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GEOGRID VIEWER FOR SUSTAINABLE EXPLOITATION OF GEOTHERMAL DIGITAL TWINS

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ABSTRACT

Geothermal energy can play an important part in energy transition. However, the uncertainty of the underground energy contents is the main barrier. To secure investments in this renewable energy source, this paper proposes a combination of different tools for obtaining a digital twin model for predicting energy use from subsurface resources. Integration of GeoGrid Viewer with a commercial numerical simulation tool is discussed in the paper to generate data sets for training a digital twin model. The data provided by GeoGrid is fed to the numerical tool for simulation to obtain the energy parameters for the training of a digital twin model of a reservoir located in the Campania Region (Southern Italy).

Key Words: *Digital Twin, Data integration, physics-based modeling, AI, Heat Transfer control.*

1. INTRODUCTION

Today, nearly all integrated 3D exploration software commercially available is based on an ArcGIS-style visualization and query model, where different data are overlaid as layers within the model. These software solutions have a specific market and purpose: processing subsurface information and dynamics rapidly during exploration and resource exploitation to make real-time decisions [1; 2; 3]. This work, the authors present a case study of heat storage in overlapping groundwaters (Cold and hot) and salt wedge, throughout the Geogrid Viewer, an innovative Digital Twin Type cloud software, developed as part of the RD project GEOGRID, funded by the CAMPANIA ERDF 2014/2020 program, for interactive 3D visualization of geothermal reservoirs.

2. THE GEOGRID VIEWER

All collected and geo-localized data have been visualized in the Web Application, Geogrid Viewer, especially developed, through different programming languages (e.g. PHP, HTML 5, CSS), during the GeoGrid project, to allow the integration of all multi-parameter analyzed and interpreted data in an interactive three-dimensional graphical format. The software, customizable with a wide range of tools and functionalities, also displays dynamic simulations of the reservoir during the extraction of "green" energy for more efficient and sustainable use of the resource over time [4]. The software is a tool designed to improve the assessment and sustainable use of geothermal resources, but due to its versatility, it can also be used for other underground investigation purposes by displaying simulations of dynamic 3D components of physical processes (water flows, heat variations, salinity, etc.). Cloud technology allows multiple users to use the software simultaneously and on different operating systems without the need for installation, ensuring compatibility, availability, and updates. The Geogrid Viewer, with its user-friendly interface adaptable to different displays, is innovative because: 1) it can quickly load preprocessed three-dimensional geolocated data and present interactive 3D models exportable in standard or vector formats; 2) it offers the possibility of visualizing multiparametric data of a specific complex query through unique color scales, to obtain an integrated and coherent view of the interpretation of various data sets.

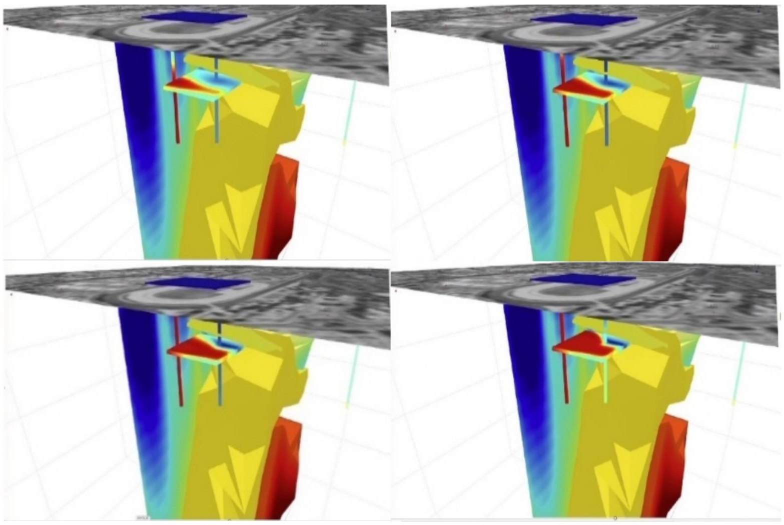

FIGURE 1. Different layers representation with GeoGrid Viewer tool

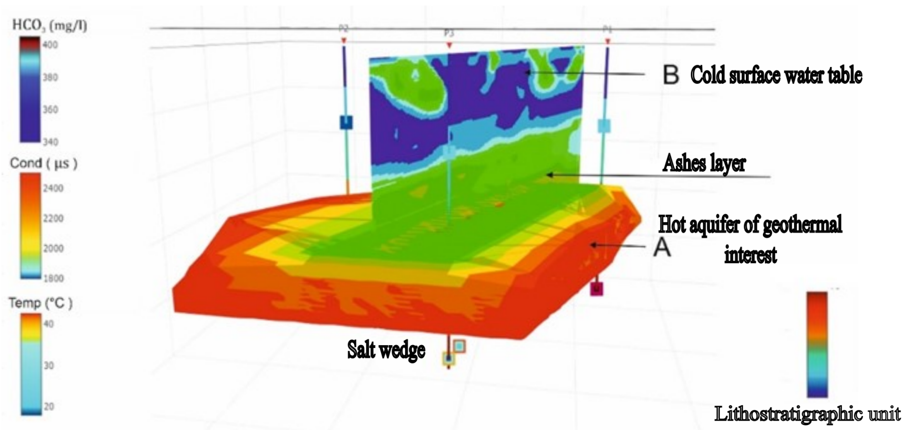

FIGURE 2. Overlapping of cold and hot aquifers located near Pozzuoli, Southern Italy

3. RESULTS

This work uses the example of the source available in Pozzuoli (Arco Felice) Phlegrean fields Campania Region in Italy and presented in Figure 2. Two overlapping aquifers and a salt wedge are integrated into the Geogrid Viewer Digital Twin for analysis of energy storage. Specifically, the multi-fold system studied is characterized by the presence of an impermeable layer consisting of fine volcanic ashes (represented in green in the tomographic section of Figure 2) identified on average between 17 and 29 m below ground level.

The study of the underground aquifer in the area under integration, aimed to recognize the geomorphological and hydrodynamic characteristics of the aquifer, as well as to calculate the groundwater transit times near well P2. The first cold aquifer consisting of sand and fill material of various origins (represented in blue in Figure 2). Below the first aquifer a fine volcanic ashes layer of 15 m constitute the impermeable layer at which base, piezometers P1, P2, and P3, intercepted a deep warm aquifer (temperatures up to 43° represented in red orange in Figure 2) with a confined nature and modest load consisting of silty sands, gravelly sands, and gravel. At the base of the deep-water body, the salt wedge, identified at about 44-45 m from the P.C. has been detected. Variable falling head permeability tests, of Lefranc type, were conducted during the installation of piezometers P1, P2, and P3 to obtain a precise characterization of the hydraulic conductivity of the different

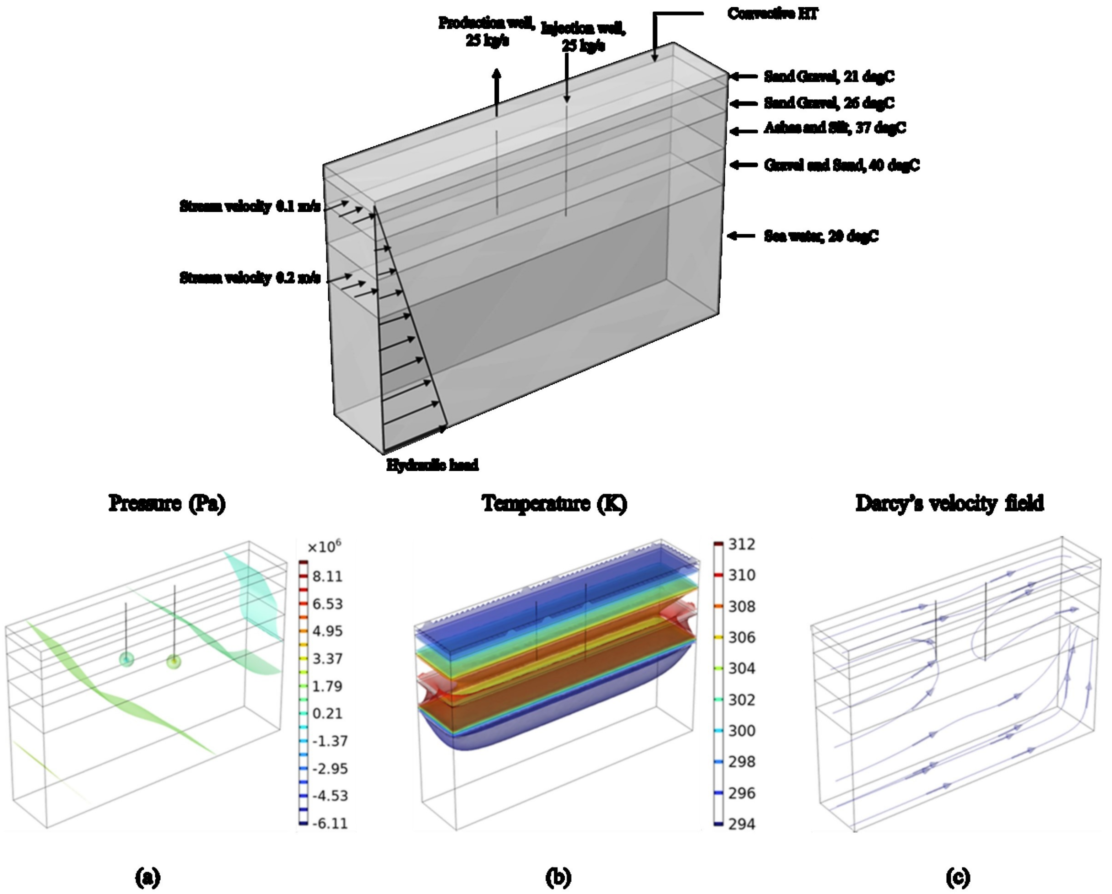

FIGURE 3. 3D Model with Boundary conditions and iso-surfaces of pressure, temperature, and Darcy's velocity field

encountered layers.

The results obtained together with a mathematical model used to post-process the data, allowed us to identify an average permeability for the warm underground aquifer and an average piezometric gradient at well P2 of 5.60

Based on the data obtained from GeoGrid Viewer, a 3D finite element numerical model for a production and injection well is simulated with given conditions to observe the behavior of Darcy's streamlines, pressure and temperatures in the domain. The details of the domain with model setting are shown in Figure 3. Figure 3 (a, b, c) presents the pressure, temperature, and Darcy's velocity field iso-surfaces obtained in the domain when production and injection wells are operating. Figure (3a) shows that the pressure at the production well is lower than the pressure at the injection well. This effect could be explain by the fact that the fluid from the hot stream is taken out for heat exchange creating a low-pressure region near the production well. On the other hand, high pressure region is formed near the injection well as the fluid is re-injected. Figure (3b) illustrates different temperature iso-surfaces due to the temperature variation of the domain according to the geological data for different underground layers while Figure (3c) shows Darcy's velocity field. The operation of production and injection wells operation can also be confirmed by Darcy's velocity field.

4. CONCLUSIONS

The application of digital twins is gaining relevance in energy systems [5]. The data obtained from the GeoGrid Viewer can be utilized for obtaining different input parameters for numerical models to simulate any proposed configuration for geothermal energy exploitation for various applications. The combination of these tools can generate data sets for training digital models for energy estimation in the future. Subsequent developments of the system may include:

• The ability to collaborate in real-time on a single 3D model

• The integration of Artificial Intelligence to automate data importation and selection from Data Lake, to create basic 3D models, and to extract complex information and hidden relationships from data.

• Parameterized temporal granularity for the visualization of reservoir simulations and exportation in video format.

Finally, digital twin can be used for sustainability analysis of low- and medium-enthalpy resource exploitation, such as for district heating and building cooling and for assessing the economic feasibility of geothermal exploitation and the development of future project facilities.

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