and started with a coralline red algae bindstone, but in this case, corallines colonizations were followed by a fine-grained, mud-supported biocalcarenite whose stratification dips landward. The top of the succession is characterized by coarser biocalcarenite deposits containing small, coral patches. Due to its stratigraphic setting and composition, this last sequence has been interpreted as a back-reef facies association, related to the progradation of a reef framework (now eroded) as a consequence of a final highstand phase of the sea-level. This work provides new information on some important shallow-water carbonate producers, for example Dağpazarı Halimeda bioherms represent so far the oldest recorded examples of this kind of structures; at the same time it offers a detailed frame for further, specific studies on Middle Miocene reef-building associations.

Burdigalian-Langhian Paleoclimatic Reconstruction of Middle and upper Globigerina Limestone (Malta Island, Central Mediterranean)

Luca Maria Foresi¹, Fabrizio Lirer², Niccolò Baldassini³, Agata Di Stefano³, Leonardo Sagnotti⁴, Chira Caricchi⁵, Luciana Ferraro², Nicola Pelosi², Roberto Mazzei¹, Gianfranco Salvatorini¹, Marina Verducci¹

¹Dip. Scienze Fisiche della Terra e dell'Ambiente, University of Siena, Via Laterina 8, 53100 Siena, Italy

²IAMC-CNR Istituto per l'Ambiente Marino Costiero, Calata Porta di Massa, 80133 Napoli, Italy

³Dip. Scienze Biologiche, Geologiche e Ambientali, University of Catania, Corso Italia 55, 95129 Catania, Italy

⁴INGV Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata, 605, 00143 Roma, Italy

⁵Dip. Scienze Geologiche, University of Roma Tre, Largo San Leonardo Murialdo, 00146 Roma, Italy

The Miocene sediments of the Maltese Archipelago were intensively studied for their geological and stratigraphical meaning, since Malta is considered a bypass area between western and eastern Mediterranean. This feature makes this site suitable for the Early-Middle Miocene paleoclimatic reconstruction. In particular, the St. Thomas (1) and St. Peter's Pool (2) sections are two well cyclically bedded exposed pelagic successions, referred to the Middle and Upper Globigerina Limestone members, spanning the Burdigalian-Langhian time intervals. They crop out along the cliffs of the Delimara Peninsula in the SE of Malta Island.

The St. Thomas and St. Peter's Pools sections are separated by a phosphate rich bed (C2 bed). The two sections are combined in a ~120 m thick composite section consisting of alternating gray marls and calcareous marls, with marly mega-beds in the middle-upper part. Upwards, the composite section is characterised by yellowish marly limestone, interlayered with typical very hard limestone, pale brown in colour and strongly protruding from the morphological profile.

The integrated stratigraphic study (calcareous plankton and magnetostratigraphy) allows us to assign the composite section to the Burdigalian-Langhian time interval (magnetochron interval C6n- C5Br), highlighting a hiatus of ~0.6 My in correspondence of the phosphate rich C2 bed (uppermost Burdigalian).

In order to reconstruct the main climatic events occurring in the St. Thomas-St. Peter Pool composite record, a planktonic foraminiferal paleoclimatic curve has been generated using the biogeographic index groups (warm, warm-temperate, cold-temperate and cold species) reported by (3). On this basis, six intervals have been identified: i) Burdigalian cold interval, characterised by three main cold/warm oscillations, occurring in the middle part of Chron C6n (between 7 and 30 meters); ii) Burdigalian warm interval, between 30 and 63 meters, spanning in the uppermost part of Chron C6n to the upper part of Chron C5En, iii) Burdigalian cold interval, between 63 and 75 meters, centred in the middle part of Chron C5Dr. According to magnetostratigraphy of the composite section, this sudden cold event could be correlated to the glaciation Miller event Milb; iv) Burdigalian warm interval, between 75 and 90 meters, occurring in the Chron C5Dn; v) Burdigalian/Langhian cold interval, just above the C2 phosphate rich bed, between 90 and 98 meters, spanning from Chron C5Cn.2n? to Chron C5Cn.1n; vi) three main cold/warm oscillations occur within Chron C5Br, characterising the lower part of the Langhian interval (Upper Globigerina Limestone).

Keywords: Mediterranean, Burdigalian-Langhian, paleoclimate, calcareous plankton, magnetostratigraphy.

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High-resolution Paleoecological and Time-series Analyses of An upper Burdigalian upwelling Site in the North Alpine foreland Basin

Gerald Auer¹, Werner E. Piller¹, Mathias Harzhauser²

¹ Institute for Earth Sciences (Geology and Palaeontology), Graz University, Heinrichstrasse 26, 8010 Graz, Austria, werner.piller@uni-graz.at

² Naturhistorisches Museum Wien, Geologisch-Paläontologische Abteilung, Burgring 7, 1014 Wien, Austria

³ Geological Survey of Austria, Neulinggasse 38, 1030 Vienna, Austria

A high-resolution analysis was performed on late Burdigalian (CNP-zone NN4) shallow neritic sediments from the North Alpine Foreland Basin in Lower Austria. Focussing on the rapidly changing environmental conditions in connection with the onset of the Middle Miocene Climate Optimum (MMCO) a section of 940.5 mm was continuously sampled yielding 100 samples covering a thickness of ≤ 1 cm each. Based on estimated sedimentation rates the studied section represents a timespan of $\sim 1,600$ years. To these samples an integrated approach was applied to study proxy records including calcareous nannoplankton, geochemical and sedimentological data.

This study is the first attempt to analyse outcrop data on such a high resolution, sub-Milankovitch scale with respect to calcareous nannoplankton in conjunction with geochemical and sedimentological data. Our results, based on multivariate statistics (cluster analyses and nMDS), indicate that changes in coccolith abundances as well as in organic carbon and sulphur contents are linked to the changing local environmental conditions. These include variations in water-column stratification, primary productivity, organic matter flux, bottom-water oxygenation and changes in relative sea level.

Time-series analyses on these proxies using REDFIT-analysis and Wavelet spectra hint at the influence of solar-cycles on local climate variation. A best-fit adjustment of assumed sedimentation rates results in cycles fitting the lower (~ 65 y) and upper (~ 113 y) Gleissberg-cycle as well as the Suess/de Vries-cycle (~ 211 y).

The investigated high-resolution section covers a timespan of $\sim 1,635$ years based on a best fit adjustment of estimated sedimentation rates by a correlation with solar cycles, resulting in an estimated sedimentation rate of 575 mm kyr⁻¹.

Keywords: Burdigalian, North Alpine Foreland Basin, Coccoliths, environmental reconstruction, solar cycles

Paratethys-southern Ocean Teleconnection in the Mid-burdigalian: European Climate on the Verge to the Miocene Climate Optimum

Patrick Grunert¹, Alexandrina Tzanova², Mathias Harzhauser³, and Werner E. Piller¹

¹Institute for Earth Sciences, University of Graz, Heinrichstraße 26, A-8010 Graz, Austria;
patrick.grunert@uni-graz.at

²Department of Geological Sciences, Brown University, 324 Brook Street, Box 1846, Providence,
RI 02912, USA

³Geological-Paleontological Department, Natural History Museum Vienna, Burgring 7, A-1030
Vienna, Austria

The Early Ottnangian Cooling (EOC) describes a distinct cold-spell in European climate at ~18 Ma preceding the Miocene Climate Optimum. Although frequently recorded in Paratethys records, the duration, magnitude, and underlying causes of the EOC are poorly understood. A new paleoclimatic data-set provides unexpected insights into this event.

$U^{K'}_{37}$ -based sea surface temperatures $> 25^{\circ}\text{C}$ between 18.5 and 17.5 Myrs substantially exceed existing estimates, and indicate a significantly warmer European climate than previously assumed for this time interval. Prevailing tropical SSTs are well supported by the temperature gradient reconstructed for the water column and the sea-floor from $\delta^{18}\text{O}$ records, and by micropaleontological data. The EOC is expressed as a 2-3°C drop in Paratethyan water temperatures between ~18.05 and 17.95 Myrs. The short duration of the EOC excludes Tethyan Seaway closure as its underlying cause. The temperature decrease coincides with a period of ice-sheet growth in Antarctica (isotope event Milb), and we propose a teleconnection between the Paratethys and the Southern Ocean as a more likely hypothesis to explain the EOC.

Keywords: Early Ottnangian Cooling; Burdigalian; Paratethys; alkenones; stable isotopes

The Discovery of Lower Miocene Loess in Europe: A New Document for the Global Aridity

Davor Pavelić¹, Marijan Kovačić², Darko Tibljaš², Frane Marković², Kristina Pikelj², Alan Vranjković¹, Gonzalo Jiménez-Moreno³

¹ University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Pierottijeva 6, HR-10002 Zagreb, Croatia. dpavelic@rgn.hr

² University of Zagreb, Faculty of Science, Horvatovac 95, HR-10000 Zagreb, Croatia

³ Departamento de Estratigrafía y Palaeontología, Universidad de Granada, Fuente Nueva S/N, 18002, Granada, Spain

Lower Miocene deposits in northern Croatia represent the oldest syn-rift terrestrial sediment accumulations that reflect extensional processes in the early phase of formation of the southern Pannonian basin. The deposits are best developed on Mt. Požeška, where elevated footwalls were intensely eroded and the principal depocentres were located in braided alluvial fans. The main characteristics of the deposits are a dominance of coarse-grained over fine-grained sediment, conspicuous variations in grain size but a lack of sandy fraction in the lower portion of the succession, rapid lateral and vertical facies alternations, rare occurrences of red beds and calcretes, and a lack of fauna. The coarse-grained deposits are represented by rock-fall breccias, as well as mid-fan channel and longitudinal bar conglomerates. These deposits are intercalated by silty units that may include thin conglomerate lenses. Within the context of deposition in an alluvial environment, these fine-grained units were previously interpreted as flood plain deposits. Palaeocurrent measurements indicated palaeotransport of alluvial material towards the north and north-east where a salina-type lake existed.

The fine-grained deposits were studied on the northern slopes of Mt. Požeška where they form numerous units occurring within coarse-grained siliciclastics in a section 109 m thick. The units are represented by loose silt varying in thickness between 6 and 180 cm. The cumulative thickness of the units is ca. 25.5 m. The lower boundaries of the individual units are irregular, while their upper boundaries usually indicate erosion. They lack any type of internal structures. Their colour may be either brownish yellow or yellowish brown, somewhere with bluish grey mottles. The upper part of some units is reddish. The silty units do not contain any fauna and the palynological analysis yielded a negative result.

According to grain-size analyses the fine-grained deposits are characterized as sandy mud which contain between 40-60% silt-sized particles, 20-45% clay-sized particles and 20-35% sand-sized particles. Their mean grain size varies between 10 µm and 25 µm. The coarse silt and sandy fraction is mostly composed of quartz grains, lithic fragments and muscovite, and it is characterized by a dominance of opaque minerals and epidote in the heavy mineral fraction. According to the – X-ray analyses the most abundant clay mineral in the fraction finer than 2 µm is illite. Scanning electron microscopy showed that most of quartz grains are angular. A smaller percentage of grains is very angular or sub angular. Most quartz grains are blocky and show conchoidal fractures.

Relatively thick units composed of fine-grained material, the lack of any type of internal structures and fossils, conchoidal fractures in quartz grains, together with a terrestrial depositional environment indicate transport and settling by wind, while the predominance of loose silt-sized particles and the brownish to yellowish color characterize them as loess. The occurrence of loess units in the succession, their thickness and the lack of pollen suggests frequent and sometimes long periods of a windy arid climate which was temporarily interrupted by more humid conditions that generated alluvial deposition. The studied loess represents the desert type probably produced by salt-weathering, and together with the penecontemporaneous salina-type lake supports the Early Miocene arid climate.

Since Miocene loess has until now been known only from China, this study presents the first discovery of Miocene loess in Europe.

Keywords: loess, Early Miocene, Europe, global aridity

Neogene Planktonic Foraminiferal Turnover in the Mediterranean Area

Fabrizio Lirer¹, Luca Maria Foresi², Silvia Iaccarino³, Nicola Pelosi¹

¹Istituto per l'Ambiente Marino Costiero (IAMC) – CNR, Calata Porta di Massa, Interno Porto di Napoli, 80133, Napoli, Italy

²Dipartimento di Scienze Fisiche, della Terra e dell'Ambiente – Università di Siena, Via Laterina 8 – 53100 Siena, Italy

³Dipartimento di Scienze della Terra, Università di Parma, V.le G.P. Usberti 157/A, 43100 Parma, Italy

The Neogene Period is characterised by several oscillations in climate and related turns in fossils community, and planktonic Foraminifera represent an important tool to monitor these climatic changes. In particular, the planktonic foraminiferal populations of the Mediterranean area show pronounced oscillations on a variety of temporal scales from Milankovitch timescale to million-year timescale. An analysis of planktonic foraminiferal literature data and species quantitative distribution datasets from Mediterranean on land sections and deep marine cores, calibrated vs the Geological Time Scale 2012, revealed the occurrence of four main increases in turnover during the Miocene, centred at 21.8 Ma (Aquitanian turnover), 15.6 Ma (Middle Miocene turnover), 11.2 Ma (early Tortonian turnover) and 7 Ma (early Messinian turnover). Contrarily, the Plio-Pleistocene time interval is characterised by a general decreases in planktonic foraminiferal turnover with three minima centred at 4.8 Ma (Zanclean turnover), 2.9 Ma (Piacenzian turnover) and at 1.2 Ma (Calabrian turnover). Power spectral analysis revealed the existence of turnover cycles with periods of 1.3, 1.0 and 2.0 Ma.

Keywords: Planktonic foraminifera, Neogene, Mediterranean

Freshwater Gastropods of the European Neogene – Setup of a New Database

**Thomas A. Neubauer¹, Mathias Harzhauser¹, Oleg Mandic¹, Elisavet Georgopoulou¹,
Andreas Kroh¹**

¹Geological-Paleontological Department, Natural History Museum Vienna, Burgring 7, 1010 Vienna, Austria; thomas.neubauer@nhm-wien.ac.at, mathias.harzhauser@nhm-wien.ac.at, oleg.mandic@nhm-wien.ac.at, elisavet.georgopoulou@nhm-wien.ac.at, andreas.kroh@nhm-wien.ac.at

More than one thousand gastropod species are currently known for European freshwater systems. Apart from faunal lists and a few general overviews, studies on the γ -diversities of European freshwater systems and the shifting biodiversity through space and time are entirely missing. For fossil assemblages, biodiversity estimates are likewise scarce and usually restricted to small regions. In many cases, even species lists do not exist and are hard to extract from the literature. The present project is aimed at compiling freshwater gastropod faunal data from the huge amount of existing works. The γ -diversity of several hundred modern and fossil European lakes will be evaluated to provide a first detailed assessment of the faunal composition during the Neogene and Quaternary at species, genus and family levels. Important topics to be addressed are factors explaining the differences and changes in the γ -diversities through time as well as geographic gradients in species richness and/or faunal composition. Diversity data and inter-lake comparison will allow estimating endemism rates and quantitatively defining biodiversity hotspots in present and past lakes. The well resolved climate history of Europe during the last 23 million years will be a frame for linking species- and supraspecific compositions with climatic trends and events. Ideally, the project will shed light on the origin of modern lake faunas by the intense cooperation between zoologists and paleontologists. A major aim is to map a statistics-based Pan-European biogeography and palaeobiogeography of Neogene to Quaternary freshwater systems. Data will be made permanently available for the public via the FreshGEN-database (Freshwater Gastropods of the European Neogene). Once established, this database will be open for geographic and/or stratigraphic expansion.

Keywords: Freshwater gastropods, paleobiodiversity, paleobiogeography, database

Towards an Understanding of the Mechanism of Cyclic Sedimentation in the Mediterranean Basin Using a Mathematical Model of Overturning Circulation

Paul Meijer¹

¹Department of Earth Sciences, Utrecht University, P.O. Box 80.021, 3508 TA Utrecht, the Netherlands, p.meijer@uu.nl

Due to its land-locked setting the Mediterranean basin has recorded orbitally-induced periodic changes in climate in the form of cyclic changes in its sediments. This Milankovitch cyclicity of course forms the basis for the high-resolution temporal framework we now have available for the region. Much sedimentological and geochemical research has been aimed at unravelling the mechanisms by which sedimentation is related to the changes in circulation and climate. As yet, however, model-based studies of the response of circulation and water properties to the driving climatic variations are few and, where it concerns ocean general circulation models, limited to runs much shorter than the precession cycle. In this contribution I will outline the first results obtained with a new approach: one in which a “minimal” mathematical model is constructed for the thermohaline overturning of the Mediterranean Sea. The model is applied to the precession-related sapropel/marl cycles. We examine the possibility that these mainly correspond to two alternative states of circulation, i.e. for the moment we disregard the role of biogeochemical processes. The model can be run in truly transient fashion and helps clarify our thinking about how circulation responds to simultaneous variation in net evaporation, atmospheric temperature and sea level.

Keywords: Milankovitch cycles, sapropels, thermohaline circulation, mathematical modelling

Model study of the circulation of the Miocene Mediterranean Sea and Paratethys: Closure of the Indian Gateway

A. de la Vara¹, P. Th. Meijer¹, M.J.R. Wortel¹

¹Department of Earth Sciences, Faculty of Geosciences, Utrecht University, Utrecht, The Netherlands;
delavarafernandez@uu.nl

The early Mediterranean Sea and Paratethys were both connected to the Indian Ocean until the Early/Middle Miocene, when the Indian Gateway was first constricted and then fully closed as a result of the convergence of the Eurasian plate and African-Arabian plate. Although little is certain concerning the timing of the closure and the consequences that it entailed, it is broadly accepted that it had a large effect on water properties and ocean dynamics on the regional and global scales and in that way may have also played a role in the evolution of climate.

While, from a modeling perspective, considerable research has been devoted to the Late Miocene period on the Mediterranean region, rather less attention has been paid to the Early and Middle Miocene. Moreover, the effects of the closure of the Indian Gateway on ocean circulation have been investigated with global climate models which are limited due to their coarse resolution. The main aim of our work is to investigate the palaeocirculation of the Mediterranean Sea and Paratethys during the different stages of closure. For this purpose we use a regional ocean model and a Burdigalian (about 20 Ma) palaeogeographic map from the Peri-Tethys Atlas. In addition to different depths of the Indian Gateway, different sets of values for the atmospheric forcing have been applied in order to assess if results are dependent on the choices we made to force the model.

The collection of experiments shows that with an Indian Gateway ranging from 1000 to 460 meters deep, the Mediterranean accommodates anti-estuarine exchange to the Indian and Atlantic oceans. According to our results, the Mediterranean outflow waters to both oceans are characterized by high salinities and temperatures - especially those flowing into the Indian Ocean, which always appear to be warmer than the Mediterranean outflow to the Atlantic Ocean. The shoaling of the Indian Gateway results in a progressive decrease in the water exchanged between the Indian Ocean and the Mediterranean basin. When the gateway is as shallow as 220 meters, there is no effective water exchange between the Indian Ocean and the Mediterranean basin, which strongly suggests that the gateway may have been closed in an oceanographical sense, even while a water passage was still in existence.

On a global scale this event interrupted, according to our results, a source of relatively salty and warm waters, which has been proposed by some authors to have played a role in the development of the East Antarctic Ice Sheet. On a regional scale, closure results in a general salinity and temperature increase. However, the variations in response to closure are spatially not homogeneous and we expect that results obtained from proxies over a certain area do not apply to the rest of the basin. The additional experiments, in which different atmospheric data sets were used, show a similar response to shoaling and closure in terms of thermohaline circulation. In addition these experiments shed light on the influence of atmospheric forcing in general.

Keywords: Mediterranean Sea; closure Tethyan Seaway; Regional modelling; Palaeoceanography; Palaeoclimate.

SESSION 10

NEOGENE MAMMALIAN SUCCESSIONS AND DISPERSALS

CONVENERS

ŞEVKET ŞEN AND MADELAINE BÖHME

The Vallesian Rodent Record from the Vallès-Penedès Basin (Catalonia, Spain): Biostratigraphy, Diversity and Structure

Isaac Casanovas-Vilar¹, Israel García-Paredes², Jan Van Dam^{1,3}

¹Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICP, Campus de UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain. isaac.casanovas@icp.cat, jan.vandam@icp.cat

²Instituto de Geociencias IGEO (CSIC, UCM), c/ José Antonio Novais, 2, 28040 Madrid, Spain. isgarpa@geo.ucm.es

³Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, the Netherlands.

The Vallès-Penedès Basin (Catalonia, Spain) is the type area for the Vallesian stage (early Late Miocene; 11.1–8.7 Ma), which is considered an interval of important changes in the European mammal faunas. Several middle Miocene taxa, associated with forested environments, seem to have disappeared abruptly at 9.5 Ma during an event known as the ‘Vallesian Crisis’ (Agustí & Moyà-Solà, 1990). Simultaneously, many taxa that later will characterize the rest of the late Miocene (Turolian) first occur in Western Europe.

We analyze the diversity dynamics and changes in the structure of the Vallesian rodent assemblages from this basin. The record comprises more than 5000 specimens recovered from 84 different fossil sites. The age of most localities can be accurately estimated using a combination of biostratigraphic and magnetostratigraphic methods. Furthermore, we have considered the biases introduced by the variations in the quality of the record using methods that consider the probability of sampling (Barry *et al.*, 2002; Van Dam *et al.*, 2006).

Five different local biozones (named V1 to V5) can be recognized on the basis of the rodent content. The rodent fauna of zone V1 is basically identical to that of the late Aragonian (latest middle Miocene), which implies that the dispersal of the equid *Hippotherium* into the area was not accompanied by any significant environmental change that influenced the rodent fauna. The lower boundary of this zone is located at the base of chron C5r.1n, which implies an age of 11.188 Ma (chron boundaries after Hilgen *et al.*, 2012). Zones V2 and V3 show a diverse rodent assemblage overwhelmingly dominated by the cricetine *Cricetulodon*, which usually accounts for more than 80 % of the specimens. In zone V2 *C. hartenbergeri* is present, while in zone V3 it is replaced by its descendant *C. sabadellensis*, which would persist into zone V4. The lower boundary of zone V2 lies within chron C5n.2n and has an estimated age of at least 10.6 Ma. On the other hand, zone V3 is would be very short, probably ranging from the base of chron C5r.1r (9.937 Ma) to the base of chron C4Ar.2n (9.721 Ma).

The boundary between zones V3 and V4 corresponds with the ‘Vallesian Crisis’. However, the impact of this event on the rodent faunas is found to be less important than previously thought. Several species of sciurids, castorids, glirids, eomyids and cricetids are said to have disappeared from the area at 9.5 Ma, but our data show that many of them did in fact survive until the end of the Vallesian, being sporadically recorded in some sites. Their apparent absence may reflect the fact that the quality of the record is much better during the early (zones V1-V3) than the late Vallesian (zones V4-V5). All the missing species are generally rare in our assemblages, so they require a great sampling effort to be recorded. Alternatively, these taxa may have been associated with very specific habitats that for unknown taphonomic reasons are not recorded during the late Vallesian. Zone V4 also records the dispersal of the first murids (*Progonomys*). In contrast to what occurred in other Iberian basins, the rodent assemblage continued to be cricetine-dominated and murids did not become the dominant rodents until the upper part of zone V5. Zone V4 further records the first appearance of the genus *Rotundomys*, represented by a yet unnamed species and *R. montisrotundi*. In zone V5 *R. bressanus* coexists for some time with *R. montisroundi*. The boundary between zones V4 and V5 occurs at chron C4Ar.1r (base at 9.311 Ma). Although some Turolian sites are known, the Vallesian/Turolian boundary is not recorded at the Vallès-Penedès. On the basis of the data from the Teruel basin such boundary is estimated at 8.9 Ma (Van Dam *et al.*, 2006), while the youngest Vallesian sites of the Vallès-Penedès have an age of about 9.1 Ma

Keywords: Vallesian, Late Miocene, Iberian Peninsula, biostratigraphy, diversity dynamics

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Two New Late Miocene Fossil Localities (Yiğitler and Hirfanlı) from Kırşehir in Central Anatolia

Ahmet Cem Erkman¹, Şakir Önder Özkurt¹, Nuretdin Kaymakçı², Cesur Pehlevan³, Yarenkür Alkan¹, Ferhat Kaya⁴

¹Ahi Evran University

²Middle East Technical University, Department of Geology, Ankara, Turkey

³Yüzüncü Yıl University, Van, Turkey

⁴Department of Geosciences and Geography, University of Helsinki, PO Box 64 (Gustaf Hållströmin katu 2a), 00014 Helsinki, Finland. ferhat.kaya@helsinki.fi

Here we report on two large mammal fossil localities, Yiğitler and Hirfanlı, projected to be from the Late Miocene of Kırşehir in central Anatolia. The localities were first discovered through a survey project conducted by Ahi Evran University in 2011.

The fossil bearing horizon of Hirfanlı is located a few metres below ground level. The fossils are exposed possibly due to the wave action of Hirfanlı Dam. They are located within red mudstone and demonstrate heavy action of Calichey limestone and limestone concretions. These characteristics imply that the environment of deposition was more or less similar to present day alluvial plains somewhat similar to the presentation of Kızılırmak floodplain. During our two field seasons we noticed a serious threat to the fossil collections in the location. Seasonal changes in the water level of the Hirfanlı dam wipe out a significant amount of fossils each year. We juxtapose our findings from surface collection with the deterioration of the locality to urge for the preservation of the promising site and commence a new excavation in the area as soon as possible. In Yiğitler, the fossil bearing horizon is just above a pinkish tuff horizon and at the basal part of 1-1.5 m thick mass flow deposits. The bulk composition of it is mainly derived from tuff and other volcanogenic material. The fossil bearing deposits are lahar deposits and fossils are the remains of transported bodies and accumulated loose pieces of bones. This is also evidenced by lack of complete bodies instead they are the collection of unrelated bones brought together by strong mud flows of volcanic origin lahar.

By the end of the second season a rich collection of vertebrate fauna including species of perissodactyls, artiodactyls, proboscids, carnivores, and fossil remains of some species of aves was recorded. These localities dominated by bovids, which accounts for about 46% of all specimens, followed by hipparion (42%), carnivore (4%), rhinos (2.5%), suids (2.5 %), giraffes (2%) and proboscids (1%).

The significance of these localities lies within the diversity and chronology of its mammal faunas. In this study we reflect briefly on our interpretations of the large mammal fauna from the localities via our first-hand experiences from the survey and preliminary investigations on the fossil materials.

Keywords: Yiğitler, Hirfanlı, Late Miocene, Fossil, Anatolia.

The Abrupt Collapse of a Diversity Hotspot? Reconsidering Vallesian (Late Miocene) Diversity in its Type Area

P. Anneke Madern^{1,2}, Isaac Casanovas-Vilar¹, David M. Alba^{1,3}, Daniel DeMiguel¹, Josep M. Robles¹, Lars W. van den Hoek Ostende², Salvador Moyà-Solà⁴

¹Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICP, Campus de UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain.

²Naturalis Biodiversity Center, PO Box 9517, 2300 RA, Leiden, the Netherlands.

³Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy.

⁴ICREA at Institut Català de Paleontologia Miquel Crusafont and Unitat d'Antropologia Biològica, Universitat Autònoma de Barcelona. Edifici ICP, Campus de la UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain. salvador.moya@icp.cat

The Miocene was a turbulent time, marked by major faunal turnovers and climate changes. Its mammal faunas showed a succession from less seasonal forests and wooded communities to more seasonal, open woodland communities. In the early Vallesian (11.1-9.7 Ma), the Vallès-Penedès Basin (Catalonia, Spain) formed the European area with the highest diversity, representing a true diversity hotspot (Casanovas-Vilar *et al.*, in press). During the late Vallesian, the distribution of mammals in Europe seems more even without any apparent diversity hotspots. After the early Vallesian climax, there appears to have been a sudden diversity drop at 9.6 Ma, known as the Vallesian Crisis (Agustí & Moyà-Solà, 1990). Initially, this crisis was considered a local event, characterised by the extinction of certain mammal species of Middle Miocene origin in the basin, but more recent works consider the Vallesian Crisis to have affected all European faunas, implying the disappearance of most forest-adapted taxa (Agustí *et al.*, 2013). However, contradictorily, doubts have arisen considering the timing of the event and even whether the Crisis can be recognized at all outside the Iberian Peninsula (Casanovas-Vilar *et al.*, 2010, in press).

Reconstructing past biodiversity is a major goal in palaeontology, but in order to recognise non-random patterns in a chaos of data, biases must be controlled. A common bias is uneven sampling; richer or more intensively sampled sites or time intervals contain more rare taxa and thus show a higher diversity. A peak in data quality could lead to an overestimation of the recorded diversity (Foote, 2000). Robust diversity measures are needed to evaluate such biases, taking into account sample size and the probability of finding a certain taxon at a specific site. To assess the effects of the quality of the large mammal record, we compiled a quantitative database of the Vallesian macromammal record of the Vallès-Penedès Basin, where the Vallesian Crisis was first recognized.

Our results show that extinction rates in the type area might be overemphasised because of the intensive sampling of the richest locality, the site of Can Llobateres 1, which immediately precedes the crisis. Overall, sampling before the crisis is much better than afterwards, which inflates diversity and exaggerates extinction rates. Therefore, we calculated new diversity estimates independent of sample size using rarefaction and sampling probability (Barry *et al.*, 2002; Van Dam *et al.*, 2006; Van der Meulen *et al.*, 2005). Our calculations show that many genera that purportedly disappeared during the late Vallesian have a discontinuous record during the early Vallesian and are generally very rare. Since the sampling effort in the late Vallesian sites is comparatively lower, we cannot discount the possibility that at least some of those taxa persisted during the late Vallesian. Thus, the crisis was not a single major event occurring at the early/late Vallesian boundary, but a more protracted period of extinctions.

Keywords: Late Miocene, Vallesian Crisis, biodiversity hotspot, sampling bias, faunal turnover

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Vertebrate Communities from Khersonian Sediments of Küçükçekmece Area, Turkey

Davit Vasilyan¹, Madelaine Böhme^{1,2}, Jérôme Prieto^{1,3}

¹Department of Geosciences, Eberhard Karls University Tübingen, Sigwartstr. 10, 72076 Tübingen, Germany. davit.vasilyan@ifg.uni-tuebingen.de.

²Senckenberg Center for Human Evolution and Palaeoecology (HEP), Tübingen, Germany. m.boehme@ifg.uni-tuebingen.de.

³Department for Earth and Environmental Sciences, Ludwig-Maximilians-University Munich and Bavarian State Collections for Palaeontology and Geology, Richard-Wagner-Straße 10, 80333 Munich, Germany. j.prieto@lrz.uni-tuebingen.de.

The area west of Istanbul, around the Küçükçekmece lagoon is well known for Khersonian Mactra-bearing limestones alternating with deltaic sediments. The section containing a rich mollusc fauna with *Chersonimactra caspia* and *Ch. bulgarica*, which also includes diverse freshwater and brackishwater groups (e.g., Unionidae, Helicidae, Planorbidae, Melanopsidae). The mactrid fauna allows correlation of the sediments with the *Mactra bulgarica* zone (Kojumdgieva *et al.* 1988) of the middle resp. late Khersonian (depending on subdivision) of the Eastern Paratethys (). These sediments represent a transgressive highstand of the Eastern Paratethys during the second half of the Khersonian regional substage.

The majority of vertebrate fossils have been collected by P. Jean Nicolas (Nicolas 1978) from the southwestern side of the Küçükçekmece lagoon. Additional material comes from several outcrops near Ambarlı (Sickenberg *et al.* 1975), as well as from Hoşdere (Rückert-Ülkümen & Kaya 1993).

The fossil ectothermic vertebrate fauna of these three localities contains: Küçükçekmece – *Lates* sp., *Lucioperca* indet., *Heterobranchius* sp., *Silurus* sp., *Barbus* sp. 1, *Barbus* sp. 2, *Latonia gigantea*, *Bufo* ex gr. *viridis*, *Varanus* sp., *Scincus* indet., *Testudo* ex gr. *T. graeca*, *Chelydrosis* sp., *Trionyx* s.l. sp., *Mauremys* sp., aff. *Sakya* sp., *Natricinae* indet., *Colubrinae* indet., *Viperidae* indet.; Ambarlı– *Barbus* (*Luciobarbus*) sp., *Barbus* cf. *grypus*, *Leuciscinae* indet., (Palaeo-) *Carassius* sp., *Heterobranchius* sp. nov., *Lates* sp., *Scincidae* indet.; Hoşdere– *Barbus* cf. *grypus*, *Luciobarbus* cf. *xanthopterus*, *Lates* sp., *Heterobranchius* sp. nov., *Silurus* sp., *Latonia* sp., *Varanus* sp., *Naja* sp., *Chelydrosis* sp., *Testudo* ex gr. *T. graeca*.

The sediments of the Hoşdere yielded also a small mammal fauna (*Byzantinia* sp. 1, *Byzantinia* sp. 2, cf. *Progonomys woelferi*, *Muridae* gen. et sp. indet., *Gliridae* gen. et sp. indet., *Stenofiber* sp., *Schizogalerix* sp., *Anourosoricini* gen. et sp. indet. 1, *Soricidae* gen. et sp. indet. 2), which allows a correlation to late Vallesian/early Turolian of the mammalian biochronologic scheme.

The ectothermic vertebrate fauna from the Küçükçekmece area provide a unique window into the biotic structure of middle/late Khersonian terrestrial to deltaic ecosystems of the Eastern Paratethys. Furthermore, bioclimatic analysis of the herpetofauna indicates humid climatic condition in the Eastern Paratethys during the Khersonian transgression.

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Vallesian Gliridae from the Vallès-Penedès Basin (Catalonia, Spain) and How were They Affected by the 'Vallesian Crisis'

Israel García-Paredes¹, Isaac Casanovas-Villar²

¹Instituto de Geociencias IGEO (CSIC, UCM), José Antonio Novais 2, 28040 Madrid, Spain.
isgarpa@geo.ucm.es

²Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICP,
Campus de UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain. isaac.casanovas@icp.cat

The Gliridae is a distinctive Old World family of rodents with an evolutionary history of about fifty million years. The 26-28 extant species are relics of a very successful and diverse family in the past. During the Early Miocene and the beginning of the Middle Miocene, they become the most diverse and abundant group within the European rodent faunas. The group started the decline during the late Aragonian (latest Middle Miocene) coinciding with the decrease in temperatures and increase in aridification that followed the Middle Miocene Climatic Optimum. Although according to Daams & de Bruijn (1995) the number of species decreases gradually until the Turolian (latest Late Miocene), the so-called 'Vallesian Crisis' (early Late Miocene) has been considered the great extinction event for glirids in the Mediterranean area (Hartenberger, 1994).

The 'Vallesian Crisis' event was proposed by Agustí & Moyà-Solà (1990) at the early/late Vallesian boundary in the Vallès-Penedès Basin (Catalonia, Spain), the type area for the Vallesian stage (early Late Miocene). This event involved the local or continental extinction of most taxa associated with humid/forested environments and is considered one of the main faunal turnovers of the European late Neogene. Among the rodents, the Gliridae were particularly affected, resulting in the disappearance of several taxa characteristic of the late Aragonian and the early Vallesian like Bransatoglis, Myoglis, Paraglrulus and some species of Muscardinus.

In the last years, new taxonomical, biostratigraphic and magnetostratigraphic information on the Vallès-Penedès Basin have become available. Current revision of Gliridae faunas from this basin, including new localities and new material from classical localities, show that many of the taxa that seemed to have become extinct in the area at the early/late Vallesian boundary are recorded in several late Vallesian localities. Although the 'Vallesian Crisis' involved a decline in the diversity and relative abundance of the group, the pattern of this event is not fully understood yet and it appears to be less dramatic for Gliridae than previously assumed. These results are in accordance with recent analysis of the diversity trends of Vallesian micromammals assemblages from this basin, which conclude that the completeness of the fossil record has influenced the magnitude of the 'Vallesian Crisis' on rodents and insectivores (Casanovas-Vilar *et al.*, 2012).

Finally, the analysis and comparison of the Vallesian glirid assemblages from other Iberian basins (e.g., Calatayud-Montalbán, Teruel and Duero) reveal different changes in the diversity, species composition and relative abundance, which indeed do not occur simultaneously. Moreover, the question relative to the difference in the completeness of the fossil record between the early and the late Vallesian should be considered as important in Calatayud-Montalbán and Duero basins. Thus, the current information does not allow the recognition of a consistent and general pattern in the effects of the 'Vallesian Crisis' on the Gliridae faunas from the different Iberian basins. This is in accordance with the environmental heterogeneity of the Iberian Peninsula during the Miocene and may reflect the differential and asynchronous local biotic responses to long-term global changes.

Keywords: Miocene, Gliridae, Vallès-Penedès Basin, 'Vallesian Crisis', Iberian Peninsula

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Pikermi; New Excavations at a Classical Locality

G. Theodorou¹, S. Roussiakis¹, A. Athanassiou², V. Mitsopoulou¹, Ch. Solomos¹, A. Lychounas¹

¹National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Historical Geology and Palaeontology, Zografou, GR-15784, Athens, Greece. gtheodor@geol.uoa.gr, srousiak@geol.uoa.gr, vamitsop@geol.uoa.gr, terrfilii@gmail.com, lychounas@gmail.com

²Hellenic Ministry of Culture, Ephorate of Palaeoanthropology–Speleology, Ardittou 34B, GR-11636, Athens, Greece. aathanas@geol.uoa.gr

The fossiliferous locality of Pikermi (Attica, Greece) is one of the oldest known and most famous Eurasian localities. The richness of the fossils discovered has marked out Pikermi as a reference locality for the European continental Upper Miocene. The first fossils in Pikermi were discovered in 1836. Subsequently, several excavations were carried out. Those conducted by Albert Gaudry (1855-56 and 1860), A. Smith Woodward and Theodore Skouphos (1901) and Othenio Abel (1912) were the most important and yielded an abundance of fossils that today constitute significant museum collections. After Abel's excavation and for almost 100 years there had been no research activity in the classical site. The fauna of Pikermi includes a great number of mammalian taxa, as well as some reptiles and birds. It is generally considered to be of Late Miocene age and is correlated to the middle Turolian (MN 12). However, early authors (Gaudry 1855; 1862-67; Woodward 1901; Abel 1922) noticed that the fossils occurred along a ravine (the ravine of the Megalo Rema stream) on two or locally three stratigraphic levels. Additionally, the exact stratigraphic provenance of the specimens unearthed is not specified in the relevant museum collections or publications. Consequently, the faunal content of each fossiliferous level is unknown and most Pikermian collections do not represent a chronologically homogenous fauna (Theodorou et al. 2010).

In 2008 the University of Athens started new research in Pikermi which resulted in the discovery of the new site "Pikermi Valley-1" (PV1). This locality is about 500 m east-southeast of the classical Pikermi site and the fossils occur at the bottom of the ravine of the Megalo Rema stream (Theodorou et al. 2010). Since 2009, when the first excavations were carried out in PV1, excavations are conducted on a yearly base. Moreover, further geological prospecting resulted in the discovery of more sites. The most recent excavations were carried out in April 2013 at the location where the historical excavations are believed to have taken place.

The aim of the new excavations is: (1) to spot new fossiliferous sites and collect a statistically adequate number of specimens; (2) to provide taphonomical data; (3) to identify the number of the fossiliferous levels and define their exact faunal content; (4) to investigate possible faunal and palaeoecological changes through time; and (5) to clarify the local stratigraphy. The research has been supported by grants 70/3/9494, 70/3/10437, 70/4/11078.

Keywords: Pikermi, Late Miocene, Turolian

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New Cranial Material of *Hipparion Sensu Lato* (perissodactyla, Mammalia) from the Classical Locality of Pikermi, Greece

V. Mitsopoulou¹, S. Roussiakis¹, A. Athanassiou², G. Lazaridis³, G. Theodorou¹

¹National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Historical Geology and Palaeontology, Zografou, GR-15784, Athens, Greece. vamitsop@geol.uoa.gr, srousiak@geol.uoa.gr, gtheodor@geol.uoa.gr

²Hellenic Ministry of Culture, Ephorate of Palaeoanthropology-Speleology, Ardittou 34B, GR-11636 Athens, Greece. aathanas@geol.uoa.gr

³Aristotle University of Thessaloniki, Faculty of Sciences, School of Geology, GR-54124, Thessaloniki, Greece. georgelazarides@yahoo.com

This abstract refers to the biometric study of unpublished hipparionine material from the classical locality of Pikermi (Attica, Greece) stored at the Museum of Geology and Palaeontology (University of Athens). The age of the Pikermi fauna is considered as Late Miocene (middle Turolian, MN 12). The material studied comes from old excavations and includes cranial, mandibular and dental specimens of adult individuals. Two hipparionine horses, are identified, the *Cremohipparion mediterraneum* (Roth and Wagner, 1855) and the *Hippotherium brachypus* (Hensel, 1862).

Cremohipparion mediterraneum is characterised mainly by the small snout and the less elongated skull compared to the second species. The praeorbital fossa is placed close to the orbital one and the choanae are wide. The upper and lower cheek teeth are relatively small, demonstrate usually simple enamel plication in moderate wear stage and have short and wide plis. Furthermore, the protocone is usually subtriangular. Biometrical observations of the *Hippotherium brachypus* indicate that its skull is elongated, with long snout. The praeorbital fossa is far from the orbital fossa and the choanae are relatively narrow. The rostral margin of the choanae terminates at the level of the M3 paracone. The praeorbital fossa is deep and oval, pocketed caudally. The upper and lower cheek teeth are long, with deep and narrow plis.

Previous studies have documented the existence of at least two fossiliferous layers at the classical locality of Pikermi. Theodorou and Nicolaides (1988) have questioned the co-existence of the two hipparionine species in each layer. However, results from Theodorou *et al.* (2010) as well as data from this study provided evidence of the co-existence of the two species in the same layer.

Keywords: *Cremohipparion mediterraneum*, *Hippotherium brachypus*, *Hipparion*, biometry, Late Miocene, Pikermi.

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Paleontology, Biochronology and Palaeoecology of the Greek Hipparionine Horses

Theodora D. Vlachou¹, George D. Koufos¹

¹Aristotle University of Thessaloniki. Department of Geology. Laboratory of Geology and Palaeontology. GR-54124 Thessaloniki, Greece. dovla@math.auth.gr; koufos@geo.auth.gr

In this study, sixteen Hipparion species have been recognized in 24 fossiliferous well-known Greek sites. Seven of them are recognized in Greece for first time whereas nine species are revised. Nine Hipparion biozones, with significant differences between them, have been identified, five for Continental Greece and four for East Aegean. Morphological comparisons between specimens revealed four morphological groups referred to as "morphotypes".

The Eastern Mediterranean primigenium-morphotype includes species of the same evolutionary lineage; *H. sebastopolitanum* has the most primitive morphology and probably is directly derived from the first hipparionine immigrant. The macedonicum-morphotype develops in two parallel lineages, converging backwardly to a common ancestor, probably *H. minus* from the Black Sea area or a related form. The dietrichi-morphotype evolved in two main branches. One includes *H. cf. dietrichi* and probably originates from a member of the macedonicum-morphotype, whereas the second includes the typical form of *H. dietrichi* and derives either from *H. cf. dietrichi* or from a member of the primigenium-morphotype. It is presumed that aff. *H. forstenaei* is an additional lineage of the dietrichi- or macedonicum-morphotype which was separated from the *H. macedonicum*-*H. cf. dietrichi* lineage during MN11. The proboscideum-morphotype derived from the primigenium-morphotype, with *H. moldavicum* as an intermediate form between the two morphologies. *H. mediterraneum* possibly derived from *H. proboscideum* as a result of climatic changes. Alternatively, it might have derived directly from *H. moldavicum* in the early MN12 as an adaptation to the new ecological conditions.

During Vallesian, the environment is thought to be open and relatively humid. It became drier at the end of MN10, while during MN12 the Hipparion fauna suggests a warm and dry environment which was more wet with grasslands in the southern Balkans. During MN13, paleoclimatic changes affect both areas, causing significant changes in the palaeoenvironment, being more wet with several water spots. The Hipparion fauna shows that there are no natural barriers preventing the dispersal of the North American Hipparion ancestor throughout Eurasia during MN 9. During MN 10 Southern Balkans isolated from Asia Minor until the early MN12, due to active tectonics. This isolation caused different faunas in the two areas, suggesting heterogeneity in the Greco-Iranian Province. Around 7.3-7.2 Ma, changes in the Mediterranean Sea hydrography led to temporary connections of areas across the Aegean Sea, which allowed mammalian species exchanges. From 7.2 Ma onwards, faunal differences between the Balkans and Asia Minor are obvious, possibly related to paleoecological changes in both areas.

Keywords: Hipparions, Greece, biochronology, palaeoecology, palaeobiogeography

The Late Miocene Proboscideans of Greece: Taxonomy, Biochronology, Palaeoecology

George E. Konidaris¹, George D. Koufos¹

¹Aristotle University of Thessaloniki. Department of Geology. Laboratory of Geology and Palaeontology.
GR- 54124 Thessaloniki, Greece; e-mail: georgeko@geo.auth.gr; koufos@geo.auth.gr

The late Miocene proboscideans of Greece, although they are known since the middle of the 19th Century, they have never been studied in detail. Their collection includes numerous specimens and increased remarkably during the last decades by the excavations in the Axios Valley and Nikiti (Macedonia, Greece), as well as in Samos Island (Central-Eastern Aegean Sea). The detailed study of this material provided significant results concerning their taxonomy, evolution, biochronology and palaeoecology.

The deinotheriids are represented by two species, *Deinotherium giganteum* and *Deinotherium gigantissimum* (= *D. proavum*). The former is recognized in the late Vallesian of Axios Valley and the latter in the Turolian of Samos, Pikermi (Attica), Halmyropotamos (Euboea) and Perivolaki (Thessaly). The mammutids, present in the Turolian of Axios Valley, Samos, Pikermi and Halmyropotamos, belong to “*Mammut*” sp. The choerolophodont material belongs to the genus *Choerolophodon*, which dominates in all late Miocene localities of Greece. Two species and three evolutionary stages of *Choerolophodon* have been recognized in the late Miocene of the peri-Mediterranean region. The more primitive species *C. anatolicus*, recognized in the early Vallesian of Axios Valley, corresponds to the first evolutionary stage. The advanced species *C. pentelici*, known from Pikermi, Samos, Axios Valley and Nikiti, can be distinguished in two stages: a primitive one recognized in the late Vallesian and an advanced one in the Turolian. The cladistic analysis of the Miocene Old World *Choerolophodon* taxa proposes that *C. anatolicus* is a sister group of *C. corrugatus* and *C. pentelici*. The study of the Pikermi tetralophodont material indicates that two late Miocene species, “*Tetralophodon*” *atticus* and “*Mastodon*” *grandincisivus*, are synonyms. The morphology of the Pikermi tetralophodonts allowed their attribution to the tetralophodont shovel-tusker *Konobelodon atticus*. This species encompasses all Turolian tetralophodont shovel-tuskers from Eastern Europe-Western Asia. In Greece it is also present at Samos and Kerassia (Euboea). The Chomateri (Attica, Turolian) material belongs to *Anancus* sp., representing the first evidence of the genus in the late Miocene of Greece.

Concerning biochronology, the genus *Deinotherium* is known from the Vallesian with the species *D. giganteum* and from the Turolian with *D. gigantissimum*. “*Mammut*” sp. is known from the early and middle Turolian. *Choerolophodon anatolicus* is present in the early Vallesian (MN 9), whereas *C. pentelici* has a longer stratigraphic distribution; its primitive form is known from the late Vallesian (MN 10), while the most advanced one covers the entire Turolian (MN 11-13). *Konobelodon atticus* is known from the middle Turolian of Pikermi, whereas its presence at Samos cannot be dated because it lacks locality information.

The dental microwear analysis of *Choerolophodon* from Axios Valley and Nikiti indicates an open environment. These results fit well with previous palaeoecological studies of the late Miocene faunas of Greece. Moreover, the absence of *Tetralophodon* from the Vallesian deposits of Axios Valley and the wider area is probably due to the different palaeoecological conditions between Central and Southeastern Europe. This is probably the reason why *Choerolophodon* could not migrate to Central Europe, although it was widespread in the Greco-Iranian Province. During the Turolian, the coexistence of *Deinotherium gigantissimum*, “*Mammut*” sp., *Choerolophodon pentelici* and *Konobelodon atticus* is probably attributed to the different ecological niches that they occupied. The appearance of *Anancus* in the second half of Turolian coincides with the gradual transition to a more closed environment and more humid conditions towards the end of Turolian.

Keywords: Proboscidea, Late Miocene, Greece, biochronology, palaeoecology

The Insectivores (Lipotyphla, Mammalia) from Hayranlı and Düzyayla (Sivas Basin, Central Anatolia): A Contribution to the Miocene Biostratigraphy from Turkey

Marc Furió¹, Jan van Dam^{1,2}, Ferhat Kaya³

¹ Institut Català de Paleontologia Miquel Crusafont. Edifici ICP, Campus de la UAB (08193) Cerdanyola del Vallès (Barcelona), Spain. marc.furio@icp.cat, jan.vandam@icp.cat

² Department of Earth Sciences, Utrecht University, Budapestlaan 4, 3584 CD, Utrecht, the Netherlands

³ Department of Geosciences and Geography, University of Helsinki, PO Box 64 (Gustaf Hållströmin katu 2a), 00014 Helsinki, Finland. ferhat.kaya@helsinki.fi

The ages of Hayranlı and Düzyayla, two continental fossil sites from the Sivas Basin, are controversial. Different authors have ascribed them to MN 10, MN 11 or MN 12 zones (Bibi and Güleç, 2008; De Bruijn *et al.*, 1999; Ünay *et al.*, 2003; Van der Made *et al.*, 2013) depending on the approach employed. In this work, we studied the fossil insectivores from these two Turkish Miocene localities. The faunal content is almost identical in the two sites, including one erinaceid (*Schizogalerix sinapensis*), five soricids (*Paenelimnoecus* sp., *Amblycoptus oligodon*, *Petenyia dubia*, *Soricinae* indet. and *Crocicurinae/Crocidosoricinae* indet.), and two talpids (*Desmanella* aff. *cingulata* and *Desmanodon* sp.). Such similarity in both sites, only differing in the absence of *Paenelimnoecus* in Düzyayla, suggests that they are not significantly different in age. From the biostratigraphical point of view, *S. sinapensis* is a common form during the Late Miocene in Turkey (Şen, 1990; Selänne, 2003). *Petenyia dubia* is also a typical species of the Turolian in Europe, with a few occurrences in Vallesian localities. *Desmanella*, *Paenelimnoecus*, and the two unknown species of *Soricidae*, do not provide further resolution on this issue. However, because of its restrictive biostratigraphical range and its high abundance, the presence of *A. oligodon* is indicative of MN 12 or MN 13 in Europe (Van Dam, 2004). The size and the primitive features of the form present in these two Turkish localities suggest its ascription to the MN 12 zone. Nonetheless, the occurrence of a *Desmanodon* species is consequently the youngest record of this genus up to date. This new biostratigraphical range of *Desmanodon*, longer in Turkey than in Central Europe, has probably a paleoenvironmental meaning.

Acknowledgements:

This study received support from Spanish Ministerio de Economía y Competitividad (Project CGL2011-28681) and AGAUR - Generalitat de Catalunya (PIPH- 2009 SGR 754).

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Late Miocene Terrestrial Biotic Record in the Northern Caucasus

V. V. Titov¹, A. S. Tesakov², E. V. Syromyatnikova³, A. N. Simakova², M. V. Sotnikova², P. D. Frolov²

¹Institute of arid zones SSC RAS, Chekhov str., 41, 344006, Rostov-on-Don, Russia; vvtitov@yandex.ru

²Geological Institute of RAS, Pyzhevsky, 7, 119017, Moscow, Russia; tesak@ginras.ru, simak2001@mail.ru, sotnikmarina@yandex.ru, Pavlenty987@mail.ru

³Zoological Institute of RAS, Universitetskaya, 1, 199034, Saint-Petersburg, Russia; esyromyatnikova@gmail.com

Late Miocene terrestrial biota of the Northern Caucasus has been increasingly known during the last decade [1, 2]. The oldest Turolian faunas are associated with the base of continental to brackish water Gaverdovsky Fm. overlying Late Sarmatian (Khersonian) deposits in the Belaya River valley near Maikop city. Coeval Gaverdovsky and Fortepianka sites (MN11) yielded rich terrestrial vertebrate fauna including *Mioproteus caucasicus*, *Chelotriton* sp., *Palaeobatrachus* sp., *Emys* sp., *Testudo* sp., *Pseudopus pannonicus*, *Lacertidae* indet., *Colubrinae* indet., *Ochotona* sp., *Paragrilulus schultzi*, *Eozapus intermedius*, *Parapodemus lugdunensis*, *Pseudocricetus* sp., *Cremohipparion* cf. *moldavicum*, *Procacpreolus* sp. and other forms. Fresh-water and land molluscs association and palynology suggest conditions of stagnant lake or river (*Lymnaea*, *Planorbarius*) with mixed conifer-broad leaved forests along the banks. Mammalian fauna from the continental Armavir Fm overlying Khersonian marine deposits in the Kuban River valley near Armavir city is tentatively correlated with middle Turolian, MN12. The fauna includes *Chilotherium* cf. *schlosseri*, cf. *Cremohipparion* sp., *Hippotherium* sp., *Gazella* cf. *pilgrimi*, *Procacpreolus* sp., *Miotragocerus* sp., *Amblyoptus oligodon*, *Prolagus* sp., *Pseudocricetus* cf. *orienteuropaeus*. Another middle Turolian record is associated with the Yanov Fm (Yanovka, Obukhovka sites) in the Lower Don area near Novocheerkassk. This Maeotian-correlated continental formation overlies Late Sarmatian and covered by Lower Pontian deposits. This fauna contains *Deinotherium* cf. *giganteum*, "Mammut" cf. *praetypicum*, *Mammut* cf. *borsoni*, "Palaeoryx" *longicephalus*. Late Turolian, MN13 is represented by the fauna of Morskaya 2, coastal zone of the Sea of Azov between Taganrog and Rostov-on-Don. Lacustrine deposits with bones of vertebrates and fresh-water molluscs expose between underlying Middle Sarmatian (Bessarabian) marine deposits and overlying Early Pleistocene continental Khapry Fm. Fresh-water molluscs (*Lithoglyphus*, *Gyraulus*) and palynology indicate conditions of slowly flowing river and dominant open steppe landscapes along its banks. The fauna includes *Sakya riabinini*, "Melanochelys" *mossoczyi*, *Emys sukhani*, *Testudinidae* indet. 1 & 2, *Testudo* s.s., *Chelydridae* indet., *Mammut* cf. *borsoni*, *Cremohipparion* cf. *moldavicum*, ?*Indarctos* sp., *Pilgrimeles woodwardi*, *Promephitis* cf. *maeotica*, *Hyaenotherium wongii*, *Pristifelis attica*, *Hypolagus igromovi*, *Pseudocricetus kormosi*, *Kowalskia* sp., *Apodemus gudrunae*, *Micromys* sp., *Hansdebruijnina* aff. *neutrum* and other forms. Another rich Late Turolian fauna occurs near Solnechnodolsk in the Egorlyk River valley SW of Stavropol city. The fauna is confined to alluvial sediments incised into Bessarabian marine deposits. The fauna includes *Sakya* sp., *Geoemydidae* indet., *Testudinidae* indet., *Chelydridae* indet., *Cremohipparion* sp., *Muntiacus* sp., *Cervavitus* sp., *Gazella* sp., *Pilgrimeles woodwardi*, *Pristifelis attica*, *Prolagus* gr. *michauchi-sorbini*, *Hypolagus igromovi*, *Micromys* sp., *Apodemus gorafensis*, *Pseudocricetus kormosi* and other forms. Most faunas have strong European affinities, indicated, for example, by mastodons and lagomorphs *Prolagus*. Apart from species and genera that have large trans-Palaearctic ranges, the presence of lophodont lophocricetines (*Sibirosmintus*), microtoid hamsters, and camels (*Paracamelus*) during Late Turolian mark immigrations from Asia.

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Murids of the Genus *Hansdebruijnina* in Late Miocene of the Peri-Black Sea

A.S. Tesakov¹

¹Geological Institute of RAS, Pyzhevsky 7, 119017 Moscow, Russia

Murids of the genus *Hansdebruijnina* are common in Turolian faunas of Greece, Turkey, Ukraine and Moldova. The type species from the classical Pikermi-Chomateri (MN12) site was originally referred to the genus *Occitanomys* (de Bruijn, 1976). The rich material of the species was studied from Maramena (MN13) by Storch & Dahlmann (1995). Based on unique combination of broad M1-2 with t12 and lacking t7, m1 with tma, and incipient stephanodonty, these authors described a new genus *Hansdebruijnina*. Several forms from Turolian of China, like primitive *H. perpusilla* from Baogedawula, equivalent of MN11-12 (Storch, Ni, 2002) and advanced *H. pusilla* from Ertemte, MN13 (Storch, 1987), indicate large range of the genus and a radiation with several lineages. Records of *H. perpusilla* from presumable early Turolian of Ukraine (Nesin, Storch, 2004), and a large specialized *H. erksinae* from Çorakyerler (MN11) in Turkey (Ünay, 2006) further complicate the story. Recently a relatively large sample of *H. aff. neutrum* was unearthed in Russian locality Morskaya 2 (MN13) near Rostov-on-Don (Titov et al., 2006). This sample is distinct from the type species in higher stephanodoty, and additionally from the Maramena sample, by lack of t1bis. Another recent find of *H. neutrum* comes from the late Turolian locality Solnechnodolsk (Stavropol Region, Russia) (Titov, Tesakov, 2013). The large transcontinental distribution and a short Late Miocene stratigraphic range of the genus emphasize its importance for biostratigraphic correlations. This study was supported by the Russian Foundation for Basic Research, projects 12-04-01691-a, 12-05-00904-a, 12-05-91372-CT-a.

Keywords: Eastern Europe, Rodentia, Muridae, Late Miocene

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Staniantzi – An exceptional Vertebrate Locality from the Miocene-pliocene Transition of Western Bulgaria

Madelaine Böhme¹, M. Aiglstorfer¹, L. Bullmann¹, M. Dolezych³, P. Havlik¹, L. Hristova², A. Ilg⁴, G. Markov², N. Ognjanova⁵, J. Prieto¹, D. Uhl^{1,6}, D. Vasilyan¹, N. Spassov²

¹ Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

² National Museum of Natural History, Bulgarian Academy of Sciences, 1-Tzar Osvoboditel Blvd., 1000, Sofia, Bulgaria

³ Senckenberg Naturhistorische Sammlungen Dresden, Königsbrücker Landstr. 159, 01109 Dresden, Germany

⁴ Schumannstrasse 83, Düsseldorf 40237, Germany

⁵ Department of Paleontology, Stratigraphy and Sedimentology, Geological Institute, Bulgarian Academy of Sciences, Acad.G.Bonchev-Street Build. 24, 1113 Sofia, Bulgaria

⁶ Senckenberg Forschungsinstitut und Naturmuseum, Senckenberganlage 25, 60325 Frankfurt am Main, Germany

The Miocene-Pliocene transition is a controversially discussed chronostratigraphic period in the Eastern Paratethys area. This is mainly because of the highly endemic marine to brackishwater faunas inhabiting this inland sea. Stratigraphic investigations are also hampered by accelerated tectonic activities and pronounced climatic changes in the region. On the other hand, the period covering the regional stages Pontian and Kimmerian is crucial for our understanding of Mediterranean processes and environmental crises, both in the sea and on land.

In the terrestrial realm this time period is characterized by a long term change from highly seasonal ecosystems of the Pikermian biome to low seasonal forested environment of the early Ruscinian. Not only the timing, but also the processes of this change are currently not understood.

In this framework, a German-Bulgarian field-project was started in 2010, and several small Neogene basins were investigated in Western Bulgaria. One of them, the Staniantzi-Masgosh basin, is situated 50 km north-northwest of Sofia. It is a 3 km long, northwest-southeast trending intramontane basin, covering the Bulgarian-Serbian border. The Staniantzi brown-coal mine exposes a >50 meter thick section, showing several erosional hiatuses and a great variety of sedimentary facies (e.g. lignite, xylite, lignitic/xylitic clay, marl, lacustrine chalk, travertine, caliche, fine-sand, conglomerate, breccia). A main characteristic feature of the overall swampy sedimentation is the cyclic change. Each cycle ends with xyloliths containing charcoal layers or with thick caliche horizons, both suggesting a strong climatic forcing of sedimentation.

The vertebrate fauna is exceptional in diversity and preservation. Our excavations recovered 15 distinct vertebrate horizons, containing mostly disarticulated bones, but also partial skeletons. We identified about 50 vertebrate species, belonging to all major vertebrate groups (fishes, amphibians, reptiles, birds, mammals). The fauna is remarkable because of the taxonomic composition and the environmental spectrum covered by some species. We found large mammal species typical for Turolian faunas (e.g. the bear cf. *Ursavus*, and both rhinos *Chilotherium* and *Ceratotherium neumayeri*) as well as Ruscinian faunas (e.g. the horse *Hipparion* cf. *crassum*, the tapirid *Tapirus* aff. *arvernensis*, and the elephantoid *Anancus* cf. *arvernensis*). The fauna contains swamp and moist forest dwellers (e.g. tapir, pigs, desman, divers and abundant deers and castorids), but also elements commonly attributed to dry and open environments (e.g. thick-shelled ostrich, *Chilotherium*).

The bulk of large mammals points to a very late Turolian age and contains the last *Chilotherium* of the continent. In addition it may already contain the earliest Ruscinian immigrants, which probably mark the waves of the first invasions of these forms in the end of the Turolian. Indeed, biostratigraphic investigations suggest an age at the very end of the Miocene (Celadensia-like microtoid rodent but no real vole), between 5.8 and 5.35 Ma, which favors a correlation with the Portaferrian to early Bosphorion of the Dacian basin, coeval with the Messinian Salinity Crisis (Krijgsman al. 2010).

Of comparable age is the well-known locality of Maramena (northern Greece), however their vertebrate fauna is quite distinct in taxonomic and ecologic composition. If this reflects bioprovinciality or fast faunistic and environmental changes needs to be elaborated by further scientific investigations. However, the stratigraphic position near the Miocene-Pliocene and the Turolian-Ruscinian transitions make Staniantzi an especially important locality within the European context.

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Paleobiogeographical Implications of Fossil Mammals from Piedmont (NW Italy) during the Latest Messinian

**Simone Colombero¹, David M. Alba^{2,1}, Giorgio Carnevale¹, Massimo Delfino^{1,2}, Paul Mazza³,
Giulio Pavia¹, Marco Pavia¹, Gianni Repetto⁴**

¹ Università di Torino, Dipartimento di Scienze della Terra, Via Valperga Caluso, 35, 10125 Torino, Italy, simone.colombero@unito.it; giorgio.carnevale@unito.it; massimo.delfino@unito.it;

giulio.pavia@unito.it; marco.pavia@unito.it

² Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICP, Campus de la UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain, david.alba@icp.cat

³ Università di Firenze, Dipartimento di Scienze della Terra, Via La Pira 4, 50121 Firenze, Italy, paul.mazza@unifi.it

⁴ Museo “F. Eusebio”, Via V. Emanuele 19, Alba, Italy, gianrepetto@yahoo.it

During the latest Messinian, significant mammal events occurred in the northern sectors of the proto-Mediterranean. Both in western and eastern Europe, taxa of African and Asian origin occupied the southernmost areas of the continent in particular during and immediately before the Messinian Salinity Crisis (MSC: 6.2-5.3 Ma). The Italian record of Messinian non-endemic mammals was hitherto restricted to very few localities, most of which located in central Italy. This permitted only a partial view of the biogeographical relationships that existed between Italy and other regions of Europe. Two uppermost Messinian, vertebrate fossil-bearing localities were recently discovered in the Tertiary Piedmont Basin (TPB), NW Italy: Moncucco Torinese and Verduno. The deposits correlate stratigraphically with the post-evaporitic phase of the MSC and can therefore be dated to between 5.55 and 5.33 Ma. Both sites have yielded rich and diverse faunas, some of which most significant paleobiogeographically. Some are ubiquitous and are reported from both eastern and western sectors of the Mediterranean. These include the murids *Paraethomys meini* and *Apodemus gudrunae*, the rhinocerotid *Dihoplus*, the hipparionin equid *Cremhipparion*, the antilopine bovid *Gazella* and the machairodontine felid *Amphimachairodus*. This suggests that latest Turolian faunal communities were quite uniformly distributed throughout southern Europe. In contrast, other taxa suggest a more complex scenario. At Verduno, remains of *Paracamelus* indicate that, during the latest Messinian, large camelids were spread to northernmost Mediterranean areas. This datum has significant biogeographical implications, because camelids were previously known only from uppermost Messinian deposits of Spain and were thus thought to enter Europe from northern Africa. The occurrence of *Paracamelus* in Piedmont suggests its possible arrival from Asia, and, in fact, the taxon is reported from the lower Pontian of eastern Europe. At Moncucco, the colobine monkey *Mesopithecus* is associated with the papionin cercopithecine *Macaca*, of African origin. This datum supports the view that the dispersal of macaques into Europe was linked to the MSC, as previously suggested by the roughly contemporaneous occurrence of the genus *Macaca* in Spain. The small mammal community includes both eastern European immigrants, such as *Occitanomys brailloni* and *Micromys bendai*, and western immigrants, as the cricetine *Apocricetus*.

Relationships between the Piedmont area and central Italy are implied by the iocerin antelope *Paraioceros occidentalis*, the canid *Eucyon monticiniensis* and the small murid *Centralomys benericettii*. The onset of the MSC likely made geographical and climate barriers less effective in limiting faunal exchanges. The ensuing widespread distribution of cosmopolitan species may account for the faunal uniformity observed in the peri-Mediterranean area at the end of the Messinian. Owing to its pivotal location in Europe, NW Italy played a crucial paleobiogeographical role in Europe at the end of the Messinian. In particular, the Piedmont area was at a key-crossroads on the route between eastern and western Mediterranean Europe, as well as towards the Apennine sectors of the rising Italian peninsula.

Keywords: Dispersals, Italy, Mammals, Messinian Salinity Crisis

The Italian Late Miocene Continental Vertebrates, a Bridge between Western and Eastern Europe

G. Carnevale¹, S. Colombero¹, M. Delfino^{1,2}, F. Masini³, P. Mazza⁴, E. Patacca⁵, G. Pavia¹, M. Pavia¹, G. Repetto⁶, A. Savorelli⁴, P. Scandone⁵

¹ University of Turin, Department of Earth Science, Via Valperga Caluso, 35, 10125 Turin, Italy, gianrepetto@yahoo.it

² Universitat Autònoma de Barcelona, Institut Català de Paleontologia Miquel Crusafont, Edifici ICP, Campus de la UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain

³ University of Palermo, Department of Earth and Sea Sciences, Via Archirafi 22, 90123 Palermo, Italy,

⁴ University of Firenze, Department of Earth Science, Via La Pira 4, 50121 Florence, Italy,

⁵ University of Pisa, Department of Earth Science, Via S. Maria 53 - 56126 Pisa, 50121

⁶ Museum "F. Eusebio", Via V. Emanuele 19, Alba

The evolution of the paleobiogeography of the central Mediterranean, and of Italy in particular, is presented in a set of time-slices. Landmass movements and the erection of mountain ridges of the Alpine orogenesis explain the isolation, mixture, or extinction of populations through time. In turn, the change of faunal communities yields crucial information for testing geological reconstructions and models.

Early Oligocene- earliest Miocene; Subduction processes active during the Oligocene–Miocene caused the opening of the Balearic basin, the Sardinian rift, the Tyrrhenian sea and the formation of the Apennines. During the Rupelian–Chattian transition the Corsica–Sardinia microplate was still connected with the European continent. Anthracotheres reached what would become Calabria. A Sardinian early Miocene herpetofauna includes taxa that dispersed before the separation from the mainland. A set of uplifted, shallow-water carbonate platforms separated by shallow- to deep-marine basins characterized the Apennine domains wedged between the Paleogene Apennine Chain and the Dinarides. The Apulia Platform is the easternmost of these structural highs. It formed a vast land connected, through a trans-Adriatic landbridge, with the Balkan mainland.

During the earliest Miocene Asian ctenodactyls colonized Sardinia. Italy then disappears from the terrestrial fossil records for the whole early-middle Miocene time span.

Early-middle Miocene; During the late Burdigalian, the Calabrian and Peloritan Arc started separating from the Corsica–Sardinia microplate. The evolution of the northern Tyrrhenian area created the Tusco–Sardinian paleobioprovince which kept connected with the European mainland to at least the early middle Miocene. Then, it remained isolated until the early Messinian, and its fauna endemised. An Albatross comes from the marine sediments accumulated between the Tusco–Sardinian paleobioprovince and the European mainland.

The trans-Adriatic landbridge gradually sank. Through this temporary connection insectivores, and rodents might have reached the Apulia Platform. From around 14.8 Ma this land remained isolated, possibly until the early Tortonian.

Tortonian; The Apulia Platform was populated by chelonians and crocodiles (the latter likely from Africa), plus sets of endemic taxa, Hoplitomerycidae, Deinogalerix, a giant bird.

The Tusco–Sardinian paleobioprovince was colonized from Europe, and possibly also from Africa. The Tusco–Sardinian paleobioprovince sustained the rich Oreopithecus Zone Faunas.

Migrating eastward, the Calabrian and Peloritan Arc connected with North Africa and were invaded by bovids, hippopotamids, giraffids, rhinos, and elephantids. Sometaxa are in common with the Pikermian biome, while others are typical Afro-Arabian species.

Messinian; The Calabrian and Peloritan Arc kept connected with North Africa enabling the colonization by faunas of both African and European origin.

The Tusco–Sardinian paleobioprovince re-connected with the European mainland. Its fauna was renewed by new incomers, i.e., hipparionin equids, tapirs, rhinos, hippopotamids, suids, cervids, giraffids, new bovids, numerous new carnivores, new primates, and small mammals. Piedmont was a cross-road for faunas coming from western and eastern areas of the European continent and directed to the Tusco–Sardinian paleobioprovince, at west, and the Northern Apennine and its outer border, at southeast.

As the Tyrrhenian sea kept opening, the Apennine domain was disrupted. The orogenic wedge stacked over the Adriatic foreland, involving the western margin of the Apulia Platform. The trans-Adriatic connection with the Balkan mainland was temporarily re-established and small mammals added to the faunal communities that were living in the foreland sector of the Abruzzo–Apulian land.

Freshwater and paralic fishes are not uncommon in Messinian deposits of Italy. Few freshwater taxa of Nilotic–Sudanian origin were found in Piedmont, Romagna, Marche and Abruzzo. Salmonids and cyprinids exhibit a clear European affinity.

Remains of many different bird orders are preserved in the typical Messinian laminate deposits of Italy. More than 40 bird taxa come from the Gargano area. Some show a high degree of endemism, while others are of European origin.

Acknowledgements:

This research was financially supported by PRIN (Research Projects of National Interest) 2009 MIUR (Ministry of Education, University and Research) grants.

New Data on the Neogene Turtles of European Russia

E. V. Syromyatnikova¹, I. G. Danilov¹, V. V. Titov², A. S. Tesakov³

¹Zoological Institute of RAS, Universitetskaya 1, 199034 Saint-Petersburg, Russia

²Institute of Arid zones, SSC RAS, Chekhova 41, 344006 Rostov-on-Don, Russia

³Geological Institute of RAS, Pyzhevsky 7, 119017 Moscow, Russia

Turtles are known from numerous Neogene localities of Eastern Europe and usually dominate in vertebrate assemblages by number of remains (Chkhikvadze, 1983). Besides families Emydidae, Testudinidae and Geoemydidae, which are present in Europe nowadays, in the Neogene there were turtle groups (Chelydridae, Trionychidae), which are absent from the modern fauna of Europe. The Neogene record of turtles in European Russia is primarily based on fragmentary and isolated materials. As a result, this phase of turtle history has not been intensively investigated. During the last few years (2000–2012) abundant new materials on turtles were collected from several Pliocene and Miocene localities of European Russia. These materials are known from the following localities (in a chronological order). Maikop, middle Sarmatian (MN9-10): few shell fragments of Emydidae indet. (Emydidae or Geoemydidae, according to the modern system) and "Trionyx" khosatzkyi (Chkhikvadze, 1983). The new materials include additional remains of "T." khosatzkyi and epiplastron of Geoemydidae indet. (Sakya sp.?). Beshpagir Quarry, middle Sarmatian (MN9-10): shell fragments of Chelydropsis sp., Geoemydidae indet. 1 and 2, Testudinidae indet. 1 and 2. Gaverdovsky, late Sarmatian (MN11): few shell fragments of Emys sp. and Testudo sp. Coeval fauna of Fortepianka: numerous fragments of Emys sp., Geoemydidae indet. 1 and 2, Testudo s.s. and Testudinidae indet. Merzhanovo, middle Turolian (MN12): remains of a single individual of Emys sp. Morskaya 2, late Turolian (MN13): numerous shell plates of Sakya riabinini, "Melanochelys" mossoczyi, Emys sukhonovi, Testudinidae indet. 1 and 2, Testudo s.s. and Chelydridae indet. (Danilov *et al.*, 2010). Razdorskaya, Lower Pontian, late Turolian (MN13): a few shell plates of "Melanochelys" sp., Sakya sp., Emys sp., Chelydridae indet. and Testudinidae indet. Solnechnodolsk, late Turolian (MN13): Sakya sp., Geoemydidae indet. and Testudinidae indet. (Tesakov *et al.*, 2010). The new material is represented by the all mentioned forms and Chelydridae indet. Kurgannyi, late Turolian–early Ruscinian (MN13-14): about 50 shell plates of Testudinidae indet. Coeval fauna of Nizhnij Vodyanoi: Agrionemys caucasica, Testudo chernovi (= T. kuchurganica), Testudinidae indet. and Protestudo sp. (Syromyatnikova *et al.*, 2011). The newly collected material is represented by the entoplastron of Sakya sp. New data on the Neogene turtles of European Russia show high diversity of the Late Miocene and Early Pliocene turtle faunas of this region and their strong similarity to synchronous faunas of Ukraine. This study was done under financial support of grant of the President of the Russian Federation to the Leading Scientific Schools (NSh-6560.2012.4).

Keywords: European Russia, turtles, Neogene.

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Fossil Otters from the Early-Middle Pleistocene of Italy: New Insights into the Mediterranean Lutrinae Evolutionary History

Marco Cherin¹, Luca Bellucci², Dawid A. Iurino^{2,3}, Lorenzo Rook⁴, Raffaele Sardella^{2,3}, Gerard Willemsen⁵

¹Dipartimento di Scienze della Terra, Perugia University, Piazza Università, 06123 Perugia, Italy; marco.cherin@gmail.com.

²IsIPU, Istituto Italiano di Paleontologia Umana, Via Aldrovandi 16/18, 00197 Rome, Italy; lucabellucci@isipu.org; dawid.iurino@uniroma1.it; raffaele.sardella@uniroma1.it.

³Dipartimento di Scienze della Terra, Sapienza University of Rome, Piazzale A. Moro 5, 00185 Rome, Italy.

⁴Dipartimento di Scienze della Terra, Florence University, Via G. La Pira 4, 50121 Florence, Italy; lorenzo.rook@unifi.it.

⁵Sjöbacken 57, 16565 Håsselby, Sweden; gerard.willemsen@skutan.eu.

Lutrinae is a subfamily of Mustelidae today represented by six genera and thirteen species of aquatic or semiaquatic mammals (commonly known as otters). Compared to other carnivores, otters are very rare in the fossil record. The oldest representative of the subfamily is *Mionictis* from the early Miocene of France, while the genus *Lutra* is not known before the Pliocene, when the early Ruscinian species *L. affinis* appears, probably evolving from a *Paralutra*-like form.

Villafranchian otters are virtually unknown in Europe. The only reported taxon is the cryptic *L. bravardi*, described in the 19th century on the basis of a fragmentary right maxilla from Étouaires (France), but unfortunately the collocation of the holotype is unknown. The species is also dubitatively reported from Saint Vallier (France), Kisláng (Hungary), and Hajnacka I/2 (Slovakia). Additional fragmentary fossil otter (*Lutra* sp.) is reported from the middle Villafranchian site of Liventsovka (Russia). The genus *Lutra* is not reported in any late Villafranchian site. After this long ghost range in the fossil record, Lutrinae “re-appear” in the latest Early Pleistocene with the species *L. simplicidens*, a taxon suggested as ancestral to a number of middle/late Pleistocene endemic island species.

The discovery of new material from the late Villafranchian site of Pantalla (Umbria, central Italy) and the “re-discovery” of an undescribed specimen from the Upper Valdarno (Tuscany) within the historical collections of the Natural History Museum of London, allow us to partially fill the knowledge gap on early Pleistocene otters in the Mediterranean region.

The Tuscan specimen consists in an incomplete right mandible with M₁-M₂. It is labeled as *Lutra ausonia*. As a matter of fact the morphologic and morphometric features of the specimen are consistent with an attribution to *L. simplicidens*, thus representing the first occurrence of this taxon. This should not be surprising in the light of the occurrence of *L. fatimazohrae* from the earliest Pleistocene of Morocco, which could be ancestral to *L. simplicidens*.

The fossil otter from Pantalla is represented by the only Lutrinae complete cranium from the Early Pleistocene of Europe. A 3D virtual model of the specimen was created starting from CT-scans, in order to study the internal anatomy and to digitally correct the diagenetic deformation. Although the cranial anatomy of *L. simplicidens* is unknown to date, we can state that the otter from Pantalla belongs to a different, still undescribed species, in the light of the larger dimensions and some features of the robust upper teeth, which were probably adapted for feeding both on fish and hard-shelled invertebrates. As a consequence, the fossil otter from Pantalla is doubly important because it testifies the occurrence of a new Lutrinae taxon during the Early Pleistocene, in addition to the *L. simplicidens* lineage.

The complex framework of the evolutionary history of otters in the Mediterranean region is enriched by a third unpublished fossil from Italy: a nearly complete mandible from the early middle Pleistocene of Calorie (S Italy) referred to a yet unknown very large-sized species.

Keywords: *Lutra*, Lutrinae, Pleistocene, Villafranchian, Italy

Mammalian Faunal Stability and Change in the Middle and Late Miocene Siwaliks of Pakistan: Time-Slice Analysis

M.E.Morgan¹, J.C. Barry², L.J. Flynn¹, D. Pilbeam², C. Badgley³, M.S. Domingo⁴, & A.K. Behrensmeyer⁵

¹Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, MA, USA, email: memorgan@fas.harvard.edu; ljflynn@fas.harvard.edu

²Department of Human Evolutionary Biology, Harvard University, Cambridge, MA, USA, email: jcbarry@fas.harvard.edu; pilbeam@fas.harvard.edu

³Department of Ecology and Evolutionary Biology, University of Michigan, Ann Arbor, MI, USA, email: cbadgley@umich.edu

⁴Museum of Paleontology, University of Michigan, Ann Arbor, MI, USA, email: soledm@umich.edu

⁵Department of Paleobiology, Smithsonian Institution, Washington, DC, USA, email: behrensa@si.edu

The Siwalik Group fossil record of the Potwar Plateau in northern Pakistan preserves abundant fossil vertebrates. During the Neogene, the Siwalik faunal province of the Indian subcontinent, here defined as the Himalayan foreland basin extending from Pakistan to Thailand and bounded by the Himalayas to the north, was either connected to or isolated from Eurasia depending on tectonic processes and sea level fluctuations. Our current goal is to evaluate how different geological and climatic conditions influenced rates of immigration, extinction, speciation and change in the ecological structure of mammalian faunas during the Middle and Late Miocene.

Here we analyze the mammalian faunal record from six well-sampled 100-ky time slices spaced at roughly million-year intervals between 13.5 and 8.0 Ma to assess the degree of faunal stability and change. A refined biostratigraphic framework includes more than 20,000 specimens from over 500 fossil localities dated to between 14 and 7.5 Ma. Notable immigrant taxa include the first hominids at 12.7 Ma, equids at 10.8 Ma, doliochoerines at 10.2 Ma, and several small mammals including a large hedgehog by 11.4 Ma, dormice at 13.8 Ma, African cane rats at 13.1 Ma, and a modern gerbil at 8.8 Ma. However, endemism at the provincial level was very high, implying considerable geographic isolation from Eurasia to the west, north, and east. Notably absent from the Miocene Siwaliks are moles, hyraxes, and tapirs; other groups, including glirid rodents, cercopithecids, canids, ursids, and cervids, appear much later in the Siwaliks than in other parts of Eurasia. The Siwaliks preserve the latest-known representatives of adapid primates, amphicyonid carnivores, hyaenodontid creodonts, sivatheriine giraffids, and (for Asia) gundis (ctenodactylid rodents).

Species were assigned to one of three body-size categories to test whether patterns of faunal change occur similarly across differently sized mammals. Categories are: small (< 1 kg; fossils primarily recovered from screening sediment), large (1 – 800 kg), and mega (>800 kg). The mammalian fauna was quite stable across all size categories between 12.3 and 11.4 Ma, a period of global climatic stability. Before 10 Ma, small mammals appear to show the greatest variation in species richness, while large mammals exhibit the greatest variation in faunal turnover. Megaherbivores show the least variation in both diversity and faunal composition across all intervals. These patterns do not hold during the Late Miocene after equids began to consume C4 grasses at 10.1 Ma; these grasses became a dominant component of the vegetation as recorded by paleosol carbonates around 8 Ma. After 10 Ma, faunal turnover rates increased in small mammals and remained relatively high in large mammals.

The Siwalik fossil record provides an important comparison for Neogene fossil sequences and localities in the circum-Mediterranean region. With increased chronostratigraphic precision in many areas, it is now possible to evaluate faunal responses to tectonics and global climatic trends across regions and continents.

Keywords: Biostratigraphy, Biogeography, Diversity, Endemism, Body size.

SESSION 11

HOMINID EVOLUTION AND CLIMATE

CONVENERS

JORDI AGUSTI AND KATERINA HARVATI

A New Interpretation of Relationships among Eurasian and African Late Miocene Hominids

David R. Begun¹

¹University of Toronto Toronto, ON, M5S 2S2 Canada, begun@chass.utoronto.ca

The cranium of the late Miocene ape *Rudapithecus* includes a large number of characters interpreted as synapomorphies of the African ape and human clade (the hominines.) This, along with abundant evidence of mammal dispersals between Europe and Africa in the late Miocene, has led to the hypothesis that the African ape and human clade originated in Europe. Putative African hominines such as *Chorapithecus* and *Nakalipithecus* are only known from a fragmentary mandible and isolated teeth, and may or may not be hominines. Either way, they are at least two million years younger than the earliest hominines from Europe. New evidence suggests that hominines may have been more widespread in Eurasia. The recent description of a juvenile cranium of *Lufengpithecus* from Yuanmou (Yunnan province, China) has also revealed potential synapomorphies of the Homininae. In addition, Yuanmou and especially Shihuiba, the *Lufengpithecus* type locality, share with Rudabánya, the *Rudapithecus* type locality, similar environments of deposition (lake margin/swamp) and many mammalian taxa. Many carnivore genera are shared among these localities, including ailuropodids (pandas), which represents a strong biogeographic link between Europe and China. Many carnivore taxa from these late Miocene European hominine localities are also known from late Miocene East Africa hominine sites (Lothagam, Lukeino). Other genera shared among Eurasian late Miocene hominine localities include *Tetralophodon*, *Trogontherium*, *Tapirus*, *Propotamochoerus*, *Parachleuastochoerus*, *Dorcatherium*, *Micromeryx*, and *Kowalskia*, not to mention hominines and the stem catarrhine crouzelines. Dispersal events involving late Miocene hominines are likely to have been even more complex than suggested by the original Eurasian origins hypothesis.

Keywords: *Rudapithecus*, *Lufengpithecus*, hominine origins

Stable Isotope Ecology of Miocene Bovids from Hominid- and Cercopithecoid-bearing Sites from Northern Greece and the Ape/Monkey Turnover in the Balkans

Gildas Merceron¹, Louis de Bonis¹, George D. Koufos², Christophe Lecuyer³, Dimitris S. Kostopoulos²

¹ IPHEP UMR 7262 (CNRS, Université de Poitiers), France, gildas.merceron@univ-poitiers.fr

² Laboratory of Geology and Palaeontology, Aristotle University of Thessaloniki, Greece

³ Laboratoire de Géologie de Lyon (CNRS, Université Lyon1, ENS), France

The Eurasian continent was home to a radiation of hominids during the Miocene. All of them were extinct at the end of the Miocene in Western Eurasia. In this study, we investigate the hypothesis of climate and vegetation changes at local scale along the Axios River, Greece, while the cercopithecoid *Mesopithecus* replaced the hominid *Ouranopithecus* in the fossil record [1]. The present stable isotope analysis is an initial effort based on mammal's teeth framing the late Vallesian/early Turolian boundary in continental Greece. Because they are herbivorous and were much more abundant than primates, bovids are preferred to primates to investigate the hypothesis of climate change in the Balkans as cause of the hominid extinction.

By measuring the enamel carbon stable isotope ratios of bovids that co-evolved with either ape or monkey, we conclude that *Ouranopithecus* and *Mesopithecus* both evolved in pure C₃ environments [2]. The present study provides results coherent with earlier studies that all concluded the dominance of C₃ vegetation in Europe during the Miocene [3,4]. However, the large range of $\delta^{13}\text{C}$ values of apatite carbonate from bovids combined with their molar wear patterns preclude the presence of dense forested landscapes. Indeed, most of dental micro- and meso-wear analyses clearly support the co-existence of grazing and mixed feeding species, and therefore the presence of open habitats with abundant grasses in the herbaceous layer during the late Miocene in northern Greece [5].

Oxygen isotope compositions of phosphate from bulk samples did not lead to detect significant differences between-sites but between-species variations within each site [2]. There are different factors that influence oxygen isotope composition [6]. We especially discuss the rate of amelogenesis in regard to the high intra-tooth variations in $\delta^{18}\text{O}_\text{p}$ reflecting important amplitudes of seasonal variations in temperatures. Coldest monthly estimated temperatures are below 10°C and warmest monthly temperatures rose close to or above 20°C for the two time intervals. Climate with winter temperatures below 10°C for the cercopithecoids habitat are not actually unexpected because many monkeys today live in regions subjected to such harsh conditions. On the other hand, this picture sharply contrasts with the expected habitat for *Ouranopithecus* in regard to the present-day distribution of great apes. The late Miocene climate conditions are similar with the present-day situation in northern Greece, coherent with paleobotanical records but slightly different from climate models for the Eastern Mediterranean area that propose higher temperatures for winter and summer.

To sum up, no significant change in climate has been detected before and after the extinction of *Ouranopithecus* along the Axios River [2]. The absence of major climate change as *Mesopithecus* replaces *Ouranopithecus* in northern Greece was actually not so unexpected. Indeed, the recent discoveries of *Ouranopithecus*-like apes found together with typical Turolian mammals in Bulgaria and Turkey [7,8] (without any sympatric species of monkeys, however) depict a less abrupt extinction for great apes in Eastern Mediterranean area.

Keywords: Hominid; Europe; Stable Isotopes; Environment; Climate

Acknowledgments:

Field excavations in Greece are currently supported by a PICS-5185 CNRS grant (PIs: Merceron & Kostopoulos). This study was supported by a research grant funding by the FYSSSEN Foundation, France (<http://www.fondationfyssen.fr/>; PI: G. Merceron).

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The End of the Miocene Hominoid Experiment in Europe. Still a lot to be Explained

Isaac Casanovas-Vilar¹, David M. Alba^{1,2}, Josep M. Marmi¹, Salvador Moyà-Solà³

¹Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Edifici ICP, Campus de UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain. isaac.casanovas@icp.cat, david.alba@icp.cat, josep.marmi@icp.cat

²Dipartimento di Scienze della Terra, Università degli Studi di Torino, Via Valperga Caluso 35, 10125 Torino, Italy.

³ICREA at Institut Català de Paleontologia Miquel Crusafont and Unitat d'Antropologia Biològica, Universitat Autònoma de Barcelona. Edifici ICP, Campus de la UAB s/n, 08193 Cerdanyola del Vallès, Barcelona, Spain, salvador.moya@icp.cat

By the Middle Miocene hominoids became widespread in Europe and successfully radiated in a plethora of new forms (Casanovas-Vilar *et al.*, 2011). However, by the early Late Miocene the group disappeared from mainland Western Europe after 9.5 Ma, coinciding with the so-called Vallesian Crisis (VC). They only persisted until the middle Turolian (c. 7 Ma) in Eastern Europe and in the Tusco-Sardinian archipelago until 7-6.5 Ma.

Although hominoid extinction is clearly diachronous, the environmental changes related to the VC are often considered the main triggering factor. According to Agustí *et al.* (2003), the VC would have coincided with a significant decrease in mean annual temperatures, leading to the substitution of pre-existing subtropical forests by a landscape more dominated by deciduous trees. However, the lack of any significant global climatic shift coinciding with the VC argues against this hypothesis. Moreover, the major Miocene cooling started much before (ca. 14 Ma). In Central Europe it involved a noticeable decrease in mean temperature during the coldest month and the progressive substitution of paleotropical plant taxa by deciduous Arctotertiary elements. According to the plant record, these changes were much slower in the Mediterranean region. In the Iberian Peninsula, hominoids are restricted to Catalonia, where the climate was more humid (particularly close to the sea, as in the Vallès-Penedès Basin), whereas arid landscapes prevailed in inner Iberia. Nevertheless, plant macrofossils from the former areas show that deciduous Arctotertiary elements were already diverse and abundant by the Middle Miocene (Barrón *et al.*, 2010), so that the VC did not coincide with an increase in their abundance. The latest surviving Iberian hominoid, Hispanopithecus, was associated to wetlands in which mega- and mesothermic taxa were more abundant and provided a continuous ripe fruit supply throughout the year (Marmi *et al.*, 2012). Such environments may have become rarer during the Late Vallesian, but this cannot account for the extinction of this group throughout Europe, where hominoids were associated to various different environments.

Most recently, Agustí *et al.* (2013) recognized the lack of correlation between the VC and any significant global climatic change, proposing instead a 'house of cards' effect as its cause. According to the latter, Vallesian mammal communities increased their diversity until they evolved in a critical self-organized state that collapsed once a certain threshold was surpassed—the VC thus being more dependent on the ecosystem's state than on the magnitude of climatic change. This ad-hoc hypothesis mostly relies on the diversity peak shown by the Vallès-Penedès mammal record just before the VC. Nevertheless, our analyses show that this peak is largely a sampling bias effect, so that the extinctions occurred during a longer time span until the latest the Vallesian. The VC is thus unlikely to be an abrupt extinction event, but part of a long-lasting faunal turnover, diachronous across Europe but tracking the global climatic changes—thereby explaining the lack of correlation between the VC and major paleoenvironmental changes as well as of the different timing of European hominoid extinctions.

Keywords: Hominoidea, Vallesian Crisis, extinction, Late Miocene, paleoecology.

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Nature, Timing, and Dynamics of Green Sahara Periods Back to the Late Miocene: Implications for Hominin Evolution

Juan C. Larrasoña¹, Andrew P. Roberts², and Eelco J. Rohling²

¹Instituto Geológico y Minero de España, Unidad de Zaragoza. Zaragoza 50006, Spain. jc.larra@igme.es

²Research School of Earth Sciences, The Australian National University. Canberra ACT 0200, Australia. andrew.roberts@anu.edu.au; eelco.rohling@anu.edu.au

Astronomically forced insolation changes have driven monsoon dynamics and recurrent humid episodes in North Africa, resulting in green Sahara Periods (GSPs) with savannah expansion across the desert. Such GSPs might have played a key role in hominin evolution by expanding the area of prime hominin habitats and favouring out-of-(and into)Africa dispersals. Despite of this, GSPs have not been fully incorporated into the narrative of hominin evolution due to poor knowledge of their timing, dynamics and landscape composition with the exception of two of the most recent GSPs, occurred in the Holocene (e.g. the “African humid period”) and in the previous interglacial (Eemian).

Here we present a compilation of continental and marine paleoenvironmental records from within and around North Africa, which is used to improve our knowledge on the nature, timing and dynamics of GSPs at timescales of millions of years that are comparable to those of hominin evolution. The synthesis of paleoenvironmental records indicates that GSPs are time-transgressive and peaked over 4-8 thousand years. By combining the main climatological determinants of woody cover in tropical Africa with paleoenvironmental and paleoclimatic data for the Holocene and Eemian GSPs, we have estimated precipitation regimes and distributions of habitats suitable for hominin occupation during these representative GSPs. Paleoenvironmental data indicate that previous GSPs might have been at least as wet as those GSPs. Overall, it appears that hominin expansion throughout North Africa was feasible during most GSPs.

GSPs coincided with the accumulation of eastern Mediterranean sapropels, whose formation is driven mainly by astronomically controlled changes in the intensity of the West African monsoon. The continental record becomes more scarce, fragmentary and difficult to date beyond few hundred thousand years. On the other hand, marine records from the Atlantic and Indian oceans do not offer a clear mechanistic link with GSPs. Therefore, we have considered eastern Mediterranean sapropels as the most continuous and precisely (astronomically) dated archive that can be used for identifying over 230 GSPs back to 8 Ma. GSPs identified this way are arranged in clusters with durations of 100 and 400 kyr that attest to the modulation of insolation by eccentricity as the main mechanism driving West African monsoon dynamics. Such clusters of GSPs are broadly coincident (within chronological uncertainties) with the ages of Saharan archeological and fossil hominin sites. These clusters are also coeval with phases of large lakes formation in East Africa, during which sedimentation was also driven by precession-driven changes in insolation. Each GSP biogeographically connected the African tropics to Eurasian mid latitudes, and ended in rapid habitat fragmentation. We argue that the well-dated succession of GSPs presented here may have been critical for evolution of hominins by affecting their population dynamics and favouring their out-of-Africa dispersals.

Keywords: green Sahara periods; North Africa; monsoon; hominin evolution.

Climate Dynamics and Early Human Dispersal Out of Africa

Jordi Agustí¹, Hugues-Alexandre Blain²

¹ICREA. Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Universitat Rovira i Virgili, Tarragona, Spain

²Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Universitat Rovira i Virgili, Tarragona, Spain

Early human settlement in Western Eurasia was strongly influenced by ecological conditions rather than locomotor capabilities, its first occurrence in Western Europe being documented in periods of favorable climatic conditions. Despite the glacial-interglacial dynamics, the late Pliocene climate in the region analyzed must have remained reasonably mild and stable. The early Pleistocene is characterized by a sharp climatic deterioration, which possibly impeded the settlement of this region by the early human population from the southern Caucasus. Shortly afterwards, when the climatic conditions are again favorable, this human presence is suddenly attested by thousands of lithic artifacts of Mode I at the sites of Fuente Nueva 3 and Barranco León 5 in the Guadix-Baza Basin (Spain), as well as hominid remains at Trinchera Elefante in the Atapuerca karstic complex (Spain). The climatic amelioration at the early-middle Pleistocene boundary again favored a human presence, as attested by Trinchera Dolina in Atapuerca and the site of Cúllar Baza 1 in the Guadix-Baza Basin. The data reported here clearly support the idea that an early human presence in Europe was strongly constrained by climatic and environmental conditions, and that physiography or cultural factors played a minor role.

Early Pleistocene Environment of Early Humans in Southern Caucasus - High-resolution Reconstruction of Climate and Vegetation in Armenia during Mis 31

Angela A. Bruch¹, Ivan Gabrielyan², Steffen Scharrer¹, Uwe Kirscher³, Valerian Bachtadse³, Klaudia Kuiper⁴, Vasilis Teodoridis⁵

¹ROCEEH Research Centre 'The role of culture in early expansions of humans' of the Heidelberg Academy of Sciences, Senckenberg Research Institute, Senckenberganlage 25, 60325 Frankfurt am Main, Germany

²Armenian National Academy of Sciences, Institut of Botany, Avan-63, Yerevan, 375063, Armenia

³Department of Earth and Environmental Sciences, Geophysics, Munich University, Theresienstr. 41, 80333 Munich, Germany

⁴Department of Earth Sciences, Utrecht University, Budapestlaan 17, 3584 CD Utrecht, The Netherlands

⁵Department of Biology and Environmental Studies, Faculty of Education, Charles University in Prague, M. D. Rettigová 4, 116 39 Prague 1, Czech Republic

The Southern Caucasus is the area of earliest human occupation in Eurasia, proven by findings of Homo fossils in Georgia with an age of ca. 1.8 Ma. The pace and causes of the early human colonization, in one or several migratory waves from Africa in new environments of the Eurasian continent during the Early Pleistocene, are still a matter of debate. However, climate change is considered a major driving factor of hominin evolution and dispersal patterns. In fact directly or indirectly by its severe influence on vegetation, physiography of landscape, and animal distribution, climate modulates the availability of resources.

Lake sediments from Sisian Formation, Vorotan River Basin, southern Armenia, provide detailed information on environmental changes during late Early Pleistocene. Based on magnetostratigraphic and radiometric dating, the exposed part of the succession covers a stratigraphic age from ca. 1.3 to 0.9 Ma and includes the Jaramillo subchron.

Due to the precise age control high-resolution pollen analysis was conducted at the Matujama/Jaramillo reversal spanning from 1.12 to 1.035 Ma (MIS 33 - MIS 30) with a mean resolution of ca. 250 years per samples. Results document a clear vegetation response on orbitally forced climatic changes with open vegetation during the less pronounced cycles MIS 33/34, the expansion of broadleaved deciduous forests during the very warm and humid MIS 31, and the expansion of needleleaved forests during the long, cool and humid MIS 30. Furthermore, the age of the numerous macro floral assemblages could be constrained to warm and humid parts of the climatic phases, most of them connected to MIS 31 confirming the dominance of forests at that time.

Plant species compositions show strong relations to Euxinian and Hycanian forests occurring today at the coasts of the Black Sea and Caspian Sea, respectively, which must have been expanded during warmer and more humid periods of the Early Pleistocene. Climate quantifications give at least 5 degrees warmer and 50-100% more humid conditions for most pronounced interglacials. Those results are a prerequisite for the extrapolation of the distribution of forests and mosaic landscapes in Southern Caucasus for different climatic phases during Early Pleistocene to reconstruct of early human environments in this region.

Keywords: palaeoclimate quantification, regional vegetation, Southern Caucasus, orbital forcing

The Forensic Anthropological Analysis of First Homo erectus from Turkey

Mehmet Görgülü¹, M. Cihat Alçiçek², Fatih Tepgeç³, Uğur Genç⁴, Seher Başaran⁵

¹Yıldız Technical Univ. İSTYAM, Biological Materials Investigation Commission, Istanbul;

²Pamukkale Univ. Dept. of Geology, Denizli;

³Istanbul Univ., DETAM, Dept. of Genetics, Istanbul;

⁴Ministry of Culture and Tourism, Directorate of Central Laboratory of Restoration and Conservation in Istanbul;

⁵Istanbul Univ. Dept. of Medical Genetics, Istanbul

Conservation in Istanbul; The first Homo erectus of Turkey, called as Kocabaş Man, was found by M. C. Alçiçek in the travertine quarrying-field near Kocabaş town to the east of Denizli during 2002 (cf. Vialet et al, 2012) consisting fragment of right parietal, fragment of right frontal preserving the torus supraorbitalis, and fragment of the left parietal which is articulated with a fragment of the left frontal bone (without torus supraorbitalis). In this study we aim to assess the Kocabaş hominin in forensic anthropological perspective along the existing bones; a. Physiological identification (age and sex determination), b. If any, of the disease state detection, c. If DNA can be obtained, genetic identification, d. Restoration and facial reconstruction, works are planned. At the first evaluation, at the region 4 (called anterior sagittal) and region 5 (bregma) of the sutura sagittalis don't include synostosis (closed articulation) and the left part of parietal bone is glued with the left part of frontal bone at the region 6 (midcoronal) of sutura coronalis. According to Meindl & Lovejoy (1985), these forms show a sutural closure's score of 0. This feature (score 0) indicates that sutural closure didn't begin and therefore the bones might belong to a person of under 22 years old, was likely to be in the period of adolescence (Çöloğlu & İşcan, 1998; Meindl & Lovejoy, 1985). In compare to modern humans of whom blunt- and sharp-edge indicate man and woman respectively; the existence of upper edge of the right orbit to be blunt-edged evidence the gender of Kocabaş individual as male (Krogman & İşcan 1986; Krogman 1955). The above-mentioned assessments and new findings will contribute to proof these circumstances more clearly.

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Persistence of Plesiomorphic Human Populations in the Middle Pleistocene of the Italian Peninsula: Deconstructing the Role of Climate Changes, Vegetation and Faunal Dynamics

Giorgio Manzi¹, Donatella Magri¹ and Maria Rita Palombo²

¹Dipartimento di Biologia ambientale, Sapienza Università di Roma, Roma, Italy
giorgio.manzi@uniroma1.it; donatella.magri@uniroma1.it

²Dipartimento di Scienze della Terra, Sapienza Università di Roma and CNR-IGAG, Roma, Italy.
maiarita.palomo@uniroma1.it

Despite the growing amount of data and the increasing interest in scrutinizing causal factors promoting dispersals and settlement of hominins in the West European territories, we are still far from deciphering the multifaceted relationships between climate changes and vegetation, fauna, and human evolutionary dynamics, in particular the causal mechanisms and factors promoting/allowing human diffusion and permanent settlement in focal areas. Humans were a generalist species, having broad niches, and were able to negotiate and survive in a variety of environments, beyond their subtropical and tropical African homeland. The available data and several lines of reasoning suggest that some complex, and not always direct, relationships existed between environmental changes and human dispersal and setting (e.g. van der Made, 2011; Manzi *et al.*, 2011a; Palombo, 2013, Rodríguez-Gómez *et al.*, 2013).

With the challenging goal of investigating the reliability of hypotheses on the relationships among climate changes, ecosystem dynamics and human dispersals and settlements, and for a more comprehensive understanding of the causal factors allowing the persistence of plesiomorphic populations in the Italian peninsula at the time when more advanced human morphotypes had spread in Europe, we examine the ecosystem functional diversity and dynamical changing through the late Early and Middle Pleistocene. Our aim is to study the relationships among intermittent changes in vegetation cover, diachronous disappearances of tree taxa and dispersal, origination and extinction bioevents in large mammal communities, in order to improve our understanding as whether the structural evolutionary trend of ecosystems differently affected the evolutionary patterns of human population in South-western Europe. This theme is developed also considering the possible dispersal of different human groups in renewed cultural contexts (Acheulean) and, particularly, the possible existence of refuge areas in Italy that would have allowed the persistence of human populations showing plesiomorphic features as compared with other areas of the continent (Manzi, 2011, 2012; Manzi *et al.*, 2011b).

Our results highlight the complex and multifaceted response of vegetation and faunal communities to the major change in the Earth climatic system known as Middle Pleistocene Revolution. At that time regionalization increased in the faunal record, while only modest differences are found in the vegetation dynamics of SW Europe. During great part of the Middle Pleistocene, the peculiar features of the Italian territory may have favoured isolation and a local persistence of plant populations and possibly mammal taxa, humans included, as for instance suggested by the corrected chronology of the Ceprano calvarium (Manzi *et al.*, 2010).

Keywords: human evolution, vegetation and faunal dynamics, refuge areas, Early-Middle Pleistocene, Italy

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SESSION 12

**QUATERNARY RESEARCHES: GEOMORPHOLOGY,
ENVIRONMENT AND GEOARCHEOLOGY**

CONVENERS

**CATHERINE KUZUCUOĞLU, MUSTAFA KARABIYIKOĞLU
AND OLENA SMYNTYNA**

Evidence of Orbital- and Sub-Orbital-Driven Climate Change in the Near East-600'000 Years of Environmental Conditions Captured in Lake Van's Subsurface

Mona Stockhecke¹, Flavio S. Anselmetti^{1,2}, Ola Kwiecien³, Mike Sturm¹, and PALEOVAN scientific party

¹Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600 Dübendorf, Switzerland, mona.stockhecke@eawag.ch

²Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1-3, 3012 Bern, Switzerland

³Ruhr-University Bochum, Sediment and Isotope Geology, Universitätsstrasse 150, 44801 Bochum, Germany

Annually-laminated (varved) sedimentary records have shown their high potential to reconstruct abrupt and global climate change within the marine and lacustrine realm (e.g. Cariaco Basin, Santa Barbara Basin, Alpine lakes). A long continental varved archive was found in Lake Van in Eastern Anatolia (Turkey). This lake is a 440 m deep terminal soda lake situated in a climatically-sensitive semiarid and tectonically active region. Within the ICDP project PALEOVAN, a 220 m long sedimentary succession reflecting the lake's history from its origin in the middle Pleistocene to the present was recovered in 2010.

The lithostratigraphic framework of the composite profile, consisting of various types of carbonaceous clayey silt intercalated by ~300 tephra layers, is overprinted by dozens of seismic-related microdeformations. This partially annually-resolved continental sediment sequence was used to reconstruct climate, tectonic and volcanic activity in the mid-latitudes over the past 600'000 years. Recurrence of lithological pattern, variations of total organic carbonate (TOC) reflected by the sediment color, and the ration between authochthonous and allochthonous sedimentation (based on XRF Ca/K-ratio) matches the last six orbitally-driven glacial/interglacial cycles as well as the sub-orbitally driven climate cycles.

Distinct changes of color and repetitive sedimentary patterns are the expression of sudden and cyclic environmental changes. They are mirrored in high-resolution color data and variations in total organic carbon concentration, both reflecting lake productivity. Our record suggests that abrupt climatic and hydrological changes in Eastern Anatolia were synchronous to the Dansgaard-Oeschger (D/O) cycles archived in Greenland ice-cores. The presence of this signal in the Lake Van archive indicates an eastward extent of North-Atlantic climate regime. Furthermore, analogous evidence of identical sub-Milankovitch climate variability during previous glacials, indicates that similar D/O mechanisms were acting already during previous glacial-interglacial cycles.

Revealing Lake Level and Sedimentary History of Lake Van, Eastern Turkey, during the Past ~580 ka: Seismic, Hydroacoustic, and Lithological Evidence

Deniz Cukur¹, Sebastian Krastel², Hans Ulrich Schmincke¹, Mari Sumita¹, Daniel Winkelmann¹, M. Namık Çağatay³, Emre Damcı³, Ayşegül Feray Meydan⁴, Mona Stockhecke⁵, and PALEOVAN Scientific Team

¹GEOMAR | Helmholtz Centre for Ocean Research Kiel, Wischhofstr. 1-3, 24148 Kiel, Germany

²Institute of Geosciences, Christian-Albrechts-Universität zu Kiel, Otto-Hahn-Platz 1, 24118, Kiel, Germany

³Istanbul Technical University, Department of Geological Engineering, 34469 Maslak, Istanbul, Turkey

⁴Van Yüzüncü Yıl University, Department of Geological Engineering, Van, Turkey

⁵Eawag, Swiss Federal Institute of Aquatic Science and Technology, Department of Surface Waters Research and Management, 8600 Dübendorf, Switzerland

Lake Van in Eastern Anatolia (Turkey) is the fourth largest terminal lake in the world with a surface area of 3,574 km², a volume of 607 km³, a maximum depth of 450 m, and a maximal length of 130 km WSW-ENE. Over 1500 km of multi-channel seismic reflection profiles in combination with ICDP drilling and bathymetric data from Lake Van, eastern Turkey, allow to reconstruct stratigraphic evolution of the lake basin. Three major basins (Tatvan, Deveboynu and the Northern basin) are separated from each other by Ahlat and Northern ridges. The sedimentary history of the lake was subdivided into 19 distinct phases reflecting major environmental and depositional changes. Five major regressive and fourteen transgressive phases have been identified. Five lake lowstands have been dated as follows: (Phase 1) ~580 ka; (Phase 5) ~355-341 ka; (Phase 7) ~320-210 ka; (Phase 12) ~170-140 ka; and (Phase 18) ~30-16 ka. Estimated paleolake levels (below present lake level) at the end of each phase are; 610 m for Phase 1, 560 m for Phase 5, 470 m for Phase 7, 310 m for Phase 12, and 210 m for Phase 18. The sediment infill history of Lake Van over the ~580 ka is characterized five types of sedimentary facies. (a) Uniform 'well-stratified' lacustrine deposits (alternating organic muds and fine grained turbidites and tephra) formed under quiescent lake level conditions characterize the deeper parts of the basin. (b) Chaotic 'mass-transport' deposits characteristics of the southern parts of the lake have likely resulted from mass-transport process possibly triggered by ongoing tectonic activity along the lake margins. (c) Oblique or complex-oblique shaped 'deltaic' deposits have formed on the eastern/southeastern shelf and slope areas most likely due to accumulation of large volumes of clastic material derived from adjacent rivers. (d) Non-uniform 'fluvial' deposits characterizing the shelves are interpreted to have mainly deposited by fluvial processes when the shelf was subaerially exposed. (e) Chaotic 'volcaniclastic' deposits that fill local basins (Northern basin) are probably due to volcanic mass flows such as pyroclastic flows. In summary, our data show that sedimentation in the basins was mainly controlled by tectonic, climatic, and volcanic factors. The effect of climate was more pronounced in sedimentary phases rather than other factors as suggested by repeated patterns of lake level fluctuations. Such lake level fluctuations which reflected in clinoforms in seismic data are also documented as morphological features (channels, terraces) in bathymetric data.

Paleomagnetic and Rock Magnetic Studies from Lake Van Sediments: Implications for Chronology and Paleoenvironment since 350 ka

L. Vigliotti¹, J.E.T. Channell², M. Stockhecke³

¹Istituto di Scienze Marine, ISMAR-CNR, Bologna, Italy. luigi.vigliotti@bo.ismar.cnr.it

²Department of Geological Sciences, University of Florida, Gainesville, USA

³Eawag, Swiss Federal Institute of Aquatic Science and Technology, Dept. of Surface Waters Research and Management, Switzerland.

A 150-m long composite record was obtained from Lake Van (Eastern Turkey; ICDP Site 5034) in the framework of the “Paleovan” project. High sedimentation rates (mean ~30 cm/kyr) allow high-resolution measurements of natural remanent magnetization (NRM), anhysteretic remanence (ARM) and magnetic susceptibility (k), and hence of anhysteretic susceptibility (k_{ARM}). The sedimentary record shows lithologic variability and reflects changes in depositional conditions, including intervals characterized by anoxic conditions similar to the present-day. The lithological pattern, geochemical proxy records (TOC), and elemental scanning (XRF) matched to Greenland ice-core stratigraphies provide a robust age-depth model that indicates that the studied sediments represent the last 350 kyr. The quality of the paleomagnetic record is affected by weak NRM including intervals with diamagnetic susceptibility as well as by the presence of tephra layers occurring throughout the sequence. Nonetheless, a reasonable correlation is possible between the relative paleointensity record (RPI), based on NRM/ARM, and the calibrated PISO stack record that supports the age model constructed independent of RPI. An important paleoclimatic signal is present in the Lake Van sediments and variations in magnetic parameters suggest that the linkage reflects control exerted by climate over magnetic mineral concentration and grain size. Concentration-related parameters, k and ARM, show variations in agreement with changes occurring in the marine oxygen isotopic record (LR04) as well as with other climatic records (dust, temperature) observed in ice cores. Higher magnetic concentration with larger magnetite grain-size (lower k_{ARM}/k values) is observed during stadials whereas lower magnetic concentration with lower magnetite grain-size occurs during warmer periods. This pattern may be attributed to a higher wind/runoff intensity during glacial/stadial periods and/or increase biogenic dilution of magnetic concentration parameters in interglacials/interstadials. k_{ARM}/k exhibits a correlation with eccentricity indicating that the magnetite grain-size parameters reflect a mechanism related to astronomical forcing.

Keywords: Paleomagnetism, Paleoclimate, Lacustrine Sediments, Lake Van, Late Quaternary

Multivariate Statistics and Cyclostratigraphy Based on Downhole Logging in the ICDP Project Paleovan

H. Baumgarten¹, T. Wonik¹

¹Leibniz Institute for Applied Geophysics (LIAG), Stilleweg 2 30655 Hannover (Germany)

Lake Van (eastern Anatolia, Turkey) is the 4th largest terminal lake worldwide and is located at a key climatic position. Past climate changes have been recorded in the sensitive hydrological system of Lake Van, which is evident from terraces around the lake. The lake sediments archives approximately 600,000 years of climate history. The ICDP project PALEOVAN aims to enhance the understanding of the paleoclimatic and paleoenvironmental conditions of the Middle East.

Investigations (shallow coring, surface geophysics) have been started in 1970's and a deep drilling campaign has been executed in summer 2010. Two boreholes with total depth of 140 m (Northern Basin) and 220 m (Ahlat Ridge) were drilled; the core recovery was about 91 % (Ahlat Ridge) and 71 % (Northern Basin). The Ahlat Ridge site is located in a deep basin of Lake Van (water depth: 375 m). Results from a geophysical survey indicate, that an undisturbed sedimentary sequence is preserved. The lithology consists mainly of clayey silt and tephra deposits, which originates from several volcanoes in the surrounding of Lake Van. The volcanic deposits in Lake Van area are from four different sources (Nemrut, Süphan, Incekaya and intralake eruptive centers) and have different dominant compositions.

A continuous dataset of downhole data (spectral gamma ray, magnetic susceptibility, dipmeter, and resistivity) as well as partly sonic data have been acquired at both sites. The presented data is from hole D of Ahlat ridge. Spectral gamma ray (total gamma ray and Th/U-ratio), resistivity, and susceptibility data have been interpreted by applying multivariate statistics (cluster analysis) for objective separation of the lithologies. Additional, data from XRF-scanning (relative contents of Zr- and Ca) have been used for the cluster analysis to include variations in the chemical properties. The analyzed section has been subdivided into five cluster units based on similarities in their physical- and chemical properties. The information from the visual core description has been taken into account and associated lithological units have been derived.

The tephra deposits are characterized by strong differences in their physical- and chemical properties and can be subdivided into three cluster units. They differ mainly in their natural radioactivity (U-, Th- and K-contents), susceptibility and Zr (XRF) values. Abundance of different tephra units from cluster analysis suggest an evolution of volcanic deposits in Lake Van record. This can be due to either compositional changes over the record or changes in volcanic activity and eruption frequency of the volcanic sources.

Further, spectral analysis has been applied on the total gamma ray data for cyclostratigraphy. This has been performed on the sections composed of lacustrine sediments. Several high amplitude signals have been identified and correlated to orbital cycles (Milanković). They have been used for estimation of mean sedimentation rates. To investigate possible changes of the sedimentation rate over the record, the sliding window method has been applied. The spectral analysis has been calculated for a certain depth interval (window size) and thereafter the window has been shifted downwards continuously by a specific step size. The resulting 3-dimensional spectral plot has been divided into two intervals based on the amplitude of the signals (position- and intensity). Refined sedimentation rates have been calculated for both intervals.

Keywords: Downhole logging, lake sediments, physical properties, cyclostratigraphy, quaternary

Environmental Context of Neolithic Birth, Development and Diffusion in Anatolia, from 12 to 7 ka Cal BP: The Evidence from Newly Studied Buried Sites in Anatolia

Catherine Kuzucuoglu¹

¹Laboratory of Physical Geography (UMR 8591), CNRS Paris 1 and Paris 12 Universities, Meudon cedex France

In Anatolia, Epipalaeolithic and Aceramic Neolithic sites are known either from excavations or from surveys in several regions in Anatolia: e.g. in the Mediterranean, south-eastern (upper Euphrates and Tigris valleys), Cappadocia, central plateaus (Lake district, Konya plain), and Marmara regions (Kuzucuoglu, in press). The distribution in these regions and also through time, of the appearance of Aceramic Neolithic will be compared and discussed in the presentation. In parallel, the palaeoenvironmental data from several dated pollen, isotope and mineral records from sediment sequences cored in different regions of Anatolia will be presented and compared to the periods of site occupation by Neolithic communities. This comparison enlightens the climate and environment context through Anatolia from the oldest dates known for the Neolithic *ca.* 12.1 cal BP (*ie.* the Younger Dryas), to the transformation from Early PPN to Late PPN cultures *ca.* 10.4 cal BP, and to the final PPN *ca.* 7500-7000/6900 BC.

The discussion will also concern the Ceramic Neolithic period, whose sites are from sparse to none north-east of a line joining the Marmara region to Eastern Anatolian highlands. It has long been suggested that this scarcity is due to Holocene sedimentation concealing Late Glacial and Early Holocene sites. Arguments sustaining this hypothesis are here provided by new evidence dated

- Younger Dryas (*ca.* 12.6-11.4) in Cappadocia near Asikli Höyük (Aceramic), and on the Mediterranean coast near Öküzini cave (Epipalaeolithic)
- Early Holocene (9 - 5 kyrs BC) in valleys north of the central plateaus (Yozgat, Kastamonu) and in a cave near Van (Eastern Anatolia).

In all cases presented here, indicators such as archaeological layers, artefacts, pollen, forest fires (charcoals) have been identified during palaeoenvironmental research programs exploring YD and EH sediment accumulations. For periods prior to 6 kyrs BC in Anatolia, these results address (a) the reality of concealment of prehistoric sites by Holocene sediments, (b) the space and time distribution and characteristics of human presence and activities.

Keywords: Pre-Pottery Neolithic (PPN), Ceramic Neolithic, Anatolia, Early Holocene, Younger Dryas

The East Caucasian Forelands during the Quaternary: Deposits and Environments

Nataliya Bolikhovskaya¹, Stanislav Faustov¹, Anastasia Markova²

¹ Faculty of Geography, Lomonosov Moscow State University, Moscow, 119991, Russia,
nbolikh@geogr.msu.ru

² Institute of Geography of Russian Academy of Sciences, Staromonetny 29, 109017 Moscow,
 Russia, *amarkova@list.ru*

The most thick and stratigraphically complete Quaternary sequences were complexly studied in the southern regions of the European Russia by group of specialists: A.Velichko and V.Udartsev studied lithology; S.Faustov and E.Virina – paleomagnetism; A.Markova – small mammals; N.Bolikhovskaya – palynology. The Quaternary deposits (~160m thick) are located in the middle reaches of the Kuma River (East Caucasian Forelands) near Otkaznoye Village (44°19' N, 43°51' E). All analyses were carried out for two vertical profiles.

Longest Profile I presents ~140 m thickness penetrated by a borehole on the interfluvial plateau (at ~245.5 m a.s.l.). Three sedimentary cycles are exposed here. The first cycle contains alluvial deposits (127.6–136.4 m) and subaerial strata including three well-developed paleosols (115.8–127.6 m); the second cycle presents alluvium (112.8–115.8 m) and subaerial formations with two paleosols (107.35–112.8 m). The third cycle presents alluvial-proluvial series (64.9–107.35 m) and a thick member of loessial deposits with 6 paleosol complexes (1.4–64.9 m). The Matuyama-Brunhes reversal (~0.778 Ma) was found at 75 m a.s.l. The Jaramillo event was recognized within the Matuyama zone in the 103.0–113.0 m interval.

According to pollen data, deposition of this interfluvial series took place during the Early–Upper Pleistocene and terminated in the formation of thick upper loess, which was deposited during the Dnieper Glaciation and during the first half of the Mikulino (Eem) Interglacial. The results obtained from Upper Pleistocene deposits were completed by analysis of Valdai sediments of lower terraces of the Kuma R.

Palynological characteristics of the deposits located below the Brunhes-Matuyama boundary are fragmentary and permit reconstruction of only some stages of the Early Pleistocene. Two phases were distinguished in the deposits related to the Jaramillo event. The first phase was characterized by cooling and aridization (steppe landscapes). The second phase was characterized by warming and increasing of humidity (broadleaf forests).

Comprehensive palynological information provided a basis for reconstructing of flora evolution, vegetation and climate changes for 15 interglacial and cold stages of the Brunhes Chron. For the most part of this period the Terek-Kuma Lowland was occupied by interglacial forest-steppes or by periglacial forest-steppes. For the first time in Middle-Pleistocene history steppes became dominant here at one of phases of Likhvin Interglacial (MIS 11; Paleosol Complex IV). More than a hundred of small mammal remains from PC IV were studied (*Spermophilus pygmaeus*, *Spalax microphthalmus*, *Cricetus cricetus*, *Cricetulus migratorius*, *Eolagurus luteus volgensis*, *Lagurus lagurus*, *Microtus ex. gr.arvalis-socialis*). Rodent fauna was attributed to Singilian-Gunkovian mammal assemblage and very characteristic to steppe landscapes. Dry steppes and semi-deserts that appeared occasionally in the Middle Kuma basin at some warm Early Pleistocene intervals assumed dominant importance during Middle-Late Pleistocene, firstly at the cryoxerotic stage of the Dnieper ice age (~MIS 6), and later at the same stage of the Valdai glacial epoch (~MIS 4-2). The vegetation at those stages was typical periglacial. Forest landscapes were dominant during five intervals. At the Muchkap Interglacial (~MIS 15) prevailed broad-leaved forests with participation of subtropical species. Broad-leaved forests (mesophytic or xerophytic) occupied the region during the interglacials corresponding to ~ MIS 9, MIS 7 and MIS 5. Some phases of the Kaluga cold epoch (~MIS 10) were marked by dominance of spruce and Siberian stone pine forests. The named five “forest” phases correspond to climate-induced rises of Caspian Sea level during the Middle-Late Pleistocene.

Keywords: Quaternary, East Caucasian Forelands, environments.

Palaeovegetational Comparison between Sediments of the 7000 BP and 6 Century in the Ancient Harbor of the Yenikapı-İstanbul Based on the Palynological Data

Funda Akgün¹, Doğan Perinçek², Mine Sezgül Kayseri-Özer¹, Mustafa Bozcu²

¹ Dokuz Eylül University, Department of Geology Engineering, Buca-İzmir, Turkey,
funda.akgun@deu.edu.tr, sezgul.kayseri@ogr.deu.edu.tr

² Çanakkale Onsekiz Mart University, Department of Geology Engineering, Çanakkale, Turkey,
perincek@yahoo.com, mbozcu@comu.edu.tr

A Byzantine harbour (Theodosian harbour) has been uncovered during excavations at Yenikapı, with a stratigraphic sequence spanning the past 7000 BP. Sedimentary sequence of the Quaternary in Yenikapı composes of seven units (Unit 1-7), and this study presents palynomorph associations of the unit 1 and unit 4. The unit 1 unconformably overlies the clastic sediments of the Miocene (Güngören Fm.) and it is deposited in swampy environment represented mud and clays. Coarse clastic sediments (gravel, sand and clay) are also observed in the lower part of this unit related to flooding. The first palynomorph association is defined from these sediments and it is characterized by abundantly *Pinus*, *Abies*, *Quercus* deciduous type and scarcely *Populus*, *Fagus*, *Buxus*, *Castanea*, *Acer*, *Carpinus*, *betulus*, Cupressaceae, *Betula* and *Sciadopitys*. Abundance of *Pictacia*, *Potamogeton-Althenia*, Cyperaceae, *Nymphaea*, *Iris* and *Alnus* has been recorded from the samples of middle part of unit 1 (before 7000 BP), and this abundance could be interpreted that freshwater condition increased after flooding. The upper part of the unit 1, brackish condition has been predominated and abundance of sporomorphs and non pollen palynomorphs (Dinoflagellates spp., *Lingulodinium machaerophorum*, copepod egg and baggy cysts) adapted to salinity has been supported this condition. Furthermore, the first ancient people remains have been found in the unit 1, and also finding of Poaceae-*Cerealia* type pollen in lower part of this unit could be indicated that ancient people have tried to growing of crops. The unit 2 which is represented by coarse-grain sediments pebbles and sands overlies the unit 1 because of sea level rise (7000 BP). The unit 3 (4000? – 4820-5380 BP) is characterized by a shelly sandy texture and corresponds to a sandy beach environment. Sedimentary sequences of the unit 4 have been deposited after earthquake of AD 557 which was caused tsunami. This unit is divided into facies consistent with different phases of the tsunami; unit 4a, and unit 4b. The unit 4a is represented by sands, laminated sand blocks and bands of black silty muds, and it is deposited under high energy. The unit 4b is characterized by the muddy sands, and also the terrestrial and marine sediment is being extensively mixed in this unit because of the tsunami effect. Abundance of the well preserved foraminiferal organic linings and baggy cysts in samples of the lower most part of the unit 4a indicates strong marine influence. Afterwards, effect of this influences decreases during deposition of the unit 4b due to backwash. Thus the unit 4 is a chaotic layer containing reworked marine and terrestrial floral material (e.g. *Pinus*, *Abies*, *Juglans*, *Fagus*, *Castanea*, *Alnus*, *Corylus*, *Carpinus*, *Ulmus*, *Salix* and *Tilia*). Presences of *Plantago lanceolata*, *Sanguisorba minor*, *Olea*, *Juglans*, *Castanea*, *Vitis* and abundantly observing of Poaceae-*Cerealia* type have been important in the identification of human impact in the palaeoenvironmental record in 6 century.

Keywords: Palynology, Human impact, Quaternary, Yenikapı-İstanbul, Tsunami

Toward a Better Knowledge of *Elephas Tiliensis* Skeletal Proportions and Morphology

E. Theodorou¹, V. Mitsopoulou², T. Vasilopoulos¹, C. Provatidis¹, S. Roussiakis²

¹National Technical University of Athens, School of Mechanical Engineering, Mechanical Design & Control Systems Section, Zografou Campus, PO 15780, Athens, GR.,
etheod@gmail.com¹, cprovat@central.ntua.gr², theodor@e-gr.net⁵

²National Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Zografou Campus, PO 15784, Athens, GR.sroussiak@geol.uoa.gr², vamitsop@geol.uoa.gr²

Elephas tiliensis fossil bones have been excavated inside Charkadio Cave on Tilos Island, since 1971. An interdisciplinary team has been put together under the auspices of Thalís MIS380135 project, in order to fill in the missing taphonomical data and to reconstruct a complete three dimensional elephant, using Rapid Prototyping technologies. The focus of this presentation is targeted on deciding and testing the correct allometric proportions of the fore-limb and hind-limb using CT Scan and CAD manipulation software, along with classical palaeontological methodologies. Up to now there is no available material from both limbs of one animal, although different bones have been found in anatomical connection. With a mathematical formula still under development, the above methods are already producing significant data sets and in turn, alternate bone geometries. The first results are quite promising towards the reconstruction of the proper anatomical CAD model. This project is still ongoing, with very good initial results towards the three dimensional reconstruction of the *Elephas tiliensis*. The final 3D mechanical reconstruction will be housed in the new permanent exhibition site on the island of Tilos. The objective of this is to combine vertebrate palaeontology and state of the art Rapid prototyping technologies employed for the first time in any Greek endemic form, in reality of the last Mediterranean elephant that migrated to Tilos island from the mainland about 45.000 years and became extinct during Holocene.

Keywords: *Elephas tiliensis*, rapid prototyping, CAD, engineering, allometry

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Ancient Irrigation Canals Detection in Pharaonic Deir El-Hagar Playa, Western Desert, Egypt, Using Egyptsat-1 Data

S. M. Hassan¹, E. A. Zaghloul¹, A. Bahay El-Dein¹

¹National Authority for Remote Sensing and Space Sciences (NARSS)

Dakhla Oasis is the second provincial oasis in Al-Wadi El-Gedid Governorate and lies about 198 km. north-west of Kharga Oasis (Fig.1). Dakhla contains several wells, the most important of which are: The Mut Wells. The Mid-Pleistocene lacustrine sediments exposed as erosional remnants in the Western Desert of Egypt provide evidence for a more humid climate than that which persists today. The persistence of climatic and hydrologic conditions amenable to maintaining a shallow freshwater lake would have allowed the region to be inhabited by a savanna fauna, as well as early human groups. The most important playa is Deir El-Hagar Playa which located about 45 k. to the west of Mut (capital of the oasis) where the famous Pharaonic Deir El—Hagar Temple is located. The extraction of geological features from satellite imagery is probably the most important objective of digital image analysis in the geosciences. The main aim of this work is to use High Pass Filter (HPF) image processing technique in order to enhance Egyptsat-1 satellite data to extract or mapping of archeological areas. The present work deals with applying a high pass filter image processing technique on Egyptsat-1 data in order to enhance and emphasis the ancient irrigation canals in Deir El-Hagar playa which covers an area about 2.5 km and owed its water to the flowing natural springs located about 2 km to the south . The enhanced Egyptsat-1 images as well as the 3D prospective view prepared by draping the enhanced Egyptsat-1 over the ASTER Digital Elevation Model (DEM) with 15m spatial resolution indicate that the playa is semicircular basin that was covered by an extensive lake deposits that owed its water to the natural springs and rainfall over the depression during the Terminal Paleolithic and Neolithic times. The sediments can be classified into three main units, namely A, B and C at top (Zaghloul, 1992). The prehistoric remains; such as Lithic-artifacts, Pottery fragments and Charcoal; in and around the playa make it possible to date the Holocene stratigraphic units in the area. Although during the Neolithic pluvial period in the early Holocene when Terminal Paleolithic and Neolithic hunters and farmers spread over the Western Desert between 9500 and 5000 years ago, by 5000 BP with no rainfall, the lakes dried up and wind erosion under hyper-arid conditions has been the main process (Haynes, 1980) which forms the deflated playa surfaces in the western Desert in the form of Yarding.

Effects of Natural and Anthropogenic Processes on a Coastal Environment during Holocene: Maritsa (Maritsa) Delta Area, NE Aegean Region, Turkey

M. Namık Çağatay¹, T. Levent Erel², Mehmet Sakınç³, Andrey Tchapylyga⁴

¹İTÜ, EMCOL, Faculty of Mining, Ayazağa, 34469 İstanbul, cagatay@itu.edu.tr

²İÜ, Faculty of Education, Vefa, İstanbul

³İTÜ, Eurasian Institute of Earth Sciences, Ayazağa, 34469 İstanbul

⁴University of Moscow, Institute of Geography, Russia

We investigated the rapid coastline and environmental changes in the Meriç (Maritsa) Delta area in the NE Aegean region during the Holocene, based on facies analysis and radiocarbon chronology of the drill cores, and archeological and historical documents and maps. The delta has been an important area for settlement since the prehistorical period, and is at the land and marine crossroads between Anatolia and Balkans and the Aegean and Black seas. The evolution of the delta dates back to early Pliocene. However, the latest phase of delta development started during later stages of the Holocene transgression.

The borehole facies analysis and chronostratigraphy indicates the presence of an estuary 8-7 ka BP, extending at least 45 km from the present coastline to the north of Ipsala (Cypsele). The estuary included some islands of various sizes, such as the Kutuntepe and Enez castle sites. The delta progradation gradually filled the estuary, and the coastline migrated to within 30 km of the present coastline around 3 ka BP, while the sea level rose in tandem with the global sea level from -17 m at 7.3 ka BP to -3 m at 3.4 ka BP.

During the Classical period, İpsala and Ferecik (Feres) ports were located within the estuary and Dedeğaç (Alexandroupoli) and Enez (Ainos) ports at the entrance. The pier of the Enez port is now buried under 10 m-thick sediments, and the Roman cemetery and streets are under 3 m-thick sediment and soil cover, suggesting subsidence, sea level rise and delta progradation.

More recently, a map of the region prepared by the famous Ottoman Captain Piri Reis in 1526, shows the Meriç River flowing into the sea through a single channel in the west, a relatively reduced size estuary with the Enez port, and the presence of various size lakes and lagoons inland between Enez and İpsala.

The topographic maps of as recent as 1912, show a large lake including the present Bari, Gala and Pamuklu lagoons and lakes, extending 25 km in an east-west direction towards the Koyuntepe Bay. Starting from the beginning of 20th century, the delta progradation gained momentum by human intervention, resulting in the disappearance of most lagoons and lakes and in the disruption of the use of the old Enez port, which is presently located 4 km inland from the present coastline.

Keywords: Meriç delta, delta progradation, estuary, coastline, Holocene transgression, NE Aegean

The Evolving Geometry of upper Quaternary Coastal Outbuilding in the East Saronikos Gulf

Panagiotis Foutrakis¹, George Anastasakis¹

¹School of Geology & Geoenvironment, University of Athens, Panepistimiopolis, Athens 15784, Greece, anastasakis@geol.uoa.gr, pfoutrakis@geol.uoa.gr

Saronikos Gulf is a semi-enclosed gulf in the eastern part of Central Aegean Sea. It hosts the northwest termination of the South Aegean Volcanic Arc with Pliocene and Quaternary volcanic activity concentrated in the central–western half of the gulf.

An elaborate marine geological study of Saronikos Gulf was carried out by Athens University in 2009 and 2010. During these surveys about 3000 km of multibeam data, 2550 km of Chirp seismic reflection profiles and 2800 km sparker data were collected, thus allowing detailed mapping of the seafloor. Sedimentation rates determined from cores help address the interrelationship of sediment supply, the rate of basin subsidence and the rate of eustatic sea level changes.

Here we concentrate on the East Saronikos Gulf, which remained connected to the rest of the Aegean Sea throughout the Quaternary and is not affected by processes linked to Quaternary volcanic events, that are recorded in the Western Saronikos Gulf. It may have been connected to Korinthiakos Gulf before the mid Pleistocene.

We report very high–high resolution seismic profiles to access the lateral and vertical variability of well-developed stratigraphically confined, retrogradational to progradational sea-level-related depositional sequences and to disentangle autogenic processes in the Upper Quaternary. On the shelf region between Aegina island and Attiki peninsula we identify lowstands MIS 2, 6, 8 and 10 displaying an aggradational character. The MIS 2 displays well preserved coastal barriers, MIS 6 is more extensive and topped by intense wave ravinment surfaces, MIS 8 and MIS10 are slightly landwards of MIS 2 and MIS 6. MIS 12 and 16 are especially well developed with enhanced lateral and vertical extent of their clinoform wedges. Lowstands of MIS 12–18 display a retrogradational alignment. Deeper older clinoform wedges 2026 or 28 are also recognized. However concurrent or prior to MIS 18 there was a more rapid basin subsidence and the older clinoform packages display a progradational alignment, suggesting autogenic processes before the mid-Pleistocene revolution, that is prior to MIS 22.

Comparison of the geometry of clinoform wedges and their respective observed inflection points with recently published data from adjacent South Evoikos Gulf (Anastasakis and Piper, 2013) reveals a more complex evolution of East Saronikos Gulf characterized by uplift prior to MIS 12 and strong basin subsidence prior to MIS 18–20.

Keywords: Saronikos Gulf, Quaternary, sea level, seismic stratigraphy, Aegean Sea.

References:

Anastasakis, G., Piper, D.J.W., 2013. The changing architecture of sea-level lowstand deposits across the Mid-Pleistocene Transition: South Evoikos Gulf, Greece. *Quaternary Science Reviews*, DOI 10.1016/j.quascirev.2013.04.018.

Geochronology of Quaternary Coastal Deposits of Evoikos Gulf / Greece by Means of Luminescence Dating

Maria Kazantzaki^{1,2}, Constantin Athanassas¹, Theodora Rondoyanni², Yannis Bassiakos¹

¹Laboratory of Archaeometry, I.M.S., N.C.S.R. "Demokritos", 153 10, Athens, Greece,
kazantzaki.mar@gmail.com

²School of Mining and Metallurgical Engineering, National Technical University of Athens, 15780,
Zografou, Greece

*Corresponding author. Tel.: +30 210 6503 803; fax: +30 210 6519 430

Evoikos Gulf is an active tectonic graben in central Greece that presents great geological and tectonic interest. It has undergone intense neotectonic and volcanic activity and also has experienced sea level changes since at least the Early Quaternary. However, investigations regarding the geochronology of the various sedimentary formations outcropping along the coastal zones are very limited. The establishment of a geochronological framework of the depositional processes during the Quaternary period would greatly contribute to a better understanding of the geodynamic and paleoenvironmental evolution of the area which could be used as a tool for forecasting impacts on vulnerable shorelines. The sediments that have been deposited into this graben are influenced by a multiphase tectonic activity and consequently their thickness varies both temporally and spatially. Three main sedimentary units have been distinguished, affected by numerous fault-zones as well as subsidence and synsedimentary slumping phenomena.

During the Last Glacial period, North Evoikos Gulf became a lake as the northwestern end of the gulf was possibly a subaerial barrier, which prohibited Aegean Sea from entering into the present day gulf. The shallow area surrounding the paleo-lake was exposed to subaerial and fluvial processes. During the last rise of the sea level, seawater entered into the gulf and fine-grained sediments covered older deposits and the pre-neogene basement. In parallel, the neotectonic activity continued to deform the Late Quaternary and Holocene age upper sedimentary sequence controlling the geomorphology of the gulf.

The ultimate purpose of this research is the reconstruction of the successive paleoenvironmental phases and their relation to the geodynamic evolution of the coastal area of Evoikos Gulf during the Early Quaternary period, by taking advantage of luminescence dating. The main idea is based on the fact that luminescence dating techniques provide a tool to examine sedimentary environments through their constituents' minerals, which act as "timers" to determine particular events of the geological past. Chronologies derived will be correlated with eustatic curves (either published or primary) so that Marine Isotope Stages (MIS) representing distinctive paleoenvironmental events might be identified. Moreover, the compilation of thematic maps in a Geographical Information Systems (GIS) environment will lead to the representation/reconstruction of the paleogeography of the greater area. This work presents preliminary results of an attempt to date the coastal deposits of the North Evoikos Gulf using a range of luminescence dating methods. Optically Stimulated Luminescence (OSL), Isothermal Thermoluminescence (ITL) from quartz and post-Infrared Infrared Stimulated Luminescence (p-IR-IRSL) from feldspars were employed on a number of potentially datable geological samples. ITL and conventional OSL methods were proven unsuitable for dating using quartz extracts of the North Evoikos Gulf, due to high saturation levels which yielded broadly scattered apparent equivalent doses, thus leading to inaccurate ages. Conversely, feldspar extracts measured by p-IR-IRSL method at 290°C (pIRIR₂₉₀) found to be more suitable for dating with much higher saturation levels and minimal rates of anomalous fading.

The proposed research is based on an interdisciplinary approach which is innovative for the study area and its significance lies on the fact that no similar scientific data by any means are available for the area. Ages of 1.2 Ma were produced by the p-IR IRSL methodology, something unprecedented for luminescence dating methods, since such old luminescence ages have never been noted on Greek sediments before.

Keywords: geochronology, luminescence, geodynamic, paleoenvironment, Evoikos Gulf

Deciphering the Paleoenvironmental Framework of Southeast Cyprus over the Late Quaternary through Luminescence Dating of Coastal Deposits

Evangelos Tsakalos¹, Constantin Athanassas¹, Yannis Bassiakos¹

¹Laboratory of Archaeometry, Institute for Advanced Materials, Physicochemical Processes, Nanotechnology and Microsystems, National Centre for Scientific Research, N.C.S.R. “Demokritos”, 153 10, Athens, Greece, tsakalos@ims.demokritos.gr

Cyprus occupies a key position in understanding the paleoenvironmental, neotectonic and eustatic evolution of the Levant during the Late Quaternary. Despite the great deal of paleoenvironmental data produced for other eastern Mediterranean coastal sites, affluence of field evidence on the southeast coasts of Cyprus has been only limited exploited to date. Specifically, archives of relative sea-level change and aeolian sand accumulation have been encoded in the coastal sedimentary deposits between Ayia Napa and Cape Greco.

Numeric dating is of great importance in resolving the sequence of paleoenvironmental events that occurred on the shores of southeast Cyprus during the Quaternary, however many challenges remain in dating near shore sedimentary deposits and surface exposures. Luminescence dating has been proven suitable for sediments that have undergone sufficient exposure to daylight prior to deposition. This necessity is met for the majority of coastal deposits encountered on the Cyprian shore. Infrared Stimulated Luminescence (IRSL) dating was concluded to be a reliable technique for establishing precise and accurate chronologies for the coastal deposits of southeast Cyprus. For the first time absolute dating information based on luminescence dating of feldspar of coastal deposits was obtained from a coastal area of south east Cyprus.

This study negotiates the paleoenvironmental and relative sea-level connotations of the deduced luminescence chronology which was proven to offer excellent potential for unraveling the geomorphic history of this region. Our current Luminescence chronological data assign the formation of the studied deposits to the Last Interglacial stage (MIS 5) and interstadials. This study also attempts to identify a common time framework for coastal deposits development in the eastern Mediterranean, linking climatic events to palaeo-sea levels. Comparison of our dating results with results obtained in other studies in the eastern Mediterranean such as in the coastal plain of Israel and raised marine terraces along the coasts of Crete has revealed that our ages are in good agreement with these studies. However, comparison of our aeolianites ages with other absolute dating studies in SE Cyprus showed that not all of the aeolian deposits were formed at a MIS 5 sea-level maxima and interstadials, the underlying mechanisms that could explain such a variety are not fully understood.

Keywords: Cyprus; palaeoenvironment; sea level change; coastal deposits; luminescence dating

Geological-Stratigraphic Criteria, Remote Sensing Data and Gis Techniques for Mapping out the Old Seashore Line. Evidence from Different Area of Greece

Chryssanthi Ioakim¹, Dimitrios Galanakis¹, Charalambos Georgiou¹, Georgios Vougioukalakis¹, Konstantinos Nikolakopoulos², Dimitrios Mitropoulos³

¹Institute of Geology and Mineral Exploration, Athens, Greece, ioakim@igme.gr, galanakis@igme.gr, georgiou@igme.gr, gvoug@igme.gr,

²University of Patras, Dept. of Geology, Patras, Greece, knikolakopoulos@upatras.gr

³Institute of Geology and Mineral Exploration, Athens, Greece, dmitropoulos@igme.gr

According to the Greek legislation (2971/2001) as “Old seashore” is defined the land zone resulted from the coastline movement toward the sea caused by natural change or technical work. It is determined by the current line of seashore and the limit of old seashore. In order to map out the line of the old seashore mainly the following four geological factors affecting the formation of coastal area and seashore are checked out:

- A) changes of sea level due to climatic periodicity
- B) geotectonic land movements resulted from fault activity
- G) land and sea interaction
- D) effects from human activity.

For the determination of old seashore the following actions take place:

Study of the Greek and international bibliography concerning the geology of the wider area, focusing on the tectonic movements and the relevant changes of sea level.

Mapping of the coastal region focusing on the spatial determination of streams and recording of the results caused by waves and winds as well as by any anthropogenic activity influencing the alternation of deposition-erosion.

Excavations take place in selected sites, where sediment and, if present, water sampling are carried out. Grain and microscopic sediments, micropalaeontological, volcanoclastic analyses as well as AMS dating, water chemical analysis are performed, in order to determine the physical – chemical characteristics of the sediments and their stratigraphy.

Study of the existing airphotos usually covering the period 1945 up to today.

The methods and results of the definition of old seashore carried out in the Prefectures of Chania, Rethymno in Crete Island, at Paralio Astros area in eastern Peloponnese, at Chalkidiki Peninsula central Macedonia, Greece, are presented in this paper.

The Record of upper Quaternary Explosive and Effusive Volcanism in the Marine Realm on the Eastern Margin of the Nisyros-yali Volcanic Islands

Vassileios Anagnostopoulos¹, George Anastasakis¹

¹Faculty of Geology and Geoenvironment, University of Athens, Panepistimiopolis, Athens 15784, Greece
anastasakis@geol.uoa.gr , vanagnosto@geol.uoa.gr

A series of Athens University high–medium resolution marine geological surveys since 2010 elucidate the imprint of significant Quaternary volcanic events in the marine realm of the southeastern end of the South Aegean Volcanic Arc. Here we present multibeam and sparker data that cover the eastern margin of the Yali-Nisyros volcanic centers. The study area consists of an uplifted 340 m² deep plateau that separates the islands from Datça (Doridos) Peninsula, West Kos basin and Tilos basin to the east, north and south respectively. Independent stratigraphic control of the advance of the volcanic-volcaniclastic deposits into the sea is based on stacked and prograded coastal clinoform packets developed on the shelf of the islands, that record Quaternary deposits during eustatic lowstands of sea level, with clinoforms developing during forced regression correlated to a global, isotopically linked, Quaternary chronology. Five volcanic-volcaniclastic layers are delineated within the upper 150 m of seafloor strata. The Kos Plateau Tuff (KPT) is easily recognizable on the shelf of the islands below the MIS 6 coastal clinoform wedge. It is a strongly chaotic acoustically incoherent unit, with a strongly erosional base, onlapping the slope of the Datça peninsula and spilling over into West Kos and Tilos basins, where it attains much greater thickness compared to the 10–20 m thick deposit east of Yali and Nisyros. Above the KPT there are well developed subparallel reflectors, 9–12m thick, and especially on the east margin of Nisyros another laterally extensive, acoustically chaotic, 8 m thick layer extends to the east and south, progressively becoming thinner and eventually passing into subparallel reflectors 4 m thick. This is correlated to the Kyra ash flows of Nisyros. Overlying 3–6 m of subparallel reflectors above the Kyra ash, especially towards north Nisyros and Yali, a 2–4 m massive layer is developed with limited eastward extent. This layer is correlated to the Yali Lower pumice, an underwater pumice eruption. Overlying 2–4 m of subparallel reflectors, a widespread 3–12 m thick acoustically incoherent bed extends eastwards, with lesser thickness SE of Nisyros. This is correlated to the Lower Nisyros Pumice, which onshore contains pumice-surge ash-flow deposits up to 15 m thick. Overlying 1–4 m of subparallel reflectors, in uppermost levels of the marine strata, there is a clearly distinguished, incoherent but strongly reflective massive bed, up to 20 m thick, with abrupt lateral lens shaped terminations, especially in the northeast and southeast. This bed extends approximately 10 km northeast and 8 km southeast of Nisyros, where it is possibly associated with subordinate debris flow deposits. These results show that due to less steep seabottom gradients, the east Yali-Nisyros margin has preserved a well-defined stratigraphy of the most important volcanic events of the last 170 000 years.

Keywords: Nisyros-Yali, seismic stratigraphy, offshore, volcanic deposits

New Tephrostratigraphic Data from South-western Turkey: insights for Regional inter-archive Correlation and Volcanic Ash Dispersal

Roberto Sulpizio^{1,2}, M. Cihat Alçiçek³, G. Zanchetta⁴

¹ Dipartimento di Scienze della Terra e Geoambientali, via Orabona 4, 70125, Bari, Italy

² Universidad Autonoma de San Luis Potosi, Av. Manuel Nava 5, San Luis Potosi, Mexico

³ Pamukkale University, Geological Engineering Department, Denizli, Turkey

⁴ Dipartimento di Scienze della Terra, via S. Maria 53, 56126, Pisa, Italy

In the last 30 years, Quaternary tephra layers have been extensively used to develop a high-resolution event stratigraphy for the late Pleistocene and Holocene across the central and eastern Mediterranean. While early work focused mainly on samples from marine cores, recent work on terrestrial archives (including Italian, Greek, Turkish and Balkan lakes, and Bulgarian, Greek and Italian cave sites) have considerably advanced the development of a long, high resolution tephrostratigraphy, which will link marine and terrestrial records of Pleistocene-Holocene-age across the Mediterranean region and mainland Europe. Nevertheless, there are some areas in the Mediterranean, in which volcanologic and tephrostratigraphic studies are still at an early stage, and the link to the general tephrostratigraphic Mediterranean network is lacking. The south-western Turkey is certainly one, in which tephrostratigraphic and tephrochronologic studies are in their infancy, although some studies on lacustrine settings indicate the area is extremely promising for tephrostratigraphic studies.

Three tephra layers have been recognised in terrestrial sediments of Acigol, Cameli and Burdur areas (south-western Turkey). Stratigraphic position of all the tephra layers indicates they are Quaternary in age, with at least one from Holocene.

EDS major element chemical analyses have been performed on three tephra layers, and classify the three samples as rhyolites (Acigol and Cameli tephra) to trachyte (Burdur tephra). Basing on comparison of geochemical composition and age interval the Acigol tephra layer correlates with the Minoan eruption from Santorini Island (Aegean sea, 3.6 cal. yr. BP), while the other two samples show similarity with Cappadocian volcanism (Cameli tephra layer) and Gölküc volcano (Burdur tephra). The proposed correlations have both tephrostratigraphic and volcanologic implications.

On one hand they link the south-western Turkey to the Cappadocia and to the Aegean sea archives. On the other hand they demonstrate the high mobility of volcanic ash, which are dispersed under the effect of high and low atmosphere dynamics over hundred thousands of square kilometres (e.g. the calculated area of dispersal for the Minoan ash is now at 359,000 km²).

Interpretation of Late Pleistocene Terrace Staircases along the Mudurnu River Valley (NW Anatolia) in Terms of Fluival Response to Climate Change and Natural Hazards

M. Korhan Erturaç¹, Sumiko Tsukamoto², Edwige Pons-Branchu³, Gürsel Sunal⁴, Pınar Gutsuz⁵, Ayşe Atalay Dutucu¹, Cercis İkiel¹

¹Sakarya University, Faculty of Arts and Science, Department of Geography, 54187 Serdivan, Sakarya.

²Leibniz Institute for Applied Geophysics, Stilleweg 2 D-30655, Hannover, Germany.

³LSCE, UMR1572, CEA-Orme des Merisiers, F-91191 Gif-sur-Yvette, France.

⁴İstanbul Technical University, Department of Geological Engineering, 34469, Ayazağa, İstanbul

⁵ İstanbul Technical University, Eurasia Institute of Earth Sciences 34469, Ayazağa, İstanbul

Mudurnu River is one of the major tributaries of the Sakarya River Drainage system which drains a wide area of 1500 km². The northern catchment of the river flows through the major uplifts such as Mt. Almacık (1830 m) in the North and Mt. Kapiorman (1590 m) and Mt Abant (1760 m) in the south forming a very narrow and deep valley with high relief. This valley is formed within the 2.5 km wide deformation zone of the North Anatolian Fault Zone (NAFZ) and called as Mudurnu Valley where the area is subject to coseismic deformation during 1957 Abant (M:7.0) and 1967 Mudurnu Valley (M:7.1) earthquakes.

The Pleistocene stratigraphy of fluvial and lacustrine formations in this narrow valley is the subject of this study. Field observations and detailed mapping indicate that these units can be classified as (1) Terrace staircases formed after the rapid incision of the Mudurnu River and preserved at the steep slopes of the valley (2) layers of fine clastics and fossiliferous (leaves, pollen and fresh water mollusks) zones which seem to be deposited in temporal lakes formed after major landslides damming the Mudurnu River, (3) slope deposits covering the first two units and (4) alluvial fans.

The fluvial processes that dominate the evolution of the valley controlled the formation of 5 different depositional terrace staircases (max +110 m.) where almost all of these levels are located on the northern side of the active fault (1967 earthquake surface rupture) The analysis of these terraces indicate intense erosional periods between T4 (+75-90 m) and T3 (+35-50 m) and also between T3 (+35-50 m) and T1-2 (+10-25 m) levels. During the second erosional period a lacustrine unit with 20 meters visible thickness is deposited. This formation appears to be deposited in a wide temporal lake formed after a major landslide affecting ~100 ha area and damming the valley. The deposits of this lake can be observed in a wide extend, distributed at the south and northern slopes of the valley and covered unconformably by the T1-T2 terrace levels. Also similar but thinner unit is located on the top of all units and indicate another landslide/damming event occurred during the Mid Holocene. These observations indicate severe control of climate changes and also the effects of earthquake/climate triggered major landslides during the Quaternary evolution of the valley.

To achieve a detailed chronology of the listed events, dense sampling of 23 different units (with 60 individual samples) is accomplished for OSL (Optically Stimulated Luminescence) dating. The sample preparation is held in İTÜ/EIES and the OSL signal is measured in LIAG OSL laboratories. U-Th (UMR-1572) and C14 (Poznan) dating of carbonate shells and charcoal from suitable layers are used for cross checking. These efforts will help us to understand the geomorphological evolution of this valley in terms of fluvial response to climate change, active tectonic deformation and cyclic landslides which form repetitively because of the steep valley slopes.

Keywords: Fluvial Terraces, Landslide, Climate Change, Valley Evolution, OSL Dating

Pollen and Non-pollen Palynomorphs as Environmental Indicators in Holocene Sediments of the North Anatolian Fault

Nurdan Yavuz¹

¹General Directorate of Mineral Research and Exploration, Department of Geological Research, Üniversiteler Mahallesi, Dumlupınar Bulvarı No: 139, 06800 Ankara-Turkey

Palynological analysis of samples collected from a trench on the North Anatolian Fault Zone, dated by ¹⁴C technique, revealed the presence of pollen and non-pollen palynomorphs. Pinus pollen is predominant at the lower part of studied sequence with the occurrence of Juglans and few other tree pollen. Asteracea is also present at the lower part. The main non-pollen palynomorphs in the sediments are fungal spores, especially Glomus, freshwater algal palynomorphs (Pseudoschizaea, Botryococcus, Zygnema, Ovoidites), copepod eggs and some animal remains. Botryococcus and Zygnema are mainly present at lower parts while Ovoidites at upper parts. Glomus and other fungal spores generally increase upwards.

Considerable decrease of Pinus and almost absence of other tree pollen together with presence of reworked dinoflagellates in the upper parts and increasing upward dominance of Glomus suggest different source areas for the samples. Palynomorph content of samples at the lower part represents regional vegetation while that of upper part represents local vegetation along river tributaries.

Keywords: pollen, non-pollen palynomorphs, palaeoenvironment, Holocene, Turkey

Late Quaternary Slip Rates of the Ecemiş Fault Inferred From Cosmogenic Cl-36 Dating

M. Akif Sarıkaya¹, Cengiz Yıldırım², Attila Çiner³

¹Fatih University, Department of Geography, Büyükçekmece-Istanbul, Turkey

²Istanbul Technical University, Eurasia Institute of Earth Sciences, Maslak-Istanbul, Turkey

³Hacettepe University, Geological Engineering Department, Beytepe-Ankara, Turkey

Ecemiş Fault is a left-lateral oblique slip fault that constitutes the southern segment of the Central Anatolian Fault Zone. We used excellent exposures of alluvial fans along a ~15 km long, NNE trending linear valley to understand the Late Quaternary tectonic activity of the Ecemiş Fault. Although the geomorphic expression of the fault is very distinct, the rate of active slip is not well-known due to the constraints of explicitly dating offset markers along the fault line. In this study, we have determined the slip of the Ecemiş Fault by remote sensing and in-situ measurements and the alluvial fan ages associated with the Ecemiş Fault by cosmogenic Cl-36 dating. Finally, we calculated the Late Quaternary slip rates of the fault based on the cosmogenic age results. According to the digital terrain model obtained from high-resolution air-borne survey, we determined the horizontal slip amount to be in between 20 to 40 m, and the vertical slip to be 15-20 m. Our cosmogenic Cl-36 geochronology analysis obtained from 22 boulder samples revealed that the surface age of the alluvial fans cut by the Ecemiş Fault is 84.3 ± 7.4 kyr (kilo years). Depending on our preliminary slip measurements, we propose horizontal and vertical mean slip rates in between 0.24 and 0.47 mm/year and 0.18 and 0.24 mm/year, respectively.

First High-Resolution Marinopalynological Stratigraphy of Late Quaternary Sediments from the Central Part of the Bulgarian Black Sea Area

Mariana Filipova-Marinova^{1,2}, Danail Pavlov², Marco Coolen³, Liviu Giosan³

¹Museum of Natural History e Varna, 41 Maria Louisa Blvd., 9000 Varna, Bulgaria

²Society of Innovative Ecologists of Bulgaria, 10 Dr. Bassanovich Str., 9010 Varna, Bulgaria

³Woods Hole Oceanographic Institution, 360 Woods Hole Rd., Woods Hole, MA 02543, USA

Spores, pollen and dinoflagellate cysts of Late Pleistocene and Holocene sediments were analyzed from Giant Gravity Core 18 from the Black Sea continental slope, recovered from a water depth of 971 m. The investigated length of the core is 203.5 cm. It includes 3 lithological units: light grey clay, sapropels and coccolith-bearing ooze. The core was sampled at 5-10 cm intervals. Sampling of the interval 141.5-126 cm was carried out at every cm. AMS radiocarbon dating of bulk organic carbon was performed on 18 selected sediment layers. This chronological data allowed the first high-resolution pollen stratigraphy of Late Quaternary sediments from the western Black Sea area to be presented. The percentage spore-pollen diagram is divided into 6 local pollen assemblage zones. The trends in the vegetation dynamics and climate changes and the early history of migration of the majority of the arboreal taxa that nowadays occur in the Eastern Balkan Range were traced out. The palynological record suggests that open oak forests were spread in the Eastern Balkan Range at the beginning of the Holocene and shows early migration of the major temperate arboreal species such as *Quercus*, *Ulmus*, *Tilia* and *Carpinus betulus*. This vegetation palaeosuccession continues with the spreading of mixed oak forests from 8950 until 2620 cal. BP (8650±40 until 3120±35 ¹⁴C yrs BP) followed by destructive changes due to human impact and climate deterioration. A cooling of Holocene climate that is well known in the North Atlantic region as the “8200 yrs cold event” is identified for the first time in marine records from the Bulgarian Black Sea area. The assemblages of dinoflagellate cysts and acritarchs were investigated to provide a reconstruction of surface seawater salinity and surface seawater temperature changes. Two main dinoflagellate cyst assemblages, one dominated by fresh- to brackish water species such as *Spiniferites cruciformis* and *Pyxidiniopsis psilata* and a subsequent one, that is characterized by euryhaline marine Mediterranean species such as *Lingulodinium machaerophorum*, *Spiniferites belerius*, *Spiniferites bentorii*, *Operculodinium centrocarpum* and acritarchs *Cymatiosphaera globulosa* testified a change in SSS from low salinity (<7‰) to present day conditions after 7990 cal. BP. Substantial freshening of Black Sea surface waters at 2570 cal. BP is established and connected with the transition from a relatively dry and warm to relatively cold and wet climate.

Lateral Variability in Stratal Architecture and Quaternary Sedimentary Evolution of the NW Cyclades Plateau

George Kontogonis¹, George Anastasakis¹

¹School of Geology and Geoenvironment, University of Athens, Panepistimiopolis, Athens 15784, Greece.
anastasakis@geol.uoa.gr, gkontogonis@geol.uoa.gr

The Cyclades plateau hosts dozens of islands that surround several small marine basins developed within a wide continental shelf zone. The NW part of the plateau is separated from the mainland by 400–600 m deep channels and includes two elliptical basins with major axis aligned across a 320–350°N direction. Here we present post 2008 collected sparker and multibeam data, collected by Athens University, that together with older air-gun and multichannel seismic reflection data elucidate the Quaternary sedimentary evolution of the region.

In the Kythnos-Sifnos basin on multichannel records we identify reflector **C**, corresponding to the Upper Pliocene–Lower Quaternary unconformity that defines a Quaternary sedimentary thickness of 400–700 msec. Above we recognize reflector **B**, corresponding to the middle Quaternary beneath a sediment column of 200–350 msec. In the Syros-West Andros basin we distinguish reflector **C** at 500–600 msec and above it reflector **B** that in the deeper sections of the basin lies at 300 msec. Based on the seismic stratigraphic scheme established by Anastasakis and Piper (2013) in the adjacent South Evoikos Gulf, we distinguish seven seismic key marker horizons (**z-w**). The shallowest four horizons (**z-w**) can be correlated with confidence throughout the grid of seismic lines. The horizon **B** defined in the multichannel lines, with a resolution around 25–30 m, lies between reflectors **u** and **s**. Most of the above marker horizons are traced on the shelf of surrounding islands and right down to specific coastal clinoform wedges formed during low sea levels. MIS 6 corresponds to reflector **z** and is encountered in water depths 160–170 msec. Reflector **y** is connected to the top of MIS 12 found at 205–230 msec. Reflector **x** corresponds to the top of MIS 16 typically at 250–280 msec. The older reflectors are also recognized, especially in the basins, allowing a detailed depiction of Upper Quaternary sedimentary facies development. Overall the NW Cyclades plateau is characterized by low subsidence rates, with the exception of the Kaireas-Kythnos straits. A strong erosional event, at the level of reflector **y** (MIS 12) suggests significant palaeoceanographic changes related to sea bottom current activity. Sedimentation rates during MIS 1–16 are generally higher than earlier isotopic stages; sedimentation rates remained extremely low on the shelf if compared to the adjacent deeper basins. The Middle Pleistocene transition below MIS 22 is also imprinted on some shelf areas, despite the low sedimentation rates. Nevertheless the NW Cyclades plateau displays some significant paleogeographic changes as deduced from the evolution of sedimentary facies in relation to Quaternary sea level changes that definitely cannot be concluded on the basis of bathymetric maps.

Keywords: Cyclades plateau; Quaternary; Sea Level; Seismic stratigraphy; Sedimentation

References:

Anastasakis, G., Piper, D.J.W., 2013. The changing architecture of sea-level lowstand deposits across the Mid-Pleistocene Transition: South Evoikos Gulf, Greece. *Quaternary Science Reviews*, DOI 10.1016/j.quascirev.2013.04.018.

Chemo-Stratigraphical Characterization of Lake Van Sediments: Implications for Holocene Ecology and Environment in Eastern Anatolia

Özlem Bulkan¹, M. Namık Çağatay², Özlem Makaroğlu³, Naci Orbay³

¹Istanbul University, Geological Engineering Department, Avcılar-İstanbul, bulkan@istanbul.edu.tr

²Istanbul Technical University, Geological Engineering Department, Maslak-İstanbul

³Istanbul University, Geophysical Engineering Department, Avcılar-İstanbul

The ecosystem of Lake Van, the largest soda lake and fourth largest terminal lake on Earth, is of special importance as it is. It exhibits high alkalinity and salinity, both properties resulting from the weathering of volcanic rocks and evaporation in a closed lake. Analyses are performed on two long cores collected from eastern and western parts of the lake; the time frame starting from the Early Holocene to recent.

Multi-element dataset for chemo-stratigraphical study was obtained by ITRAX-XRF core scanner analysis. Furthermore time dependent variations of the intensity of internal (salinity, water level, and redox) and external (weathering, erosion and transportation processes) conditions are discussed. Basically, lithological observations and Ti/Ca ratio is used to determine the chemical variations in the water column and tephra layers. Ca/Fe, Sr/Ca and P variations are used for determination of the primary conditions and nutrient supply. Additionally, Zr+Rb/Sr and Zr/Rb ratios are applied to define time dependent variations in clastic input.

Apparent environmental changes occurred starting from the Early Holocene. Here, we could define two different types of changes respectively; fast response for the volcanic events and the long termed-permanent environmental changes. Tephra layers indicate sharp and short termed changes in the environment. Basically high Ti/Ca, Zr+Rb/Sr and Zr/Rb ratios and higher P contributions reflect enhanced detrital supply and nutrient enrichment. Contrarily, primary conditions were probably less important, during these events. Basically biogenic carbonate and organic matter content are rare in the tephra layers. As well as such short termed volcanic events, Lake Van ecosystem has significantly and long termed changed after the accumulation of the Tephra-3 layer. After this event, average clastic material contributions have been decreased (lower Zr+Rb/Sr values). However, the overall nutrient supply (enhanced P accumulation), average biogenic carbonate and organic matter accumulation increased.

As a summary, primary conditions have been more effective during the Late Holocene (after the accumulation of T-3 tephra layer) than previous terms. The recent lake system type is a closed lake environment; however, conditions were probably more hydrological open during the early periods of Holocene. Furthermore, during the short termed volcanic events, which are recorded as tephra layers, external conditions were probably the dominant controlling factor for the total ecosystem.

Keywords: Lake Van, Ecosystem, Environment, Holocene

Quaternary Sediments Characteristic of Urmia Lake by 100 Meters Cores

Razyeh Lak¹, Javad Darvishi Khatooni², Ali Mohammadi³

¹Research Institute for earth sciences, Geological Survey of Iran

²Abadan center, Geological Survey of Iran

³ETH Zurich University

The Urmia Lake is one of the largest hypersaline lake of the world, with average 5000 to 6000 Km² area, in Azerbaijan, northwest of Iran. Today, it has been endangered by drying up processes. This environmental hazard is one of the most significant geological problems of Iran. Verification of evolutionary history of Holocene and understanding the reasons for sudden downfall of Urmia Lake water level is the main subject for current study. In this research, undisturbed sedimentary cores of western Lake sediments were prepared by Auger coring method. 16 cores having a maximum depth of 9 meters, and totally 100m of the Lake sub-floor sediments were verified. Sedimentary facies were separated by color, grain size, mineralogy specifications, sedimentary fabrics and evaporative minerals. With regard to vertical sedimentary facies (from surface to sub-surface areas) changes, geography, climatic conditions and Lake water level fluctuation were re-constructed. Results indicated 17 separable types of sedimentary facies in cores. Facies are from Lacustrine, Playa, Swamp, fluvial and terrestrial environments. Coring and verification of Lake Sub-environment sedimentary facies indicate that sequential drying up tracks are visible in the coastal areas of Urmia Lake. However, the main part of the Lake has had Lacustrine environment (6.5m of the Lake floor sediments) for 13000 years. Sedimentation was continuous during the mentioned period and seismic data confirm this issue. Climate change and particularly evaporation increment are significant agents in downfall of Lake water. But these are not the main causes for drought in Urmia Lake region. Iran has experienced a long-term drought since 13000 years ago up to now. Hence, shallow Lakes, such as Maharloo, Mirabad and Zarivar were frequently dried. It is important to note that Urmia Lake has never experienced dryness except in coastal areas. The main stage of Urmia Lake region drought commenced about 13000 years ago. This event indicated coincidence with the last Ice Age. Regarding the Ice Age, downfall of moisture and Lakes' water levels of North Africa and southern Asia was pointed out. Therefore, today, the important agent in downfall of the Urmia Lake water is anthropogenic factor.

POSTER SESSIONS

SESSION 1

**NEOGENE TECTONICS AND SEDIMENTARY EVOLUTION
OF PERI-MEDITERRANEAN AREAS**

**CONVENER
IMRE MAGYAR**

Middle Miocene Relative Sea-level Changes in the Peri-pontide Branch of Eastern Paratethys: An interplay of Eustasy and Terminal Orogen Tectonics

Ayhan Ilgar¹, Yeşim İslamoğlu², Serap Demirkaya¹

¹Department of Geological Research, General Directorate of Mineral Research and Exploration (MTA),
06800 Ankara, Turkey, ayhan_ilgar@yahoo.com

²Department of Marine and Environmental Research, General Directorate of Mineral Research and
Exploration (MTA), 06800 Ankara, Turkey

The reported field study is from the Miocene Sinop marginal trough (SMT), which formed as a narrow terminal foredeep basin at the northern margin of a tectonically inverted foreland basin of the Central Pontides. The SMT contains a well-preserved succession of mid-Miocene shallow-marine deposits which bear a high-resolution record of relative sea-level changes in this southern branch of the Eastern Paratethys. The study integrates sedimentary facies analysis, sequence stratigraphy and biostratigraphy to reconstruct the depositional history of the basin in relation to relative sea-level changes, to assess the role of tectonics and eustasy in the formation of mid-Miocene incised valleys in the basin and to evaluate the relative control of eustasy, tectonics and sediment supply on the valley-fill conditions.

Sedimentation in the SMT commenced with the deposition of the littoral Sinop Formation in Tarkhanian to Tchokrakian time, forming a regressive succession of offshore-transition, shoreface, foreshore and tidal-flat deposits up to 300 m thick. The shallow-marine sedimentation was interrupted by a forced regression, correlative to a eustatic sea-level fall in the Paratethys at the Tchokrakian–Karaganian boundary. Incised fluvial valleys formed in the basin and were subsequently filled with sediment as the Paratethys sea level rose in the Konkian through Volhynian to Bessarabian time, causing a marine transgression and general increase in basin accommodation. The resulting lowstand and transgressive tract valley-fill deposits constitute the overlying Gelincik Formation, up to 120 m thick. The infill of best-exposed palaeovalley shows vertical alternation of shoal-water and Gilbert-type deltaic, shoreface and foreshore deposits, which indicates conditions of a general ‘overfilling’ due to consistently high sediment supply from the inverted Pontide foreland, but with distinct short-term fluctuations in the available accommodation space. The fluctuations are attributed to pulses in the SMT subsidence due to activity of the bounding Balıfakı fault, the outer thrust of the inverted foreland basin. Each episode of thrusting probably caused an immediate increase in subsidence and accommodation in the marginal basin, facilitating formation of a Gilbert-type bayhead delta, whereas the accommodation tended to decrease in the intervening quiet periods of the orogen isostatic uplift, when a shoal-water bayhead delta would form or other type of littoral sedimentation prevail – depending on the water depth and the current rate of sediment supply. The Gelincik Formation is thus considered to have recorded an interplay of the rising eustatic sea level and the terminal tectonic ‘heartbeat’ of the Central Pontide orogeny in accommodating an abundant sediment supply from the denudated mountain belt.

The study has two key aspects: (1) it documents and dates the latest pulses of orogenic activity in the Central Pontides; and (2) it shows that a major ‘uniform’ eustatic transgression, when modulated by local tectonics, may have a ‘jerky’ record of the alternating episodes of deepening and shallowing, which can easily be misinterpreted as higher-order eustatic cycles.

Keywords: Tchokrakian–Karaganian boundary, forced regression, Konkian–Sarmatian transgression, Balıfakı thrust, incised valley-fill, sequence stratigraphy

Sequential Analysis of Burdigalian-badenian Gypsum from Cernesti (Romania, Prahova County)

Dumitru Frunzescu¹

¹Petroleum-Gas University of Ploiesti, Department of Petroleum Geology and Reservoir Engineering, 39
Bucharest Street, 100680 Ploiesti, Romania, dfrunzescu@yahoo.com

The paper diagnoses, describes and interprets the facieses of sulphate evaporitic rocks and associated rocks of the tuff and gypsum formation of the Doftana Molasse belonging to the Drajna syncline. In correlation with data related to mineralogical and petrographical composition and with data related to the palinomorph distribution, the paper proceeds to the setting up and descriptions of facieses associations. By decoding facies data, references are made to ambient significances. The high frequency of occurrences of silty-lutitic laminite facies alternating with arenitic and silty facies, with stream or wave structures suggests alternating deep/shallow media with periodically emerged media. Correlation with recurrences of the upset facies (understood as a periodical flooding/drying effect in the sabkha area) of the nodular gypsum, laminite clastic gypsum, laminite cryptalgal gypsum facies places the accumulation of examined formation in environments of lutitic coastal plain, periodically flooded with reduced tidal and strong aeolian energy, with a prevailing process of vertical accretion. Cyclicities of various orders attributable to a general mollase model can be distinguished.

Keywords: Moldavides, Lower Miocene Formations, Doftana Molasse, sulphatic evaporates, sequential analysis

Geological Evolution and Deep Structure of the Pacific Mobil Belt (The Comparison with Tethys Area)

A. G. Rodnikov¹, N. A. Sergeyeva¹, L. P. Zabarinskaya¹

¹Geophysical Center, Russian Academy of Sciences, Russia

The Pacific Mobile belt. The Pacific mobile belt is characterized by high seismicity, volcanic eruptions and other natural disasters in this populated region. It is an area of recent intense tectonic movements and hydrothermal processes, a place of accumulation of mineral deposits. It was established that the formation of island arcs and sedimentary basins of the marginal seas of the Pacific mobile belt was associated with processes going on in the upper mantle, specifically in the asthenosphere. The asthenosphere is located at depths of order 10-20 km beneath rift structures of the sedimentary basins in the Pacific mobile belt. The asthenospheric rise to the crust causes a split of the lithosphere, a formation of the rift sedimentary basins with the eruption of basalt magma, manifestation of hydrothermal activity and the intense degassing of mantle substance. It is evidently that asthenospheric diapirs represent channels along which hot mantle fluids bearing degassing products of the upper mantle penetrate into the sedimentary basins changing the organic substance. In this case the hot mantle fluids may account for the additional source of hydrocarbons. Correlation of the geological processes. There is an obvious correlation between the geological features, tectonomagmatic activity, and the structure of the upper mantle. The active regions such as the island arcs and the rifts of the marginal seas correlate with a thick magma-generating asthenosphere. It is expressed in the growth of heat flow in the younger tectonic zones caused by the upwelling of asthenospheric diapirs into the lithosphere, which involves tectonomagmatic reworking. Rifts in the marginal seas and island arcs may be accompanied by intense mineralization. The combination of high heat flow, volcanicity and hydrothermal activity in these structures, could lead to the formation of sulfides and other mineral deposits in the past and at present.

Sedimentary basins of the Pacific Mobil belt. The sedimentary basins are characterized by anomaly deep structure: rift structures or spreading centers at their basement; active magmatism at the initial stage of formation; hydrothermal processes associated with sulfides formation; high density of heat flow caused by the uplift of the asthenosphere to the crust; localization of asthenosphere diapirs beneath the sedimentary basins.

Sedimentary basins of the Caspian Sea. The comparative examination of the sedimentary basins of Pacific Mobil belt and sedimentary inland basins of the Caspian Sea were carried out using the results obtained in the International Geotraverse Project. Some common regularity in the deep structure and the history of evolution of these rather different sedimentary basins were revealed, and the connection of their origin with the deep processes was examined. The suggestion on the common character of the origin of these basins and the connection of this process with the asthenospheric plums and the relative deep fluid enrichment occurring in the mantle is presented. The interconnection of the processes of origin of these basins with the recent and paleosubduction zones is discussed. The subduction zones are treated as sources of tensile tectonic stresses and of the deep fluid penetrating the mantle in the recycling process after the subduction.

Acknowledgement. We would like to thank the Russian Foundation for Basic Research for financial support of our research work (RFBR Project No: 12-05-00029-a).

Keywords: Pacific Mobil belt, Caspian Sea, deep structure, geological evolution, asthenosphere diapir

Late Miocene Model of the Area between Vardar and Middle Struma Rivers

Tzanko Tzankov¹, Nikolay Spassov², Krasimir Stoyanov¹, Denis Geraads³

¹South-Western University "Neofit Rilski" – Blagoevgradq Natural-Mathematical Faculty, 3 Polkovnik Dimov Str., 2700 Blagoevgrad – Bulgaria, tzankov1936@abv.bg, kراسي_sto@yahoo.com

²National Museum of Natural History, Bulg. Acad. Sci., 1 Tzar Osvoboditel Blvd., 1000 SOFIA, Bulgaria, nspassov@nmnhs.com

³UPR 2147 CNRS – 44 rue de l'Amiral Mouchez – F-75014 Paris, France

Our previous palaeogeographic analysis in Southwestern Bulgaria (middle streams of the rivers Mesta and Struma) show that in the late Miocene, these areas had savanna landscape of flat, hilly and plateau terrain, drain by a number of braided rivers. Along the Middle Struma river, upper neogene alluvial sediments are included in those in superposition, but with different spatial soundness Oranovski and Slatinovski genetic lithocomplex, Gradishtenska benchmark group of strata, Strumyanski and Piperishki genetic lithocomplex at the age of late Vallesian respectively to the end of the middle Turolian, according to the fauna (Tzankov, Spassov, Stoyanov, 2005; Spassov, Tzankov, Geraads, 2006)

Our first comparative studies (2011-2012) conducted in the region of Middle Vardar river, in the vicinity of Strumitsa - Strumeshnitsa river in the border region between FYROM-R. of Macedonia and Bulgaria, enable preliminary summaries concerning this area, with unfolding upper Miocene continental alluvial deposits. Our paleontological researches on mammal fauna in FYROM-R. of Macedonia show a predominance of localities with middle Turolian age but it's seems that in the region of Strumeshnitsa river they reach the border of the Vallesian (Geraads, *et al.*, 2012). In the valley of the Middle Vardar, between Skopje and Demir Kapia the examined alluvial deposits are represented by a thick several tens of meters, relatively monotonous, mostly close-grained, whitish to greyish-whitish sands. These Upper Miocene deposits can be defined as Middle Vardar genetic lithocomplex. For the present, his base has not been well investigated. The discovered fossil mammals at the localities of Umni Dol, Kiro Kjachuk, Karaslari and Vozartsi show an age of middle to early Turolian for this complex (Geraads, Spassov, Hristova, Markov, Garevski, 2011).

The reveals of Prsten genetic litokompleks were ascertained for the time being in the large coom, just in the south of the village Prsten. The visible part of the section is represented by a thick (up to ten meters) parallel to obliquely layered, poorly spatial sound dense limiest or clayey-limiest sandstones with rusty-reddish color. Here, over the section concerned is placed the Bashibos genetic lithocomplex. It consists of unsorted medium to small in size conglomerates and breccias with abundant sandstone solder. In these rocks are found fossils of mammals (near the village Bashibos and Prsten). The thickness of these alluvial deposits up to several tens of meters. The discovered mammal fauna indicates an older age than the Middle Vardar lithocomplex: related to the Valesian/ Turolian boundary.

In the gorge between the town of Strumitsa and Kosturino village and its western slopes are revealed alluvial deposits, which are, with respect to their lithological and textural characteristics, similar to those of Piperishki genetic lithocomplex from the valley of Struma river. In the region of Delchevo along the Bregalnitsa river (Fig. 1) near the villages Zvegor and Stamer a fossil mammal fauna is found in the late Miocene sandy alluvial deposits which determine the age as close to the Miocene/ Pliocene boundary.

During the late Miocene, the investigated areas were field of powerful water arteries of several braided rivers in a hilly plain relief and plateaus. The most powerful processes of sediment transport are observed in the region of "Palaeostruma" and the transportation processes in the region of "Palaeovardar" are the most calmed, but the deposits suggest the existence of running continental waters with peripheral spills and swampy, rather than the presence of lacustrine basin.

Keywords: deposits, lithocomplex, Late Miocene, braided rivers

Marine Habitat Mapping and Sea-Floor Surface Structures Using Side Scan Sonar and Visual Data: Northern Cyprus Shelf Survey

Tarık İlhan¹, Barış Akçalı¹, Müge Atalar¹, Muhammet Duman¹

¹Dokuz Eylül University, Institute of Marine Sciences and Technology, 35340 İnciraltı, Balçova, İzmir, tarik.ilhan@deu.edu.tr

The aim of this study, to map seafloor surface structures and benthic areas by using side scan sonar supported with underwater photography and video recordings. In the Northern Cyprus Shelf the outcrop of basement rocks, sedimentary boundaries, habitat areas and the other local targets have been mapped at various target zones by using SSS records at NE Mediterranean. Afterwards, video and photo of submarine have been recorded. SSS records have been specify by mosaic maps which are created by using SonarWiz software and possible sediment boundaries of biota have been defined as matching locations with visual data. Particularly, observed morphological anomalies which belong to mainly flora have been proved by bathymetry maps, as well. The resulting morphologic and seabed classification maps were combined to plot the distribution of the predominant habitats in the coastal waters of Northern Cyprus, some of which are of high conservation value. Ground-truthing of the habitat map using sediment data, video imagery and dive observations confirms that our approach produces a simplified and accurate representation of seafloor habitats while using all the information available within the SSS data sets.

Keywords: Mediterranean, Side Scan Sonar (SSS), Sea-floor Mapping, Surface Sediments, Video Recording

Stratigraphy and Structural Features of the Neogene Sequence in the Bozüyük (Bilecik)-Kızılınler (Eskişehir) Area

Elif Apaydin Poşluk¹, Hayrettin Koral¹

¹İstanbul University, Department of Geology, Istanbul Turkey, elifapaydin@gmail.com

This study aims to explore structural features and stratigraphic sequence of the Neogene units deposited in the Bozüyük (Bilecik) - Kızılınler (Eskişehir) area, a zone of collision between the Sakarya continent and the Anatolides. The stratigraphy of the study area is determined in the field by investigating the interrelationship of the Neogene age units which lie over the basement rocks. Ageological model is proposed for the formation of the Neogene basin.

Pre-Mesozoic age marbles, schists and granodiorites, Mesozoic age marbles, schists, ophiolitic units and limestones are considered basement units. Neogene cover units are the Porsuk Formation, Akpınar Limestone, İnönü Volcanites, Ilica Formation, Akçay Formation and Quaternary alluvium from the bottom to the top. Paleontological data which could yield a geological age are not observed in the Porsuk Formation and the Akpınar Limestone. The K^{40}/Ar^{40} dating analyses on trachy-andesite of the overlying İnönü Volcanites indicate middle Miocene ages (15.0-15.5 Ma), suggesting the underlying sedimentary units to be lower-middle Miocene age. Fossils are discovered in the limestone of the Ilica Formation in Oklubalı (İnönü-Eskişehir) and Kızılınler (Eskişehir) villages, and the age is determined to be Pliocene. Unconsolidated, cross-bedded fluvial sediments observed in the Musaözü Village (Eskişehir) area are attributed to the Pleistocene age Akçay Formation.

Imbrication orientations of the fluvial sediments in the Porsuk and Akçay Formations and structural data on faults are determined in study area. From the west to the east, the Ormangüzle, Kızılcapınar, Bozalan, Kandilli and İnönü Faults are observed. Based on sedimentary and structural data collected in the Neogene basin, the faults in NW-SE directions are considered influential during the formation of the Neogene stratigraphy in the study area. However, faults in WNW-ESE orientations in the Eskişehir Fault Zone still keep their seismic activity and have a potential of producing damaging earthquakes as indicated by the Çukurhisar earthquake of February 2, 1956 (M=6.4).

Keywords: Neogene stratigraphy, basin evolution, Eskişehir fault zone, 1956 Çukurhisar earthquake

An Updated, Geo-Referenced 1:250.000 Scale Geological Map of the Betics

Ana Crespo-Blanc^{1,2}, Balanya³, J.C., Barcos³, L., Díaz-Azpiroz³, M., Expósito³, I., Jiménez-Bonilla³, A., Luján^{1,2}, M., Suades^{1,2}, E. and Ana Retuerta^{1,2}

¹Departamento de Geodinámica, Facultad de Ciencias, Universidad de Granada, Fuentenueva s/n, 18071 Granada – Spain. acrespo@ugr.es

²Instituto Andaluz Ciencias de la Tierra, Consejo Superior de Investigación Científica- Universidad de Granada, Avenida de las Palmeras 4, 18100 Armilla (Granada - Spain).

³Departamento de Sistemas Físicos, Químicos y Naturales, Universidad Pablo de Olavide, Ctra. de Utrera km. 1, 41013 Sevilla – Spain.

The Betics is part of the Gibraltar Arc System (GAS), which closes the Alpine-Mediterranean orogenic system to the west. Since the seventies, the various tectonic domains which build up the Betic cordillera have been studied from very different points of view: structural analysis, stratigraphy, sedimentology, paleontology, mineralogy, petrology, metamorphism, geophysics, and so on. For the geological setting, the authors of these works generally use a 1:400'000 geological map of Andalucía, published on paper in 1985. Other 1:200.000 geological maps, covering the entire Spanish territory were published in the seventies and are clearly obsolete. Accordingly, it was necessary to update and geo-reference this information.

In this poster, we want to present a new 1:250'000 geological map, of the western and central Betics. It is generated with ArcGIS software and based on the 1:50'000 geological maps of the Spanish Geological Survey. These maps, sometimes published in the seventies, were actualized; their legends were unified and their outlines eventually redrawn according to an extensive bibliography that also included PhD Thesis. The result was smoothed for a major scale. The map caption was made with great care, following criteria coherent with generally accepted models of the tectonic evolution of the Betics. Other layers include the digital elevation model (20x20m) and orthophotographs, in color and/or in black and white. This geo-referenced geological map also permits to generate an updated tectonic map.

In a next future we want to include various thematic layers in the ArcGIS files. In these layers, all the available geological information will be compiled and grouped by type of information, from paleomagnetic vectors to kinematic criteria, going through seismic profiles or structural trend-line pattern. This work of synthesis is a hard-working labor but we are sure that it will be useful as it is a frequent request of the geologists and geophysicists who work in the westernmost termination of the Alpine-Mediterranean orogenic system. For this purpose, collaborations are welcome.

Keywords: Betics, geological map, geo-referenced, 1:250.000, thematic layers

Acknowledgements:

This study was supported by grants RNM-3713, RNM-215, CGL2008-03474 E/BTE, CTM2009-07715/MAR and CGL2009-11384.

Expression and Importance of Alpine Phase in the Tadjerouna Region (Laghouat, Central Saharan Atlas)

Abdellah Bettahar¹

¹Faculty of Earth Sciences, Geography and Planning – U.S.T.H.B -BP 32 El-Alia Algiers Algeria.
bettaharabdellah@gmail.com

The Tadjerouna region is located at the southern termination of Dj Amour, last is the southern part of the Central Saharan Atlas.

Atlasic basin formation took place over a long period of openness that was Triassic to Upper Cretaceous; there, however the existence of phases of disturbance within this great cycle, of which the neo-cimmerian that occurs at the Jurassic-Cretaceous.

At the end of the Cretaceous, the beginnings of Alpine cycle are felt and the basins Atlasic enter in a process of closing with an emersion who undertakes the SW to NE. Two phases are involved in structuring the Alpine cycle, the phase known as Atlas Eocene and Miocene phase.

This work is a partial contribution to the achievement of the geological map of Tadjerouna (southwest of Laghouat) to 1/100 000, the land consisting is Upper Jurassic to Cretaceous age from Kimmeridgian to Senonian, overlain unconformably by the tertiary and quaternary formations; it has a geometric and kinematic analysis of the structural elements identified in the field related to the last phase of structuring.

This analysis has identified the importance of this last phase structure, which results from compression with a shortening axis NW-SE to NS, which probably comes from the Early Miocene. The mainly expressions are: the detachment of the Turonian, the Cretaceous formations of flaking and reorientation of existing structures. They represent the effects of the conjugated system of accidents N-S and NW-SE.

Keywords: Tadjerouna, Central Saharan Atlas, Compressive phase, Miocene.

New Proboscidean Site from the High Karst Dinarides in Southern Bosnia and Herzegovina

Oleg Mandić¹, Ursula B. Göhlich¹, Hazim Hrvatović², Jadranka Mauch Lenardić³, Božena Čvorović⁴, Goran Glamuzina⁵, Denis Radoš⁶

¹Geological-Paleontological Department, Natural History Museum, Burgring 7, 1010 Vienna, Austria.
oleg.mandic@nhm-wien.ac.at, ursula.goehlich@nhm-wien.ac.at

²Federal Institute for Geology – Sarajevo, Ustanička 11, 71210 Ilidža, Bosnia and Herzegovina.
hharish@bih.net.ba

³Croatian Academy of Sciences and Arts · Institute for Quaternary paleontology and geology, Ante Kovačića 5/II, HR-10000, Zagreb, Croatia. jml@hazu.hr

⁴The National Museum of Bosnia and Herzegovina, Zmaja od Bosne 3, 71000 Sarajevo, Bosnia and Herzegovina. bozenabc@gmail.com

⁵Elektroprivreda Hrvatske Zajednice Herceg-Bosne, Mile Budaka 106a, 88000 Mostar, Bosnia and Herzegovina. ggglamuz@yahoo.com

⁶University of Zadar, Department of Geography, Center for Karst and Coastal Research, Trg kneza Višeslava 9, HR-23 000 Zadar. drados@unizd.hr

A new late Neogene proboscidean site, Cebara has been currently discovered by the local fossil collector Vinko Ljubas south of Tomislavgrad in Bosnia and Herzegovina. It is located in one ~40 m deep, ~20 m high and ~17 m wide incision of the escarpment opened during quarry exploitation at the southwestern margin of a typical Dinaride karst polje termed Duvanjsko polje. The latter represents a ~240 km² large and NW-SE striking intra-mountainous basin that was initiated in the early Miocene (~17 Ma) as the eastern part of the Livno-Tomislavgrad basin. Herein two sedimentary cycles accumulated more than 2500 m of coal bearing lacustrine deposits until the latest Miocene (~6 Ma) therein.

The posterior wall of distally narrowing incision shows coarsening upward succession of clays, fluvial gravels and block-breccia including up to 5 m diameter boulders developed through reoccurring cave roof collapses. Upward the incision is unroofed passing into a ~35 m wide and ~10 m deep funnel-shaped doline. The logged succession is 10 m thick with the base covered by debris and top not reachable at present outcrop conditions. It comprises two units of equal thickness. The lower one is characterized by deposition of brownish clay that can include sand lenses and/or laterally grade to block-breccia. Beyond that up to 1 m thick sand, gravel and boulder intercalations are present. The upper unit is composed of two conglomerate packages both topped by cave-in breccia. The lower gravel shows through- and cross-bedding and at its base operculi accumulations of freshwater snail *Bythinia* occur supporting the inference of riverine and/or lacustrine origin of the sediment.

The bone bed interval is about 1.5 m thick and marks the middle part of the lower unit. The fossil bones, tusks and teeth oriented horizontally to the bedding plane, are disarticulated and concentrated in three 10 to 30 cm thick horizons. The lower one appears on top of one 30 cm thick gravel bed, the other two mark lower and upper part of one 90 cm thick sandy layer. Strongly increased magnetic susceptibility values ($>100 \times 10^{-6}$ SI) detects the black color of the bones and matrix sediments as containing iron-bearing minerals. The inspection of up to now available fossil remains allows their tentative classification as *Anancus arvernensis* (Croizet & Jobert 1928) representing a tetralophodont gomphothere characterized by two oversized straightened tusks in the upper jaw and a body-size of today's elephant. This European gomphothere has the peak distribution in the late Pliocene, and the stratigraphic range from the latest Miocene MN11 to the early Pleistocene MN17. Although the stratigraphic data does not allow a precise inference of the age yet, the lithostratigraphic evidence supports the correlation with the Pliocene and/or Pleistocene in a phase post-dating the Miocene long-lived lake conditions.

Keywords: Dinarides, Proboscidea, late Neogene

Biostratigraphy of the Neogene Southwestern Alboran Basin (Western Mediterranean, Nador Offshore, Morocco)

M. Z. Yousfi¹, N. Barhoun²

¹ Office National des Hydrocarbures et des Mines (ONHYM), 34 Avenue Al Fadila, 10050-Rabat-Morocco

² Department of Geology, Hassan II-Mohammedia University, Faculty of Science Ben M'Sik, BO 7955, Casablanca, Morocco.

During a Moroccan exploration program within the late eighties, two holes (ELJABHA 1 and NADOR 1) were drilled in the southwestern Alboran basin (Nador offshore, Morocco), we investigated by a biostratigraphic point of view this wells, and the aim of this study is to describe the biostratigraphic framework of the Neogene sequence in this area.

A detailed analysis of planktonic foraminifera assemblages has highlighted a series of bio-events directly onto the calibrated Magnetostratigraphic and astronomical time scale (Hilgen et al, 1995, and Lourens et al., 2004), revising and precisely dated sediments from these two wells. The succession of these events has awarded the deposits of the upper Tortonian at (ElJebha1), whereas (Nador 1), we recognized the Zanclean, Piacenzian and Pleistocene. This confirms the dating proposed by Feddi et al. (2011).

The two holes (ELJABHA 1 and NADOR 1) are correlated with Neogene series of neighboring Mediterranean basin to better understand the impact of tectonics in the individualization and structure of the basin. Our results allowed us to recognize major and small hiatuses in the Neogene sequence of these wells. By confronting our results with the previous subsurface data interpretations, we believe that these are local manifestations affected by an intensive tectonic phase in a way that continues up to present.

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Stratigraphic and Structural Interpretation of Regional Seismic Sections from the Pannonian Basin

Attila Balázs¹, Imre Magyar^{2,3}, Ferenc Horváth^{1,4}

¹Eötvös Loránd University, Department of Geophysics and Space Sciences, Budapest, Hungary, balatt@gmail.com

²Research Group for Paleontology, Hungarian Academy of Sciences-Hungarian Natural History Museum-Eötvös University, Budapest, Hungary

³MOL Hungarian Oil and Gas Plc, Budapest, Hungary

⁴Geomega Ltd, Budapest, Hungary

Composite reflection seismic sections were constructed and interpreted from Hungary in order to examine the tectonic and stratigraphic evolution of the Pannonian Basin. A database was compiled using a network of 2D seismic lines, well data, gravity and magnetic anomaly maps of Hungary. From the beginning of Late Miocene the Pannonian Basin separated from world seas and Lake Pannon persisted for about 6 million years. Paleobathymetric calculation was performed using precise depth conversion and decompaction of the slope clinoforms (sediments of Algyő Formation) on the flattened seismic sections. It led to the conclusion that the maximum water depth could have reached even 1000 metres in early Pannonian.

Changes of the relative water level have been in the focus of debates for many years. Construction of shelf-edge trajectories show periods of stagnation and rise of relative water level. The composite sections show no evidence of larger base-level drop than the seismic resolution. Even the Mio-Pliocene unconformity can be explained by intra-plate stress-level increase without a major water level fall in Lake Pannon.

Acknowledgements

We would like to thank the MOL Hungarian Oil and Gas Plc for the provided seismic and well data. The Hungarian National Science Foundation (OTKA) grant NK83400 is also acknowledged.

Keywords: Pannonian Basin, Lake Pannon, shelf-edge trajectory method, paleobathymetry

SESSION 3&7

**MEDITERRANEAN-ATLANTIC EXCHANGE: CAUSES AND
CONSEQUENCES
&
TOWARDS NEW UNDERSTANDING OF THE LATE MIOCENE
MESSINIAN SALINITY CRISIS**

**CONVENERS
RACHEL FLECKER AND FRANCISCO SIERRO
CHRISTIAN GORINI AND ANTONIO CARUSO**

Result of Messinian Crisis Impact on the Territory of Azerbaijan and Ps Paleobasin Formation

Malahat Afandiyeva¹, Ulvi Vahabov¹

¹Geology Institute of Azerbaijan National Academy of Sciences, H.Javid av.29A, Baku, AZ1143, Azerbaijan, m.efendiyeva@mail.ru

Deposits of Productive series (PS) has long been considered the main oil reservoir for the territory of Azerbaijan and the adjacent water area of the South Caspian Depression. For this reason, they are always the object of study for geologists different specialties and areas.

Analysis of all available literature, file and original data as well as consideration of PS deposits from the point of system analysis allowed for the first time to compile a table in which all data obtained earlier from the point of historical-geological development of the region, depositional environment and accumulation of each stratigraphic unit of PS in the territory of Azerbaijan including a certain paleontological complex and formed under direct impact of Messinian crisis.

As early as in the early and middle Cenozoic the territory of Azerbaijan was the part of Tethys ocean isolated as a result of collision of Afro-Arabian, Hindustan and Eurasian plates, but the basic orogenic movements within it can be observed from Miocene, but beginning from Sarmatian stage and up to Meotis continue forming mountain structures of alpine belt. With the beginning of Messinian crisis terrigenous rocks drifted from flank parts and accumulated in the South Caspian Depression. By the end of the Miocene as a result of differential tectonic movements there was formed framing of the Caspian basin territory, which was covered by a folding of Kopetdag and downwarping of the Great Caucasus, Talish and Elburz, including other marginal areas of the South Caspian Basin (SCB).

All these processes have resulted in changes in paleogeographic environments situation both in the West and in the East of Azerbaijan. Late Miocene, is characterized by uniform and interchangeable regressive processes. This began as early as in the Sarmatian. It was a time when the waters of the sea began to free the territory of Azerbaijan in the direction from west to east. Beginning of the age of productive series was characterized by strengthening of transverse uplifts which come from axis of Caucasian isthmus resulted by a complete drying of all Kura depression and displacement of paleobasin waters into the South-caspian basin. Thus at the end of Miocene the marine paleobasin shifted toward the South Caspian depression and the territory of Azerbaijan becomes the area of accumulation of a thick sand formations. As a result of these processes there started formation of unique deep water Kalinian paleobasin of lake type, which characterized by a complex relief that was stipulated by presence of numerous islands formed on the base of anticlinal uplifts that was the logical end of tectonic processes started as early as at the end of late Miocene.

Recent studies allowed restoring paleobionomic conditions under which there occurred accumulation of sediments of different lithostratons of productive series within Absheron peninsula. It was determined that the sediments of distinguished suites formed under following conditions:

- PK Suite – in the coastal zone of subsaline-sea basin at depth of 40-60 m, with salinity 14-17‰;
- NKP Suite – in lithoral zone of subsaline –sea paleobasin at depth of 25-30 m at a temperature 10-16°C and salinity 13-17‰;
- NKG Suite – in lithoral zone of subsaline sea paleobasin at depth of 50-60 m at a temperature 10-16°C and salinity 13-18‰;
- “Pereryva” Suite – in shallow water at a depth of 2-8 m at 15 °C and 10 salinity from 2 to 6-7 ‰;
- Balakhan, Sabunchi and Surakhani Suites – in shallow waters in the area of the river delta, with a salinity of 16-18 ‰.

Conclusions. Thus, as a result Messinian crisis when under influence of global tectonic processes together with climatic factors in the territory of Azerbaijan there occurred formation of unique sedimentation paleobasin of productive series which acquired the following characteristics of faunistic complexes:

- Kalin Suite there are redeposited Miocene forms and unlike Pontian deposits there absent macrofauna (Pelecypoda embryo);
- PK Suite differ by a noticeable content of redeposited Miocene and paleogene foraminifera; – NKP Suite the number of Paleogene redeposited forms predominate over Cretaceous and Miocene ones;
- NKG Suite there appear redeposited Cretaceous foraminifera and again after Pontian appear Pelecypoda embryo;
- NKP Suite deposits the number redeposited Paleogene form, prevail on Cretaceous and Miocene forms;
- In “Pereryva” Suite representative of Ostrakoda fauna considerably decrease, there one can find redeposited forms of Cretaceous, Paleogene and Miocene age and appear a unique representative of terraneous mollusks Helix;
- Sabunchi and Surakhani Suites there completely absent foraminifera and considerably in relation to Balakhan Suite there increases a number of redeposited foraminifera forms of Cretaceous, Paleogene and Miocene

Keywords: Azerbaijan, Productive series, Messinian crisis

The Neogene Basins in Ne Morocco: Impact of the Messinian on Groundwater Salinization on the Mediterranean Littoral Plains

El mandour Abdennabi¹, Elgettafi Mohammed¹, EL Yaouti Fouzia², Samia Rochdane¹, Himi Mahjoub³, Benavente José⁴, Casas Albert⁵

¹Faculty of Sciences; University Cadi Ayyad. Laboratory GEOHYD, Marrakesh, Morocco.
a.elmandour@uca.ma

²Faculty of Sciences; University Mohammed I. Oriental Center of Water Sciences and Technology Oujda, Morocco.

³Ecole Nationale des Sciences Appliquées, Al Hoceima, University Mohammed I, Morocco.

⁴Water Research Institute, Université de Granada. Ramon y Cajal. 4. 18071. Granada. Spain.

⁵Water Institute. Faculty of Geology, University of Barcelona, Martí & Franques, s/n. 08028 Barcelona, Spain.

The northern Moroccan plains have a semi-arid climate, with a low rainfall (about 245 mm/year). These agricultural plains are generally small, but they play a very important role in the economic development of the region. The plains are divided in two by the Moulouya river: on its right bank are the plains of Triffa and Saïdia; and on its left bank, those of Bou Areg, Gareb and Kert.

The study area is structurally characterized by the small syncline basin between the Alpine mountains to the south and the Mediterranean Sea to the north. There are Quaternary outcrops formed by silts, sands and gravels, which constitute the upper unconfined aquifers. The thickness of this reservoir varies between 30 and 150 m from one area to another and the values of transmissivity range between $2 \cdot 10^{-2}$ and $5 \cdot 10^{-4}$ m²/s. The bottom of the aquifers is constituted of marl from the Mio-Pliocene.

In the coastal zone, the groundwater is affected by high salinity. In the plain of Bou Areg, near the Mediterranean Sea and the lagoon of Nador, the salinity is caused by seawater intrusion and reaches 18 mS/cm. Further upstream, the salinity is induced by leaching from Messinian marls and can be as high as 21 mS/cm. The Saïdia plain has even higher values of salinity; the maximum observed is 55 mS/cm, and is probably the result of residual brine left over from previous marine encroachments.

Inland, the groundwater of the Triffa, Gareb and Kert plains is less saline than in the coastal zone. However, it varies between 1 and 13 mS/cm. It is related to leaching from marly gypsiferous deposits of the Messinian and Mio-Pliocene ages, as attested by their sulfate enrichment. Another source of salinity that leaves its mark on the plains is the recycling of brackish groundwater by irrigation pumping wells during periods of drought.

The chemical data clearly indicate the contribution of the local geology to the increasing salinity of the groundwater in the area. The identified potential sources of salinity include the dissolution of the evaporite sediments which comprise the aquifer substratum. The groundwater within the five plains is generally rich in Cl⁻, Na⁺ and SO₄²⁻. In addition to the intrusion of salinity, caused by the sea level near the coastal plains of Saïdia and Bou Areg, the groundwater salinity of the other plains is caused by the dissolution of gypsum and halite. High values of mineralization are observed near the gypsiferous Pliocene outcrops and where the marl is not very deep. The chemical data show that the fresh water observed in some areas reflects the influence of fresh water coming from the metamorphic massifs of Tamsane and Gourougou for the Kert, Gareb and Bou Areg plains; and from the calcareous massifs of Beni Snassen and Kerdana for the Triffa, Bou Areg and Saïdia plains.

Keywords: Neogene basins, groundwater, Messinian crisis, Salinization, hydrochemistry.

Messinian Erosional Surface around the Levantine Basin: Geodynamic Implications.

L. Mocochain^{1,2}, C. Gorini², G. Clauzon³, J.-P. Suc², C. Blanpied⁴, J. L. Rubino⁴, A. Al Abdala⁵, F. Azki⁵

¹Laboratoire de Géologie, École normale supérieure (CNRS URA 1316), 24 rue Lhomond, 752031 Paris,

²UPMC Université Paris 06 (UMR 7193) IStEP, 75005, Paris, France,

³CEREGE (UMR 6635), Université Paul Cézanne, Europôle de l'Arbois, BP 80, 13545 Aix-en-Provence Cedex 04, France

⁴TOTAL, TG/ISS, CSTJF, Avenue Laribéau, 64018 Pau Cedex, France.

⁵University of Tishreen, Lattakia, Syria.

Recent studies in three areas in the Eastern Mediterranean region, especially in the of Hatay (Turkey), Lattakie (Syria), and Psematismenos (Cyprus) basins confirm the presence of the Messinian Erosional Surface which separates uppermost the Miocene deposits from the Pliocene ones clearly inbedded within the latters.

Chronologically, three main sedimentary and morphological features characterize this unconformity.

The first cartography of this unconformity and a systematic effort in chronostratigraphy in the Rhône Valley established that it is related to a fluvial erosion responsible for the presence of the now well-known Messinian fluvial canyons in relation with the peak of the Messinian Salinity Crisis. Similar canyons have now been identified in many places in Eastern Mediterranean region, truncating all the pre-existing rocks with the peculiar fluvial erosional pattern.

On the edges of the canyons, the Messinian Erosional Surface impacts the previously deposited Messinian marginal evaporites which date from the first step of the Messinian Salinity Crisis. Products of this erosion are often locally preserved along the canyons edges and made of breccias with blocks of variable size of gypsum and other pre-Messinian rocks. They deposited during debris flows events along the edges of the canyon walls, the only part visible in outcrops.

The Pliocene marine reflooding of the Mediterranean Basin resulted in large scale Gilbert type fan delta complexes infilling the Messinian canyons with a prograding sedimentary process. The most spectacular one developed in the Nahr El Khabir Valley in northern Syria.

The recent identification of these three components in three basins of the Eastern Mediterranean region fit very well with the generally accepted scenario of the Messinian Salinity Crisis in the Western Mediterranean (Clauzon *et al.*, 1996; CIESM, 2008).

Preliminary observations suggest that the scenario can be validated and applied also in the Antalya and Adana basins in southern Turkey.

This model consists in a two distinct steps of the Messinian Salinity Crisis: 1- circum-Mediterranean deposition of marginal evaporite between 5.96 and 5.6 Ma in suspended basins, and 2- the downcutting of the Messinian fluvial canyons between 5.6 and 5.32Ma ending with the Pliocene marine reflooding.

Recovery of Molluscan Fauna in the Eastern Mediterranean (Crete, Greece) After the Messinian Salinity Crisis

Efterpi Koskeridou¹, Christina Giamali¹, Bruno Delrieu¹

¹Department of Historical Geology and Palaeontology, Faculty of Geology and Geoenvironment, National and Kapodistrian University of Athens, Panepistimioupolis 15784, Athens, Greece, ekosker@geol.uoa.gr

Early Pliocene macrofaunistic content from deposits of eastern Mediterranean is relatively unknown (Dornos & Wilson, 1999; İslamoğlu *et al.*, 2012). In order to improve our knowledge regarding the recolonization of the megafauna in the eastern Mediterranean after the Messinian Salinity Crisis, palaeobiodiversity and palaeoecology of mollusc fauna of a Zanclean succession in central Crete are here studied.

Specifically, the early Pliocene eastern Mediterranean molluscan record is revealed through the study of a 60m – thick stratigraphic sequence in Voutes section which is located on the western part of the Heraklion basin (Crete, Greece). Our research focused in the basal part of the section which consist of unstratified, mass flow deposits. These deposits are made of shallow marine sand lenses into deep water marls and they afford the opportunity to study high diversity mollusc assemblages which appear to characterize depth range from the mediolittoral to the upper bathyal zone.

Zanclean age is assigned to these deposits through calcareous nannoplankton biostratigraphy (Agiadi *et al.* in press).

133 molluscan species are recorded. A comparison of their biostratigraphical interval to recently suggested ecostratigraphical units for the Western-Central Mediterranean and Eastern Atlantic, which are a chronological series of molluscan extinction events in the Mediterranean and Atlantic Plio-Pleistocene as a succession of “faunal units” (MPPMUs) (Raffi & Monegatti, 1993; Monegatti & Raffi, 2001, 2007; Landau *et al.* 2011), has been done. The presence of thermophilic taxa in the sand lenses, such as *Strombus coronatus*, *Conidae*, *Terebridae*, *Mitridae* and thick-shelled *Veneridae* is characteristic for MPPMU1 between 5.0-3.0 Ma (Raffi & Monegatti, 1993; Monegatti & Raffi, 2001; Landau *et al.* 2011). Similar tropical - subtropical climatic conditions occurred in the study area as a part of the tropical Mediterranean - West African paleobiogeographical bioprovince.

Deep water elements as *Calliotropis sp.*, *Kelliella miliaris*, *Kelliella ruggierii*, *Limopsis spp.*, *Ledella nicotrae*, *Nucula sulcata*, *Jupiteria concava*, *Leda clavata*, *Dimya fragilis*, *Saccula commutata*, *Limea strigilata* are encountered for the first time in the Early Pliocene of the Eastern Mediterranean.

Keywords: Early Pliocene, Eastern Mediterranean, molluscs

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Biostratigraphy and Palaeoecological Implications of the Tortonian – Messinian Transition of Faneromeni Section, Sitia Basin, Eastern Crete

A. Antonarakou¹, H. Drinia¹, E. Koskeridou¹, E. Manoutsoglou², P. Moissette³, J.-J. Corneé⁴, V. Karakitsios¹

¹National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Hist. Geology - Palaeontology, aantonar@geol.uoa.gr

²Technical University of Crete, Department of Mineral Resources Engineering

³Laboratoire de Géologie de Lyon, UMR CNRS 5276, Université Lyon 1 et Ecole Normale Supérieure de Lyon, 69622 Villeurbanne, France

⁴Géosciences Montpellier, UMR 5243, CC 60, Université Montpellier 2, Place E. Bataillon, 34095 Montpellier, France

Integrated biostratigraphic and palaeoenvironmental analyses of foraminiferal and mollusk assemblages are presented for the late Tortonian/early Messinian succession of the Faneromeni succession, Sitia Basin, Eastern Crete.

The study focused on the basal part of the succession which consists of blue grey marls interrupted by a *Neopycnodonte cochlear* bioconstruction, about 2 m thick in total. The basal sediments contain forms of *Globorotalia miotumida* group, astronomically dated at 7.238Ma, (Hilgen et al., 1995). This event can be used as a reliable marker for the Tortonian/Messinian boundary. *Neogloboquadrina acostaensis*, sinistral coiling specimens, are dominant in the faunal assemblages. In the upper part, the scattered occurrence of *Globorotalia nicolae* indicates an age of 6.829 Ma.

The microfossil assemblage of the studied facies records an offshore marine setting and contains planktic and benthic foraminifera. Both on the basis of the P/B ratio and benthic foraminiferal assemblages an outer shelf to upper slope environment is estimated for this interval. *Cibicidoides kullenbergi* and *Siphonina reticulata* are common in the basal part. The upward disappearance of *S. reticulata* constitutes an important bioevent, which occurred just after the Tortonian/Messinian boundary.

Benthic foraminiferal pattern is characterized by alternations of *Uvigerina peregrina* s.l. and *Cibicidoides kullenbergi* assemblages, suggesting that the benthic foraminiferal assemblages through the section are mainly controlled by the trophic conditions, specifically by the quantity and quality of the organic matter reaching the sea floor (Fontanier et al. 2002; Koho et al., 2008; Schmiedl et al., 1997, 2000, 2003).

The presence of *Neopycnodonte cochlear* which is forming clumps as a monospecific community reinforce the results of benthic forams, indicating a very specific set of environmental conditions such as a unique hydrodynamic environment, in upper slope or outer shelf when increased nutrient supply accumulated.

Acknowledgments:

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: THALIS –UOA- "MESSINIAN SALINITY CRISIS: THE GREATEST MEDITERRANEAN ENVIRONMENTAL PERTURBATION AND ITS REPERCUSSIONS TO THE BIOTA" (70/3/11605, MIS: 375405).

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The Role of Biotic and Abiotic Processes in the Origin of Messinian Evaporite-Associated Carbonates (Southern Italy)

E. Perri¹, A. Caruso², M. Cefalà¹, L. Gindre-Chanu³, G. Scopelliti²

¹Dipartimento di Biologia, Ecologia e Scienze della Terra – Università degli Studi della Calabria (Italy)

²Dipartimento di Scienze della Terra e del Mare – Università degli Studi di Palermo (Italy)

³Statoil RDI - Bergen (Norway)

This paper presents the preliminary results of a multi-scale textural and compositional analysis of sedimentary and post sedimentary facies of carbonates associated with evaporites in Messinian successions of Northern Calabria (Rossano basin, Crati Valley Basin) and Central Sicily (Caltanissetta Basin). The carbonate deposits vary in composition from dolomite to aragonite and calcite, with celestite, barite, strontianite and quartz as minor components. Massive to laminated microbial boundstones represent the most common sedimentary facies forming low relief stromatolitic or thrombolitic sub-metric bodies. The fabric of the micrite varies from peloidal to aphanitic, and almost always preserves bacterial filamentous bodies which typify original microbial mats. Microbial boundstones are rich in pseudomorphs of Ca-sulphates and halite, which occurred during and after the deposition of the microbialitic carbonates. Layers of detrital to laminated microcrystalline gypsum are interbedded locally with carbonates, whilst gypsum nodules and veins of fibrous gypsum are frequent in the lower part of the carbonate successions (mostly dolomitic). Microbial carbonates, interbedded with decimetric beds of laminated marly-limestones, also present a variable amount of detrital and authigenic clay minerals. Brecciated layers of all of the previous facies are common. Their origin could be due to an early post-depositional dissolution of evaporites followed by the collapse of the carbonates and/or by hydraulic fracturation. The stable O and C isotopic composition of carbonates suggests a complicated interplay between climate changes during precessional cycles, a signal of the variable organic compounds metabolised by the bacterial communities that mediate the formation of the microbial carbonates, and the late diagenetic phases.

Keywords: Messinian Salinity Crisis, evaporites, microbialitic carbonates, geochemistry

The Effect of Contourite Deposition in the Gulf of Cádiz on Late Pleistocene Assemblages of Benthic Foraminifera

Vera Schrempf¹, Patrick Grunert¹, Werner E. Piller¹, Craig Sloss², Emmanuelle Ducassou³, Carlos Alvarez-Zarikian⁴, F. Javier Hernández-Molina⁵, Dorrik A.V. Stow⁶, and IODP Expedition 339 Scientists*

¹ Institute for Earth Sciences, University of Graz, Austria; patrick.grunert@uni-graz.at

² Department of Biogeosciences, Queensland University of Technology, Brisbane, Australia

³ EPOC, UMR CNRS 5805, Université de Bordeaux 1, Talence, France

⁴ Integrated Ocean Drilling Program, Texas A&M University, College Station, Texas, USA

⁵ Facultad de Ciencias del Mar, Departamento Geociencias Marinas, Universidad de Vigo, Vigo, Spain

⁶ Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, Scotland, United Kingdom

*IODP Expedition 339 Scientists: Acton, G., Bahr, A., Balestra, B., Flood, R., Flores, J.-A., Furota, S., Hodell, D., Jimenez-Espejo, F., Kim, J. K., Krissek, L., Kuroda, J., Li, B., Llave, E., Lofi, J., Lourens, L., Miller, M., Nanayama, F., Nishida, N., Richter, C., Roque, C., Sanchez Goñi, M., Sierro Sanchez, F., Singh, A., Takashimizu, Y., Tzanova, A., Voelker, A., Williams, T., Xuan, C.

Studies on the distribution of benthic foraminifera in the world's oceans indicate that those areas with intense bottom current activity harbor a distinct foraminiferal fauna. Epibenthic suspension feeders seem to be strongly favored in such environments, and distinctive abundance patterns along a hydrodynamic gradient have been suggested. Besides the advection of considerable quantities of food, this particular niche is determined by the deposition of contouritic sediments. Surprisingly, models of contourite deposition, established in great detail from the sedimentary record of the Cenozoic, lack the integration of micropaleontological data. The present study aims to evaluate the effect of variations in the strength of bottom currents and thus contourite deposition on the benthic foraminiferal fauna in the Gulf of Cádiz.

The study contributes to the post-cruise work of the IODP Expedition 339 (Mediterranean Outflow) in which ~4.5km of Pliocene and Quaternary contouritic sediments of the Mediterranean Outflow Water have been recovered. The investigated samples have been taken from upper Pleistocene contouritic deposits of the Faro Drift, drilled at IODP Site U1386A in the northern Gulf of Cádiz. The sampling resolution of 20cm will allow the evaluation of changes in the benthic foraminiferal assemblages on a sub-millennial scale over a time-span of c. 30 ka. The observed trends will then be integrated with a detailed sedimentological analysis of the highly variable contouritic sequences.

Keywords: benthic foraminifera; contourites; Mediterranean Outflow; IODP Expedition 339

Mineralogy, Geochemistry and Genesis of Plio-Quaternary Evaporites in Seyfe Lake (Kırşehir, Central Anatolia) Turkey

Nergis Önalgil¹, Selahattin Kadir¹, Tacit Külah¹, Muhsin Eren², Ali Gürel³

¹Eskisehir Osmangazi University, Department of Geological Engineering, TR-26480 Eskisehir, Turkey, onalgil_05290218@hotmail.com, skadir_esogu@yahoo.com, tacitkulah@gmail.com

²Mersin University, Department of Geological Engineering, TR-33343, Mersin, Turkey, m_eren@yahoo.com

³Niğde University, Department of Geological Engineering, TR-51200 Niğde, Turkey, agurel_1999@yahoo.com

Abstract: Seyfe Lake (Kırşehir, Turkey) developed within a depression zone along a NW-SE-trending fault in central Anatolia. The lake is underlain by evaporites and carbonate rocks, and is fed by high-sulfate spring and well waters circulating NW-SE through salt “domes.” The recent sediments of Seyfe Lake are characteristic of deposition in delta, beach, mud-flat and shallow mid-lake environments. Mud-flat sediments consist of calcite, gypsum, halite and thenardite associated with fine-grained detrital sediments. Calcite occurs at the margins, gypsum in the intermediate and center zones, and halite±thenardite in the center of Seyfe Lake, yielding an annular distribution pattern. The association of calcite and gypsum in the sediments is due to replacement of calcite by gypsum. The relative increases of Na₂O, SO₃ and S and decrease of CaO from the margin to the center of lake suggest an increase in gypsum, halite and thenardite toward the lake’s center. On the other hand, a positive correlation of SiO₂ with MgO, K₂O, Na₂O, Al₂O₃ and Fe₂O₃+TiO₂ suggests the presence of smectite, illite and feldspar. A positive correlation of Sr and Ba with CaO contents reveals that Sr and Ba are related to gypsum. Strontium is associated with *in situ* gypsum crystals and increases in the intermediate and central zones of the lake relative to increasing salinity as compared to the lake’s margins. The association of Sr with gypsum in the lake sediments suggests that Ca and Sr originated from Sr-bearing evaporites and that carbonate host rocks were the likely aquifers for the brine. Relative increases in HCO₃, NaO, Cl, S, and SO₄ and decrease in CaO concentrations in the spring and well waters that feed Seyfe Lake during the summer and autumn are controlled by NW-SE-directed flushing of waters through the salt “domes,” seasonal evaporation induced precipitation of halite and locally thenardite in the brine-lake environment. The S- and O-isotopic compositions of sulfate crystals range from +19.1 to +21.7‰, and from +16.9 to +20.9‰, respectively, suggesting precipitation in a closed lake system. A relative increase of oxygen and sulfur isotopes toward the lake’s center suggests dissolution of gypsum in the host rock, with the contributions of circulating groundwater and sulfate reduction (possibly by bacterial reduction). ⁸⁷Sr/⁸⁶Sr isotope ratios range from 0.707286 to 0.707879, suggesting a non-marine Oligo-Pliocene evaporitic host-rock source for precipitation in the Plio-Quaternary evaporitic Seyfe Lake basin. The concentration of Sr- and S-isotope ratios in the gypsum crystals indicate formation by precipitation/recrystallization from brine rather than from seawater.

Keywords: calcite, gypsum, halite, thenardite, geochemistry, mineralogy, genesis, Seyfe Lake, Plio-Quaternary.

Acknowledgments:

This study was supported financially by the Scientific Research Projects Fund of Eskisehir Osmangazi University in the framework of Project 201015030, and comprises part of the first author’s M.Sc. study.

Mean Annual Air Temperature (Mat) in Sorbas Basin during Messinian Pre-evaporite Period: Glycerol Dialkyl Glycerol Tetraether Lipids as Temperature Proxy

C. C. Martins^{1,2}, J. P. Mayser¹, R. Flecker³, F. J. Sierro⁴, R. D. Pancost¹

¹School of Chemistry, University of Bristol - Cantock's Close, BS8 1TS, Bristol, UK.

²Universidade Federal do Paraná - Caixa Postal 61, 83255-976, Pontal do Paraná, PR, Brazil.

³School of Geographical Sciences, University of Bristol - University Road, Bristol, BS8 1SS, UK.

⁴Departamento de Geología, Universidad de Salamanca, Salamanca, Spain.

The Messinian salinity crisis (MSC) is one of the most dramatic episodes of oceanic change of the past with the onset dated at *ca.* 5.96 Ma¹. The gradual modification of water exchange with the Atlantic caused important palaeoceanographic changes in the Mediterranean that starts at *ca.* 7.24Ma with alternations of open marine marls and sapropels, and ends, with the Upper Evaporites and fresh to brackish water deposits². The Messinian pre-evaporite sedimentary cycles deposited in SE Spain (6.620-6.546 Ma), prior to MSC, consist of a succession of three lithologies: a sapropel at the base, a homogeneous marl, a diatomite and a homogeneous marl on top³. The sequence of sapropelitic beds interbedded within homogeneous marls represents the most common response to orbitally driven climatic variability and has been used to construct astronomical time scales^{1,2}. The aim of this study was to analyze the changes in mean annual air temperature (MAT) of three astronomically tuned, sedimentary cycles in the Abad section, Sorbas, according to different lithologies, using glycerol dialkyl glycerol tetraether lipids (GDGTs) as MAT proxy. The GDGTs were analysed by high performance liquid chromatography - mass spectrometry after Soxhlet extraction. Results indicates a large input of terrigenous organic matter in the study area, indicated by higher BIT-index value⁴ (mean = 0.79 ± 0.17 ; $n = 35$) and, confirmed by odd long-chain n-alkanes and even long chain n-alkanols derived from higher land plant leaf waxes. The MAT was calculated by the MBT/CBT index⁵ throughout the three cycles and the range was 9.1 – 22.3 °C (mean = 15.5 ± 3.2). High MAT values occurred in sapropels layers (14.0 – 22.3 °C; mean = 17.7 ± 2.3 , $n = 15$), following of homogenous marls (mean = 14.0 ± 2.9 ; $n = 12$) and diatomites (mean = 13.6 ± 2.4 ; $n = 8$). High temperatures are expected in sapropels because their deposition occurs during times of insolation maxima, when higher precipitation and runoff over Mediterranean regions could produce bottom water stagnation, which in turn could force organic-rich sediments deposition. Our results are confirmed by previous studies that indicated the predominance of warm-oligotrophic water foraminifer species in sapropels layers and the cold-eutrophic ones in marls/diatomite layers⁶. Due to the difficulty to find preserved marine organic matter in the Abad section, the use of branched GDGTs as temperature marker seem to be useful in order to verify environmental changes in pre-MSC sections in Sorbas basin.

Keywords: Messinian Salinity Crisis, organic markers, temperature, sapropels.

Geochemical Features of Messinan Evaporites of the Adana Basin

Erhan Karakuş¹, Erdoğan Tekin², Ayhan Ilgar¹

¹General Directorate of Mineral Research and Exploration, Department of Geological Research
06520 Balgat, Ankara, erhankarakus81@hotmail.com

²Ankara University, Faculty of Engineering, Department of Geological Engineering,
06100, Tandoğan/Ankara

The Adana Basin, which is one of the easternmost sub-basin of the Mediterranean basins, is located southern part of the Tauride Orogenic Belt. Basement of the basin, which belongs to Tauride Orogenic Belt, comprises Paleozoic, Mesozoic limestones, metamorphic and ophiolitic rock units and, it was subjected to intensive tectonic movements and drastic erosional processes before Neogene deposition. Re-establishment of equilibration of base level led to Neogene deposition. Neogene deposition commenced with alluvial fan deposits which overlie the basement rocks with an angular unconformity surface. Deposition succeeded by shallow-sea, deep-sea, fluvial, shallow-sea deposits, respectively. Due to relative sea level fall, which formed as a result of tectonic movements a forced regression was occurred in the basin, and the ultimate shallow-sea deposits are sharply overlain by deltaic deposits. Changes on tectonic regime of the basin led to inundation of hypersaline marine water of the Mediterranean, which had been affected by Messinian Salinity Crisis. This hypersaline water flooding resulted in precipitation of evaporitic deposits of the Adana Basin, which constitute the subject of this study.

Three facies associations were recognized in the basin, characterizing the mud-flat/sabkha, shallow-water and deep water environments which are transitional laterally and vertically to each other. The evaporites that precipitated in mud flat/sabkha environment consist of gypsum dikes and sills, nodular gypsum facies, enterolithic gypsum facies, discoidal gypsum facies and gypsum rosettes. Shallow water evaporite facies association comprised of gypsum rosettes, which mentioned above, crudely stratified selenites, gypsum balls, grass-like selenites, palisade gypsum facies, bedded selenites, gypsarenites and gypsum-bearing sandstones. Deep water evaporites include massive gypsum, bedded micro-crystalline gypsum and laminated (balatino) gypsum facies.

Petrographic, X-Ray diffraction, EDS, SEM, X-ray fluorescence and trace element studies have been carried out on the evaporitic rocks which outcropping in the basin. Porphyroblastic, granoblastic, alabastrine and balatino type textures observed in petrographic studies. Anhydrite remnants have been recognized many of the samples. XRD studies have shown that gypsum is the only evaporitic and the most abundant mineral, with very very small amounts of quartz, anatase, calcite, feldspar group minerals are another minerals that accompanying to the gypsum. The presence of quartz, calcite, anatase and feldspar group minerals indicates detritic material input to the precipitation area. Dolomite and clay are the other minerals that have been identified by SEM and EDS analysis. Furthermore fibrous gypsum, tabular shape of gypsum and swallow-tail twinning of gypsum have been recognized by SEM analysis. Major oxide values that are provided by XRF studies indicate homogenous hydrochemical conditions during precipitation. SO₃ and CaO constitute main amount of major oxide values and these values indicate precipitation from brine in sulphate-bearing brines. However, gypsum-bearing sandstones denote different precipitation conditions. Trace element values do not indicate hydrothermal effect in the precipitation area, during precipitation of gypsum. Strontium contents of the gypsum deposits is between <500 ppm-11000 ppm which consistent with peri-Mediterranean basins strontium content.

The precipitation area had been subjected to constant hydrochemical conditions and clastic input, intermittently. The evaporites which have outcropped in the Adana Basin are substantially secondary gypsums and precipitated in the inter-deltaic areas due to relative sea level changes

Keywords: Adana Basin, forced regression, Messinian Salinity Crisis, evaporite, facies association, precipitation

SESSION 4

**MEDITERRANEAN-PARATETHYS GATEWAYS AND
CONNECTIONS DURING THE NEOGENE**

CONVENERS

MATHIAS HARZHAUSER AND SPERANTA POPESCU

Stratigraphy of the Middle Miocene Salt Deposit Tetima near Tuzla (the Central Paratethys, North Bosnia)

Sejfidin Vrabac¹, Stjepan Ćorić², Zijad Ferhatbegović¹, Izudin Đulović¹

¹University of Tuzla, Faculty of mining, geology and civil engineering, Geology Department Univerzitetska 2, 75000 Tuzla, Bosnia and Herzegovina, jvrabac@yahoo.com, fzijad@yahoo.com, izudin.dulovic@untz.ba

²Geological Survey of Austria, Neulinggasse 38, A-1030 Vienna, stjepan.coric@geologie.ac.at

During 2008 in the salt deposit Tetima four exploratory boreholes: B-72, B-73, B-81 and B-91 have been done. Sediments of the roof of salt formations have been drilled without coring and salt formation has been drilled with coring. Micropalaeontology sediments samples were taken from the sieve and the core drilling at the distance of 1-5 m. The main goal of the micropaleontologic research was to make biostratigraphic analysis of the salt roof and an attempt to define a new stratigraphic levels. On the basis of foraminifera it was defined the lower Badenian, which is divided into two local foraminiferal zones. The older part of the lower Badenian is presented by *Ammonia viennensis* and *Nonion commune* and the younger part of the lower Badenian makes the zone of *Globigerinoides trilobus* and *Orbulina suturalis*. These zones correspond to the Lagenid zone of the Vienna basin. Within these zones the two new bench mark stratigraphic levels have been separated. The first is the immediate roof of salt formation with a thickness of about 3 m, and the second level is 60-70 m above the salt formation with a thickness of about 10 m. The first stratigraphic level is characterized by an extremely rare, dominantly planktonic foraminifera and lack of zoning type of *Ammonia viennensis* (d 'ORBIGNY). The second stratigraphic level is indicated by the presence of species *Uvigerina macrocarinata* PAPP & TURNOVSKY, which is in the Central Paratethys related exclusively to the lower Badenian. This species on Tetima is represented in the boundary sediments of isolated foraminiferal zones. In laminated and thinly stratified dolomicrite of immediate substratum of salt some very rare foraminifera predominantly planktonic forms *Globigerina praebulloides* BLOW and *Globigerina bulloides* d 'ORBIGNY have been found. Discovery of foraminifera in salt formation has confirmed the hypothesis about lagoon genesis and lower Badenian age of rock salt in Tuzla basin. The immediate roof of salt formation is presented with massive marls thickness of 65-80 m. About 3 m above the salt formation species *Ammonia viennensis* (d 'ORBIGNY) emerges with the species *Nonion commune* (d 'ORBIGNY) which together have the highest frequency and abundance in massive marls.

It is interesting that shells of species *Ammonia viennensis* (d 'ORBIGNY) are of orange colour and about three times larger than those in the upper Badenian. Above massive marls there are marls with interbeds of sandstones. These sediments with local foraminiferal zone *Globigerinoides trilobus* and *Orbulina suturalis* have a thickness of 220-242 m. Based on nannoplankton it was determined that the zone *Ammonia viennensis* and *Nonion commune* corresponds to zone NN5 (Martini, 1971), while zone *Globigerinoides trilobus* and *Orbulina suturalis* corresponds to upper part of zone NN5 and lower part of NN6 zone (Martini, 1971).

The results of these studies will be applied for the next investigations of the salt formation.

Keywords: Lower Badenian, foraminifera, nannoplankton, stratigraphy

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Cimmerian Gastropod Fauna in Abkhazia (Eastern Paratethys) with Special Reference to Relations of Some Groups

Vitaliy V. Anistratenko¹, Frank P. Wesselingh², Olga Yu. Anistratenko³

¹Institute of Zoology of NAS Ukraine, Kiev 01601, Ukraine, anistrat@izan.kiev.ua

²Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, the Netherlands,
frank.wesselingh@naturalis.nl

³Institute of Geological Sciences of NAS Ukraine, Kiev 01601, Ukraine, anistrat@rambler.ru

We review the Cimmerian gastropod fauna from Abkhazia (Duabian layers, lower Pliocene, Eastern Paratethys). The Cimmerian Basin was a giant Lake-sea with brackish water similar as the modern Caspian Sea, but with lower salinities (up to circa 5-7 ‰).

The Cimmerian malacofauna from an outcrop on the left bank of river Duab near the Moquian convent is characterized by fresh- and brackish-water set of taxa e.g. Theodoxus, Viviparus, Tylopoma and numerous “Pyrgula” and Caspia (Seninski, 1905; Anistratenko, 1993; Anistratenko & Gozhik, 1995). Around 40 gastropod species are found, hydrobiid and melanopsiid snails dominate in species numbers and in abundance. Other common taxa include Bithyniidae, Viviparidae, Planorbidae and less common Litoglyphidae and Neritidae.

Some species are morphologically unusual and stand apart from their close relatives from Pliocene Paratethyan deposits elsewhere. The Duabian fauna contains forms extremely similar to those from so-called “Paludina Beds” of Central Europe. Earlier a direct correlation between the Daubian Beds and the Paratethyan beds were made (e.g. Andrussov, 1908, 1929). However, some Cimmerian species from the locality are very similar as those living in the Caspian basin during the Pliocene. The Duabian fauna probably is crucial in understanding the paleobiogeography and stratigraphy of the eastern Paratethys during the Pliocene.

The lower age limit of the Duabian fauna is provided by gastropods from the underlying Moquicardium Beds. Most of these are endemic (Mikhailowsky, 1902; Seninski, 1905) or recently described (Anistratenko, 1993; Anistratenko & Gozhik, 1995) and therefore are of little useful for correlation. Meanwhile the Duabian species Viviparus sadleri, V. cyrtomaphorus and V. dezmanianus also occur in upper Pontian, Dacian and lower Paludina Beds of the Dacian Basin (e.g. Brusina, 1874; Jekelius, 1944). This allows attributing the age of Duabian Beds as Early Cimmerian.

This taxonomic review will provide insights into migration events and can be used for the reconstruction of ancient gateways between the different Paratethyan basins.

This work was partially supported by a Program of joint research projects of the NAS Ukraine and Russian Foundation for Basic Research, Grant No. 08-04-12 (U).

Keywords: Gastropoda, Cimmerian, Transcaucasia, immigration, Paratethys.

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Characteristics of the Uppermost Lower–Lowermost Middle Miocene (Tarkhanian) in Akliman, Northern Sinop, Turkey

I.A. Goncharova¹, M.E. Bylinskaya², Yu.V. Rostovtseva³, A.L. Tchepalyga⁴

¹ Borisyak Paleontological Institute RAS, Moscow, Russia, iringonch@gmail.com

² Geological Institute RAS, Moscow, Russia, marina.012@mail.ru

³ Lomonosov Moscow State University, Moscow, Russia, rostovtseva@list.ru

⁴ Institute of Geography RAS, Moscow, Russia, tchepalyga@mail.ru

Outcrops of the Tarkhanian and Chokrakian sediments of the Eastern Paratethys in Turkey were reported (Özsayar, 1977) from the Black Sea coast in the northern Sinop Province. Here, in 1996 A.L. Tchepalyga collected Miocene marine fauna from the Akliman location at 10 km west of the city of Sinop. At this point yellow, porous, heterogranular Mesozoic volcanic rocks are unconformably overlain by coarse, dense, yellow coquina about 1–5 m thick. They yield numerous bivalve molds and impressions of *Crassostrea gryphoides* Schl., *Aequipecten opercularis* L. (= *A. domgeri* (Mikh.), after Özsayar) and of venerids. This coquina represents a characteristic shallow facies of the Lower Tarkhanian and is a marker bed recorded not only in Turkey but in other coastal parts of the Tarkhanian mixoeuhaline sea, namely, in Bulgaria, Romania, Ukraine, Georgia, and Turkmenia (Goncharova, 1989). The overlying dark, yellowish-brown foraminiferal limestones (5 m) contain fragments of bryozoans, red algae, echinoderms, ostracodes, and large shells of *Neopycnodonte cochlear* (Poli) (9 specimens) and *Aequipecten opercularis* L. (8 specimens). The presence of the latter provides an age estimate as Tarkhanian–Chokrakian, which corresponds to the terminal Burdigalian–lowermost Langhian.

These limestones also yield planktonic and benthic foraminifers. Among planktonic forams *Globigerina praebulloides*, *G. diplostoma*, *G. cf. euapertura*, *Hastigerina praesiphonifera*, *Globoquadrina langhiana*, and *Globigerinoides* sp. are identified. The benthic microfauna is represented by numerous *Pararotalia* spp. and common *Quinqueloculina akneriana*, *Q. sp.*, *Cibicides* spp., *Cibicidoides* sp., *Anomalina* sp., *Reussella* sp., *Triloculina* sp., and others. The members of *Pararotalia* have not been reported from the Miocene sediments in the northern and eastern realms of the Black Sea. These foraminifers inhabit the surface of predominantly sandy grounds and, like the encountered mollusks, characterize the basin as an open sublittoral zone.

Globoquadrina langhiana was described in the Mediterranean in the lower half of Langhian (Iaccarino, 1985), which permits with a high degree of probability the age estimate of the foraminiferal limestones as Langhian and, judging from the composition and relative diversity of planktonic forams, we can suggest their correspondence to Tarkhanian.

Pyroclastic material was revealed in foraminiferal limestones. Pyroclastics of about 15–20% in total is composed of fragments of crystals and lithoclasts. Fragments of crystals are represented by plagioclases of intermediate composition (No.32–37), often with polysynthetic twinning. Fragments with varying degree of crystallinity occur among the lithoclasts, namely, with a clear porphyry structure with separate phenocrysts and laths of plagioclase or more glassy. Lithoclasts correspond to basic and intermediate effusive rocks. Pyroclastics are represented by angular grains usually with ferruginous crusts hardening on the edges. Some plagioclase grains have euhedral shape. Pyroclastics is 0.1 to 0.3 mm in size (generally 0.15–0.25 mm). The presence in foraminiferal limestone of pyroclastics, which fell out of ash cloud, indicates the development of intense explosive volcanism at that time. Volcanic structures Galatean Volcanic Province (GVP) and the Central Anatolian Volcanic Province (CAVP) with known occurrence of magmatism in the Miocene can be sources of this pyroclastic material.

Keywords: Turkey, Bivalvia, Tarkhanian, Pararotalia, pyroclastics.

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Late Messinian Lago-mare Deposits of the Island of Mallorca (Western Mediterranean). Implications on the MSC Events

G. Mas-Gornals¹, J.J. Fornós¹

¹Departament de Ciències de la Terra. Universitat de les Illes Balears. Crta. Valldemossa, km 7.5, 07122 Palma (Mallorca, Spain). masgornals@gmail.com

The neogene basins of Mallorca provide an adequate record to illustrate the sequence related to the Messinian Salinity Crisis events and may serve to test various debated scenarios (Mas and Fornós, 2011, 2012). The island of Mallorca is conveniently located near the central Balearic Basin and has been relatively stable in terms of vertical movements since the Miocene.

In these basins, the Messinian and Pliocene stratigraphic record shows four main stratigraphic units and two major unconformities. The Reef Unit (Late Tortonian-Messinian) documents the pre-crisis marine sedimentation. This unit is limited at the top by the intra-Messinian unconformity, representing a subaerial erosive phase related to a first major sea-level fall. The evaporitic marginal episode is characterized by the Terminal Carbonate Complex (Esteban, 1979), which changes basinward into massive selenite gypsum (Upper Evaporite). The post-evaporitic deposits (latest Messinian) are characterized by lacustrine sedimentation, related to the *Lago-Mare* episode. At the top of the *Lago-Mare* Unit there is the end-Messinian unconformity, caused by a second major sea-level fall. Over this unconformity lie the Pliocene Units (Early Pliocene), represented by marine deposits that mark a transgression, and the subsequent end of the Messinian Salinity Crisis.

The sediments belonging to the *Lago-Mare* Unit comprise the strata deposited above the uppermost TCC-Upper Evaporite facies and below the marine Pliocene. This unit is composed of marls and sandy-marls lacustrine deposits with brackish to freshwater faunal assemblages.

They contain (i) plants remains: charophyte oogones (*Chara* spp.), *Microcodium*; (ii) Paratethyan bivalves: *Dreissena* (*Pontodreissena*) ex gr. *D. (P.) rostriformis* (Deshayes, 1838), *Lymnocardium adriaticum* Gillet, 1969, *Euxinocardium subodessae* (Sibzov, 1877), *Pseudocatillus* cf. *P. pseudocatillus* (Barbot de Marny, 1869), *Prosodacnomya* sp., *Lymnocardiinae* indet.; (iii) non-marine prosobranch gastropods from the families Hydrobiidae (cf. *Saccoia* sp.), Neritidae (*Theodoxus* sp.), Melanopsidae (*Melanopsis* sp.), Thiaridae (*Melanoides* sp.); (iv) scarce pulmonata gastropods (Planorbidae indet. cf. *Hippeutis* sp., Helicidae-Higromidae indet.); (v) ostracods with Paratethyan affinities: *Cyprideis agrigentina* Decima, 1964, *Tyrrhenocythere pontica* (Livental in Agalarova et al., 1961), *Loxoconcha* sp.; (vi) insect ichnites and (vii) scarce reworked benthic foraminifera (*Ammonia*, *Elphidium*, Miliolids). This is a typical Paratethyan affinity *Lago-Mare* assemblage from elsewhere in the Mediterranean basins, from Cyprus to Malaga.

In Mallorca, the *Lago-Mare* deposits appear in a single episode, with a sudden but not erosional transition from the TCC-Upper Evaporite to *Lago-Mare* beds. No major discontinuity between these two units is observed.

Evaporite deformation and dissolution may have affected the geometry (brecciation, fracturing, and gliding) of both TCC and *Lago-Mare* depositional sequences.

Subsequently, a new major erosion surface develops on top of *Lago-Mare* deposits, sometimes resulting in their complete erosion that may also affect the TCC deposits.

Finally, the Pliocene marine deposits, abruptly and extensively overlie the end-Messinian erosion surface, which forms the Mio-Pliocene boundary in the basins.

No planktonic foraminifera are known, suggesting that normal marine conditions were not present during the deposition of the *Lago-Mare* unit.

Thus, the *Lago-Mare* unit constitutes a marker bed, since both evaporites in the basinward area and the TCC in the margins end (are covered directly by) with brackish and fresh water deposits of the *Lago-Mare* unit, with no apparent erosion surface separating them. However, deeper-platform and basinal equivalents of the TCC are the massive gypsum of the depocentre (Upper Evaporite).

Keywords: Lago Mare, Upper Evaporite, Messinian Salinity Crisis, Mallorca, Western Mediterranean

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Mediterranean-Paratethys Connections during the Miocene: Shrimp's Point of View

Matúš Hyžný¹

¹Comenius University, Dept. of Geology and Paleontology, Mlynská dolina G, SK-842 15 Bratislava, Slovakia; hyzny.matus@gmail.com

The current state of our understanding of decapod distribution patterns makes palaeobiogeographic inferences feasible. The dispersal pattern of decapod crustaceans is roughly similar to that of gastropods, bivalves or some bryozoans, as most decapod larvae are planktonic as well and, therefore, are passively drifted by ocean currents.

Based on the Middle Miocene bryozoans, Moissette et al. (2006) suggested that the exchange of the faunas between Paratethys and Mediterranean was probably regulated by an anti-estuarine circulation in which normal marine surface water entered the Mediterranean, while deeper hypersaline water flowed out from the Paratethys. This permitted an easier incursion of Mediterranean bryozoan species into the Paratethys, but probably hindered the Paratethyan endemics from entering the Mediterranean. If this scenario applies to decapod crustaceans it will imply that the Middle Miocene Mediterranean and Paratethys decapod assemblages as taken together were relatively homogeneous, although distinct when considering increasing rate of endemites in the Paratethys during the Miocene.

A laomediid shrimp *Jaxea* today inhabits the Mediterranean. The oldest fossil record (Ottangian of the Molasse Zone) points to the Central Paratethys as an ancestral area of *Jaxea* (Hyžný 2011). Recently, a new occurrence of the genus from the Early Miocene (Karpatian) of Slovenia, i.e. close to the Slovenian Corridor, has been documented (Gašparič & Hyžný in prep.), and as such it may support the hypothesis proposed for bryozoans as discussed above.

On the first sight, the story around the callianassid shrimp *Glypturus* may contradict this scenario. *Glypturus munieri* is known from Middle Miocene of Central Paratethys and Late Miocene of Mediterranean (Hyžný & Müller 2012) which may implicate migration in an opposite direction. Nevertheless, the genus itself has been well established already in Eocene – its occurrences span across the entire circum-Mediterranean area including Egypt, Spain, Italy and Hungary.

These two cases represent only a small portion of known decapod fossil record from the respective areas. More than 130 species are known from the Miocene of the Central Paratethys (Hyžný 2012) and a similar number is known from the Mediterranean. Detailed quantitative evaluation of these data is a goal for the future studies. No closer attention has been paid so far to the potential of decapods for palaeobiogeographic studies. The research in this respect is only in its beginnings, nevertheless, it is argued that decapods are highly promising to provide enough data for independent testing of hypotheses on the Mediterranean-Paratethys connections during the Miocene.

Keywords: Mediterranean, Paratethys, Miocene, decapod crustaceans

Acknowledgements:

The research has been funded by Lise Meitner Postdoc programme M 1544 and APVV 0099-11.

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Biomarker-Based Reconstruction of Salinity and Temperature during the Lead-in to the Messinian Evaporite Crisis (sorbas Section, Spain)

Jan Peter Mayser¹, Cesar Martins^{1,2}, Rachel Flecker³, Rich D. Pancost⁴

¹Organic Geochemistry Unit, The Cabot Institute, School of Chemistry, University of Bristol, Cantock's Close, BS8 1TS, UK

²Centro de Estudos do Mar, Universidade Federal do Paraná, PO Box 61, 83255-976, Pontal do Paraná, PR, Brazil

³Bristol Research Initiative for the Dynamic Global Environment (BRIDGE), School of Geographical Sciences, University of Bristol, University Road, Bristol BS8 1SS, UK

The Messinian Salinity Crisis (MSC) during the end of the Miocene from 5.96 Ma until the Miocene/Pliocene boundary at 5.33 Ma is a time of great change in the Mediterranean system. Large evaporites deposits were formed in the deep basins during this period due to high evaporation and non-continuous connections to surrounding water bodies in the Mediterranean system. These changes are not only recorded in the deep basins, but also in the easily accessible surrounding basins of the Mediterranean Sea. The sediments found in the Sorbas Basin in South-East of Spain, especially in the Perales section (Sierro *et al.*, 2001), represent a sediment succession that leads through the Upper Abad and into the MSC, which is characterized by the onset of gypsum precipitation. We are analysing the lipid biomarker composition of sediments deposited from the 600,000 years preceding the MSC in order to examine environmental changes prior to the MSC. The sediments comprise regular alternations of marine marls and terrigenous clays as well as diagenetically altered diatomites. The changes in lithology are thought to be induced by climate forcing due to astronomically-induced differences in insolation. The understanding of the general environmental changes, not only the inter-precession changes that lead into the Salinity Crisis is crucial to understand the evolution of the marine gateways in the Messinian. We will use biomarkers to examine the changes in temperature and salinity. In particular, we will determine how salinity changed during precession minima, ultimately linking the changes of salinity to the closure of the gateways.

In order to examine the long-term consequences of the closure of the gateways between the Mediterranean and the Atlantic, we are extracting environmentally and source-diagnostic biomarkers from sapropels and marls of the Sorbas Section. The sapropels are of particular interest, because of anoxic conditions during their formation leads to a better preservation of organic matter. These can be correlated to very specific time periods due to the high resolution chronostratigraphy through astronomical tuning of the regular alternations (Hilgen *et al.*, 2007). Among the biomarkers present are alkenones, n-alcohols, n-alkanes, alkyl diols and keto-ols, long-chain fatty acids, and both isoprenoid and branched GDGTs. These can be used do the reconstruction of paleoenvironments and reconstruction paleo-depositional systems. The biomarkers have been identified and are being utilised to reconstruct past sea surface temperatures and sea surface salinities as well as constrain parameters such as sources of organic matter and its thermal maturity. We are able to reconstruct different climatic forcing scenarios during different intervals of a precession cycle. In addition we will give general tendency throughout the whole sediment section leading up into the actual MSC. The proxies that are in our main focus are U^{K}_{37} , TEX86, BIT-Index and compound-specific deuterium values. U^{K}_{37} and TEX86 will be used to determine the sea surface temperature, the BIT-Index will give information about the terrigenous input to the system and the deuterium values will give an indication for the change in sea surface salinity.

Preliminary data on a high resolution scale from a neighbouring section Los Molinos (6.55-6.62 Ma) already shows that there is a large input of terrigenous organic matter in the Sorbas indicated by the predominance of branched GDGTs derived from soil bacteria (BIT-Index: 0.24 -1), odd long-chain n-alkanes and even long chain n-alcohols derived from higher land plant leaf waxes. The mean annual air temperature was calculated by the MBT/CBT using the branched GDGTs throughout the sapropels in a range of 14.0-22.3°C.

Effects of the Tethys Seaway Closure on Palaeoceanography of the Miocene Mediterranean Sea and Paratethys: Regional Ocean Model Study

M.P. Karami¹

¹Georges Lemaître Centre for Earth and Climate Research, Catholique de Louvain University, Louvain-La-Neuve, Belgium, pasha.karami@uclouvain.be

Opening or closing of oceanic gateways, due to for instance tectonic movements, may affect circulation and the properties of water residing in the basin which leaves an expression in the accumulating sediments on the seafloor. Role of oceanic gateways in the climate, ocean circulation and sedimentary environment of the basins has recently become subject of interest for paleoclimatologists, paleoceanographers and projects on oil source rock predictions.

Around 20 million years ago (Early Miocene), Paratethys and the Mediterranean Sea were connected to the Indian Ocean through a seaway laid at the present-day Zagros and Persian Gulf region. The northward motion of the African plate, together with the counter-clockwise rotation of Arabian plate, ultimately closed the gateway connecting the Mediterranean/Paratethys to the Indian Ocean around Middle Miocene. The closure had significant impact on sedimentary environment of the Mediterranean Sea, Paratethys and proto-Persian Gulf region, and affected the climate over Europe, north-eastern Africa, Arabia and Iranian basin.

In this study, I used a hierarchy of numerical ocean models to study how the closure of gateways between the Mediterranean Sea/Paratethys and the Indian Ocean affected the circulation and water properties of these basins. The starting point was oceanic box-models proceeding with 3-D general circulation models.

The results show that gateways played an important role in controlling the circulation and water properties of the basins. Based on model analysis it was found that with open and deep gateways to the Indian Ocean, surface (deep) flow was eastward (westward) in Paratethys and the Mediterranean Sea. Restriction of the gateways to the Indian Ocean reversed the overturning circulation in Paratethys and the Mediterranean Sea, and increased the sensitivity of these basins to changes in climate. The response to closure was a non-linear process and the change in salinity and temperature of the Mediterranean and Paratethys after closure was not uniform throughout these basins. Deep layers were found to show a stronger change than the surface layers. Furthermore, the regions where the closure had the most significant effects on the water properties were identified. These areas would be good candidates for future geological investigations to provide important insights in timing and effect of closure. Paratethyan temperature computed in the model by considering the inferred gateway states were compared with the ones estimated from data to assess the effect of gateways. It is suggested that closure of gateways between the Paratethys/Mediterranean and the Indian Ocean played a role in the mysterious mid-Burdigalian cooling evidenced by the sedimentary record of Paratethys.

This study is appropriate for studying the development of Eurasian climate during Miocene. Moreover, it is applicable in exploring the distribution of sediments that are likely to be hydrocarbon source units to predict the existence of petroleum systems.

(* This study benefits from the author's PhD thesis at Utrecht University)

The Paleogene–Neogene Boundary in the Northern Caucasus and Ciscaucasus

N. Yu. Filippova¹, L. A. Golovina¹, E. V. Beluzhenko²

¹Geological Institute RAS, Pyzhevskiy per. 7, 119017, Moscow, Russia, golovinal@mail.ru

²Kabardino-Balkaria Geological Exploration Expedition, Kalininastr. 262, 360005, Nalchik, Russia

The boundary between the Paleogene and Neogene in the Caucasus is placed in the middle part of a thick, mostly non-carbonate Maikopian sequence, however, its position is controversial. In the Middle Maikopian the Alkunian Formation (the phase of carbonate sedimentation) is a good regional lithological marker and is traced in many areas of the Northern Caucasus and Ciscaucasus. The Alkunian Formation is the lower unit of the Caucasian regional stage and its age is the key to determining the position of the Pg/N boundary. The Caucasian in the stratotype area (the Kuban River) includes: Alkunian, Zelenchukian Formations and the lower part of the Karadzhalgian Formation. There are three main points of view on the position of the Paleogene–Neogene boundary in the region: (1) at the base of the Caucasian (the base of Alkunian Formation) (Nosovskiy, Bogdanovich, 1980; Nevesskaya et al., 2004; Filippova et al., 2010); (2) at the base of Karadzhalgian (Popov et al., 1993; "Separate opinion" Akhmet'ev et al. in Nevesskaya et al., 2004); and (3) in the middle part of Karadzhalgian (top of the Caucasian) (Andreeva-Grigorovich, 2004). The sections of Alkunian Formation and the adjacent deposits were examined on the Kuban River (Central Caucasus, Karamurzinsky section) and in North Ossetia, stratotype area of Alkunian deposits (central part of the Northern Slope of the Greater Caucasus; sections Fiagdon and Mayramadag). Initially, according to nannoplankton, due to the lack of typical species, the Alkunian was correlated with the undivided zones NP25–NN1 (Nosovskiy, Bogdanovich, 1980) or with the Paleogene zone NP25 (Andreeva-Grigorovich, 2004). Later, on the basis of findings in Alkunian on the Belaya River of the index-species *Triquetrorhabdulus carinatus*, the beds were assigned to zone NN1, but it does not make clear their belonging to the Neogene or Paleogene (Krhovsky et al., 1995). As a result of the present studies of the Alkunian deposits, in the section Karamurzinsky on the Kuban River *Tr. carinatus*, the index-species of zone NN1, was found in association with *Tr. milowii*, etc. These data indicate a high probability of belonging of Alkunian to the Lower Miocene zone NN1 and permit their correlation with the lower part of the Aquitanian.

The Alkunian dinocyst assemblage includes *Deflandrea phosphoritica* var. *spinulosa*, large *Cribroperidinium tenuitabulatum* and *Pentadinium* ex. gr. *lophophorum* / *laticinctum granulum*, *Apteodinium* cf. *australiense*, *Palaeocystodinium golzowense*, *Cordosphaeridium cantharellus*, *Tuberculodinium* cf. *vancampoeae*, etc. Typical Paleogene taxa, such as *Wetziliella* and *Rhombodinium*, are completely absent; the representatives of *Chiropteridium* are few. In the overlying Assian Formation in the North Ossetian sections an important correlation level, the Early Miocene epibole of *D. phosphoritica spinulosa* is found, which is also recorded in the stratotype Lemme-Carrosio boundary section.

The Alkunian nannoplankton and dinocyst assemblages of the Central Caucasus and the Northern Slope of the Greater Caucasus are of similar composition, which contradicts the assumption of significant diachrony of boundaries of the Alkunian Formation. A comparison with the data from other Paratethys areas and stratotype section Lemme-Carrosio indicates that the Paleogene–Neogene boundary in the Caucasus passes in the interval of the uppermost layers of the Batalpashian (Argunian) Formation and lower beds of the Alkunian Formation, which corresponds to the Chattian and Aquitanian boundary layers. The upper part of the Alkunian and the overlying deposits of the Assian Formation are correlated with the lower half of the Aquitanian.

The most reasoned position for the Paleogene–Neogene boundary in the Caucasus is at the base of the regional marker, Alkunian Formation. The Caucasian regional stage in this version most fully belongs to the Neogene, except for the lower layers of the Alkunian Formation, for which there exists some uncertainty.

Keywords: Eastern Paratethys, the boundary Paleogene/Neogene, nannoplankton, dinocysts.

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How dry was the Messinian Salinity Crisis? - A Molecular Study of the Eraclea Minoa Section (Sicily)

I. Vasiliev^{1,2}, E. M. Mezger¹, S. Lugli³, M. Roveri⁴, V. Manzi⁴, G. J. Reichart^{1,5}, F. Sangiorgi⁶, W. Krijgsman²

¹Organic Geochemistry, Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands, email: i.vasiliev@uu.nl

²Paleomagnetic Laboratory 'Fort Hoofddijk', Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands

³Dipartimento di Scienze della Terra, Università di Modena e Reggio Emilia

³Dipartimento di Scienze della Terra, Università di Parma

⁵Alfred Wegener Institute for Polar and Marine Research, Biogeosciences, Bremerhaven, Germany

⁴Biomarine Sciences, Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands

The Messinian Salinity Crisis (MSC; 5.96-5.33 Ma) is considered one of the most enigmatic episodes of paleoceanographic change. Kilometres-thick evaporites were deposited in the Mediterranean basin, during periods when the connections between the Atlantic Ocean and the Mediterranean basin were restricted. The development through time of this crisis is still under debate. Although it is generally accepted that the MSC was a dry period with higher evaporation than precipitation and runoff, how dry climate was and how saline the water, has not yet been quantified accurately. Samples from the Upper Evaporites (MSC stage 3; 5.53 - 5.33 Ma) and from gypsum cumulate - time equivalent to the halite unit (MSC stage 2; 5.61-5.55 Ma) - were collected from the Eraclea Minoa section, Sicily, to measure the compound specific hydrogen isotopic composition (δD) of organic molecules from the gypsum, marls and halite. Hydrogen isotopes, being closely related to the hydrological cycle and build into organic molecules, offer the opportunity to reconstruct past changes in the hydrological cycle and salinity during the MSC. The δD of terrestrial *n*-alkanes ($C_{25} - C_{31}$) mainly records the δD of precipitation, modified by meteoric conditions and evapotranspiration in leaves. The δD of long-chain alkenones, produced by benthic haptophyte algae, depends on the δD of the water, salinity and to some degree growth rate. Both long chain *n*-alkanes with a high odd over even predominance (higher plants) and long chain alkenones were found, recording heavy (deuterium enriched) hydrogen isotopic values. The magnitude of the hydrogen isotopic excursion indicates high rates of evaporation. Furthermore, presence of alkenones in the Upper Evaporites suggests that the connections between Atlantic and Mediterranean, despite reduced, were active also during the stage 3 of the MSC.

Rapid Paleoenvironmental Change during the Late Maeotian -Early Pontian (6.6 Ma-5.9 Ma) in the Eastern Paratethys (Taman Peninsula)

Elenora Radionova¹, Larisa Golovina¹

¹Geological Institute RAS, Pyzhevskiy per. 7, 119017, Moscow, Russia, radionova@ginras.ru

Late Maeotian and Early Pontian sedimentary sequences are very well exposed in the key- sections of the Taman Peninsula (Zheleznyi Rog, Popov Kamen, Panagia). The lower part of Upper Maeotian represented by no -marine massive clayey diatomite. The overlaying deposits (upper part of Upper Maeotian-lower part of Lower Pontian) have a transgressive character and are represented by three units of the "Transitional strata" (according Radionova, Golovina, 2011). Based on detailed sampling and numerous studies of diatom and nannoplankton assemblages were carried out to reconstruct paleoenvironmental conditions during the Late Maeotian -Early Pontian time. The base of Upper Maeotian sequence is marked by the rapid change from marine to brackish/ freshwater conditions and represented by diatom clay with brackish-water association of diatoms. According Popov and Goncharova (2012), the mollusk assemblage includes brackish *Congeria panticaepea*, *Congeria amygdaloides navicula* Andrus, euryhaline marine *Ervillea pusilla*, rare brackish *Theodoxus stefanescui* (Font.), and eurybiontic marine *Abra tellinoides*. In the lower part of the strata some marine diatom species still present, then they disappear completely. Diatom assemblage contains numerous species of *Actinocyclus* genus, including a freshwater one, *Mesodictyon ornata*, *Mesodictyopsis* sp., *Tertiariopsis* sp. *Pliocaenicus costatus*, *Ellerbekia arenaria* var. *teres*, *Cyclotella iris*, *C. distinguenda*, *C. radiosa*, *Tryblionella* sp.sp., *Epitemia* sp.sp., *Campialodiscus* sp.sp. and other. *Concentrodiscus* (*Coscinodiscus*) *jambori* is an ecological marker for these deposits. This is the endemic species was described by Hajós from the Pannonian of Hungary. The peculiar composition of the diatom assemblages and the absence of nannoplankton correspond to the conditions of isolated freshwater basin. According to the stratigraphic data time of disconnection is determined in a short interval - 6.6-6.3 Ma. The diatom and nannoplankton assemblages from the overlaying deposits reflect once again the rapid changes of environmental conditions. The deposits transitional from top of Upper Maeotian to lower part of the Lower Pontian are composed of thick clayey beds interbedded with laminated diatomite strata, over 60 m thick, that were named "Transitional strata" (Radionova, Golovina, 2011). Laminated diatomites are characterized by occurrence of both mass diatoms and calcareous nannofossils, mainly represented by monoassociations *Actinocyclus octonarius* and *Braarudosphaera bigelowii*. Calcareous nannoplankton from base of "Transitional strata" (Unit I) includes abundant *Braarudosphaera bigelowii*, *Syracosphaera pulchra*, *Syracosphaera* sp., and rarer *Coccolithus pelagicus*, *Discoaster* sp., *Lithostromation perdurum*, *Reticulofenestra* sp., *Rhabdosphaera* sp., *Thoracosphaera* sp. Some specimens *Discoaster intercalaris* (CN9A - CN10A Zones) are found in the Upper Maeotian deposits (Popov Kamen section). Absence of zonal species and very small size of coccoliths both point to the restricted connection with marine basin of normal salinity. Diatom assemblages are represented by open-marine species including marker-species of *Thalassiosira convexa* Zones of tropical oceanic zonal scale. Unit II was going on in the environment of mixed marine and brackish-water masses. Structure of diatom assemblages shows that sedimentation was taking place in the inner part of frontal zone. Unit III show the growing regression process and connection with marine basin coming to the end. Marine diatom species and nannoplankton are absent. Shallow water conditions are developing, and numerous brackish water mollusks appear in carbonate clays, the Lower Pontian species *Paradacna abichi* among them. Short final impulse of marine invasion is reflected in the last carbonate diatomite containing *Actinocyclus octonarius* together with oceanic *Thalassiosira praeoestrupii* (FO-6.1Ma) and *Th. ostrupii* (FO-5.9Ma) and *Braarudosphaera bigelowii* nannoplankton. Consequently, the Maeotian-Pontian "Transitional Strata" in the Taman Peninsula sections corresponds to the period of indirect Mediterranean waters invasion into the Eastern Paratethys. At the first stage, indirect connection between these two basins was relatively free, and at the second and third stages it was of a pulsing intermitted character. Maximum duration of the invasion event is estimated from 6.3 to 5.9 Ma.

Keywords: biostratigraphy; diatom, nannoplankton, Eastern Paratethys, Maeotian, Pontian

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SESSION 6

**MEDITERRANEAN-BLACK SEA CONNECTIONS DURING
QUATERNARY**

CONVENERS

M. NAMIK ÇAĞATAY AND VALENTINA YANKO-HOMBACH

Episodes of Isolation from the Mediterranean and Brief Lowstands of the Black Sea Lake

William B. F. Ryan¹, Anastasia G. Yanchilina¹

¹Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA,
billr@ldeo.columbia.edu, nyanchil@ldeo.columbia.edu

Brief intervals of post-glacial evaporative drawdown of the surface Black Sea's Neoeuxine lake below its outlet are evidenced by two widespread gaps in sedimentation everywhere on the outermost continental shelf. The first occurred during the Bølling-Allerød interstadial and ended with a Younger Dryas flooding surface. Thick Younger Dryas highstand deposits are rich in beds of articulated *Dreissena rostriformis*. Their strontium isotope values show a return to the late glacial baseline. A more recent drawdown occurred in the early Holocene. Its flooding surface corresponds with the entry of marine water and population by euryhaline mollusks. This flooding deposit has strontium isotope compositions that abruptly shift from lacustrine values to the composition of the global ocean. The two flooding surfaces are expressed as a shell hash composed of sand to gravel sized fragments of broken and pulverized dreissena shells that were eroded from the each hash's substrate, respectively. Hash deposits are rich in the beaks (umbo) of the mollusk shells whose outer surfaces are smoothed by abrasion. This fragmentation and selective preservation of only the most resilient parts of the shell are in contrast with the specimens within the substrates that have their shells still articulated and with surfaces coated with a brown and hairy scum of residual algae. Measurements of $d^{18}O$ and $d^{13}C$ on the same specimens also dated with AMS 14C methods are compared to similar measurements from stalagmites in the Sofular Cave near the Black Sea coast in Northern Turkey. The stalagmites are dated by ^{230}Th with an error of ± 50 years. Alignment of the lacustrine and stalagmite isotope measurements for both $d^{18}O$ and $d^{13}C$ allows us to derive calendar ages for the flooding surfaces and the substrates without prior knowledge of the reservoir age of carbon in the Neoeuxine lake. Conversely we use our derived calendar age by calibration with the cave deposits to obtain a history of the lake's changing reservoir age. This comparison clearly reveals the two gaps in sedimentation. Shell material in the hash is bleached and co-exists with plant fibers, twigs, sand and pebbles. The older shell hash overlying a stiff, de-watered substrate is found as deep as -164m. To expose the lake bed to this elevation requires a substantial lowering of the lake surface below any conceivable lake outlet.

Coincidence of the lake lowstands with Bølling-Allerød and early Holocene warming suggests that rising temperatures amplified the rate of evaporation. Although some prior researchers have proposed a glacial lowstand of the enclosed Neoeuxine lake, the identical composition and evolution of the strontium isotopes in the Black Sea mollusks and Marmara Sea mollusks during the late glacial period requires the Neoeuxine lake to have been an uninterrupted source of water to the Marmara Sea. Since the rate of sediment accumulation on the lakebed during glacial times was more than an order of magnitude greater than during the post-glacial period, water supply by rivers had to have been substantial during glacial times. The supply would have been more than adequate to keep the Neoeuxine lake's surface at the elevation of its outlet. Isotopic fractionization as a consequence of enhanced evaporation during the enclosed lake phases would have been a contributing factor in the observed shift of the $d^{18}O$ composition from -8‰ to -1‰ . The absence of an outlet would also explain the observed increase of the ^{14}C reservoir age of the lake water during the lowstand episodes.

Ultra-High Resolution Paleoceanography and Paleoclimatology during Sapropel S1 Deposition in the NE Aegean Sea (South Limnos Basin): Evidence of Black Sea Inflow Establishment

Maria Triantaphyllou¹, A. Gogou², S. Kostopoulou¹, M. Dimiza¹, I. Bouloubassi³, G. Rousakis², C. Parinos², M. Geraga⁴, An. Diamantopoulou⁴, V. Lykousis²

¹Faculty of Geology and Geoenvironment, University of Athens

²Institute of Oceanography, Hellenic Center for Marine Research

³Laboratoire d'Océanographie et du Climat, Expérimentation et Approche Numérique, Université Pierre et Marie Curie

⁴Faculty of Geology, University of Patras

The north Aegean Sea, can be described as a 'continental margin' ecosystem, and is characterized by generally cyclonic circulation. The area receives low saline and cool BSW (Black Sea Water) through the Bosphorus Strait and the Dardanelles. The cold and low saline BSW flows along the eastern coast of Greece until it reaches the southwestern Aegean, and enhances the productivity in the northern Aegean Sea. Low saline surface BSW, whose increased spreading during winter may affect the Mixed Layer Depth variability, promotes the stratification of the water column and plays a vital role on the dense water formation activity.

Gravity core M-4 has been recovered in South Limnos basin (NE Aegean) from water depth 216 m, at 39°38.662'N, 25°35.165'E. Sapropel S1 is very well exposed with overall thickness reaching 96 cm. During S1a and S1b depositional intervals the dominant planktonic foraminiferal species are *Turborotalita quinqueloba* and *Globigerina bulloides*, suggesting the development of a low salinity surficial layer rich in nutrients over South Limnos basin. S1a interval is characterized by the intense presence of anoxic/dysoxic benthic species, such as *Chilostomella mediterraneensis*, *Globobulimina affinis*, *Cassidulinoides bradyi*, *Bulimina* spp., *Bolivina* spp. However, the presence of mesotrophic to eutrophic oxic species *Uvigerina mediterranea*, *Gyroidinoides* spp. indicates that less severe dysoxia has been developed in South Limnos basin during the deposition of layer S1a, in respect to what has been documented before for other Aegean basins. Higher values of OC during the deposition of S1a than those of S1b, indicate highest organic matter production and preservation in S1a, supporting previous results in the Aegean area. The almost constant values of $\delta^{13}\text{C}_{\text{org}}$, shifted towards marine end-member values during S1a, confirm the hypothesis that the deposition of sapropel S1 has been caused by enhanced primary productivity along with extended preservation of organic matter, when compared to the present-day levels in the north Aegean. The interruption of sapropel S1 at 8.0 ka BP is probably associated with the northern hemisphere cold event at 8.2 ka BP. During this interval, the increase of agglutinated forms confirms both higher oxygen bottom conditions and freshwater input. This is accompanied by decrease in OC and the presence of planktonic foraminifera assemblages (*Globorotalia inflata* and *Neogloboquadrina*) which suggest stronger mixing of the water column at least during winter. The more negative values of $\delta^{13}\text{C}_{\text{org}}$ identified at ~7.7 ka BP are indicative of terrigenous organic matter, that may cause high value of OC, during the interruption interval, probably associated with the inflow of Black Sea waters. Within the sapropelic layer S1b dysoxic foraminiferal species abundances are once more increased but to a lesser degree when comparing with S1a; in accordance with OC values. *U. mediterranea*, *Hyalinea balthica*, miliolids and agglutinants are increased, supporting even less dysoxia for S1b interval in respect to S1a. All acquired data records present rapid simultaneous fluctuations, suggesting short term paleoceanographic and palaeoclimatic changes in the studied area.

Keywords: sapropel S1, foraminifera, geochemical indices, SST, North Aegean

SESSION 8&9

**ADVANCES IN MEDITERRANEAN PALEONTOLOGY
&
RECENT DEVELOPMENTS IN MEDITERRANEAN
PALEOCLIMATOLOGY**

CONVENERS

**MARIO SPROVIERI AND LAURENCE VIDAL
FABRIZIO LIRER AND GONZALO JIMENEZ-MORENO**

High Climatic Resolution during the Last 13,000 Cal Years BP Inferred from a Charcoal Record from Lake Ifrah (Middle Atlas, Morocco) West Mediterranean Region

Brahim Damnati¹, Hanane Reddad¹

¹Department of Earth Sciences, Faculty of Sciences and Techniques, Environmental, Oceanology and Natural Resources Laboratory, B.P 416, Tangier, Morocco, b.damnati@fstt.ac.ma, b_damnati@yahoo.fr

Fire activity in West Mediterranean region particularly North-West Africa and its connections with past climatic changes still remains poorly documented. A new multiproxy analysis using mineralogy, geochemistry and microcharcoal data from Lake Ifrah (Middle Atlas, Morocco) provides new insights for better understanding fire occurrence from the Last 13,000 cal yr BP.

Before 13,000 cal yr BP, the concentration in microcharcoal was very low in connection with low fire activity and probably cold climate. Between 13,000 and 12,300 cal yr BP, there is increase in microcharcoal in relation with the increase aridity. This period corresponds to the Bölling-alleröd period. Between 12,300 and 10,800 cal yr BP, there is a new decrease of the microcharcoal corresponding to the Younger Dryas period. Between 10,800 and 4,500 cal yr BP, marked a significant increase in microcharcoal abundance which likely testifies to regional emissions from forest fires. Such biomass burning events were associated to prolonged periods of drought. The maximum of dryness occurred ca 8,400 cal yr BP.

Keywords: Morocco, microcharcoal, climate, Bölling-alleröd, Younger Dryas

Eastern Mediterranean Foraminiferal Palaeoecological Responses to Late Pliocene Environmental Changes

H. Drinia¹, A. Antonarakou¹, G. Kontakiotis¹, E. Tsiolakis²

¹National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Hist. Geology - Palaeontology, cntrinia@geol.uoa.gr

²Geological Survey of Cyprus

This study focuses on the Late Pliocene deposits in Cyprus, a period during which dramatic, global climatic events occurred as the probable consequence of a downturn in atmospheric carbon dioxide concentrations. Pliocene is characterized by glacial (expansion) and interglacial (ablation) periods (e.g. Lambeck et al., 2002), which had inevitable impacts upon the global eustatic sea level, oceanic circulation and latitudinal temperature.

The studied section is located in the center of the Pissouri sub-basin, in southern Cyprus (Pissouri basin) and contains a relatively thick succession (thickness of ~45 m) of rhythmically bedded marls, which constitute regularly bedded, fining upward packages. Each package typically has a sharp-based fine-grained, frequently laminated sandstone/siltstone bed fining upwards into claystone.

The lithological cyclicity of the sediments together with the foraminiferal pattern is used to reconstruct the ocean-climate interactions in the eastern Mediterranean. The regularity of the lithological cyclicity appears to be recording a predictable systematic control, most plausibly related to astronomical forcing which is often expressed as lithological cycles in the sedimentary record.

Benthic microfauna composition and distribution allow an evaluation of the bottom water ventilation during deposition, whereas the combined study of benthic and planktonic assemblages is used to evaluate the impact of climate changes on bottom palaeoenvironment.

A statistical analysis, Hierarchical Cluster Analysis, was performed in order to better describe the composition and distribution of the benthic foraminiferal assemblages. Two main benthic foraminiferal assemblages were recognized. BFA-1 is characteristic of a mixed oligotrophic to mesotrophic, dominantly epiphytic and epifaunal assemblage in a relatively oxic environment. In contrast BFA-2 is interpreted to be indicative of an ecologically stressed environment, with epiphytics becoming absent, in favour of species with a tolerance to high organic matter flux. The stressed conditions are likely to be related to the influx of organic matter through freshwater input (e.g. analogous to periods of sapropel formation).

Moreover, benthic foraminiferal species diversity parameters, including information function (H), equitability (E) and number of species (S) were analysed at Pissouri Section, Cyprus Island, Eastern Mediterranean. The values of these parameters have enabled us to understand deep sea palaeoceanographic changes in the eastern Mediterranean during the studied interval. The major changes in diversity parameters show close linkages to changes in the water mass stratification and productivity.

A cyclostratigraphic approach has been attempted to obtain a detailed chronostratigraphic subdivision. The fluctuations curves of *Globigerinoides* spp. were used to verify the orbital forcing climate variability (Sprovieri et al. 2006). The ratio *Globigerina bulloides* / *Globigerinoides ruber* were used in order to establish the stratification of the water column (Sbaffi et al. 2001).

Keywords: Benthic and planktonic foraminifera, Eastern Mediterranean, Late Pliocene, palaeoceanography

Acknowledgments:

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: THALIS – UOA- "Island biodiversity and cultural evolution: Examples from the Eastern Mediterranean, Madagascar, Mauritius, Philippines during the past 800,000 years" (70/3/11669, MIS: 375910).

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First Colonization of the Genus *Amphistegina* and Other Alien Benthic Foraminifera in the Pelagian Islands and in the South-Eastern Sicily (Central Mediterranean Sea)

Antonio Caruso¹, Claudia Cosentino¹

¹Dipartimento di Scienze della Terra e del Mare (DiSTeM), University of Palermo, Italy

A detailed study on inner shelf marine sediments, collected in the central Mediterranean Sea (Pelagian Islands and south-eastern coasts of Sicily), has been carried out in order to determine the diversity of living benthic foraminifera. Over the last decades, coastal marine environments of the Mediterranean Sea have been increasingly colonized by a lot of species coming from the Atlantic Ocean and the Red Sea. Due to their geographical position, the studied islands represent an ideal place to understand how alien species may have colonized new ecological niches in the Mediterranean basin. In particular, since the opening of the Suez Canal in 1869, a great number of Indo-Pacific organisms have migrated into the Mediterranean. This phenomenon, known as the “Lessepsian migration” (Por, 1978), is also influenced by increasing Mediterranean Sea Surface Temperatures (SSTs). Today, the consequence is that alien organisms of tropical and sub-tropical affinity can play an important role in the Mediterranean Sea’s biodiversity.

This study indicates that the genus *Amphistegina* is progressively colonizing the inner shelf sediments of the Pelagian Islands and the south-eastern coast of Sicily. In particular, *A. lobifera* and *A. lessonii* are very abundant off of Linosa Island. Here, *A. lobifera* reaches percentages up to 87%, testifying to the invasive character of this genus. In addition, two new ecomorphotypes (*A. cflessonii* and *A. cfpapillosa*), never described before, have been found off of Linosa. *Amphistegina cflessonii* lives attached to algae, including the species *Caulerpa racemosa*, a green algae of Indo-Pacific origin.

Rare specimens of *A. lobifera* have been found off of Vendicari (NE Sicily), probably due to an early stage of colonization. On the contrary, *Amphistegina* has not been found along the northern coast of Sicily.

In addition to *Amphistegina*, other alien species of benthic foraminifera are now established off of the Pelagian Islands and in some areas of the Sicilian coast. The higher number of alien species, including *Amphisorus hemprichii*, *Entosigmomorphina sp.* and *Peneroplis arietinus* has been found off of the islands of Linosa and Lampedusa, where the higher winter SSTs might have favoured their progressive colonization. Other species such as *Cymbaloporella squamosa* and *Sorites orbiculus* have also colonized the South Tyrrhenian Sea. In particular, the diffusion of *Amphistegina* spp., *Amphisorus hemprichii*, *Entosigmomorphina sp.* and *Peneroplis arietinus*, might have been through the Suez Canal, while *Sorites orbiculus* and *Planorbulina acervalis* might have colonized the Mediterranean Sea through the Gibraltar gateway during different phases.

Keywords: benthic foraminifera, *Amphistegina*, alien species, Lessepsian invasion, central Mediterranean Sea.

Benthic Foraminiferal Assemblages from the St. Peter's Pool Section (South Eastern Malta Island)

B. Russo¹, L. Ferraro², F. Lirer², L. Foresi³, M. Verducci³, N. Baldassini³, R. Mazzei³, G. Salvatorini³

¹Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università "Federico II", Largo San Marcellino, 10, 80138, Napoli, Italy

²Istituto per l'Ambiente Marino Costiero (IAMC) - CNR, Calata Porta di Massa, 80133, Napoli, Italy

³Dipartimento di Scienze della Terra, Università di Siena, Via Laterina 8, 53100, Siena, Italy

Preliminary paleoecological data on benthic foraminiferal assemblages of St. Peter's Pool section (south-eastern Malta Island), are presented. The upper Burdigalian- Langhian St. Peter's Pool section (MMi4a-MMi4b planktonic foraminiferal biozonal scheme of Di Stefano et al., 2008 emended by Iaccarino et al., 2011) that outcrops at Delimara Peninsula, belongs to the Upper Globigerina Limestone, the youngest member of the Globigerina Limestone formation. The sedimentary record consists of cyclic alternations of calcareous marl, marly limestone and bioturbated hardened limestone.

Benthic assemblages are mainly represented by species typical of an upper-middle bathyal environment. Throughout the section the most abundant species are *Siphonina reticulata*, *Cibicidoides dutemplei-subhaidingerii*, together with *Uvigerina peregrina*, *Bulimina costata* and *Bolivina spathulata*. The opposite trend of *S. reticulata* and *U. peregrina* together with the distribution patterns of the other significant species point out three main intervals along the section. The ecological/paleoecological meaning of the main benthic species is reported in literature (Kouwenhoven and Van der Zwaan, 2006, among others).

Interval A (0 - 6 m): increasing trend of the oxic species *S. reticulata* up to 20% and occurrence of the high productivity species *U. peregrina* (average value 11%), *B. costata* (average value < 1%) and of the dysoxic species *B. spathulata* (average value 4%). This interval suggests a well oxygenated bottom environment.

Interval B (6 - 12 m): increasing trend of *U. peregrina* and *B. costata* with a peak respectively of 27% and 13% at 12 m; decreasing trend of *S. reticulata* with its minimum value of 2% at 12 m. This interval reveals high productivity and high organic matter content at the sea floor as consequence.

Interval C (12 - 30 m): increasing trend of *S. reticulata* and of the oxic species *C. dutemplei-subhaidingerii*; general decreasing trend of *U. peregrina*, which shows a peak of 17% at 24 m, and of *B. costata*. This interval allows to hypothesize a relatively well oxygenated bottom environment with an episode of increased productivity at 24 m.

Keywords: benthic foraminifera, paleoecology, Mediterranean, upper Burdigalian –Langhian

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Approximating the Autecology of Endemic Lake Pannon Ostracods by High-Resolution Sampling (Late Miocene; Styrian Basin, Austria)

Frank Gitter¹, Martin Gross¹, Werner E. Piller²

¹Department for Geology & Palaeontology, Universalmuseum Joanneum, Weinzöttlstrasse 16, 8045 Graz, Austria; frank.gitter@museum-joanneum.at

²Institute for Earth Sciences, Karl-Franzens University, Heinrichstrasse 26, 8010 Graz, Austria

The Mataschen clay pit is located approx. 45 km SE of Graz (SE-Austria, 15°57'16"E/46°54'15"N) in the Styrian Basin, a c. 100 km long and 60 km wide sub-basin in the NW of the Pannonian Basin. From a paleogeographic point of view Mataschen is situated close to the western paleo-shoreline of Lake Pannon during Early Tortonian times.

The entire c. 30 m thick succession records a transition from swampy to limnic-deltaic environments. Based on integrated stratigraphy (lithostratigraphy, biostratigraphy (molluscs and vertebrates), sequence stratigraphy and paleomagnetic analyses), the whole section was deposited within a maximum of 45,000 years.

Here we focus on the lower part of the section comprising the drowning of a swamp forest due to a transgression of brackish water and the establishment of a meromictic lake system. Five cores covering a ~2.3 m long high-resolution sampling interval were cored using a percussion drill. Each core, about 50 cm long and 100 mm in diameter, was cut in 5 mm thick half-discs resulting in 457 samples and a time-resolution of just a few years per sample.

A general increase in ostracod abundance throughout the 2.3 m long section is noted. With the change to a deltaic environment and the establishment of meromictic conditions in the upper part of the section, a sudden decrease in abundances is observed. This sudden decrease is related to increased fluvial influence, leading to stratification of the lake waters and thus oxygen depleted bottom waters. Two earlier sharp decreases in ostracod abundance could be related to precipitation driven eutrophication events causing oxygen depleted conditions in bottom waters. Additionally, three stepwise decreases in abundances are paralleled by a reduction of fluvial input leading to oligotrophic phases.

Due to the high resolution and detailed paleoecological data, conclusions on the autecology of several ostracod species could be drawn. A change in salinities within the section is supported by diverging abundances of *Hemicytheria folliculosa* and *Callistocythere* sp. While *H. folliculosa* - most dominant in the lower part of our section - is known from salinities between 3 and 8 psu from the Vienna Basin, *Callistocythere* sp. - occurring in the upper part of our section - is known to occur in high salinities between 15 and 25 psu in Lake Pannon. The two most dominant species, *Cyprideis mataschensis* and *C. kapfensteinensis*, clearly prefer different ecological niches. *C. mataschensis* tolerates a wide range of salinities and is even able to cope with hypoxic conditions, comparable to recent *Cyprideis torosa*. Conversely, *C. kapfensteinensis* is clearly restricted to well-oxygenated conditions with salinities above ~10 psu.

We are able to distinguish three different groups within the ostracod fauna. The first group represents typical Pannonian brackish water ostracods with *Cyprideis* spp., *Loxoconcha* spp., leptocytherids and *Xestoleberis* sp. The second group contains typical Pannonian species adapted to lower salinities like *Hemicytheria* spp., *Herpetocypris* sp. and *Amplocypris* sp. Three taxa, "*Typhlocypris*" incertae sedis, *Cypria* sp. and *Fabaformiscandona* ex gr. *balatonica*, are included in the last group. These ostracods are most dominant in lower oxygenated conditions. This refinement of knowledge of the autecology of endemic ostracods of the long-lived Lake Pannon will facilitate more precise interpretations based on ostracods in future paleoecological studies.

This work is supported by the FWF (P21748-N21).

Keywords: Lake Pannon, Styrian Basin, Early Tortonian/Early Pannonian, paleoecology, ostracods

Late Interglacial to Holocene Paleoenvironmental Evolution of Western Cyclades Plateau (SW Aegean Sea)

**G. Rousakis¹, M. Ratopoulou², M. Triantaphyllou², I. Bouloubassi³, M. Dimiza², A. Gogou,¹,
K. Parinos¹, K. Kouli², V. Kapsimalis¹, V. Lykousis¹**

¹Institute of Oceanography, Hellenic Center for Marine Research

²Faculty of Geology and Geoenvironment, University of Athens

³Laboratoire d'Océanographie et du Climat, Expérimentation et Approche Numérique, Université Pierre et Marie Curie

The Aegean Sea is located at the northern part of NE Mediterranean region, linked to the Black Sea through the Dardanelles and the Bosphorus Straits and to the eastern Mediterranean through the Cretan Straits; being recognized as a particularly important area for both regional and global climate changes.

Gravity core SK-3 (total length 217cm, water depth 249 m) has been recovered from the South Western Cyclades plateau (36°51', 342 - 24°38', 730) in the south western Aegean Sea. In this study, we have performed sedimentological (grain size), micropaleontological (benthic and planktonic foraminifera) and geochemical (Organic Carbon; OC) analyses in sediments of core SK-3, aiming to determinethe paleoenvironmental changes during the late interglacial-Holocene at the western edge of Cyclades plateau.

The dominant lithology of the sediment core, which exhibits two sapropel layers, represents alternations of light gray sandy silt to grayish olive silty sand, sand in dark color-grayish olive and olive black silt within sapropel intervals. The grain-size data of SK-3 core show a high percentage of sand that is distinctly decreased within the sapropelic beds. In these intervals the silt is prevailing as a result of low dynamical conditions of the region during the deposition.

The first sapropelic layer (24-37 cm) represents sapropel S1; an AMS dating at 22.5cm reveals an age of 7160 + / - 40 yr uncal. BP. A second sapropelic layer appears in between approximately 150-190 cm with OC content more than 3 %. An AMS dating performed at 153.5 cm provided age > 43.5 ka. Benthic foraminiferal analysis suggests high redeposition during the sapropel formation; the presence of *Chilostomella mediterraneensis* and *Globobulimina affinis* indicates dysoxic bottom conditions. Redeposition is actually nullified in between 175-190 cm; in the same interval in-situ benthic foraminifera are totally absent and the microfauna is dominated by planktonic foraminifera, mainly *Globigerinoides ruber* and *Orbulina universa*. Pollen flora is characterized by high abundances of *Quercus* accompanied by *Pinus*, *Fraxinus* and *Pistacia*. *Artemisia*, Poaceae and Chenopodiaceae are also represented though in lower percentages. Apparently this interval represents anoxic conditions during a high sea-level warm event.

Long chain alkenones have been proved a valuable tool in order to estimate past sea surface temperatures (SSTs), using the ketone unsaturation index Uk³⁷. Various biomarkers of marine and terrestrial origin, namely sterols, alkandiol, keto-ols, long-chain alkenones and long chain *n*-alkanes and *n*-alkanols have been used in order to reconstruct paleoproductivity rates and different algal species (diatoms, coccolithophorids, dinoflagellates) predominance and time succession along with fluctuations in the delivery of terrestrial organic matter in the study site.

Keywords: Aegean Sea, Cyclades plateau, sapropel

Foraminiferal Mg/Ca-Paleothermometry in the Mediterranean Sea: Constraints and Implications

S. Boussetta¹, N. Kallel¹, F. Bassinot², J. Nouet⁴, N. Caillon², H. Rebaubier², L. Labeyrie²

¹Faculty of Sciences, Sfax, FSS, Lab. GEOGLOB, Route de Soukra, BP 802, 3028 Sfax, Tunisia
(soumaya.boussetta@lsce.ipsl.fr)

²LSCE (CEA/CNRS/UVSQ), Domaine du CNRS, Bat 12, Avenue de la Terrasse, 91198 Gif-sur-Yvette, France

³Dipartimento di Scienze del Mare, Università Politecnica delle Marche, Via Brecche Bianche, 60131 Ancona, Italy

⁴UMR IDES 8148, Université Paris-Sud 11, 91405 Orsay, France

Mg/Ca ratios in planktonic foraminifera have been developed into a powerful tool in paleoceanography to reconstruct past sea surface temperatures (SST). In the Mediterranean Sea, accurate prediction of glacial Sea Surface Temperatures (SST) using the Modern Analog Technique has been hampered by the absence of modern analogs to be compared with the fossil foraminifera fauna found in glacial Mediterranean sediments, in particular in the Eastern basin.

We have therefore generated a high-resolution Mg/Ca record for the surface-dwelling planktonic foraminifera *Globigerina bulloides* from the core MD99-2346 recovered in the Gulf of Lion and converted Mg/Ca values into temperature using the North Atlantic calibrations. The obtained record, which covers the last 28 000 years, is very similar to that inferred using modern analogue technique applied to fossil foraminiferal assemblages. However, the Mg/Ca based sea surface temperature estimates are usually several degrees warmer than those provided by planktonic foraminiferal assemblages indicating an enrichment of Mg in the foraminiferal shells of the Mediterranean Sea. Nevertheless, the temperature shift caused by the Mg enrichment remains constant along the core. This indicates an undeniable effect of temperature in the incorporation of Mg into foraminiferal shell of *G. bulloides* in the Western Mediterranean Sea.

The situation is totally different in the Levantin Basin. The Mg/Ca record generated along the MD84-641 core provides extreme values, implying thereby that the carbonated digenesis had a main role in this basin in the past. SEM observations and X-ray diffractometry analyses, demonstrate the presence of a post-depositional precipitation of inorganic Mg-rich calcite on foraminiferal shells. This diagenetic alteration is therefore a potential source of error on estimation of surface paleotemperature in the eastern Mediterranean Sea. The amount of diagenetic calcite varies over time and appears to be generally more important during the last glaciation.

Keywords: Mediterranean Sea, Mg/Ca, Planktonic foraminifera.

First Evidence of Palms in the Island of Crete, Southern Greece

D. Velitzelos¹, M. Dermitzakis¹, A. Antonarakou¹, T. Denk², G. Kontakiotis¹

¹National and Kapodistrian University of Athens, Faculty of Geology and Geoenvironment, Department of Hist. Geology - Palaeontology, veljim@geol.uoa.gr

²Swedish Museum of Natural History, Department of Palaeobiology, Box 50007, 10405 Stockholm, Sweden.

It is well known that Palms thrived in Greece and many evidences have been found within the fossil layers of various localities dating from the Oligocene of Evros (Northern Greece) up to the youngest findings (60.000 years) inside the volcanic layers of the Santorini Island. The section of Makrilia in Crete (Late Miocene) has been studied extensively from many geologists, but only in the last years fossil remains of palms belonging to *Phoenicites* sp. have been discovered and described. These findings are of great importance for the evolution of plants in the Aegean Sea.

The Late Miocene section of Makrilia is located near Ierapetra, South Eastern Crete and consists of rich fossiliferous marly beds rich in plant fossils. The plant macrofossils are not very well preserved in many cases rendering unambiguous identification difficult, but more than 130 taxa have been described (Sachse & Mohr 1996; Sachse 1997). Their climatic signal indicates a warm climate of MAT: 17 - 20 °C (Sachse et al. 1999). This palaeotemperature ranging corresponds perfectly with the paleoclimatic characteristics of our palm findings and the palm archive from the rest of Greece.

The revised floral assemblage (Velitzelos & Denk 2013) includes elements of wetlands and riparian stands such as *Taxodium*, *Alnus*, *Daphnogene*, *Fraxinus*, *Myrica*, *Nyssa*, *Phoenicites* sp., *Pterocarya*, *Salix*, and *Ulmus*. Lianas were represented by Vitaceae, *Hedera*, *Smilax*, and cf. *Toddalia*. On well-drained stands the fully humid to relatively drier spectrum of characteristic plant taxa includes *Cathaya*, *Fagus gussonii*, *Tilia*, possibly Magnoliaceae and Symplocaceae, *Tetraclinis salicornioides*, *Acer decipiens*, *A. integerrimum*, *Celtis*, *Cistaceae*, *Engelhardia*, *Zelkova*, and *Quercus mediterranea*.

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Climate Variability in Lebanon during the Last Four Climate Cycles: A Multiproxy Approach

Laurence Vidal¹, Françoise Gasse¹, Elise Van Campo², François Demory¹, Kazuyo Tachikawa¹, Anne-Lise Develle³, Noelle Buchet¹, Marta Garcia¹, Corinne Sonzogni¹, Edouard Bard¹, Nicolas Thouveny¹

¹ CEREGE, UM 34 Aix-Marseille Univ. – CNRS (UMR 7330) – IRD (UMR 161) - Collège de France ,
Europôle de l'Arbois, BP 80, 13545 Aix en Provence, cedex 4

² ECOLAB UMR 5245, Univ. Paul Sabatier, bat. 4R1, 118 route de Narbonne, 31055 Toulouse cedex

³ EDYTEM, UMR 5204, Univ. de Savoie, bat. Pôle Montagne, 73376 Le Bourget du Lac, cedex

Knowledge on the hydrological cycle variability in the Levant is a key question to understand water resource dynamics as well as human society evolution in this area. The present work focuses on Late Quaternary environmental evolution in Lebanon by studying interactions between local/regional paleohydrological variability and global climate changes. Paleo-lake sediments (73 meters long) retrieved in the Yammouneh basin (34.06°N–34.09°N, 36.0°E–36.03°E, 1360 m a.s.l.) located on the eastern flank of the Mount Lebanon were investigated for a multiproxy analysis (biogenic carbonate stable isotopes, sedimentary geochemistry and magnetic properties, pollen assemblages). The Chronological framework of the Yammouneh sedimentary sequence still needs to be improved, especially before 240 000 years. However, paleomagnetic, lithological and pollen results reveal for the first time a nearly continuous record for the Lebanon area, likely spanning approximately the last 360000 years. Wet climate with enhanced seasonality is documented during interglacial periods in line with paleoclimate records from the northern Mediterranean area (Gasse *et al.*, 2011) and western central Levant (Bar-Matthews *et al.*, 2003, Langgut *et al.*, 2011). Variable aridity conditions are identified during glacial phases, with MIS 6 being relatively humid compared to the other glacial periods. These climate conditions are tentatively linked with several local factors (ice/water storage on the Mont Lebanon, different air sources and variable influence from air masses with western, northern or subtropical origin).

Keywords: hydrological cycle, Levant, interglacial/glacial periods

Potential of Lipid Biomarkers and High Resolution Holocene to Last Glacial Archives from the Gulf of Genoa, Ligurian Sea (NW Mediterranean Sea)

Jérôme Kaiser¹, Helge W. Arz¹, Nicoletta Ruggieri², Jens Hefter², Herbert Siegel¹, Gesine Mollenhauer², Frank Lamy²

¹Leibniz Institute for Baltic Sea Research (IOW), Seestrasse 15, 18119 Rostock-Warnemünde, Germany; jerome.kaiser@io-warnemuende.de;

² Alfred-Wegener-Institute (AWI) Bremerhaven, Postfach 120161, 27515 Bremerhaven, Germany

During R/V Poseidon cruise P413 (May 2011), ~60 sediment cores were taken along the Ligurian shelf, continental slope, and in the basin between off Livorno and the French border. Results based on surface sediments suggest that some biomarker-based proxies are well-suited to reconstruct sea surface temperature (SST), the input of terrestrial organic material (TOM), and marine primary productivity (PP). The estimated $U^{K'}_{37}$ SST reflects very closely the autumnal and annual mean SST distributions, while TEX^H_{86} SSTs correspond to summer SST at offshore sites and to winter SST for the nearshore sites. Using both SST proxies together may thus allow reconstructing seasonality changes. Proxies for TOM input (terrestrial n-alkane and n-alkanol concentrations, BIT index) have higher values close to the major river mouths and decrease offshore suggesting that these may be used as proxy for the variability in TOM input by runoff. Interestingly, high n-alkane average chain length in the most offshore sites may result from aeolian input from northern Africa. Furthermore, some sterols and isoprenoid glycerol dialkyl glycerol tetraethers are reflecting PP in the working area.

Coring profiles from the coastal area to the deep basin allow reconstructing past environmental variability over the last ca. 90000 years with sedimentation rates varying between ca. 0.5 cm*yr⁻¹ for the latest Holocene to ca. 10 cm*kyr⁻¹ for the last glacial. For example, high resolution (mm) analyses of major elements using XRF core-scanning from two cores with extremely high resolution (0.2-0.4 cm/year) over the last 2.5 kyr were performed. Typical elements of detrital origin (i.e. Ti, Fe) present a very high variability, probably related to extreme runoff events during the late Holocene. An attempt of spectral analysis on these records reveals significant periodicities around 4-5 and 7-8 years, i.e. within the spectral band of the Arctic Oscillation / North Atlantic Oscillation (AO/NAO) variability. We expect that our new records will provide important information on Holocene and last glacial changes in continental rainfall and surface ocean conditions and will allow establishing relationships to regional oceanographic changes as well as to large-scale atmospheric variability.

Keywords: Ligurian Sea; biomarkers; high resolution; Holocene; glacial

SESSION 10

NEOGENE MAMMALIAN SUCCESSIONS AND DISPERSALS

CONVENERS

ŞEVKET ŞEN AND MADELAINE BÖHME

Chinese Neogene Mammalian Succession and Biostratigraphy

Tao Deng¹, Sukuan Hou¹

¹Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China, dengtao@ivpp.ac.cn

Based on a series of fruitful studies of mammalian fossils, an accurately defined biostratigraphic sequence of the Chinese terrestrial Neogene has been proposed, including seven chronostratigraphic units, the Xiejian, Shanwangian, Tunggurian, Bahean, Baodean, Gaozhuangian, and Mazegouan stages. In the past, the positions of the Chinese mammalian faunas in the chronological chart and their correlations to the European faunas were determined mainly by evolutionary levels of mammals for lack of accurate absolute ages. During the last three decades, great progress has also been made in Chinese Neogene terrestrial stratigraphic studies. Most of the classic regions have been revisited, such as the Yushe and Baode areas in Shanxi, the Lantian area in Shaanxi, and the Tunggur area in Inner Mongolia, and so on. New discoveries are made in well-exposed fossiliferous regions, such as Tongxin in Ningxia, central Inner Mongolia, the northern Junggar Basin in Xinjiang, the Linxia Basin in Gansu, the Qaidam Basin in Qinghai, and so on. Magnetostratigraphic work was also undertaken in several classic regions. Great gaps, however, still exist between China and its European and North American counterparts in terms of accumulation of fossils as well as such basic tasks as documentation of fossil occurrences and their biostratigraphic contexts. Nowadays, the land mammal ages have been strongly broadened by data from new localities and new taxa in China. The significance of these new data is that they are beneficial toward our understanding of mammal turnovers and boundary calibrations. The faunal components are thought to be stable throughout each chronostratigraphic unit, without large changes occurring. For each unit, a series of species or genera are regarded as characteristic forms on the basis of the correlation to the European taxa. Usually, the chronostratigraphic units deal with the first appearance datum (FAD) of mammals at the generic or specific level. Some of these genera and species are immigrants, and their entry into China often marks the beginning of a unit. The precise correlations between the Chinese and European mammalian ages based on more accurate dating will increase our ability to recognize mammal migrations between China and Europe. Asia acted as a faunal dispersal center for Europe during the Neogene, and the great majority of the exchanges were migrations from Asia into Europe. China was one of the main dispersal centers of the Neogene. In recent years, the Chinese Neogene mammal ages have become more accurate with the introduction of magnetostratigraphy, which has enabled ages to be calibrated and well-dated at their boundaries. Increasingly abundant paleomagnetic measurements make a good calibration for the correlation of the Chinese Neogene mammalian faunas with their European and North American counterparts. A new Neogene chronostratigraphic framework is proposed, and it is more consistent with the reality of the state of research and conditions in China. This will provide a foundation for the establishment of a formal Chinese Neogene terrestrial chronostratigraphic system. Given that China possesses well-developed Neogene terrestrial strata that are richly endowed with fossil mammals, such a system should play a role in the establishment of an Asian Neogene terrestrial scheme in the future.

Origin of the Elements of the Endemic “Terre Rosse” Fauna (Gargano, South-Eastern Italy).

Andrea Savorelli¹, Federico Masini²

¹University of Firenze, Department of Earth Science, Via La Pira 4, 50121 Firenze, Italy,
andrea.savorelli@unifi.it

²University of Palermo, Department of Earth and Sea Science, Via Archirafi 22, 90123 Palermo, Italy,
federico.masini@unipa.it

The attention of the scientific community has recently been addressed on various aspects of the Messinian endemic vertebrates from the foreland sector of the Abruzzo - Apulian paleobioprovince: several new papers dealing with ruminants, glirids, insectivores, cricetids, as well as with biochronological, palaeographic and biogeographic aspects have been published in the last ten years. New fossils finds enriched the taxonomic composition of the Gargano endemic fauna: a new Cricetodontinae genus, a new Murinae genus representing the direct ancestor of the endemic murid *Mikrotia*, and a new species of primitive giant moonrat *Deinogalerix*. The recently published taxonomic description of the smaller moonrat *Apulogalerix* also contributed to a better knowledge of the endemic Gargano fauna.

Although these new data and contributions brought substantial improvement to the taxonomy of the fauna and to the ecology of the moonrats, the debate on the origin and age of dispersal of most of the faunal elements is still open. In this contribution we present some of the open problems regarding the origin of several of the elements of the “Terre Rosse” fauna.

The study of the small moonrat *Apulogalerix* has shown that its most likely continental ancestor should be found in *Parasorex socialis* – *ibericus*. Such phylogenetic relationship constrains the age of its dispersal on the insular realm to the Late Vallesian (MN9-10). This is in partial contradiction with paleogeographic reconstruction based on geological data, which suggest that the time slice MN6-MN11 is the least favourable time interval for the dispersal of the taxa on the insular domain. The study in progress of the new genus of Cricetodontinae shows that this form is not clearly related to any of the known continental genera. The features of this new genus, however, are more compatible with a possible derivation from some Cricetodon-like genus. This affinity suggests an age of dispersal of Early Miocene-early Middle Miocene (MN4-5) or older and implies that the “Terre Rosse” fauna is the result of different dispersals event scattered in different time slices.

A still open problem is represented by the Crocidosoricinae shrew named as *Lartetium* in the literature. Indeed, the absence of residual a3, a character considered as diagnostic of the genus, renders the generic attribution very problematic and would require further investigations.

The new discovered Murinae genus shares a number of synapomorphies with *Mikrotia* genus. Its description should be completed, however, by the comparison with the smallest and most primitive *Mikrotia* from the Terre Rosse. The question of the continental ancestor of this taxon is still unresolved and the preliminary comparisons with European Murinae taxa unfortunately did not shed light on its phylogenetic relationship and therefore this matter deserves much more efforts.

The *Apodemus* species from the “Terre Rosse” has never been studied in details. Preliminary observations pointed out that this form shows similarities with late Turolian-Ruscian *Apodemus* forms from continental Europe. A more detailed analysis, currently under development, seems to confirm this interpretation and, therefore, permits to exclude a derivation of this form from more primitive *Apodemus* species (referred to as genus “*Parapodemus*” by several authors).

Hoplitomerycidae, a Possible Example of Giantism among Insular Ruminants

Paul P.A. Mazza¹, Maria Adelaide Rossi², Silvano Agostini²

¹University of Firenze, Department of Earth Science, Via La Pira 4, 50121 Florence, Italy,
paul.mazza@unifi.it

²Servizio Geologico e Paleontologico, Soprintendenza per i Beni Archeologici dell'Abruzzo, Via degli
Agostiniani 14, 66100 Chieti, Italy, silvano.agostini@beniculturali.it; mariaadelaide.rossi@beniculturali.it

So far, the ruminant genus *Hoplitomeryx*, endemic to the vast paleoisland Abruzzo-Apulian Platform, was known to include six species. Discovery of new specimens from Upper Miocene limestones of Scontrone (Abruzzo, central Italy) allows recognition of still a new species. The remains belong to the largest *Hoplitomeryx* known to date. Hoplitomerycids derived from small-sized Oligocene basal ruminants. This newly discovered representative might be the first giant insular ruminant ever described. Insular giantism was notoriously exhibited by other taxa, such as rodents, but never by artiodactyls. This large *Hoplitomeryx* was a lightly built animal with long, slender limbs. This case shows not only that insular giantism might be attained also on large islands, but also confirms that it can be promoted by competitive release and immigrant selection.

Acknowledgements:

This research was financially supported by PRIN (Research Projects of National Interest) 2009 MIUR (Ministry of Education, University and Research) grants.

Anisodon (Chalicotheriidae, Perissodactyla) from China and the Phylogenetic Relationships of the Genus

Shao-kun Chen^{1,2}, Tao Deng¹

¹ Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China

² Chongqing Three Gorges Institute of Paleoanthropology, China Three Gorges Museum, Chongqing 400015, China

Anisodon is a Eurasian genus of the subfamily Chalicotheriinae. This genus, including four species, *A. grande*, *A. macedonicum*, *A. salinum*, and *A. yuanmouensis*, has been found from many Mid-Late Miocene localities of Europe and South Asia. The phylogenetic relationships for this genus, however, are still unclear until now. The anisodont fossils from the Middle Miocene Laogou locality of Gansu Province and the Late Miocene Shihuiba locality of Yunnan Province in China can be very helpful for improving our understanding. The Laogou specimens are identified as *Anisodon* sp. based on the size and the developed protoconule. The Shihuiba specimens are identified as *A. yuanmouensis* (Gao & Ma, 1997) based on the size, the variable protocone on upper molars, the marked “three-lobed” structure on P4, the reduced M3/m3, and the narrower lower cheek teeth than other species in this genus. A Late Miocene mandible from Irrawaddy in Myanmar mentioned by Chavasseau *et al.* (2010) can be also referred to *A. yuanmouensis*.

The phylogenetic relationships in *Anisodon* are proposed that *A. salinum* is likely the most primitive species and constitutes a sister group with *A. yuanmouensis*. It is possibly that anisodonts originated from southern Asia or the borderland of the Tibetan Plateau. The absence of *Anisodon* in the north side of the Tibetan Plateau after the Middle Miocene probably indicates the uplift of the plateau to a high elevation which prevented the free migration of anisodonts during the Mid-Late Miocene.

Keywords: Chalicotheriidae, *Anisodon*, phylogeny, Miocene, China

Comparison of Miocene Xerini (Sciuridae, Mammalia) from Central Spain and Germany

Jérôme Prieto¹, Verónica Hernández-Ballarín², Adriana Oliver², Pablo Peláez-Campomanes²

⁽¹⁾ Department for Earth and Environmental Sciences, Ludwig-Maximilians-University Munich & Bavarian State, Collections for Palaeontology and Geology, Richard-Wagner-Strasse 10, D-80333 Munich, Germany, and Senckenberg Center for Human Evolution and Paleoecology (HEP), Eberhard-Karls University, Institute for Geoscience, Sigwartstr. 10, D-72076 Tübingen, Germany; j.prieto@lrz.uni-muenchen.de

⁽²⁾ Departamento de Paleobiología, Museo Nacional de Ciencias Naturales MNCN, CSIC, 28006 Madrid, Spain. verohernandez@mncn.csic.es; adriana@mncn.csic.es; pablopelaez@mncn.csic.es

Despite the extensive record of sciurids of the tribe xerini from Miocene European localities, few have been the works that have tried to present an overview of this group at continental scale (Cuenca Bescos, 1988; De Bruijn, 1999; Aguilar, 2002). The xerini squirrels have a characteristic dental morphology that can be easily recognized by mammal paleontologist. The few species described within this tribe show a very similar dental morphology and the diagnostic characters for the diverse genus are in most cases minor differences, due to the maintenance of primitive dental patterns. This characteristic, and rather conservative, morphology has promoted, in our opinion, an oversimplified taxonomy. This is especially evident on the genus *Heteroxerus* Stehlin & Schaub, 1951, with a temporal distribution of around 20 My. and only six species described (De Bruijn, 1999). This work shows a morphological comparison between the xerine record of central Spain and Germany. Most of the materials recorded from these areas have been assigned to *Heteroxerus rubricati*, *H. huerzeleri* and *H. grivensis* (Cuenca Bescos, 1988; Ziegler & Fahlbush, 1986; Ziegler, 2005). The comparison has demonstrated the existence of constant morphological differences between the ground squirrels from these two areas. This result shows the existence of taxonomical differences, not indicated by previous authors, and points out the need for a revision of this tribe in order to have a better understanding of its evolution and paleobiogeography. This result also reinforces the idea of a strong bioprovincialism during most part of the Miocene postulated on the basis of other mammal groups.

Acknowledgments:

SYNTHESYS Project (ES-TAF-2742), financed by the European Community Research Infrastructure Action under the FP6 “Structuring the European Research Area” Programme. This work is a contribution to the Spanish MICINN/MINECO projects CGL2008-04200/BTE, CGL2011-28877 and the Universidad Complutense de Madrid Research Group UCM-910607. VHB and AO are supported by FPI and FPU Spanish predoctoral contracts.

Key Words. Ground squirrels, Early and Middle Miocene, dental Morphology, provincialism.

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Cricetodontini from the Calatayud-daroca Basin (Miocene, Spain)

P. López-Guerrero^{1,2}, I. García-Paredes², M. A. Álvarez-Sierra^{1,2}, P. Peláez-Campomanes³

¹Universidad Complutense de Madrid, Spain; palomalo@geo.ucm.es, masierra@geo.ucm.es

²Instituto de Geociencias IGEO (CSIC, UCM), Madrid, Spain; isgarpa@geo.ucm.es

³Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain; pablopelaez@mncn.csic.es

The Cricetodontini is a rodent tribe commonly found in the Miocene from Europe and Asia which provides relevant information regarding the biochronology, biostratigraphy and palaeoecology of the continental deposits. We describe the updated stratigraphical distribution and evolutionary pattern of the representatives of Cricetodontini from the middle Aragonian to the early Vallesian (middle-late Miocene) in the Calatayud-Daroca Basin (Spain). The first occurrence of the tribe in this area is in the local biozone E (MN5, middle Aragonian) (Daams & Freudenthal, 1988; de Bruijn et al., 1993; López-Guerrero et al., 2013). After that, during biozones F, G1 and G2 (MN6, late Aragonian,) two different species are present. All these taxa have a homogeneous morphology typical of *Cricetodon*, which is considered primitive among the tribe. In the biozone G3 (MN7/8, latest late Aragonian) the homogeneity of dental characters disappears and the intraspecific variability is higher than in the older representatives. There is a replacement of the species and an increase of the diversity, being registered the highest number of species (four) in the basin. These taxa show a combination of primitive and derived characters, including record of a new species in this area. The acquisition of derivative characters typical of *Hispanomys* is achieved during the local biozone H (MN7/8-MN9, late Aragonian-early Vallesian). The last record of *Hispanomys* in the basin occurs in the biozone I (MN9, early Vallesian). The evolutionary patterns observed in the Calatayud-Daroca Basin are recognized in the rest of the European Cricetodontini faunas, although not synchronously. This asynchrony in the Aragonian rodent events has been previously detected by van der Meulen et al. (2011, 2012).

The current studies on the material of Cricetodontini from the well-known Calatayud-Daroca Basin (López-Guerrero et al., 2008, 2009, 2013) increase the information of this tribe in the Iberian Peninsula, allowing us to better understand its evolution and diversification in Europe.

Keywords: Rodentia, Cricetodontini, Aragonian, Vallesian, stratigraphical distribution.

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Parasorex Depereti (Crochet, 1986) (Lipotyphla, Mammalia), from the Upper Maessinian (MN13) Fissure Filling of Brisighella (Faenza, Northern Apennine, Italy)

Federico Masini¹, Flaviano Fanfani², Andrea Savorelli²

¹Università degli Studi di Palermo, Dipartimento di Scienze della Terra e del Mare, Via Archirafi, 22 – 90123, Palermo Italy. federico.masini@unipa.it

²Università degli Studi di Firenze, Dipartimento di Scienze della Terra, via G. La Pira, 4 – 50121, Firenze Italy

A large-sized species of *Parasorex* is rather common in the MN13 mammal assemblages from the uppermost Messinian sandy - marly fissure fillings within the Gessoso Solfifera Formation at Brisighella (Northern Apennine). This erinaceid had been originally classified as *Galerix* sp. in the first papers on the Brisighella fauna. Later on, it was described in detail in an unpublished dissertation by Fanfani (1999) who had referred it to *Galerix depereti*. Unfortunately, the study remained virtually unknown to the scientific community. Hoek Ostende (2001) included *G. depereti* in the genus *Parasorex*, while Ziegler (2005) accommodated it in *Schizogalerix*. Hoek Ostende's (2001) opinion is followed here.

Parasorex depereti has been described by Crochet (1986) on rather scarce material from a few Early Pliocene (MN14-15) localities of southern France and Spain. *Parasorex* cf. *depereti* is represented in the Italian Messinian/Zanclean deposits of Borro Strolla, (Val d'Elsa Basin, Tuscany) by a single M3 (Abbazzi et al., 2008). Several other remains from the Early Pliocene fauna of Capo Mannu (Mandriola, Sardinia) have been referred to *Parasorex depereti* (Furió and Angelone, 2011). The species seems actually distribute in south-western Europe, where it represents the youngest occurrence of genus *Parasorex*.

The very abundant sample of *P. depereti* from fissure filling BRS25 enables a more accurate and comprehensive biometrical description of the species. It also permits to inspect the mesial traits of the dentition which Crochet (1986) had failed to describe. The systematic position of the species can also be revisited and compared with those of other European Galerici taxa.

Keywords: *Parasorex*, MN13, taxonomy, biometry

Acknowledgments:

This research was financially supported by PRIN (Research Projects of National Interest) 2009 MIUR (Ministry of Education, University and Research) grants.

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New Data on the Late Turolian Carnivora of Southern Russia

M.V. Sotnikova¹

¹Geological Institute of RAS, Pyzhevsky 7, 119017 Moscow, Russia, sotnikmarina@yandex.ru

Since the beginning of the last century an abundant assemblages of the Late Turolian Carnivora has been found in the Black Sea area in Ukraine, Moldova and Georgia. Until recently in the neighboring areas of Southern Russia, the finds of synchronous counterparts were almost completely absent.

Due to the decade of research, a representative assemblage of Late Turolian carnivorans was first found in localities Morskaya 2 (MN12 - beginning MN13) in the North coast of Azov sea and Solnechnodolsk (MN13) near Stavropol. In addition to Carnivora the freshwater mollusks, fishes, amphibians, reptiles, birds, and about 20 taxa of mammals (in Morskaya 2) and more than 30 forms of small and large mammals (in Solnechnodolsk) were reported from these Russian sites [1, 2].

Despite the fact that the bone material was obtained by screen-washing for microvertebrates, the Carnivore list includes 9 different taxa: Ursidae -*Indarctos* sp., *Martes lefkonensis*, *Pilgrimeles woodwardi*, *Promephitis* cf. *maeotica*, *Enhydriodon* sp., *Ictitherium* sp., *Hyaenotherium wongii*, *Metailurus parvulus*, *Pristifelis attica* in Morskaya 2 and *Pilgrimeles woodwardi*, *Pristifelis attica*, Hyaenidae gen. (large form) in Solnechnodolsk. Among these taxa the rarely known mustelids are of the particular interest.

The species *Martes woodwardi* is only known by its holotype (a mandibular fragment) and referred mandibular ramus from the type locality Pikermi in Greece [3]. Ginsburg [4] erected a new genus *Pilgrimeles* for *M. woodwardi* based on of meline-like, basined talonid of m1 comprising the set of small cuspids on its lingual border. The small mustelid from the south Russian faunas is similar in dimensions to *P. woodwardi* and demonstrates the same morphology of m1.

The second small mustelid from Morskaya 2 has a trenchant talonid of m1. In size and morphological characteristics of upper and lower molars it is entirely consistent with *Martes lefkonensis* from Maramena in Greece (MN13).

Members of the genus *Promephitis* were widespread in Eurasia from the Vallesian to Ruscinian and presented a large number of species, often having no clear diagnoses. Despite the difficulties with species identification of *Promephitis*, some evolutionary trends in the Eurasian forms has been recently identified [5]. According to the data, the M1 of specimen from Morskaya 2 shows an advanced morphology of upper molar. In size it is close to *Promephitis maeotica* from Ukrainian localities Novoelizavetovka and Novaya Emetovka, both MN12. But it is more derived in having a short postprotocrista, well developed styles, reduced buccal and developed lingual cingulae on M1. In conclusion, it should be noted that majority of studied carnivores such as *Indarctos*, *Ictitherium*, *Hyaenotherium wongii*, *Metailurus parvulus* and *Pristifelis attica*, were common members of Turolian faunal assemblages of Eurasia. Their abundant finds in some cases are known from Spain to China. The majority of mustelids are represented by Mediterranean taxa and some of them indicate the Late Turolian age for Southern Russia mammal communities.

Keywords: Late Turolian, Carnivora, South Russia

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Biostratigraphy of the Upper Miocene to Lowest Pleistocene Deposits of the Guadix Basin (Spain) Based on Small Mammals

Raef Minwer-Barakat¹, Antonio García-Alix², Elvira Martín Suárez³, Matthijs Freudenthal³, César Viseras³

¹Institut Català de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, 08193 Cerdanyola del Vallès, Barcelona, Spain; raef.minwer@icp.cat

²Instituto Andaluz de Ciencias de la Tierra, Avda. de las Palmeras 4, 18100 Granada, Spain; agalix@ugr.es

³Departamento de Estratigrafía y Paleontología, Universidad de Granada, Avda. Fuentenueva s/n, 18071 Granada, Spain; elvirams@ugr.es, mfreuden@ugr.es, viseras@ugr.es

The recent study of the rodents and insectivores identified in several fossil sites from the central sector of the Guadix Basin (Southern Spain) has notably increased the knowledge of the mammal assemblages that occurred in Iberia from the latest Miocene to the earliest Pleistocene. On the basis of this new information, we propose a biozonation for the continental deposits of the Guadix Basin, which consists of six biozones ranging in age from the late Turolian (MN13) to the early Villanyian (MN17). These zones include not only the mentioned recently discovered sites, but also other, previously known, localities of the basin.

The *Apodemus gudrunae* Assemblage Zone is defined by the association of *Apodemus gudrunae*, *Apocricetus alberti*, *Occitanomys alcalai*, *Paraethomys meini*, *Myocricetodon jaegeri*, *Debruijnimys almenarensis* and *Parasorex ibericus*. This biozone includes the sites Negratín-1, Rambla de Chimeneas-3, Bacochas 1 and Pino Mojón. It can be included in the Upper Turolian (MN13). The maximum age of its lower limit can be placed at 6.25 Ma (first occurrence of *P. meini* in Spain); its upper limit coincides with the MN13-MN14 boundary (~ 5.3 Ma).

The *Trilophomys* Assemblage Zone is defined by the association of *Apocricetus barrierei*, *Stephanomys cordii*, *Castillomys gracilis*, *Apodemus gorafensis*, *Paraethomys meini* and *Trilophomys*. It includes the sites Gorafe-4, Gorafe-1, Gorafe-A, Yeguas, Colorado 2, Aljibe 2 and 3. This biozone corresponds to the Lower Ruscinian (MN14), and its lower and upper limits can be considered equivalent to the MN14 boundaries (~ 5.3 and 4.19 Ma).

The *Dolomys adroveri* Taxon-range Zone is defined by the total range of this arvicolid. It includes the localities Tollo de Chiclana-1 (TCH-1) and Galera-C; a careful revision of the arvicolids from other Ruscinian sites of the basin will probably lead to the inclusion of other sites in this biozone. It can be situated in the Upper Ruscinian (MN15). The maximum age of its lower limit is 4.19 Ma (MN14-MN15 boundary), while its upper limit is younger than 3.60 Ma.

The *Mimomys hassiacus*-*Stephanomys donnezani* Concurrent-range Zone is defined by the simultaneous occurrence of these two species. It includes the sites TCH-1B and Moredal-A. As in the case of the *Dolomys adroveri* Zone, the revision of the arvicolids from other Ruscinian localities of the basin is need to allow their inclusion in these biozones or, alternatively, the definition of other units. This biozone is assigned to the upper part of the Upper Ruscinian (MN15). Its age is constrained between 3.60 Ma and 3.21 (MN15-MN16 boundary).

The *Stephanomys minor* Assemblage Zone is defined by the association of *Stephanomys minor*, *S. thaleri*, *Castillomys crusafonti*, *Mimomys stehlini* and *Kislangia ischus*. This biozone includes the sites TCH-3, TCH-13, Zújar-11 and Moredal-B, and corresponds to the Lower Villanyian (MN16). Its lower and upper limits coincide with the boundaries of MN16 (3.21 and 2.58 Ma).

Finally, the *Mimomys medasensis* Taxon-range Zone is defined by the total range of this species. It includes the levels TCH-10B, TCH-10, Galera-2, Galera-G and Cortes de Baza-1. This biozone is correlated to the lower part of the Upper Villanyian (MN17). Its lower limit can be placed at the MN16-MN17 boundary (2.58 Ma). The age of its upper limit must be younger than the base of the Olduvai chron (1.95 Ma).

This is the first definition of local biozones according to the rules of the Stratigraphic International Guide for the continental deposits of the Guadix Basin. The proposed biozonation constitutes a solid framework for situating other localities from this basin whose faunal contents are in need of revision, and will also allow the inclusion of future findings.

Keywords: Biostratigraphy, micromammals, Miocene, Pliocene, Pleistocene.

Biochronology and Historical Biogeography: Testing Symmetric Versus Asymmetric Time Models

M. Ángeles Álvarez-Sierra^{1,2}, Israel García-Paredes², Verónica Hernández-Ballarín³, Lars W. van den Hoek Ostende⁴, Kees Hordijk⁵, Paloma López-Guerrero^{1,2}, Albert J. van der Meulen⁵, Adriana Oliver³, Pablo Peláez-Campomanes³

¹Universidad Complutense de Madrid, Spain; masierra@geo.ucm.es; palomalopez@geo.ucm.es

²Instituto de Geociencias IGEO (CSIC, UCM), Madrid, Spain; isgarpa@geo.ucm.es

³Museo Nacional de Ciencias Naturales MNCN (CSIC), Madrid, Spain; verohernandez@mncn.csic.es; adriana@mncn.csic.es; pablopelaez@mncn.csic.es

⁴Naturalis Biodiversity Center, Leiden, The Netherlands; Lars.vandenHoekOstende@naturalis.nl

⁵Institute of Earth Sciences, Utrecht University, The Netherlands; K.Hordijk@uu.nl

Historical biogeography has two general models for describing the theoretical life-span of a species. The first one is the “Symmetric Time Model” (Jenkins, 1994) which implies having a gradually expanding distribution area after origination and a gradually decreasing area before extinction; the second is the alternative (and partially opposite) “Asymmetric Time Model” proposed by López Martínez (2003, 2009), which implies a rapid dispersal at the beginning, but maintaining the gradual extinction. López Martínez (2001, 2003, 2009) pointed out that the fossil record supports the Asymmetrical Time Model because new taxa seem to appear simultaneously over a large area (their rapid expansion makes many of them excellent biostratigraphic/biochronologic markers) and because the number of First Appearance Datum (FAD) is higher than that of Last Appearance Datum (LAD) in biostratigraphical schemes.

In this study, we analyse the Middle Miocene micromammal appearance and extinction events (FADs and LADs) based on well-calibrated local biostratigraphic scales from different European basins. The main aim is to determine which of the proposed biogeographical models better fits the Middle Miocene European micromammal record, using the correlations of bio-events recently published by Van der Meulen *et al.* (2011, 2012). The results support that the Asymmetric Time Model of palaeobiogeography is only applicable in rare cases. The analyzed fossil record shows one event of occurrence and one of extinction that can be considered synchronous at continental level. In fact, most of the palaeobiological events studied fit the Symmetric Time Model better. Finally, the implications of the biochronologic data in the proposal of palaeobiogeographic models are also discussed, pointing out that palaeobiogeographic frameworks need to be based on extensive local biostratigraphic data and well-calibrated biochronologic scales.

Keywords: Micromammals events, Middle Miocene correlations, Historical Biogeography, Diachrony.

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Carnivore Biodiversity Changes among Neogene, Quaternary and Present Time Period in Turkey

Sakir Önder Özkurt¹

¹Ahi Evran University Faculty of Education Department of Science Education Kırşehir, Turkey

In this study Carnivore Biodiversity Changes in different time periods (Neogene, Quaternary and present) were explained in Turkey. The oldest carnivore fossils in Anatolia have been dated at 17 mya. In this study carnivore fossils collected from 56 localities in Anatolia existed between 17 to 0,10 mya were focused. These fossil carnivores comprise 9 families, 51 genera and 58 species whereas; extant carnivores in Anatolia were consisted of 6 families, 14 genera and 18 species. Ecological changes caused by geological evolution in Anatolia have brought about a decrease of 3 families, 37 genera 40 species in carnivore biodiversity.

Keywords: Carnivore, Changes, Biodiversity, Turkey.

Paleoenvironmental Reconstructions Based on Small Mammals (Isotopic vs. Faunistic Data)

Antonio García-Alix¹, Antonio Delgado Huertas¹, Elvira Martín Suárez², Matthijs Freudenthal^{2,3}

¹ Instituto Andaluz de Ciencias de la Tierra (IACT-CSIC-UGR). Universidad de Granada-Consejo Superior de Investigaciones Científicas. Avenida de las Palmeras nº4, 18100 Granada, Spain

² Departamento de Estratigrafía y Paleontología, Universidad de Granada, 18071 Granada, Spain

³ Netherlands Centre for Biodiversity, Naturalis, P.O. Box 9517, NL-2300 RA Leiden, the Netherlands

Paleoenvironmental reconstructions based on ecological preferences of small mammals provide qualitative environmental interpretations of past continental landscapes. These results can be complemented with isotopic data from these fossil remains and from the sedimentary sequence they were found in.

The analyses of the isotopic composition of organic matter and carbonates from lacustrine sediments, together with that of tooth phosphate and carbonate of a latest Messinian paleo-lake record in the Granada Basin have provided quantitative paleoenvironmental information. Comparison between traditional paleoenvironmental reconstructions and those from isotopic data may unravel if the fluctuations in the faunal distribution in the Granada Basin during the latest Miocene were mainly influenced by the paleogeographic configuration (changes in the landscape) of the basin or by the climatic conditions.

Fossil rodents from three levels have been studied: CAC-5, CAC-6 and CAC-9 in the Cacín section (Granada Basin), and the carbonates and organic matter from the sedimentary sequence (7 m).

In the sediments, the isotopic composition of carbonates ranges from -12.8‰ to -3.8‰ PDB, in the case of carbon isotopes ($^{13}\text{C}_c$), and from -6.9‰ to -3.1‰ PDB, in the case of oxygen isotopes ($^{18}\text{O}_c$), with mean values of -7.11.7 ‰ and -5.5‰0.8‰ PDB respectively. The carbon isotopic composition of the organic matter ($^{13}\text{C}_{om}$) ranges from -26.1‰ to -23.0‰ with a mean value of -24.00.9‰ PDB.

$^{18}\text{O}_p$ values of phosphates of rodent teeth range from +18.8 to +19.9‰ SMOW. The carbonate fraction from rodent teeth of the fossil localities CAC-5 and CAC-6 have $^{18}\text{O}_c$ values of -3.8‰ and -3.3‰ PDB (+27.0 and +27.6 vs. SMOW), and -12.4‰ and -12.7‰ ($^{13}\text{C}_c$) PDB, respectively.

Environmental data from small mammal paleoecology suggest open-herbaceous habitats with C3 plants and warm temperatures, and has been corroborated and specified by stable isotope geochemistry from sediments and small mammal teeth. The differences between humidity conditions deduced from isotopes and those from faunal assemblages suggests that the tectonic activity, which reduces the extension of the lacustrine system, affected taxa with high dependence on humid conditions, instead of a drastic change in climatic (humidity) conditions. Because the distribution of some taxa is also affected by temperature, we conclude that the distribution of the small mammal assemblages from the latest Messinian in the Granada Basin were affected by both climatic (temperature and humidity) and tectonic (influencing the humidity) activity.

Keywords: small mammals; lacustrine sediments; isotopic geochemistry; Iberian Peninsula; late Miocene

Paleo-humidity Parameters in Fossil Rodents (Mammalia): Isotopic vs. Morphological Approach

Antonio García-Alix¹, Matthijs Freudenthal^{2,3}, María Ríos⁴, Francisco Ruiz-Sánchez⁵, Elvira Martín-Suárez², Antonio Delgado Huertas¹

¹Instituto Andaluz de Ciencias de la Tierra CSIC-UGR, Avda. de las Palmeras, nº 4. 18010. Granada, Spain.

²Departamento de Estratigrafía y Paleontología, Campus Fuentenueva, Universidad de Granada, 18071 Granada, Spain.

³Netherlands Centre for Biodiversity, Naturalis, P.O. Box 9517, NL-2300 RA Leiden, the Netherlands

⁴Museo Nacional de Ciencias Naturales (CSIC) C/ José Gutiérrez Abascal, 2 28006 - Madrid, Spain

⁵Department of Geology, University of Valencia, Dr. Moliner s/n, 46100 Burjassot, Spain.

Environmental reconstructions of fossil rodent faunas have traditionally been based on the tooth pattern: The dental pattern of recent rodents is linked to their environment and these ecological relationships are extrapolated to fossil rodents. We applied one of the most widely used models for paleohumidity reconstruction, based on rodent dental morphology, for the early Miocene (Daams et al., 1999), to two different areas in the Iberian Peninsula (Morteral in the Ibero-Levantine bioprovince and Aragón in the Ibero-Central bioprovince). The results suggest that during the Early Miocene the coastal Ibero-Levantine bioprovince, was drier than the Ibero-Central one (central Iberian). This result seems little probable, and led us to a re-evaluation of the humidity inferences of fossil rodents.

In order to contrast this hypothesis, we compare these results with another humidity proxy, the isotopic composition of rodent enamel. The carbon isotopic composition of structural carbonate of hydroxylapatite from mammals is related to the carbon isotopic composition of its diet, and therefore of the local vegetation. In the case of specimens that feed on the same kind of plants (i.e. C3 plants), as in our case, the level of water or moisture stress can be established by these isotopic studies. The best skeletal tissue to carry out this kind of paleoenvironmental analyses is the hydroxylapatite of tooth enamel, due to the preservation of the isotopic signal.

The carbon isotopic composition ($\delta^{13}\text{C}_\text{c}\text{‰}$) of the teeth from the Ibero-Levantine bioprovince section ranges from -11.3‰ to -9.5‰, with a mean value of $-10.2 \pm 0.7\text{‰}$ (PDB). Carbon isotopic composition ($\delta^{13}\text{C}_\text{c}\text{‰}$) of the teeth from the Ibero-Central bioprovince section ranges from -10.5‰ to -8.9‰, with a mean value of $-9.7 \pm 0.7\text{‰}$ (PDB).

Our results suggest less water-stress conditions in plants (wetter conditions) in Morteral, and drier in Aragón (Fig. 2). This scenario agrees with the paleogeographical reconstruction, being the Ibero-Levantine province coastal and wetter, and the Ibero-Central province situated more land inward, and is opposite to the results based on the dental pattern. This fact suggests that paleoecology based on rodent dental morphology should be taken with extreme precaution.

Keywords: Paleoenvironment, rodents, isotopic geochemistry, Miocene, Iberian Peninsula

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New Finds of Rodents from the upper Miocene Sediments of Danube Basin (Slovakia)

Peter Joniak¹

¹Comenius University, Department of Geology and Paleontology, Mlynská dolina G, SK-842 15 Bratislava, Slovakia

A new mammal locality Krásno was discovered within the framework of the project DANUBE (APVV-0099-11 - Development of the Danube Basin depositional systems). The locality is an artificial outcrop near Parizánske and is situated in the Rišňovce Depression that forms the northern border of the Danube Basin. The outcrop is characterized by alternation of whitish, greenish and pinkish silty clays and fine sands within the body of freshwater limestone (the Hlavina Member). The outcrop was sampled for small mammals during the field campaign in Autumn 2012. The sample came from bottom of sandy horizon rich in organic material and yielded promising content of both small and large mammals. The mammal assemblage is dominated by rodents, but there are some insectivores and remains of large mammals also. Lagomorpha are absent. The insectivores are not yet processed; this contribution presents the first results from the study of rodents.

The rodent assemblage is highly diverse and comprises at least 17 species. In number of specimens, members of the Muridae dominate the assemblage. They are represented by *Parapodemus lugdunensis*, *Kowalskia* cf. *skofleki*, *Collimys* sp., *Epimeriones austriacus* and *Anomalomys* sp. Family Sciuridae comprises 4 species (*Spermophilinus turolensis*, *Blackia miocaenica*, *Hylopetes* sp., *Pliopetaurista* cf. *bressana* and *Miopetaurista* sp.). Glirids are represented by 4 species (*Graphiurops austriacus*, *Glirulus lissiensis*, *Myomimus* cf. *dehmi* and *Muscardinus* sp.). Eomyids are represented by 2 species (*Keramidomys* cf. *ermanorum* and *Eomyops* sp.) and Dipodidae are represented by *Eozapus intermedius*.

The sedimentation took place in a swampy freshwater lake. The association of rodents suggests an Early Turolian age (MN11). On their basis, the palaeoenvironment has been reconstructed as a patchy landscape dominated by open woodland areas and steppe-like environments. The general composition of the fauna is similar to the Austrian locality Eichkogel (MN11).

Keywords: Upper Miocene, small mammals, Rodentia, Danube Basin, Slovakia

Lower to Middle Miocene Small Mammal Faunas from the Tudela Formation (Bardenas Reales Natural Park, N Iberian Peninsula); Biostratigraphic Implications

Oier Suarez-Hernando¹, Xabier Murelaga¹, Juan C. Larrasoana², Francisco J. Ruiz-Sánchez³, Matthijs Freudenthal⁴, and Miguel Garcés⁵

¹Departamento de Estratigrafía y Paleontología, Universidad del País Vasco / Euskal Herriko Unibertsitatea, Bilbao 48080, Spain. oier.suarez@ehu.es, xabier.murelaga@ehu.es

²Instituto Geológico y Minero de España, Unidad de Zaragoza. Zaragoza 50006, Spain. jc.larra@igme.es

³Area de Paleontologia, Universitat de València. Burjassot 46100, Spain. francisco.ruiz@uv.es

⁴Departamento de Estratigrafía y Paleontología, Universidad de Granada. Granada 18002, Spain, and Netherlands Centre for Biodiversity Naturalis, NL-2300 RA Leiden, the Netherlands. mfreuden@ugr.es

⁵Grup de Geodinàmica i Anàlisi de Conques, Universitat de Barcelona. Barcelona 08028, Spain. mgarces@ub.edu

In this work we present an update of the micromammalian faunas of the Tudela Formation. This formation is composed of 650 metres of lacustrine, palustrine and distal alluvial sediments that accumulated in the west-central sector of the Ebro Basin during the Lower and Middle Miocene. We have studied more than 25 fossil localities distributed throughout the Tudela Formation, which crops out in continuous and excellent conditions at the Bardenas Reales de Navarra Natural Park (N Iberian Peninsula). We have identified 30 genera of mammals: 22 rodents (11 glirids, 5 cricetids, 3 eomyids, 2 sciurids and 2 castorids), 4 insectivores, 2 lagomorphs and 1 bat. These faunas comprise a continuous succession from zones MN2 to MN5 and are magnetostratigraphically dated between 15.5 and 20.5 Ma. Given the lack of continuous and well-dated sedimentary mammal successions spanning this age range, the Tudela Formation serves as a key location for providing a calibration of European mammal zones near and below the Lower/Middle Miocene boundary. Besides, the data from micromammals, along with those obtained from other microvertebrates, ostracods and charophytes will also allow the study of palaeoenvironmental variations recorded in Southwestern Europe before and during the Mid Miocene Climate Optimum.

Keywords: small mammals; Lower-Middle Miocene; Ebro Basin; biostratigraphy; palaeoecology.

The Fossil Record of the Genus *Vasseuromys* (Mammalia, Gliridae) in Europe and Asia and Its Relation with the Climatic Conditions in the Late Oligocene-Late Miocene Period

Francisco J. Ruiz-Sánchez¹, Oier Suarez-Hernando², Xabier Murelaga², Juan C. Larrasoana³, Matthijs Freudenthal⁴, Miguel Garcés⁵

¹Area de Paleontologia, Universitat de València. Burjassot 46100, Spain. francisco.ruiz@uv.es

²Departamento de Estratigrafía y Paleontología, Universidad del País Vasco / Euskal Herriko Unibertsitatea. Bilbao 48080, Spain. oier.suarez@ehu.es, xabier.murelaga@ehu.es

³Instituto Geológico y Minero de España, Unidad de Zaragoza. Zaragoza 50006, Spain. jc.larra@igme.es

⁴Departamento de Estratigrafía y Paleontología, Universidad de Granada. Granada 18002, Spain and Netherlands Centre for Biodiversity Naturalis, NL-2300 RA Leiden, The Netherlands. mfreuden@ugr.es

⁵Grup de Geodinàmica i Anàlisi de Conques, Universitat de Barcelona. Barcelona 08028, Spain. mgarces@ub.edu

The genus *Vasseuromys* (Mammalia, Gliridae) was created by Baudelot and de Bonis (1966) on the basis of material from the localities of Laugnac and Moissac I (France, Lower Miocene) in order to distinguish Gliridae of medium size marked by concave occlusal surfaces and a tendency for the molar cusps to form longitudinal walls. The fossil record of the genus *Vasseuromys* extends throughout the upper part of the Oligocene and the Miocene (Daams 1999; Ruiz-Sánchez et al. 2012, Ruiz-Sánchez et al. 2013), with all but one (Turkish) species being reported from Europe. From the Late Oligocene (MP30) to Late Miocene (MN11), several taxa of the genus have been recognized: *V. bergasensis* (MP30), *V. priscus*, *V. autolensis*, *V. rugosus*, *V. bacchius*, *V. aff. duplex* and *V. duplex* (MN1-MN2), *V. elegans* and *V. ramblensis* (MN3), *V. aff. elegans*, *V. aff. priscus*, *Vasseuromys* sp., *V. cristinae* and *V. aff. multicrestatus* (MN4-MN5) and *V. pannonicus* (MN10/MN11) (Daams 1999; Ruiz-Sánchez et al. 2012, Ruiz-Sánchez et al. 2013). Therefore, a continuous record of *Vasseuromys* comprises the intervals MP30 to MN5 (25–13.8 Ma) and MN10-MN11 (9.7–7.6 Ma). This stratigraphic range roughly coincides with warm periods in global climate as deduced from the study of deep-sea oxygen (Zachos et al., 2001). A cooling shift and rapid expansion of Antarctic continental ice-sheets was initiated in the early Oligocene and persisted until the Late Oligocene, when a shift towards warming conditions was punctuated with brief periods of glaciation (Wright and Miller, 1993), culminating in the Mid-Miocene Climatic Optimum (MCO) (17–15 Ma). According to the global deep-sea oxygen isotope record (Zachos et al., 2001), this period was followed by a stepwise cooling until the Early Pliocene, a long-term trend which was interrupted by periods of warmer conditions around 8 Ma (Late Miocene, MN11). Thus, recurrent warm conditions of the global climate seem to correlate with the stratigraphical record of *Vasseuromys*.

Noticeably, the record of *Vasseuromys* in the Iberian Peninsula is, to date, restricted to the Ebro basin, and there are no citations of this genus in the well-documented faunas from the Tertiary basin of Calatayud-Daroca (Daams and Freudenthal, 1988; Daams et al., 1999; Van der Meulen et al., 2012), a fact that may be related with some kind of negative correlation with other rodent taxa. Apart from the correlation with warm conditions, at least during the Early Miocene, the common association of *Vasseuromys* with, among other, representatives of the family Castoridae, has led to consider *Vasseuromys* as an inhabitant of humid environments.

Keywords: Gliridae, Late Oligocene; Late Miocene; Ebro Basin, biostratigraphy, palaeoecology.

The Insectivores from Hasznos (Middle Miocene, Hungary, Nógrád County)

Jérôme Prieto^{1,2}, Lars W. van den Hoek Ostende³, János Hír⁴.

¹Institute for Geoscience, and Senckenberg Center for Human Evolution and Palaeoecology (HEP), Sigwartstraße 10, 72076 Tübingen, Germany; Department für Geo- und Umweltwissenschaften,

²Paläontologie und Geobiologie, and Bayerische Staatssammlung für Paläontologie und Geologie, Richard-Wagner-Str. 10, 80333 München., j.prieto@lrz.uni-muenchen.de

³Naturalis Biodiversity Centre, P.O. Box 9517, NL-2300 RA Leiden, The Netherlands, Lars.vandenHoekOstende@Naturalis.nl

⁴Nógrád Megyei Múzeumi Szervezet, Pásztói Múzeum, 3060, Pásztó, Múzeum tér 5, Hungary, hirjanos@gmail.com

Hasznos was the first pre-Pannonian mammal site to be found in Hungary (Kordos 1986). Since then, it has grown to be a classical locality. The cricetid rodents from Hasznos have been extensively described and discussed, but solid data on the insectivores were so far sadly lacking. Indeed, this was the fate of all Middle Miocene insectivore assemblages from Hungary, even though intensive field work in the Miocene deposits from Hungary has led to the discovery of large and well-preserved micromammal faunas (e.g., Hír 2010).

As a first step in the elaboration of the Middle Miocene insectivore faunas from Hungary, we reviewed the material from Sámsonháza 3 (S3, Prieto et al. 2012). This locality is biostratigraphically and geographically very close to Hasznos. Therefore, it is not surprising that the assemblage from Hasznos proved to be very similar to the of S3. However, the new material provided important taxonomic information, as well as some species previously not recorded in the area.

The insectivore assemblage from Hasznos is dominated by Erinaceidae: *Parasorex* sp., ?*Galerix* sp., *Lantanothereum sansaniense* vel *L. longirostre*, cf. «*Postpalerinaceus*» *intermedius* vel «*Mioechinus*» sp. Three species of shrew were present, mostly however not identifiable to genus level: cf. *Panaelimnoecus* sp. (sensu Prieto et al. 2012), Crocidosoricinae gen. et sp. indet., Soricidae gen. et sp. indet.. The moles are represented by *Desmanodon crocheti*-related species. This is the first time this form is found outside the North Alpine Foreland basin.

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New Small Mammal Faunas of Early Miocene Age (mn4-mn4/5) from the Magro and Ribesalbes-Alcora Basins (E. Spain)

Vicente D. Crespo¹, Francisco J. Ruiz-Sánchez¹, Samuel Mansino¹, Matthijs Freudenthal², Plinio Montoya¹, Marc Furió³, Oier Suarez-Hernando⁴, Xabier Murelaga⁴, Juan C. Larrasoña⁵, Miguel Garcés⁶

¹Area de Paleontologia, Universitat de València. Burjassot 46100, Spain. vicente.crespo@uv.es, francisco.ruiz@uv.es, samuel.mansino@uv.es, plinio.montoya@uv.es.

²Departamento de Estratigrafía y Paleontología, Universidad de Granada. Granada 18002, Spain and Netherlands Centre for Biodiversity Naturalis, NL-2300 RA Leiden, The Netherlands. mfreuden@ugr.es

³Institut Català de Paleontologia M. Crusafont, Edifici ICP, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, 08193 Barcelona, Spain. marc.furio@icp.cat

⁴Departamento de Estratigrafía y Paleontología, Universidad del País Vasco / Euskal Herriko Unibertsitatea. Bilbao 48080, Spain. oier.suarez@ehu.es, xabier.murelaga@ehu.es

⁵Instituto Geológico y Minero de España, Unidad de Zaragoza. Zaragoza 50006, Spain. jc.larra@igme.es

⁶Grup de Geodinàmica i Anàlisi de Conques, Universitat de Barcelona. Barcelona 08028, Spain. mgarces@ub.edu

The Magro and the Ribesalbes-Alcora basins are two intramontane Neogene basins in the Iberian Range (eastern Spain). In the western area of the Magro basin, and unconformably on the red clays and gypsum of the Upper Triassic (facies Keuper), is located the section of Barranco de Morteral, made up of 140 meters of grey mudstones and white limestones, with two intercalations of sandstones, conglomerates and red clay. These deposits have yielded twelve fossiliferous levels with small mammals. Among these, Morteral 1 is the oldest locality and contains *Ligerimys ellipticus*, whereas the youngest localities (Morteral 41 and 44) record *Megacricetodon collongensis*, the first representative of the *Megacricetodon* lineage in the Middle Miocene (MN5). Therefore, the age of these levels comprises the Early/Middle Aragonian (Early-Middle Miocene transition).

The Ribesalbes-Alcora basin (Castellón Province) is situated in the southern Maestrazgo, between the Sierra de Espadán and the Desierto de Las Palmas. The basin sedimentary fill has been divided into five units (Anadón 1983), which in the case of unit C, where are located the fossil sites with small mammals, consist of yellow and grey shales with intercalated sandstone, dolomite and limestone beds. Several fossil levels with mammalian remains have been found in the unit C, in the vicinity of Mas de Antolino (Agustí et al., 1988; Ruiz-Sánchez et al. 2010; Furió et al., 2010). These localities contain faunal associations of Early Aragonian age (MN4) (upper part of Early Miocene). In the Ribesalbes-Alcora basin, we have identified, among other mammalian taxa, the southernmost record of the last European herpetheriid *Amphiperatherium frequens*, the youngest record of the dormouse *Altomiramys* and the oldest record of the genus *Plesiodimylus* in the Iberian Peninsula. The joint presence of the genera *Megacricetodon* and *Ligerimys* in nearly all levels indicates that these localities are of Early Miocene age (MN4).

The faunal record of the youngest localities from Mas de Antolino is equivalent to that of Morteral 1, the oldest locality from the Morteral section. The Magro and the Ribesalbes-Alcora basins are situated in the same paleobiogeographic context, which allows us to study the succession of small mammal faunas in an interval poorly known until now.

Keywords: Small mammals; Early and Middle Miocene; Ribesalbes-Alcora Basin; Magro Basin; biostratigraphy.

Large Mammal Dispersal and Faunal Dynamics in Southern Europe during the Quaternary

Maria Rita Palombo¹

¹Dipartimento di Scienze della Terra, Sapienza Università of Roma and CNR-Istituto di Geologia ambientale e Geoingegneria, Roma, Italy mariarita.palombo@uniroma1.it

The multifaceted and intriguing evolutionary history of mammals, which led to the present day biodiversity and biogeographical settings, undoubtedly mingles with the palaeogeographic, climatic and environmental changes experienced by our planet especially during the Cenozoic. Nonetheless, the actual role of climate in conditioning time and mode of dispersal of large mammals and driving faunal dynamics along geographical gradients is still a hotly debated topic in palaeobiology and palaeoecology (e.g. Barnosky 2001, Prothero 2004, Vrba 2005).

With the challenging goal of investigating hypotheses on the relationships among climate changes and ecosystem dynamics it is crucial to provide a chronological framework, allowing correlations among distant sequences, which in turn may enable to disentangle between asynchronous and diachronous dispersal bioevents across geographical and ecological boundaries, and to define ecosystem functional diversity and its changes through time. The analysis of local versus regional biological dynamics could shed new light on whether ecological and evolutionary changes and turnovers developed on a backdrop of global climate changes and related phenomena, or on intrinsic biological factors. The South European Quaternary fossil record is particularly suitable to study the role of climate changes at local and regional scales because of the complex physiographic and climatic heterogeneity of the focal territories, the presence of important geographical/ecological barriers, and the complex history of invasions of species of varying geographical origin and provenance.

This research aims to contribute to the debate by analyzing timings and mode of dispersal towards Southern Europe of large mammals (focusing on asynchronous versus diachronous first local appearances/extinctions), turnover dynamics and changes in functional diversity of palaeo-communities. The data base consists of taxonomically revised lists of large mammal species from selected Southern European local faunal assemblages ranging in age from the Early to the late Middle Pleistocene (middle Villafranchian to early Aurelian European land mammal ages). The newly biochronological scheme here proposed permits to compare local turnovers and functional diversity trends, allowing a better understanding of the action of geographical/ecological barriers that either prevented the range of some taxa to reach some regions or caused delays in the dispersal of a taxon in some territories.

The results obtained provide evidence that major environmental perturbations, triggering dispersal events and removing keystone species, modified the structure of the pre-existing mammalian faunas, merging previously independently evolved taxa into new palaeo-communities. The altered internal equilibrium gave rise to new inter-guild and intra-guild competition/coevolution dynamics, leading in turn to shifts in community structure and promoting biotic and functional turnovers.

All in all, available evidence suggests that during the last 3 Ma (excluding the manifold phenomenon of Late Pleistocene megafaunal extinctions), the main global climate changes (particularly changes in periodicity) activated significant faunal dispersals and taxonomical turnovers. Some other progressive faunal changes developed during periods exceeding Milankovitch's cycles as the cumulative result of the responses of individual species to climate change, contraction and expansion of species range, and reassessment of biotic interactions. The coupled action of climatic changes and internal biotic dynamics caused Quaternary South European faunal complexes to significantly restructure. Diachroneity in local turnover across the focal territories probably relied on differences in local dynamic patterns of competition/coevolution, though different manifestations of global climate changes in different geographic settings would have contributed to scale local bioevents.

Keywords: Biochronology, Dispersal, Functional diversity, Mammals, South Europe

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Paleogene Rodents from S.E. Serbia**W. Wessels¹, Z. Marković², H. de Bruijn³**

¹ Utrecht University, Department of Earth Sciences, Budapestlaan 4, 3584 CD Utrecht, The Netherlands.
w.wessels@uu.nl

² Natural History Museum Belgrade, Njegoseva 51, Beograd 11000, Serbia. zoran.markovic@nhmbeo.rs

³ Utrecht University, Department of Earth Sciences, Budapestlaan 4, 3584 CD Utrecht, The Netherlands.
hdbruijn@uu.nl

Small mammal sites were discovered in south eastern Serbia during field campaigns in 2010-2012. Preliminary identification of the rodents indicate that the assemblages are quite diverse containing at least thirteen species, including many new species. The Family Muridae is quite dominant, which is in strong contrast to assemblages in western Europe, where the Family Theridomyidae is dominant. Moreover, *Atavocricetodon*, the most common member in Eurasian fauna's, is absent as well as representatives of the Families Eomyidae, Sciuridae and Gliridae. This unusual composition hampers a straightforward correlation with the European Oligocene succession. Somewhat similar compositions are known from early Oligocene faunas from Anatolia, Baluchistan and the Lesser Caucasus.

These new faunas are quite important in our understanding of the distribution and evolution of the rodents during and after the "Grande Coupure" and in reconstructing the paleogeography of this part of the Paratethys. For example, the occurrence of a representative of the Diatomyidae in south eastern Serbia is remarkable, since the closest occurrence of the family is known from the late Oligocene of Pakistan, indicating a different area of origin and a more complex evolutionary history of the family than previously assumed.

Hystrix Primigenia from the Staniantzi Locality (Miocene-Pliocene Transition) in Western Bulgaria

L. Bullmann¹, M. Böhme¹, J. Prieto¹, N. Spassov²

¹ Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

² National Museum of Natural History, Bulgarian Academy of Sciences, 1-Tzar Osvoboditel Blvd., 1000, Sofia, Bulgaria

Among a large sample of micro- and macrovertebrate remains from the coal mine Staniantzi (Western Bulgaria) only three lower cheek teeth (p4 – m2) and two fragmentary incisors of one porcupine individual have been recovered. In spite of the quantitative richness of Neogene fossil localities in Bulgaria this is the fifth recovered hystricid fossil so far, confirming the rarity of this mammalian group.

Two species are known from the Neogene of Bulgaria, *Hystrix primigenia* Wagner, 1848 and *Hystrix depereti* Sen, 2001 (Van Weers & Rook, 2003). Morphological and metric comparisons with other Hystricidae samples from the Neogene and Quarternary support the taxonomic assignment of the Staniantzi specimen to *Hystrix primigenia*, a large-sized, brachyodont species recorded in Eastern Europe, Western Asia and India during the Turolian. In Bulgaria, the species is known from the middle Turolian localities Hadji Dimovo (Sen, 1999), Azmaka (Spassov et al., 2012) and Strumyani (Geraads et al., 2011). The Pliocene record is limited to a single damaged tooth described by Popov (2004) from Muselievo as *Hystrix* sp.

The Staniantzi locality is situated in a coal basin belonging to an intramontane graben (Mazgosh-Staniantzi basin) with a width of about 3 km and a length of about 10 km. The basement of the graben is formed by Lower Jurassic limestone; the Neogene fill consists of rhythmically bedded lacustrine-palustrine cycles. The lower part of the sequence consists of alternating autochthonous brown coal and marls with diverse mollusk assemblages and the upper part consists of alternating dark to light grey clays and calcareous silts (Utescher et al., 2009). The porcupine teeth were found in lacustrine clays and marls just above the coal seam.

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A Rich Desman Record (Mammalia, Talpidae) from Staniantsi (Miocene-Pliocene Transition, Western Bulgaria)

J. Prieto¹, M. Böhme¹, D. Vasilyan¹

¹Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

Deposits of the small Staniantsi-Masgosh intramontane basin, situated 50 km north-northwest of Sofia are exposed at the Staniantsi brown-coal mine. Excavations started in 2010 have resulted in the recovering of 15 fossil bearing vertebrate horizons. Mammals represent the larger part of the vertebrate finds. In term of abundance, the desman moles are completely dominating the faunal assemblage.

Beside a large amount of isolated dental elements, well preserved mandibles and maxillaries are now available to science. As a result, the material allows a deep taxonomic analysis of the Bulgarian fossils. The data are compared in a phylogenetic context, and we propose some relationships with samples recorded around the Miocene-Pliocene transition.

The exceptional abundance of the semiaquatic mole in the mammal sample of Staniantsi is in complete accordance with a swampy environmental interpretation for the excavated layer in which this animal occurs. This fact is corroborated by the presence in these horizons of a rich and diversified castorid fauna.

Small Mammals (Rodentia, Lipotyphla, Chiroptera) from Staniantsi (Miocene-Pliocene Transition, Western Bulgaria) – An Overview

J. Prieto¹, M. Böhme¹, J. Bullmann¹, D. Vasilyan¹

¹Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

Small mammals, and rodents in particular, are of first importance for biostratigraphic purposes in terrestrial context, and thus for the understanding of large scale processes. Considering that the Miocene-Pliocene transition is a controversial chronostratigraphic period in the Eastern Paratethys area, the discovery of a rich fauna in the coal mine of Staniantsi is a promising step in comprehension of the processes of environmental change at the end of the Miocene.

The collecting and screen-washing efforts during the last three years have resulted in the sampling of a representative dental collection of more than 250 specimens.

The moles are the most abundant group, but the desmans represent the high majority of the remains among the three talpid genera. Shrews are recognized with a species of the highly specialized tribe anourosoricini, while at least two other soricids are documented. Surprisingly gymnures and hedgehogs are totally absent.

Regarding the rodents, most of the teeth are assigned to two murid species, but hamsters are also present. Beavers are common and diversified. Very rare are microtoid cricetids, squirrels and eomyids. The total absence of dormice and voles is remarkable.

Preliminary biostratigraphic investigations are discussed and suggest an age at the very end of the Miocene near to the Messinian Salinity Crisis.

First Vallesian Small Vertebrate Fauna from Bulgaria

J. Prieto¹, M. Böhme¹, N. Spassov², L. Hristova²

¹Senckenberg Center for Human Evolution and Palaeoenvironment, Universität Tübingen, Sigwartstraße 10, 72076 Tübingen, Germany

²National Museum of Natural History, Bulgarian Academy of Sciences, 1-Tzar Osvoboditel Blvd., 1000, Sofia, Bulgaria

The Late Miocene fossil vertebrate record of Bulgaria is remarkable by its richness and the conservation of the remains. Along the Struma River (south-western Bulgaria), that extends North-South from the Vitosha Mountains (South of Sofia) to Greece, many large mammal localities have been discovered, especially in its middle part (Spassov *et al.* 2006 and references therein). Paradoxically continental small vertebrate finds, although extremely important in terms of environmental reconstructions and biostratigraphy, are almost unknown for this time range. In order to test the potential of the region regarding the continental fossil small vertebrates, field campaigns have been achieved between 2009 and 2011, leading on the discovery of promising layers. In this poster we present the first results concerning two new localities from the Blagoevgrad graben. The new localities Blagoevgrad and Badino contain small mammals that allow a correlation to the late Vallesian, providing thus the oldest evidence of small mammals from Bulgaria.

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SESSION 11

HOMINID EVOLUTION AND CLIMATE

CONVENERS

JORDI AGUSTI AND KATERINA HARVATI

Small Mammals from Acheulean cave site Sel'-Ungur (The Fergana Valley, Uzbekistan)

Anastasia Markova¹

¹Institute of Geography of Russian Academy of Sciences, Staromonetny 29, Moscow 119017, Russia;
e-mail: amarkova@list.ru

The Acheulean cave site Sel'-Ungur is located about 1900 m above sea level in the Obishir valley on the lower slope of the Karantau Ridge. The later one is a front ridge on the Alai Range (the Fergana Valley, Uzbekistan). The cave has length 120 m, height -34 m and the width near entrance about 20 m. This Acheulean site contained five cultural layers. Teeth and the fragment of the occipital part of skull, identified as *Homo erectus* was found in this site (Islamov et al., 1988). The most reliable C14 data from the layer above the horizon with anthropological remains is 126,000 ±5000 (LU-936) yrs BP by uranium - ionium technique. B.Kh. Batyrov and A.R. Batirov (1988) described large mammal remains and distinguished *Ursus spelaeus*, *Crocota spelaea*, *Panthera (Leo) cf. spelaea*, *Uncia uncia*, *Equus* sp., *E. hydruntinus*, *Dicerorhinus cf. kirchbergensis*, *Sus scrofa*, *Cervus elaphus bactrianus*, *Gazella subgutturosa*, *Capra sibirica*, *Ovis ammon*, *Bos primigenius*, *Bos (Poephagus) mutus*. K.A. Kremenetski analysed spore and pollen assemblage (Velichko et al., 1990). A.A. Velichko and V.P. Udartsev studied the geological sequence (1990). Small mammal remains were analysed by author of this contribution. The rich fauna of small mammals from 3, 4 and 5th cultural layers includes several characteristic species: *Ochotona (Ochotona) rufescens* (Gray), *Ellobius* ex gr. *tancrei* Blasius, *Apodemus* sp., *Cricetulus migratorius* Pallas, *Meriones (Pallasiomys) libycus selunguricus* Markova, *Alticola (Alticola) argentatis* Severzov, *Clethrionomys centralis* (Miller), *Microtus (Neodon)* ex gr. *jaldaschi* (Severtzov).

Most of the remains belong to endemic species of the Central Asian mountainous region, such as *Microtus (Neodon)* ex gr. *jaldaschi*, *Ellobius* ex gr. *tancrei*, *Meriones (Pallasiomys) libycus selunguricus*, *Alticola (Alticola) argentatis*, *Clethrionomys centralis*.

The ecological preference of species determined from Sel'-Ungur site shows that their environmental requirements vary in a broad range. This can be explained by the mosaic pattern of montane landscapes. The remains of rodents and pikas originate mostly from owl pellets. These birds prey upon small mammals within a distance of 1-2 km from the cave and bring the prey from various biotopes. Sel'-Ungur fauna indicates montane-steppe environments.

The palynological analysis permits to conclude that the fossiliferous layers were of Middle Pleistocene age (Velichko et al., 1990).

The morphological characters of rodent's remains show noticeable differences from recent populations. It refers to the morphology of *Microtus (Neodon)* ex gr. *jaldaschi*, *Ellobius* ex gr. *tancrei*, *Meriones libycus selunguricus*, *Clethrionomys* ex gr. *centralis*. However, we didn't found species of Early Pleistocene age. Dating is very difficult for the lack of comparable fossil materials. The C 14 data indicates that early man lived here before the late interglacial period. So, the data given above permit us to assign the Middle Pleistocene age to all the bone bearing layers of Sel'-Ungur Acheulean site.

This study was supported by the grant of RFBR project N 13-05-00056.

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Ecology of European Hipparionines and the Diversity of Late Miocene Hominids in Western Eurasia

R.S. Scott^{1*}, J.Clavel², D. DeMiguel³, T. Kaya⁴, D.S. Kostopoulos⁵, S. Mayda⁴,
G. Merceron⁶

¹Department of Anthropology and Center for Human Evolutionary Studies, Rutgers, The State University of New Jersey, New Jersey, USA

²Laboratoire de Géologie de Lyon, France

³Institut Català de Paleontologia Miquel Crusafont (ICP), Barcelona, Spain

⁴Natural History Museum, Ege University, Izmir, Turkey

⁵Department of Geology, Aristotle University of Thessaloniki, Greece

⁶IPHEP UMR 7262, CNRS & Université de Poitiers, France

*robertsc@rci.rutgers.edu

One important observation with respect to Western Eurasian hominids concerns the breadth of hominid adaptation [1,2]. Here we aim to reconstruct environmental differences in Europe during the hominids radiation.

Based on dietary and locomotor adaptations of hipparionines (the most abundant herbivorous mammals that co-occurring with hominids), we track environmental dynamics [3,4] in the late Miocene. This study focuses on Late Miocene sites from Spain (Can Llobateres CLL and Can Poncic CP) and Greece (Nikiti-1 NKT and Ravin de la Pluie RPL). These sites have yielded hominid remains: *Ouranopithecus macedoniensis* in Greece [5,6], and *Hispanopithecus laietanus* in CLL and *H. crusafonti* in CP [1,7].

Biostratigraphically, CLL records the early/late Vallesian boundary (MN9/MN10) [7,8] whereas CP ranges from ca. 10.6 to 9.9 Ma, and is thus older than CLL [8]. Through the combination of magnetostratigraphy and biochronology, the Greek site RPL is dated to the late Vallesian (MN10) whereas NKT is dated to the very end of the late Vallesian (MN10, [9]).

For ecomorphological analyses, we focused on equid metatarsals utilizing published approaches and metrics [10]. Incomplete or damaged specimens were also assessed through Multiple Imputations procedure [11]. These metrics allowed quantification of relative metapodial length and mediolateral width which have previously been linked with habitat preference.

Dietary reconstructions are based on upper molar mesowear following published procedures [12]. However, we made the choice here to digitize all specimens and to measure relief parameters.

Results suggest a single species of hipparion at the Spanish sites tied to forested habitats while the Greek sample comprises multiple species with more diverse habitat preferences. The dental mesowear clearly depicts differences in the diet between the Spanish and Greek hipparionines, the former were browsers while the later were more likely to graze.

These results constitute new evidence of a wide ecological range for late Miocene hipparionines. Based on both dietary reconstruction and postcranial ecomorphology, the Spanish hipparionines should be regarded as a forest dweller. The polyspecific assemblages of Greek hipparionines depict different habitats suggesting the presence of open and wooded areas. Moreover, the molar mesowear signal clearly suggests a wealth of herbaceous vegetation.

All these environmental proxies are coherent with expected ecological habits of the Late Miocene hominids. *Hispanopithecus* species were arboreal [1] and they likely had a diet similar to that of present-day *Pan* [13]. Conversely, *Ouranopithecus* included harder and more abrasive items in its diet [13,14] and occupied open to mixed habitats under more challenging climatic conditions for hominids [15,16].

Acknowledgments: This study was supported by a “Wenner-Gren ICRG” (PIs: Scott & Kaya).

Keywords: Hominid; Hipparion; Ecomorphology; Mesowear; Environment

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First Results of a Pollen Record from Lake Iznik (NW Turkey) Encompassing the Last C. 30,000 years

Andrea Miebach¹, Patricia Angelika Roeser¹, Thomas Litt¹

¹Steinmann Institute of Geology, Mineralogy and Paleontology, University of Bonn, Nussallee 8, 53115 Bonn, Germany (a.miebach@uni-bonn.de, patricia.roeser@uni-bonn.de, t.litt@uni-bonn.de)

The reconstruction of the paleoenvironment for the Marmara region in northwestern Turkey is a key factor for understanding the migration routes of the modern *Homo sapiens* towards Europe. Therefore, the investigation of the vegetation and climate history of the area is of particular interest. Lake Iznik is located in the southeast of the Marmara region and with c. 300 km² it is the largest lake in this area. The lithostratigraphic frames for the present investigation were presented in Roeser et al. (2012). Furthermore, new datings improved the existing age model, and geochemical and mineralogical reconstruction register striking changes during lake's history. However, a palynological investigation encompassing the late Pleistocene to Holocene transition of Lake Iznik is still missing. Here we present the first pollen record of the last 31 ka cal BP from Lake Iznik sediments.

Sediment samples were taken in a resolution of 50 cm along 13 m of the composite profile. The sampling was increased along the Pleistocene-Holocene boundary. For the preparation of the pollen samples, we followed a standard protocol. The pollen reference collection of the Steinmann Institute (University of Bonn) and pollen keys (e.g. Beug 2004) were used for the pollen identification. A minimum of 500 terrestrial pollen grains were counted in each sample.

Recent vegetation of the Marmara region is dominated by (sub-) Mediterranean forests and shrublands. Pontic elements including warm mixed and temperate forests characterize the southern area. Towards the east are subtropical forest-steppes.

The pollen record of Lake Iznik shows the shift from steppe vegetation towards an oak dominated mixed forest with Mediterranean elements. This important change in vegetation reflects the Pleistocene-Holocene boundary. The steppe is dominated by grasses, Chenopodiaceae, *Artemisia*, and other Asteraceae suggesting cool and dry conditions. Deciduous oak dominates the vegetation since the early Holocene indicating warmer temperatures. It is followed by an increase of other warm-temperate trees like *Corylus* and *Ulmus*. The increase of *Fagus* and *Abies* indicates more humid conditions since the middle Holocene. *Pinus* is an important floral element during the steppe period but also since the middle Holocene.

Lake Iznik sediments have the potential for detailed palynological investigations to improve the vegetation and climate reconstruction for the Marmara region.

Keywords: Marmara region, palynology, Pleistocene-Holocene boundary, paleoenvironmental reconstruction

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SESSION 12

**QUATERNARY RESEARCHES: GEOMORPHOLOGY,
ENVIRONMENT AND GEOARCHEOLOGY**

CONVENERS

**CATHERINE KUZUCUOĞLU, MUSTAFA KARABIYIKOĞLU
AND OLENA SMYNTYNA**

An Evaluation of Several Representative Geoarcheological Sites from the Black Sea Coast

**Dr. Frînculeasa Mădălina Nicoleta¹, Dr. Murărescu Ovidiu¹, Dr. Murătoareanu George¹,
Dr. Țurloiu Rareș²**

¹Valahia University of Târgoviște, Faculty of Humanities, str. Lt. Stancu Ion, no.34-36, 130024, Târgoviște, Dâmbovița County, tel.: (04) 0245206105, Romania, madalina_chitescu@yahoo.com, ovidiu_murarescu@yahoo.com, gmuratoreanu@yahoo.com

²Council of Dâmbovița County, Tricolorului Square, no. 1, Târgoviște, Romania; raresturloiu@yahoo.com

Situated in the South-East of Romania, the Black Sea Coast stands out due to its two dimensions that act in a synergic way: the first of them refers to the morphological aspects, while the second concerns the cultural peculiarities. Morphologically, it is part of the Plateau of Dobrogea and it presents relief elements in agreement to the tectonics and lithology of the area, dominated by the crystalline rocks of the bedrock, Mesozoic limestone, and thick loess deposits. The vicinity of the Black Sea and of the Danube Delta gives originality and complexity to the landscape. The cultural mix of the area is mainly the result of its geographic position, with two main means of communication – the Danube and the Black Sea. This mix has determined an idiosyncratic history reflected in the archeological discoveries. The archeological remains certify the fact that this area has been inhabited since the Neolithic (Hamangia culture) until the modern epoch, with an idiosyncrasy generated by the Greek civilization that colonized the western Black Sea coast. In the same time, those amaze, reflecting the impact of the Quaternary climatic transformations on the environment.

Geoarcheological sites represent complex geomorphosites with a marked diversity given by the association of the natural element with archeological sites, antique and medieval fortresses. Starting from these premises, in the present study we have made an evaluation of a series of geoarcheological sites considered representative:

- the rupestral complex from Basarabi-Murfatlar (from the Middle Ages, 10th-11th centuries) located in the foraminifera limestone / chalkstone deposits in the north-western slope of the Tibișir Hill;
- the Dumbrăveni complex, Independența (the small church from Dumbrăveni, the Atrium Cave, dating from the Middle Ages, 10th-11th centuries), developed in the limestone massif with caves of Canarala Fetei;
- the caves from the Jurassic calcareous stones of the Keys of Dobrogea, Casimcei Valley, represented by: Peștera Craniilor, Grădina Commune (with Gumelnița, Hallstatt, Dacian, Romano–Byzantine and Early Medieval elements), Casian Cave (with elements from the Roman-Byzantine period), La Izvor Cave, Cheia, Grădina Commune (levels of habitation with Hallstatt, Dacian with Hellenistic imports, Roman, Roman-Byzantine, early medieval, modern elements). These are part of the geological and botanical reserve of the Geological Massif Cheia;
- the Orgame/Argamum fortress (superposed remains of the habitations of the epochs: Hallstatt, Greek, Roman, Middle Byzantine, city walls, with afferent necropolises - 10th-11th centuries B.C., 7th century B.C., 9th century A.D.) situated in the points Dolojman Cape, Jurilovca, on the cliff of lake Razim;
- the Enisala fortress, whose ruins are situated on the calcareous cape situated in between Babadag and Razim Lake, at the boundary with the Danube Delta Biosphere Reserve.

The assessment method applied to these geoarcheological sites from the Black Sea basin area goes through the criteria proposed by the methods developed so far in the specialized literature on geomorphosites. They were adapted to the reality of the area under analysis and aim to determine the value of the geoarcheological site from the perspective of its scientific, ecological, cultural and economic value.

The aim of this study was to calculate the total value of each geoarcheological site, an important parameter in the future protection and promotion strategy for these points of interest, as the pressure of the natural and anthropic factors, very pregnant in the area under analysis, may lead to their disappearance or destruction. Also, we brought to light the relation between the geomorphological attribute and the cultural, historical one but also the gap between these two individual values, in order to determine which one of them amplifies the other's potential in relation to the total value of the respective geoarcheological site.

Past Seismic Activity in Eastern Anatolia Recorded in the Sediments of Lake Van over Six Glacial/interglacial Cycles

Mona Stockhecke¹, Flavio S. Anselmetti^{1,2}, Kaspar Gaeggeler², Aysegül F. Meydan³ and PALEOVAN scientific party

¹Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, 8600 Dübendorf, Switzerland, mona.stockhecke@eawag.ch

²Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland

³Yüzüncü Yıl Üniversitesi, Mühendislik-Mimarlık Fakültesi, Jeoloji Mühendisliği Bölümü 65080, Van, Turkey

Lake sediments document besides paleoenvironmental and paleoclimate conditions also paleoseismic activity through various forms of deformation structures. These are especially visible in finely-laminated sediments. Being situated in a tectonically active region, the partly annually-laminated sedimentary sequence of the hydrologically closed Lake Van, recovered in 2010 in the context of the ICDP Paleovan project, shows dozens of earthquake-triggered microdeformations that document past seismic events, which occurred during the last half a million years.

Lithological and multiproxy analysis revealed that the Lake Van's depositional conditions varied in correspondence to Milankovitch and sub-Milankovitch cycles. Glacial/stadial and interglacial/interstadial conditions were recorded continuously over the last half a million years excluding two discontinuities, which indicate major hydrological and geomorphological changes in Lake Van's early history. Two sites were drilled 10 km apart: A primary drill site, situated on a ridge, covers the entire lake history since its initial transgression in the middle Pleistocene (~610 ka ago); A secondary drill site, located in a more shallow northern basin, covers the past 90'000 years. Multiple coring at both drill sites allows to establish two almost complete 220 m and 145 m long composite sections, respectively.

Observing deformation structures in multiple parallel cores at each site is used as a criteria to distinguish 'true' paleoseismic deformation structures from potential drilling artifacts. Deformation structures consist of i) silt-filled vertical fractures, ii) microfaults with displacements at cm-scale, iii) microfolds, iv) liquefaction structures (mushroom, pseudonodules), iv) disturbed varve laminations and v) mixed layers. While the ridge site records the paleoseismic events as microdeformations, the northern basinal site rather records seismic events through the deposition of seismo-turbidites. In some cases, individual earthquake events can even be identified with this respective pattern at both sites. From 168 to 189 meters below the lake floor, a 21 m-thick unit of major irregularities and accumulation of deformations (deformed, tilted, overturned, repeated layers, and discrete unconformities) was identified. This unit is sealed by a several meter-thick massive dark brown clayey silt, interpreted to be a megaturbidite. The entire unit is visible as acoustically chaotic layer in the seismic sections and can be mapped throughout the Tatvan Basin. This large-scale mega-event deposit is likely to be related to an exceptionally strong seismic trigger mechanism ~420 ka ago likely coupled with seiche waves and cyclic water movement.

The ongoing mapping of the earthquake-triggered microdeformations are used to deduce the first paleoseismic record documenting reoccurrence rates of prehistoric earthquakes. Furthermore, the results of a follow-up field campaign in 2012 are used to groundtruth the response of the sedimentological record to the devastating earthquake of magnitude 7.2 close to the city of Van on 23 October 2011.

Keywords: microdeformations, varved lake sediments, ICDP project PALEOVAN, paleoseismic, earthquakes

Reconstruction of Vegetation and Climate during the Last Glacial/Interglacial Cycle at Lake Van (Eastern Anatolia, Turkey)

Nadine Pickarski¹, Thomas Litt¹, and the PALEOVAN scientific team

¹University of Bonn, Steinmann Institute for Geology, Paleontology and Mineralogy, Nussallee 8, 53115 Bonn, Germany, pickarski@uni-bonn.de

Lake Van is situated on the Eastern Anatolia high plateau (Turkey), in a climatically and tectonically highly sensitive region. Especially several earthquakes and volcanic eruptions (e.g. Nemrut and Süphan volcano) have affected the region significantly. In addition, the semi-arid continental climate, with cold, wet winters and hot, dry summers, plays an important factor for the vegetational development. Lake Van is the largest soda lake in the world (surface area 3,570 km²), which is characterized by high salinity (~ 22 ‰) and high alkalinity with a pH reaching ~ 9.8. Furthermore, it is the fourth largest hydrologically closed lake system on earth (volume 607 km³) with a maximum water depth of about 460 m. According to the distribution of precipitation, Lake Van is located in the transitional zone between two vegetation types: The vegetation of the south and southwest belongs to the Kurdo-Zagrosian oak-forest belt, which extends from east-central Turkey to southwest Iran, whereas the vegetation of the northern and northeastern area (Irano-Turanian plant zone) is dominated by steppe plants, such as *Artemisia fragrans* with some oak-forest remnants. One of the aims of the International Continental Scientific Drilling Program (ICDP) project 'PALEOVAN' is the reconstruction of vegetational and climatic variability in the Eastern Mediterranean and the Near East during the last glacial/interglacial cycles. In summer 2010, an international drilling campaign recovered several sedimentary cores with up to 220 mcbf (meters composite below lake floor) length from Lake Van. Therefore, the composite sections from the drill location 'Ahlat Ridge' site yields a long continuous archive of the terrestrial paleoecology and paleoclimate history in Eastern Anatolia during the last c. 600 ka. The background sedimentation is characterized by a fine laminated mixture of detrital and authigenic minerals, which can be interrupted by turbidites (events) and volcanic ash layers. The major focus of the study presented here is to identify and interpret the vegetation and climatic oscillations during the last glacial/interglacial cycle in more detail. Therefore, we have generated a well-dated, high resolution palynological record of the first 60 mcbf encompassing the last c. 130 ka. Warmer environments are characterized by higher amounts of thermophilous trees, especially by deciduous oak and pine, whereas dominance of steppe elements and pollen of semi-desert plants like *Artemisia*, chenopods and grasses suggest periods with more arid, continental and probably colder climate. In addition, the Dansgaard-Oeschger events (DO) are reflected by the vegetation signal. The events are documented in detail between 7 and 35 mcbf of the Lake Van pollen record, which represent the DO 1 to DO 20. The chronology of the core is confirmed by varve counting, tephrostratigraphy, paleomagnetic events, and the oxygen isotope composition, which allow a comparison with SPECMAP (marine) and NGRIP (ice core).

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Litt *et al.* (2012): 500,000 Years of Environmental History in Eastern Anatolia: The PALEOVAN Drilling Project, *Scientific Drilling Journal*, pp. 18-29.

Keywords: Lake Van, Palynology, Semi-arid climate, Dansgaard-Oeschger events, Glacial/interglacial cycle

Preliminary Results of the Palaeontological Investigations of the Late Early Pleistocene Somssich Hill 2 Locality (South Hungary)

Piroska Pazonyi¹, Lukács Mészáros², Zoltán Szentesi³, Mihály Gasparik³, Attila Virág^{1,2}

¹ MTA-MTM-ELTE Research Group for Palaeontology, H-1431 Budapest, P.O. Box 137;
pinety@gmail.com

² Eötvös Loránd University, Department of Palaeontology, H-1117 Budapest, Pázmány Péter sétány 1/c;
salpin@freemail.hu, virag@caesar.elte.hu

³ Hungarian Natural History Museum, H-1431 Budapest, P.O. Box 137; crocutaster@gmail.com,
gasparik@nhmus.hu

The Somssich Hill 2 site, situated near the municipality of Villány (South Hungary) was originally excavated by Dénes Jánossy between 1975 and 1984. It is one of the richest Pleistocene vertebrate localities of Hungary. Present study aimed to revise the fauna and to draw biostratigraphical, taphonomical, and palaeoecological consequences.

On the basis of the vole fauna, the age of the locality (approximately 900-800 ka) is slightly older than the Early-Middle Pleistocene boundary (Betfian or Nagyharsányian Phase within the Biharian Stage of the local biochronological system). Similar conclusions can be drawn from the insectivore remains.

The exceptionally rich fauna allowed us to separate six different stage (representing 6 different environments) in the section. The oldest part (from layer 50 to 47) is characterized by the dominance of the genera *Mimomys* and *Lagurus*. This period represents most plausibly a wet climate with closed, forested vegetation. Between layer 47 and 35 the abundance of *Lagurus* species and cricetids are indicators a somewhat drier climate with probably the oldest known open steppe vegetation of Hungary. In the next phase (between layer 35 and 25) the abundance of the lemmings is replaced by the dominance of *Pitymys*, *Myodes* and *Pliomys*. In addition, mice belonging to the genus *Apodemus* and dormice also become frequent. Species that are closely bound to areas of water (such as the shrew, *Beremendia fissidens*, and the frogs, *Bombina variegata* and *Rana temporaria*) are also present. This phase represents a warmer and more humid climate with the re-closure of the vegetation. Semi-closed areas with a creek or a lake in the area are likely. The phase attributable to layers 25-18 is characterized by the dominance of voles *Microtus* and *Myodes* and the small decline of *Pitymys* and *Pliomys*. The fauna is most likely the result of further closure of the vegetation to deciduous forest. The absence of some shrews and frogs can be explained by this suggested dense vegetation. Lemmings become abundant from layer 18 to 12 again, which suggest the re-build of the cool, dry and open steppe conditions. However the stable presence of the *Beremendia fissidens* and some moist environment preferring frogs indicate, that a few shrubby areas and an open water surface were somewhere near the locality. In the youngest part (from layer 12 to 1) the abundance of the lemmings is replaced by the dominance of *Pitymys*, *Myodes* and *Pliomys* again. The presence of forest elements (e.g. *Apodemus* and dormice) with *Desmana* sp. and *Beremendia fissidens*, as well as some moist environment preferring frogs (e.g. *Hyla arborea*, *Bombina variegata*, and *Rana temporaria*) suggest warm and humid climate with closed vegetation.

Layer 28 was selected for a preliminary taphonomical study. Approximately 10% of the small mammal remains can be originated from animal carcasses, which were get stucked on the surface or in the uppermost soil horizon before the final accumulation. More than 60% of the remains were originally accumulated as owl pellets. The remains were transported after the loss of the collagen fibres by water (probably by the intense spring rainfalls) within a short distance into the carstic fissure of the Somssich Hill 2 site.

This project was supported by the OTKA K104506 grant.

Keywords: late Early Pleistocene, microvertebrates, palaeoecology, taphonomy, South Hungary

Geomorphological, Environmental and Geoarcheological Structure of Akbuk Gulf

Suheda Edremit¹

¹Institute of Marine Sciences and Technology, Bakü Boulevard, 35340, Inciralti, Izmir, Turkey,
suheda_edremit@yahoo.com

Akbuk Gulf located in northeastern of Aegean Sea is very important area because of situation between Mediterranean and Marmara Sea for the examination of geomorphology, environment and geoarcheology. Because the effect of Buyuk Menderes Delta that formed by erosion and deposition during Quaternary period is observed in Akbuk Gulf and has marks of two antique cities. Akbuk Gulf is found an area between Menderes Massif and Likya Naps as geologic. Hence, carbonate limestones and schist are available around the gulf. Quaternary units are units which occurred the result of several geologic and geomorphological process with deposition and erosion. In this study area, geological, geophysical and environmental researches will plan in order to determine Quaternary units. For this purpose, delta inputs, erosion process and archaeological ruins in the study area will investigate for geological formation. Furthermore, a major tectonic movement incurred during Quaternary period of study area will be examined using seismic datas that collected along study area. Sediment sampling and physical parameters will apply some important points in the gulf and these results will evaluate for geomorphology and environment researches. In conclusion, Akbuk Gulf will investigate point of view Quaternary researches.

Keywords: Akbuk, geomorphology, seismic, Aegean Sea, Quaternary.

Recent Fluvial Clastic Input and Sedimentary Climate Records in Eastern Part of Lake Van, Eastern Turkey: Implications for Interpretation of Lacustrine Climate Records

Ayşegül Feray Meydan¹, M. Namık Çağatay², Sefer Örçen¹

¹Yuzuncu Yil Universitesi, Muhendislik-Mimarlık Fakultesi, Jeoloji Muhendisligi Bolumu, 65080, Van, Turkey, feraygokdere@yyu.edu.tr

²Istanbul Technical University, Faculty of Mines, Eastern Mediterranean Centre for Oceanography and Limnology, Istanbul, Turkey

Lake Van is the world's largest soda lake by area and the world's fourth largest hydrological closed lake by volume (3570 km² and 607 km³). Lake Van is situated in a tectonically active area and surrounded by active volcanoes on a high East Anatolian plateau. Three climate systems (Monsoon System, Midlatitude Subtropical High Pressure System, North Atlantic and Siberian High Pressure System) affects the Lake Van region, where a continental climate (cold and wet winters, warm and dry summers) prevail. Because of its interesting location, Lake Van was drilled by the International Continental Scientific Drilling Program (ICDP-PaleoVan Project) in 2010 to depths of 220 m below the lake floor to study the paleoclimatic, paleoenvironmental and paleotectonic records. In this regard, it is important to understand the recent detrital input by tributary rivers and its relation to the lake sediment archives. Geology and climate is the main factor determining the detrital load of tributary rivers and water chemistry as well as the lithology of lake sediment.

The main goal of this work is to study the seasonal differences (spring and fall) in detrital load of rivers discharging into the lake and to find its relations with lacustrine archives in the sediment cores. With this aim seasonal sediment sampling was done in the Karasu and Engil rivers draining the eastern catchment area of the Lake Van, and sediment cores were collected in the lake close to the river mouths.

Mineralogical (XRD, smear slides) analysis of the river sediments show that Engil and Karasu River have the same mineralogical composition (quartz, calcite, plagioclase, illite, kaolinite). Calcite, illite, kaolinite minerals decrease during spring and increase during fall season. Total Inorganic Carbon (TIC) increase during fall season, supporting the result from the mineralogical analysis showing increase in calcite during the fall season in the river bed. Total Organic Carbon (TOC) increasing during the spring season because of the increase in the primary productivity.

Using ²¹⁰Pb data, a sedimentation rate of 0.13 cm/yr is calculated in the on of short sediment cores. This sedimentation rate is higher than that found in the deeper part of the lake. XRF core scanner elemental profiles of elements, such as K, Si, Ti and Fe, along the cores provide information on the detrital mineral input. These core analysis, together with lithological observation and mineralogical (XRD) analysis of both the cores and river sediment samples, show the detrital mineral-rich layers form during high precipitation periods and carbonate-rich layers during evaporative dry periods. The geochemical and mineralogical profiles along the short cores show that environmental conditions did not change significantly over the last 150 years. During 150 – 370 BP, there is an increase in the detrital input, suggesting a wet period, corresponding to the Little Ice Age (1650- 1900 A.D.) which prevailed in the Northern Hemisphere.

Keywords: Lake Van, Geochemistry, Mineralogy, Climate, Little Ice Age

New Early Middle Pleistocene Locality of Small Mammals (Lower Dniester) and Its Position in Early Middle Pleistocene Mammal Sequence

Anastasia K. Markova¹

¹Institute of Geography Russian Academy of Sciences, Moscow, Russia

New small mammal locality of small mammals was discovered by Prof. A.L. Chepalyga and D.S. Zakharov near Levada station 30 km eastward from Tiraspol town, Moldova (Chepalyga et al., in press). This locality related to the deposits of V terrace of the Dniester (Kolkotova terrace) (Chepalyga, 1962). The sequence of this outcrop from the top to the down is about 20 m and includes four paleosols interleaved with the loess horizons. The lower fossil soil resembles by the morphological features and stratigraphical position to the Vorona paleosol, which correspond to the Muchkap Interglacial (Shik, 2005). Under this sequence the fluvial deposits presented by consertal sand and gravel (the thickness of this layer is about 5 m) are located. Small mammal remains were found in this layer.

The deposits of the Kolkotova terrace form the wide plain on the left bank of the Dniester from the Tiraspol town till the mouth of the river. Earlier rich mammal and mollusk fauna was discovered in the fluvial deposits of this terrace near the Tiraspol town in the Kolkotova Balka section and was described as Tiraspolian Faunistic Complex (Pleistocene of Tiraspol, 1971). By the opinion of Dr. A. Chepalyga (personal communication) the fluvial deposits from the Levada section is related to the upper part of fluvial deposits in the Kolkotova Balka.

Small mammals found in Levada locality include *Spermophilus* sp., *Lagurus transiens* Yanossy, *Eolagurus* sp., *Microtus (Terricola) arvalidens* Kretzoi, *Microtus (Stenocranius) gregaloides* Hinton. The species composition of this fauna indicates its close similarity with the same of the fauna from Kolkotova Balka, described by Dr. L. Alexandrova (1976). On the contrary it differs from the small mammal fauna found in the Vorona paleosol in Kolkotova Balka, which contains *Lagurus transiens* Jannosy, *Eolagurus luteus volgensis* Alex., *Microtus (Stenocranius) gregalis* Pall. and others (Markova, 2007). The last species is more evolved than *M. (S.) gregaloides* found in Levada. This indicates older age of the Levada fauna than the fauna from the Vorona paleosol in the Kolkotova Balka (Muchkap Interglacial = Interglacial IV of Cromer) and its closeness to the fauna from fluvial deposits of the Kolkotova Balka with *Mimomys savini*, *Lagurus transiens* Yanossy, *Microtus (Terricola) arvalidens* Kretzoi, *Microtus (Stenocranius) gregaloides* (Alexandrova, 1976). The later fauna could be correlated with the Third Ilinka Interglacial (Interglacial III of Cromer) (Shik, 2005).

The fauna from the Levada section is not the oldest Early Middle Pleistocene fauna. Several early Middle Pleistocene faunas were described from the Russian Plain which have more archaic species composition than the Levada one. They include *Mimomys pusillus* Mehely, *Prolagurus pannonicus* Kormos and some others. These faunas are correlated with older First and Second Ilinka Interglacials and Pokrovka cooling (Shik, 2005).

Acknowledgments

I am very grateful for Dr. D.S. Zakharov and Dr. Teodor Obada for their help with receiving small mammal remains in the Levada section and for Prof. A. Tchepalyga for his important comments. This study was supported by the grant of Russian Foundation of Basic Sciences № 13-05-00056.

Keywords: Rodents, Early Middle Pleistocene, Dniester basin, stratigraphy

Chemo-Stratigraphical Characterization of Lake Van sediments: Implications for Holocene Ecology and Environment in Eastern Anatolia

Özlem Bulkan¹, M. Namık Çağatay², Özlem Makaroğlu³, Naci Orbay³

¹Istanbul University, Geological Engineering Department, Avcılar-İstanbul, bulkan@istanbul.edu.tr

²Istanbul Technical University, Geological Engineering Department, Maslak-İstanbul

³Istanbul University, Geophysical Engineering Department, Avcılar-İstanbul

The ecosystem of Lake Van, the largest soda lake and fourth largest terminal lake on Earth, is of special importance as it is. It exhibits high alkalinity and salinity, both properties resulting from the weathering of volcanic rocks and evaporation in a closed lake. Analyses are performed on two long cores collected from eastern and western parts of the lake; the time frame starting from the Early Holocene to recent.

Multi-element dataset for chemo-stratigraphical study was obtained by ITRAX-XRF core scanner analysis. Furthermore time dependent variations of the intensity of internal (salinity, water level, and redox) and external (weathering, erosion and transportation processes) conditions are discussed. Basically, lithological observations and Ti/Ca ratio is used to determine the chemical variations in the water column and tephra layers. Ca/Fe, Sr/Ca and P variations are used for determination of the primary conditions and nutrient supply. Additionally, Zr+Rb/Sr and Zr/Rb ratios are applied to define time dependent variations in clastic input.

Apparent environmental changes occurred starting from the Early Holocene. Here, we could define two different types of changes respectively; fast response for the volcanic events and the long termed-permanent environmental changes. Tephra layers indicate sharp and short termed changes in the environment. Basically high Ti/Ca, Zr+Rb/Sr and Zr/Rb ratios and higher P contributions reflect enhanced detrital supply and nutrient enrichment. Contrarily, primary conditions were probably less important, during these events. Basically biogenic carbonate and organic matter content are rare in the tephra layers. As well as such short termed volcanic events, Lake Van ecosystem has significantly and long termed changed after the accumulation of the Tephra-3 layer. After this event, average clastic material contributions have been decreased (lower Zr+Rb/Sr values). However, the overall nutrient supply (enhanced P accumulation), average biogenic carbonate and organic matter accumulation increased.

As a summary, primary conditions have been more effective during the Late Holocene (after the accumulation of T-3 tephra layer) than previous terms. The recent lake system type is a closed lake environment; however, conditions were probably more hydrological open during the early periods of Holocene. Furthermore, during the short termed volcanic events, which are recorded as tephra layers, external conditions were probably the dominant controlling factor for the total ecosystem.

Keywords: Lake Van, Ecosystem, Environment, Holocene

**A Pleistocene Freshwater Community and Rodents from the Pasinler Basin
(Erzurum Province, North-Eastern Turkey)**

Davit Vasilyan¹, Simon Schneider², Sevket Sen³, Salih Bayraktutan⁴

¹Department of Geosciences, Faculty of Science, University of Tübingen, Sigwartstr. 10, 72076 Tübingen, Germany. davit.vasilyan@ifg.uni-tuebingen.de

²CASP, University of Cambridge, 181A Huntingdon Road, Cambridge CB3 0DH, UK.
simon.schneider@casp.cam.ac.uk

³Laboratoire de Paléontologie du Muséum, CR2P-CNRS-UPMC, 8 rue Buffon, 75005 Paris, France.
sen@mnhn.fr

⁴Atatürk University, Erzurum, Turkey.

A Lower Pleistocene lacustrine faunal assemblage from the Pasinler Beds at Pasinler (Erzurum Province, north-eastern Turkey) is studied, which encompasses thirteen mollusc, five fish, two amphibian, one reptile and one mammal species. The autochthonous freshwater mollusc fauna indicates shallow stagnant waters and a fine-sandy to muddy lake bottom, grown with submersed plants. The fish community (*Leuciscus* sp., *Rutilus* sp., *Chondrostoma* sp., *Leuciscinae* indet., *Capoeta* sp.) and autochthonous herpetofauna (*Latonia* sp., *Natrix* sp.) provide evidence of a well-oxygenised palaeo-lake with rich periphyton and partially rocky to gravelly bottom. Moreover, the presence of the terrestrial snail *Caspicyclotus* cf. *akramowsii* and the peri- to semiaquatic *Latonia* and *Natrix* reflect wet-shore habitats surrounding the lake. The record of *Latonia* sp. from Pasinler represents the youngest one of the genus from western Asia. Apparently, *Latonia* survived well into the Early Pleistocene in western Asia and southern Europe, but finally became extinct due to progressive cooling in the Late Pleistocene. The presence of the arvicolid *Allophaiomys* cf. *A. pliocaenicus* allows for dating the locality at ca. 1.0 to 1.5 Ma. The overlying alluvial sediments of the Pasinler Beds mark the onset of sedimentation of the Palaeo-Araks River into the basin, and are Late Pleistocene in age.

AUTHOR INDEX

Abdennabi E.L.	196	Baldassini N.	112, 226
Afandiyeva M.	195	Barcos L.	187
Agostini S.	237	Bard E.	88, 93, 231
Aguirre J.	107	Barhoun B.	68
Agustí J.	147	Barhoun N.	41, 50, 54, 190
Aiglstorfer M.	135	Barin B.	31
Akçalı B.	185	Barin B.	35
Akgün F.	159	Barry J.C.	140
Al Abdala A.	197	Bartha I. R.	15
Alba D.A.	145	Bassetti M-A.	68
Alba D.M.	125, 136	Bassiakos Y.	164, 165
Albert C.	196	Bassinot F.	229
Alçıçek M.C.	101, 149, 168	Başaran S.	149
Aliyeva A. G.E.	84	Baudin F.	24
Alkan Y.	124	Baumgarten H.	156
Aloisi G.	88	Bayraktutan S.	275
Álvarez-Sierra M. A.	240	Begun D.R.	143
Álvarez-Sierra M.A.	244	Behling H.	93
Alvarez-Zarikian C.	42, 201	Behrensmeyer A.K.	140
Alçıçek H.	63	Belkebir L.	52, 69
Alçıçek M.C.	63	Bellucci	37
Anagnostopoulos V.	167	Bellucci L.	139
Anastasakis G.	17, 163, 167, 173	Beluzhenko E. V.	214
Andalibi M.J.	66	Benammi M.	27
Anderson R.S.	100	Bertini A.	99
Anistratenko V.	63	Bessedik M	69
Anistratenko V.V.	208	Bessedik M.	52
Anistratenko Yu. O.	208	Bettahar A.	188
Anselmetti F.S.	153, 268	Beu A.	5
Antonarakou A.	199, 224, 230	Biltekin D.	37, 104
Apaydin Poşluk E.	186	Blain H-A.	147
Armijo R.	31	Blanc-Valleron M-M.	57
Arpe K.	90	Blanpied C.	197
Arz H.W.	93, 232	Bolikhovskaya N.	158
Asiabanha A.	28	Bosellini F.R.	111
Atalar M.	185	BouDagher-Fadel M.K.	67
Atalay Dutucu A.	169	Bouloubassi I.	97, 220, 228
Atgün O.	34	Boussetta S.	229
Atgün O.	35	Boyes A.	5
Athanasίου M.	97	Bozcu M.	159
Athanassas C.	164, 165	Böcker A.	109
Athanassiou A.	129	Böhme M.	83, 103, 126, 135, 255, 256, 257, 258
Athanassiou A.	128	Brachert T. C.	109
Auer G.	12, 113	Bracone V.	58
Augier R.	11	Bradshaw C.	45
Auxiètre J.L.	54	Brandano M.	12, 56
Azki F.	197	Briceag A.	92
Babault J.	48	Brinkhuis H.	81
Bache F.	41	Bruch A.A.	148
Bachiri Taoufiq N.	50	Buchet N.	231
Bachtadse V.	148	Bukowski K.	13, 70
Badgley C.	140	Bulkan Ö.	174, 274
Bahay El-Dein A.	161	Bullmann J.	257
Balanyá J.C.	9, 10, 187	Bullmann L.	135, 255
Balázs A.	191	Büyükmeric Islamoğlu Y.	63
		Bylinskaya M.E.	209

Caillon N.	229	Delgado Huertas A.	247
Camerlenghi A.	60	Dellwig O.	93
Caricchi C.	112	Delrieu B.	198
Carmen M.	31	DeMiguel D.	125, 262
Carnevale G.	75, 136, 137	Demirkaya S.	181
Carrión J.S.	100	Demory F.	231
Caruso A.	57, 200, 225	Deng T.	235, 238
Casanovas-Vilar I.	123, 125, 145	Denk T.	230
Cefalà M.	200	Dennielou B.	16
Ch. Solomos	128	Dermitzakis M.	230
Chalié F.	90	Deschamps R.	24
Channell J.E.T	155	Develle A-L.	231
Chen S-K.	238	Di Stefano A.	112
Cherin M.	139	Diamantopoulou An.	220
Chiossi I.	111	Díaz-Azpiroz M.	187
Cifçi G.	34	Diepenveen F.	101
Cipollari P.	22, 58, 108	Dimiza M.	220, 228
Cipriani A.	111	Dimiza M.D.	97
Cita M.B.	57	Dmitrieva E.	49
Civis J.	43, 107	Do Couto D.	11, 41, 54, 68
Clari P.	59	Dobrinescu M.	31
Clauzon G.	197	Dolezych M.	135
Clavel J.	262	Domingo M.S.	140
Colombero S.	136, 137	Dondurur D.	35
Comas M.	9, 10	Drinia H.	199, 224
Constantinescu A. M.	16	Ducassou E.	201
Coolen M.	172	Dudek K.	13
Cooper R.	5	Đulović I.	207
Ćorić S.	207	Duman M.	185
Cormier M.H.	35	Edremit Ş.	271
Cornée J.-J.	199	El Habib Mansouri M.	69
Cosentino C.	225	Elbek Ş.	32
Cosentino D.	22, 58, 108	Ellam R.	46, 47
Crespo V.D.	252	Erel L.	37
Crespo-Blanc A.	9, 10, 187	Erel T.L.	162
Çukur D.	154	Eren M.	202
Čvorović B.	189	Erkman A.C.	124
Czapowski G.	70	Ersoy E.Y.	20
Çağatay M. N.	37	Erturaç M.K.	169
Çağatay M.N.	31, 162, 174, 272, 274	Esirtegin T.	21
Çakır Z.	31	Estrada F.	54
Çifci G.	31	Esu D.	58
Çifçi G.	35, 36	Expósito I.	187
Çiner A.	21, 171	F. Grant S.	25
D'Amico C.	58	Fanfani F.	241
Daamstee J-S.	82	Fassoulas C.	109
Damnati B.	223	Fauquette S.	104
Danilov I. G.	138	Faustov S.	158
Darba G.	22	Ferhat Kaya	132
Davoodi Z.	28	Ferhatbegović Z.	207
de Bonis L.	144	Ferraro L.	112, 226
de Bruijn H.	254	Fietzke J.	47
de la Vara A.	119	Filipova-Marinova M.	172
De Leeuw A.	70, 79, 110	Filippova N. Yu.	214
Dela Pierre F.	59	Filippova S. V. Yu. N.	73
Delaygue G.	88	Flecker R.	42, 45, 46, 47, 212
Delfino M.	136, 137	Fleitmann D.	93
		Flores J. A.	42, 43, 44

Flores J-A.	55	Grunert P.	71, 110, 114, 201
Florioiu A.	80	Guerrieri P.	58
Flynn L.J.	140	Gumiaux C.	11
Folcher N.	11	Gutjahr M.	42, 47
Foresi L.	226	Gutsuz P.	169
Foresi L.M.	112, 116	Güngör E.	37
Fornós J.J.	210	Güngör L. N.	37
Foutrakis P.	163	Gürbüz K.	22
Fouzia E.Y.	196	Gürel A.	202
Frank M.	47	Gürler G.	111
Franz S.O.	98	Hakyemez A.	21, 23
Freudenthal M.	243, 247, 249, 250, 252	Harzhauser M.	12, 56, 71, 74, 75, 113, 114, 117
Frezza V.	58	Hassan S. M.	161
Frolov P. D.	133	Hassan S.M.	26
Furió M.	132, 252	Havlik P.	135
Gabrielyan I.	148	Hawie N.	24
Gaeggeler K.	268	Hefter J.	232
Galanakis D.	166	Helvacı C.	20
Garcés M.	249, 250, 252	Henry P.	33, 34, 36, 37, 88
Garcia M.	231	Herbert T.D.	105
García-Alix A.	100, 243, 247	Hernández-Ballarín V.	239, 244
Garcia-Castellanos D.	48	Hernández-Corbalán M.D.	100
García-Paredes I.	123, 240, 244	Hernández-Molina F. J.	42
Gardner J.	101	Hernández-Molina F.J.	201
Gasiewicz A.	70	Hickler T.	103
Gasparik M.	270	Hilgen F.	5
Gasperini L.	37	Hir J.	251
Gasse F.	231	Hodell D.	42
Géli L.	34, 36	Hordijk K.	244
Genç U.	149	Horváth F.	191
George M.	267	Hou S.	235
Georgiou C.	166	Hoxha V.	18
Georgopoulou E.	117	Hristova L.	135, 258
Geraads D.	184	Hrvatović H.	189
Geraga M.	220	Hu P.	51
Giamali C.	198	Hyžný M.	211
Gindre-Chanu L.	200	Iaccarino S.	116
Giosan L.	172	Iadanza A.	58, 108
Gitter F.	227	Ilg A.	135
Gladstone R.	45	Ilgar A.	21, 23, 111, 181, 204
Glamuzina G.	189	Ioakim C.	166
Gliozi E.	58	Ion G.	91, 92
Gogou A.	97, 220, 228	Isaac Casanovas-Villar	127
Golovina L.	72, 216	Israel García-Paredes	127
Golovina L. A.	73, 214	Iurino D.A.	139
Goncharova I. A.	73	Ivanov D.	106
Goncharova I.A.	209	Ivanovic R.	45, 46
González-Delgado J. A.	43	İkiel C.	169
González-Delgado J.A.	107	İlhan T.	185
Gorini C.	11, 24, 31, 54, 68, 197	İslamoğlu Y.	181
Göhlich U.B.	189	Jaeger J.J.	27
Görgülü M.	149	Jan van Dam	132
Görür N.	32	Jiménez Espejo F.J.	100
Grall C.	33, 34, 36, 37	Jiménez-Bonilla A.	187
Granjeon D.	24	Jimenez-Espejo F. J.	42
Gross M.	227	Jiménez-Moreno G.	100, 104, 107,
Grossi F.	58	115	
Grothe A.	79, 81, 82	Jolivet L.	11

Joniak P.	248	Lenardić J.M.	189
Jorry S.	16	Lericolais G.	16
José B.	196	Leroy H.A.G.	25
Jouannic G.	11, 31	Leroy S.	90
Kaberi E.	97	Lirer F.	112, 116, 226
Kadir S.	202	Litt T.	98, 263, 269
Kaiser J.	93, 232	Liu Q.	51
Kakroodi A.	90	Lofi J.	48, 55
Kallel N.	229	Lohmann H.	109
Kapsimalis V.	228	López-Guerrero P.	240, 244
Karakas C.	31	López-Merino L.	25
Karakitsios V.	199	Lourens L.	5
Karakuş E.	23, 204	Lugli S.	53, 215
Karami M.P.	213	Luján M.	187
Kasiński J.	13	Lunt D.	45
Kaya F.	124	Lychounas A.	128
Kaya T.	262	Lykousis V.	97, 220, 228
Kaymakçı N.	124	Mădălina Nicoleta F.	267
Kazantzaki M.	164	Madern P.A.	125
Kenna T.	87	Magri D.	150
Khademi F.	28	Magyar I.	14, 191
Khatooni J.D.	175	Mahboubi S.	27
Kirscher U.	148	Mahjoub H.	196
Konidaris G.E.	131	Maillard A.	55
Kontakiotis G.	224, 230	Maiorano P.	57
Kontogonis G.	173	Makaroglu Ö.	174, 274
Koral H.	186	Mandic O.	56, 70, 74, 110, 117, 189
Koskeridou E.	198, 199	Manoutsoglou E.	199
Kostopoulos D.S.	144, 262	Mansino S.	252
Kostopoulou S.	220	Mansour B.	52, 69
Kotsakis T.	58	Manzi G.	150
Koufos G.D.	130, 131, 144	Manzi V.	53, 215
Kouli K.	97, 228	Marino M.	57
Kovačić M.	115	Markov G.	135
Krastel S.	154	Markova A.	158, 261
Krézsek C.	15	Markova A.K.	273
Krijgsman W. 5, 70, 79, 80, 81, 82, 84, 110, 215		Marković F.	115
Kroh A.	117	Marković Z.	254
Kroonenberg S.	90	Marmi J.M.	145
Krüger S.	109	Marsset B.	34, 36
Kuiper K.	148	Martins C.	212
Kuiper K.F.	70, 84	Martín-Suárez E.	247
Kurt H.	35	Marzocchi A.	45
Kuzucuoglu C.	157	Mas-Gornals G.	210
Kulah T.	202	Masini F.	137, 236, 241
Kwiecien O.	153	Mata P.	43, 51
Labeyrie L.	229	Matamoros E.	87
Lacassin R.	31	Mayda S.	262
Lahijani H.	90	Mayser J.P.	212
Lak R.	175	Mazza P.	136, 137
Lamy F.	232	Mazza P.P.A.	237
Larrasoña J. C.	43	Mazzei R.	112, 226
Larrasoña J.C. 51, 107, 146, 249, 250, 252		McHugh C. M.	37
Lazar I.	80	McHugh C.M.	35
Lazaridis G.	129	Meijer P.	118
Lebret N.	11	Meijer P. Th.	53, 119
Lecuyer C.	88, 144	Melinte-Dobrinescu M.C.	41, 54, 65, 68,
Ledesma S.	44		91

Ménot G.	93	Pavia G.	136, 137
Merceron G.	144, 262	Pavia M.	136, 137
Mertz-Kraus R.	109	Pavlov D.	172
Messina C.	21	Pazonyi P.	270
Mészáros L.	270	Pehlevan C.	124
Meydan A.F.	268, 272	Peláez-Campomanes P.	239, 240, 244
Mezger E. M.	215	Pellen R.	68
Miebach A.	263	Pelosi N.	112, 116
Milushi I.	18	Pérez-Asensio J.N.	51, 107
Minwer-Barakat R.	243	Pérez-Martínez C.	100
Mitropoulos D.	166	Perinçek D.	159
Mitsopoulou V.	129, 128, 160	Perri E.	200
Mocochain L.	197	Peterson L.	105
Modestou S.	47	Pickarski N.	269
Modestu S.	46	Pikelj K.	115
Mohammadi A.	175	Pilbeam D.	140
Mohammed E.	196	Piller W.E	5, 12, 56, 71, 113, 114, 201, 227
Moissette P.	199	Piper D. J.W	17
Mola M.	108	Plessen B.	93
Mollenhauer G.	232	Polonia A.	37
Montadert L.	24	Pons-Branchu E.	169
Montoya P.	252	Popescu S-M.	31, 41, 54, 68, 104
Morgan M.E.	140	Popov S. V.	73
Mosbrugger	103	Portmann F.	103
Moyà-Solà S.	125, 145	Prange M.	93
Muñoz S.B.	47	Prieto J.	126, 135, 239, 251, 255, 256, 257, 258
Mulders Y.R.	82	Provatidis C.	160
Murelaga X.	249, 250, 252	Rabineau M.	60, 68
Murray A.	101	Radeff B.	22
Nader F.H.	24	Radionova E.	216
Natal'in B.A.	19	Radionova E. P.	73
Natalicchio M.	59	Radoš D.	189
Nemec W.	21, 23	Ramadan T.M.	26
Neubauer T.A.	117	Rareş Ț.	267
Nikolakopoulos K.	166	Ratopoulou M.	228
Nouet J.	229	Rebaubier H.	229
Nowaczyk N.R.	93	Reddad H.	223
Oaie G.	92	Reichart G-J.	81, 82, 215
Ocakoglu F.	102	Repetto G.	136, 137
Ochoa D.	55	Retuerta A.	187
Ogg J.	5	Reuter M.	12, 56, 109
Ognjanova N.	135	Ricci M.	99
Okay S.	31, 35	Richards K.	25, 64
Oliver A.	239, 244	Rios M.	247
Orbay N.	174, 274	Rivas-Carballo M.R.	107
Ovidiu M.	267	Roberts A.P.	146
Önalgil N.	202	Roberts G.	67
Örçen S.	272	Robles J.M.	125
Özkurt S.Ö.	124, 245	Rochdane S.	196
Paganelli E.	111	Rodés A.	47
Palombo M.R.	150, 253	Rodnikov A. G.	183
Pancost R.D.	212	Roeser P.A.	98, 263
Panin N.	16	Rohling E.J.	146
Parinos C.	97, 220	Rondoyanni T.	164
Parinos K.	228	Rook L.	139
Pashko P.	18	Rossi M.A.	237
Patacca E.	137	Rostovtseva Yu.V.	209
Pavelić D.	115	Rousakis G.	97, 220, 228

Roussiakis S.	129, 160	Suarez-Hernando O.	249, 250, 252
Roveri M.	53, 215	Suc J-P.	11, 31, 41, 50, 54, 68, 104, 197
Rubino J. L.	31, 54, 197	Sulpizio R.	168
Ruggieri N.	232	Sumita M.	154
Ruiz-Sánchez F.J.	247, 249, 250, 252	Sunal G.	169
Russo B.	226	Syromyatnikova E. V.	133, 138
Ryan W.B.F.	4, 87, 89, 219	Szentesi Z.	270
S. Roussiakis	128	Sztanó O.	15
Sagnotti L.	112	Şengör A. M. C.	3, 36
Sakinç M.	162	Tachikawa K.	231
Salvatorini G.	112, 226	Taoufiq N.B.	104
Sampalmieri G.	108	Tchapalyga A.	162
Sancar Ü.	37	Tchepalyga A.L.	209
Sangiorgi F.	79, 81, 82, 215	Tekin E.	204
Sant K.	110	Teodoridis V.	148
Sardella R.	139	Tepgeç F.	149
Sarıkaya M.A.	171	Tesakov A. S.	73, 133, 138
Sarıtaş H.	34, 36	Tesakov A.S.	134
Satour L.	52	Theobalt D.	110
Sauvestre R.	88	Theodorou	128
Savorelli A.	137, 236, 241	Theodorou E.	160
Say A.G.	19	Theodorou G.	129
Scandone P.	137	Thomas Y.	34, 36
Scharbert S.	74	Thouveny N.	231
Scharrer S.	148	Tibljša D.	115
Schildgen T.F.	22	Titov V. V.	133, 138
Schmincke H.U.	154	Tőkés L.	15
Schneider S.	56, 275	Toney J.L.	100
Schrempf V.	201	Topper R.P.M.	53
Scopelliti G.	57, 200	Toucanne S.	16
Scott R.S.	262	Triantaphyllou M.	97, 220, 228
Seeber L.	35	Trubikhin V. M.	73
Sen S.	275	Tsakalos E.	165
Sergeyeva N. A.	183	Tsiolakis E.	224
Sezgül Kayseri-Özer M.	159	Tsukamoto S.	169
Shillington D.J.	35	Tudryn A.	90
Shumilovskikh L.	93	Türkmen B.	21
Siegel H.	232	Tzankov T.	184
Sierro F. J.	42, 43, 44, 55	Tzanova A.	105, 114
Silye L.	15	Uhl D.	135
Simakova A. N.	133	Underwood C.	67
Sloss C.	201	Urgelés R.	48
Sonzogni C.	231	Utescher T.	103
Sorlien C.	34, 35, 36	Vahabov U.	195
Sotnikova M. V.	133, 242	Valle-Hernández M.F.	107
Soulet G.	88	Van Baak C.G.C.	79, 80, 84
Spasov N.	135, 184, 255, 258	Van Bennekom L.	101
Steckler M.S.	35	Van Campo E.	231
Stefaniuk M.	13	Van Dam J.	5, 123
Steininger F.F.	74	Van den Berg B.D.J.	43
Stockhecke M.	153, 155, 268	Van den Hoek Ostende L.W.	101, 125, 244, 251
Stoica M.	65, 70, 79, 80, 81, 84, 92	Van der Meulen A.J.	244
Stow D.A.V.	42, 201	Van der Schee M.	42
Stoyanov K.	184	Van Roij L.	82
Strecker M. R.	22	Vasiliev I.	79, 80, 81, 82, 215
Sturm M.	153	Vasilopoulos T.	160
Suades E.	187	Vasilyan D.	126, 135, 256, 257, 275
Suárez E.M.	243	Velitzelos D.	230

Verducci M.	112, 226
Vescogni A.	111
Vidal L.	231
Vigliotti L.	155
Virág A.	270
Viseras C.	243
Vlachou T.D	130
Vougioukalakis G.	166
Vrabac S.	207
Vranjković A.	115
Wagner M.	13
Wallmann K.	88
Wegwerth A.	93
Weijers J.	82
Wesselingh F.P.	63, 208
Wessels W.	254
Wigley T.	67
Willemsen G.	139
Wilson D.	5
Wonik T.	156
Wortel M.J.R.	119
Yanchilina A.	87, 89
Yanchilina A.G.	219
Yanina T.	63
Yavuz N.	170
Yıldırım C.	171
Yılmaz İ.Ö.	102
Yousfi M. Z.	190
Yousfi M.Z.	50
Zabarinskaya L. P.	183
Zaghloul E. A.	161
Zanchetta G.	168

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