

# Comment on Rogozin et al., (2023), Morphology of Lakes of the Central Tunguska Plateau (Krasnoyarsk krai, Evenkiya): New Data on the Problem of the Tunguska Event of 1908

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**Abstract**—In a recent paper, Rogozin and coauthors present a morphologic/seismostratigraphic study of two small lakes, Lake Zapovednoye (LZ) and Lake Peyungda (LP), located 50–60 km east from the alleged epicenter of the 1908 Tunguska Event (TE), a large explosion believed to have been caused by an extraterrestrial impact. Data presented in that paper suggest a similar (although not specified) origin of these two lakes and Lake Cheko, located close to the TE epicenter. This led Rogozin et al., to question the impact crater origin of Lake Cheko, whose depression was interpreted by Gasperini et al., as caused by the freefall of an extraterrestrial fragment, which survived an atmospheric explosion. We analyze Rogozin et al., data, focusing on similarities and differences between Lake Cheko, LZ and LP, to determine whether their findings are relevant to the TE problem.

**Keywords:** Tunguska Event, Lake Cheko, impact crater, Lake Zapovednoye, Lake Peyungda, seismic stratigraphy

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## 1. INTRODUCTION

Based on a morphological/seismostratigraphic study of two small lakes, Lake Zapovednoye (LZ) and Lake Peyungda (LP), located 50 to 60 km west of the alleged epicenter of the 1908 Tunguska Event (TE), Rogozin et al. [1] suggest that they show similar morphology, stratigraphy, and age to Lake Cheko, that was proposed as a possible impact crater formed during this event. They conclude that since the three lakes bear a similar (although not specified) origin they cannot be related to the TE.

However, shape and morphology of Lake Cheko, already known since the '60 [4], were only two among a number of independent observations supporting the impact crater hypothesis. They are: lake morphology and stratigraphy [2, 5]; age and lithology of sediment in the lake depocenter [6]; magnetic and seismic reflection data [7]; dendrochronological observations; lake-floor geophysical data and video camera images [8].

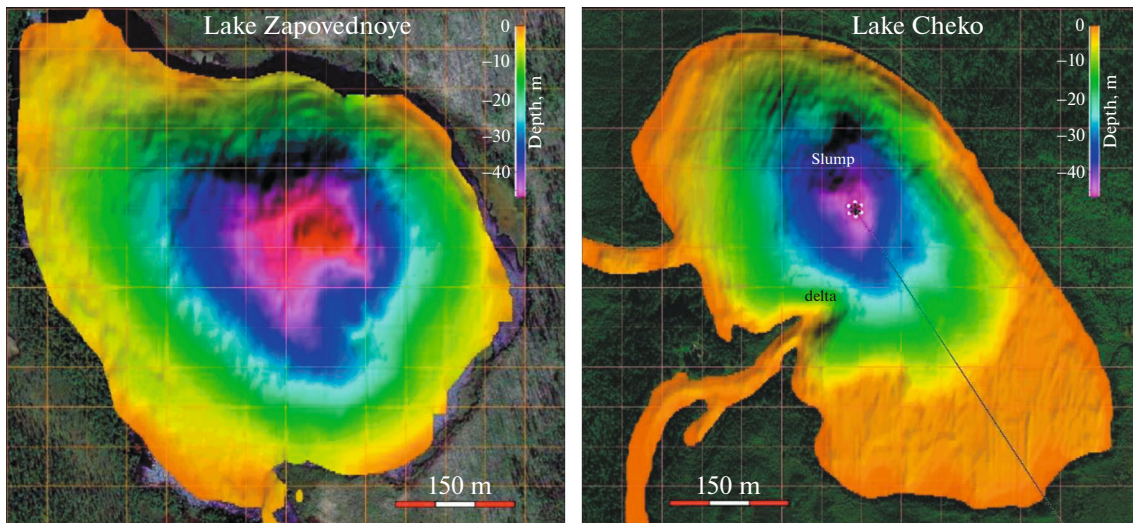
A comprehensive review of all these data could be found in [9].

Rogozin et al. [1] also cite a previous [3] study of the Lake Cheko sediments. Questioning its impact crater origin, Rogozin et al. (2017) stated: “*The most reliable direct evidence could be obtained by radiometric dating, but these authors (i.e., Gasperini et al.,) had not provided it in their works on the problem of the origin of Cheko Lake.*” However, Cs<sup>137</sup> and Pb<sup>210</sup> radiometric dating of the Lake Cheko sediments were provided in Gasperini et al. (2009) [2], together with a number of other evidences including: photo and Rx imaging, pollen and geochemical data, as well as facies analysis, all pointing towards a recent (around 100 years) formation of the lake. Unfortunately, Rogozin et al. (2017) did not provide fundamental information on the sediment cores they collected from Lake Cheko. In fact, the short-lived radionuclides were used to date the uppermost part of the core; for the lower part, Rogozin et al. [3] used the varve counting methods (but show only a blurry image as an example, instead of an X-ray which can better highlight changes in density and particle size; we believe that these uncertain evidences are not enough to confute a 1908 CE age for the formation of Lake Cheko, while evidences provided in the several papers published by the Italian team can be hardly reconciled with an origin not related to the TE.

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**Fig. 1.** Morphobathymetry of Lake Cheko from a dense-spaced grid of echosounder profiles. The black line indicates one of the most likely trajectories of the Tunguska Cosmic Body (see Gasperini et al., 2015), which appears parallel to the major axis of the elliptically-shaped coastline.

## 2. DATA ANALYSIS AND DISCUSSION

### 2.1. Shape and Morphology of the Lakes

Many lakes, not necessarily related to extraterrestrial impacts, have circular or sub-circular shapes, similar to those of LZ and LP. They could fill tectonic depressions, volcanic craters, thermokarst basins in terrains with permafrost, gypsum or limestone dolines, etc. One of these cases could also be that of LZ and LP, which appear perfectly aligned along a rectilinear fluvial stream probably controlled by geologic or topographic features. However, Rogozin et al., [1] do not investigate the origin of these lakes. The Pokamennaya Tunguska region is punctuated by tens if not hundreds of circular-shaped lakes, not necessarily related to the 1908 TE.

During the TUNGUSKA2018 expedition, we also collected echographic data from LZ using a 200 kHz echosounder, embedded in a datalogger typically mounted onboard of the OpenSwap autonomous vehicle [10]. Processing of the echographic data through the open software packages SeisPrho [11] and GMT [12], enabled us to compile a morphobathymetric map of the lake (Fig. 1a).

The morphology of LZ is not “funnel-like” as Rogozin et al. [1] suggest, but eventually “bowl-like,” as also confirmed by the seismic reflection profile displayed in their Fig. 3. In fact, this profile shows that the lake is filled with sediments (see next section) and this produce a rather flat lake floor at the depocenter. LP shape is also not “funnel-like,” as Fig. 2 of Rogozin et al. [1] clearly shows.

Lake Cheko’s morphobathymetric map of Fig. 1b is derived by a densely-spaced grid of echosounder profiles collected in 1999 [2]. Comparing LZ and Lake Cheko morphologies (Fig. 1) we find other differ-

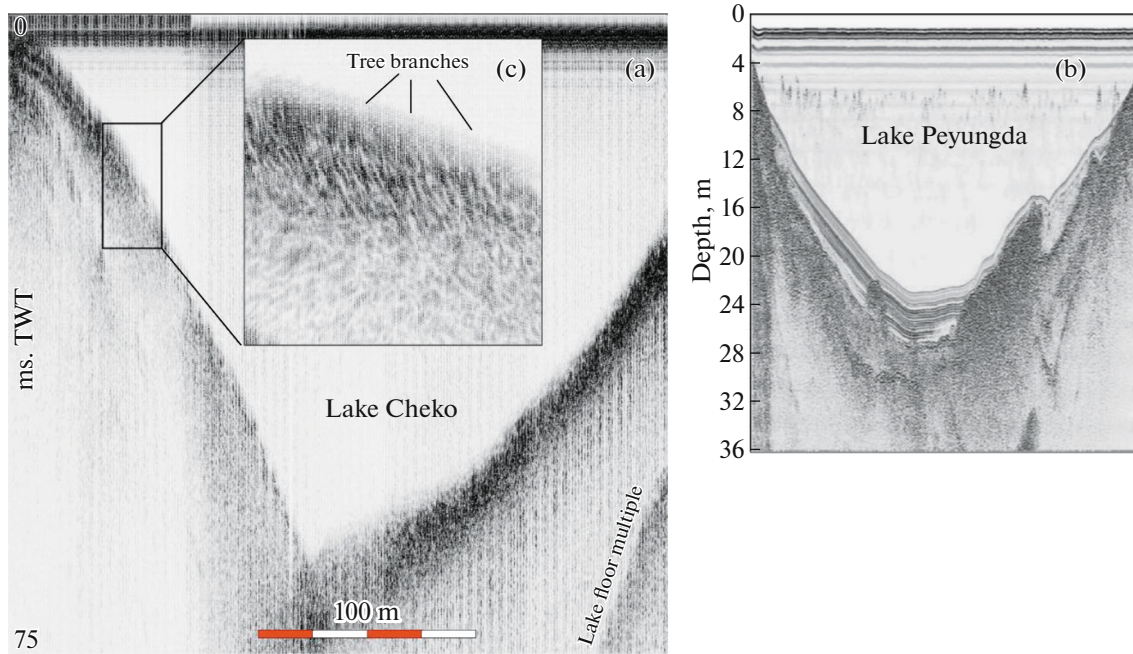
ences. In fact, if we exclude the shallow southern sector and the presence of a river delta, both post-dating the TE impact, Lake Cheko’s shape is elliptical, with the major axis oriented parallel to the most likely trajectory of the TE cosmic body (Fig. 1b). In [2, 5, 9], this occurrence was explained as possibly related to a low-velocity/oblique trajectory of a fragment survived from the main atmospheric 1908 explosion. The final geometry of the depression, without an impact rim and a southern shallow shelf, was considered compatible with a secondary collapse of the crater due to permafrost melting and degassing. In fact, a permafrost layer as thick as ~30 m is present in the region [13].

Another important difference is that both LZ and LP lay along the course of a fluvial stream, the Verkhnaya Lakura river, and their inflows and outflows are located on opposite sides of the shores. This is not the case of Lake Cheko (Fig. 1b), where inflow and outflow are located on the same side 150 m apart in correspondence of a large meander; we discarded an oxbow lake origin for Lake Cheko because of the relatively large depth (over 50 m) of the central depression [2].

### 2.2. Comparing Seismic Reflection Images from Lake Cheko and LZ/LP

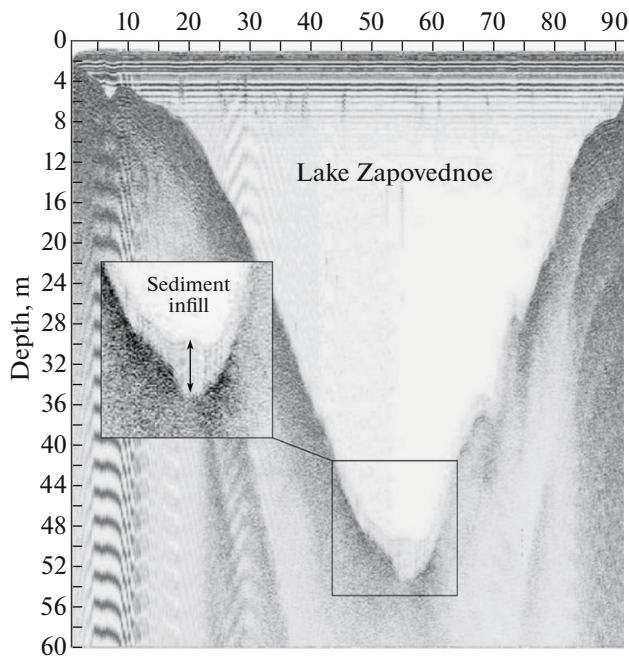
Rogozin et al., [1] carried out seismic reflection surveys of LZ and LP using a “seismoacoustic complex” consisting of “a source of elastic waves, a receiver, a seismic station, a laptop, a GPS-receiver, allowing for the acquisition of seismic acoustic sections with vertical resolution at least 15 cm” [13].

Although Lake Cheko was investigated through a different system (see [2]), vertical resolutions are sim-



**Fig. 2.** (a) seismic reflection profile collected across Lake Cheko center in 1999; (b) seismic reflection profile from Lake Peyungda, showing a “typical” draping of well layered lacustrine sediments over a hard substratum. Profile from Lake Cheko (a), and the close-up shown in (c), indicate that the its bottom is dominated by the diffuse presence of three branches and trunks, most likely the remnants of the forest three destroyed by the impact.

ilar, allowing for a comparison between the two datasets. We compare two seismic reflection profiles across lake depocenters, one from Lake Cheko and the second from LP (Fig. 2). We note that seismic facies



**Fig. 3.** Seismic reflection profile crossing the center of Lake Zapovednoye showing a lacustrine sediment infill as thick as ~4 m (mod. From Rogozin et al., 2023).

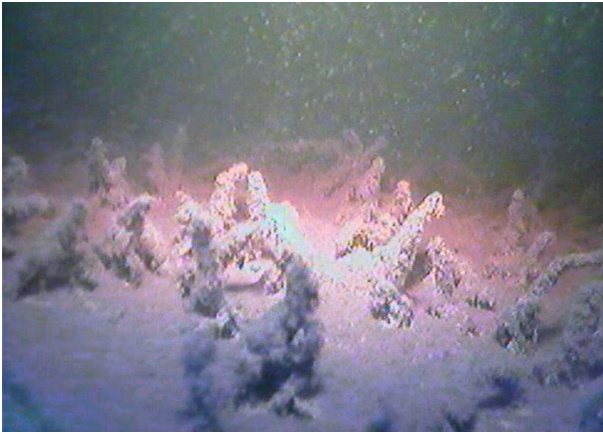
from the LP (Fig. 2b) consists of a well layered and undisturbed sequence of finely laminated lacustrine deposits draping the acoustic basement. A very similar pattern, with over 3 m thick sediment infill characterizes the LZ depocenter, where the acoustic response of the sediments appears “weaker” (Fig. 3). This might be due to a characteristic of the employed instrument, because a similar weak pattern was observed in other sites [14].

Sub-bottom profiles from Lake Cheko (Fig. 2a) show a completely different pattern, characterized by chaotic to massive seismo-stratigraphic facies. Diffuse diffractions with poor lateral continuity on lake slopes indicate the presence of buried “objects,” dimensionally close to the wavelength of the seismic signal (tens of centimeters). Ground-thruting of seismic reflection images performed using side-scan sonar imaging and underwater camera inspections (Fig. 4) indicated that this pattern is due to the widespread presence of tree branches and trunks of fallen trees partially or completely draped by lacustrine sediments [8]. These trees remnants were interpreted as caused by the forest disruption caused by the impact, as also testified by the absence of aquatic plant pollens in sediments pre-dating the TE [6].

### 3. CONCLUSIONS

Comparison between the multidisciplinary dataset collected in Lake Cheko during the last twenty years, and new data from Lake Zapovednoye and Lake Pey-





**Fig. 4.** Underwater photo collected from the Lake Cheko floor (see Gasperini et al., 2014) showing a diffused pattern of tree trunks and branches buried over a relative thin (<1 m) layer of lacustrine sediments, as also indicated by echographic, seismic reflection, and side-scan sonar images.

ungda has shown that Lake Cheko is very different in many important features. We stress that the argument used by Rogozin et al. [1] to question an impact crater origin for Lake Cheko are not supported by data. Conversely, seismic reflection data collected from the three lakes highlight Lake Cheko's peculiarity and reinforce the hypothesis of its impact origin. We hope that it will be possible to carry on a systematic study of the Tunguska region lakes in order to reconstruct differences in their origin and acquire new elements to reconstruct the TE. However, the ultimate test to verify the impact crater hypothesis is drilling Lake Cheko's center, where indirect geophysical hints of a relatively large object located some meters below the lake floor were observed [7]. Since for "western" scientists this region is, and will be in the near future of difficult access, we hope that local research teams will take this opportunity to definitively clarify the long-standing Tunguska mystery.

#### ACKNOWLEDGMENTS

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#### CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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