

# Geophysical/sedimentological study of a lake close to the epicenter of the great 1908 Siberian (Tunguska) Explosion

L. Gasperini<sup>1)</sup>, F. Alvisi<sup>1)</sup>, G. Biasini<sup>2)</sup>, E. Bonatti<sup>1)</sup>, M. Di Martino<sup>3)</sup>, C. Morigi<sup>1)</sup>, G. Longo<sup>4)</sup>, M. Pipan<sup>5)</sup>, M. Ravaioli<sup>1)</sup>, F. Sacchetti<sup>1)</sup>, M. Sacchi<sup>6)</sup>, L. Vigliotti<sup>1)</sup>

1) *Istituto di Geologia Marina, CNR, 40129 Bologna, Italy. (lucag@igm.bo.cnr.it)*

2) *Communication Technology, Cesena (FC), Italy.*

3) *Osservatorio Astronomico di Torino, Torino, Italy.*

4) *Dipartimento di Fisica, Università di Bologna, Bologna, Italy.*

5) *Dipartimento di Scienze della Terra, Univ. di Trieste, Trieste, Italy.*

6) *Istituto Geomare Sud, CNR, Napoli, Italy.*

A scientific expedition took place in July 1999 in the region of Tunguska (Siberia). The objective (Longo et al. this volume) was to gather data that could help understand the so-called “Tunguska event”, namely, an explosion that on June 30 1908 devastated over 2000 square km of Siberian Taiga. Several hypotheses have been put forward to explain the Tunguska event. Most assume the explosion in the atmosphere of a small asteroid or comet. However, fragments of the cosmic body have not been found to date, although several data (including iridium anomalies in peat deposits) support a cosmic impact hypothesis (Longo et al. 1994, Kolesnikov et al. 1999). One of the main tasks of the 1999 expedition was a geophysical/sedimentological study of Lake Cheko, a small (~ 500m diameter) lake located 8 km from the inferred epicenter of the Tunguska event (Florenskij 1963, Fast 1967). An inflatable catamaran was used both for the geophysical survey, and for the coring operations. Our work had two main objectives: 1) to check whether or not the lake fills an impact crater related to the event; 2) if the lake is not an impact crater related to the 1908 event, to detect in the lake sediments mineralogical, chemical and biological evidence on the nature of the cosmic body. The field study lasted 12 days, and included acquisition of: a) morphobathymetry; b) bottom acoustic reflectivity; c) side scan sonar; d) high resolution reflection seismic and Ground Penetrating Radar (GPR) profiles; and e) sediment coring. The bottom topography of the lake was obtained using a digital single-beam echosounder. Reflectivity data from each ping have been collected, together with the depth sounding, by sampling and on-line analyzing the bottom echoes. This, together with accurate DGPS positioning, allowed the creation of a detailed bathymetric map of the lake. The sedimentary infill of the lake has been studied collecting a

tight grid of high resolution seismic reflection profiles with two different systems that allowed a vertical resolution of about 1 and 0.05 m respectively, and by a GPR that has been employed on the shallowest portion of the lake and on shore.

Gravity cores were collected from the lake bottom at different locations chosen after a preliminary analysis of the geophysical data. Sedimentological, geochemical, mineralogical as well as radiometric and magnetic analyses were subsequently carried out on selected samples. The large body of data collected during our fieldwork is still being processed. However, some preliminary results can be discussed.

Aerial images collected during the 1999 expedition (Fig.1) show that the lake stands within an alluvial plain (lighter, flat areas), covered by the sedimentary deposits of a river (the Kimchu River) that flows into the lake on its SW side, and outflows ~200m away on the same side. The western shore of the lake is partially bounded by a about 200m high relief made of igneous rocks (mainly dolerites), part of the pre-Mesozoic regional basement (Sapronov 1986). The river, like other rivers in this region, displays wide meanders, due to the low topographic gradient. The lake, if we exclude a shallow (< 2m) flat area on its SW side, has a nearly circular shape, slightly elongated in the SE-NW direction, and a funnel-like morphology, with a maximum depth of about 50 m close to its center (Figure 1). The slopes are slightly asymmetrical, the northern being a little steeper than the southern, but do not show important morphological breaks. The major irregularities are related to recent sedimentary processes, observed mostly in two areas: the northern slope where slump deposits are shown both in side-scan and bathymetry imagery, and the southwestern sector, where the inflowing river's deposits prograde into the lake, off the river's mouth, forming a ~100m-long, 50 m-wide sedimentary wedge (Fig.1).

From the high resolution seismic reflection profiles we can divide the sedimentary sequence in two units: a finely layered upper unit, roughly from 20 to 100 cm thick, and a lower chaotic unit, the base of which was not imaged by our profiles (Fig.2).

The lake's sediments show a general dark brown-blackish colour, a high content of organic matter, a fine grain

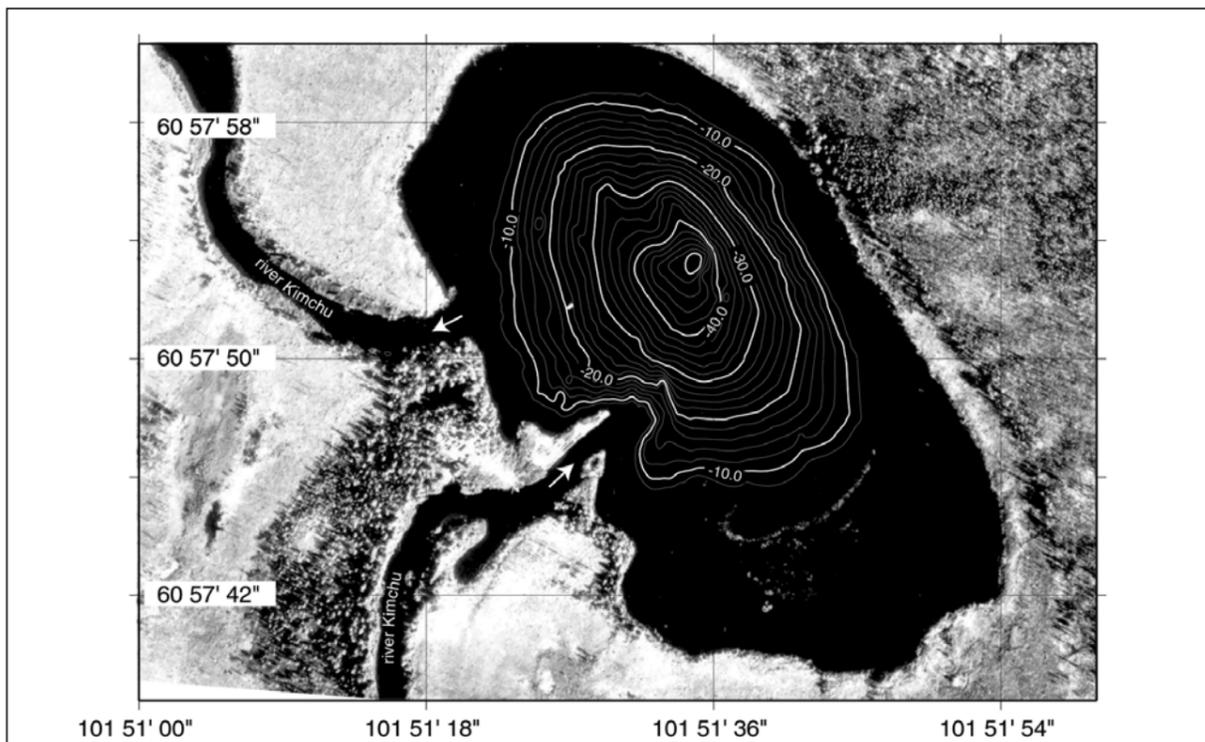


Figure 1. Aerial image and superimposed bathymetric map (isolines each 2 m) of the Lake Cheko obtained during the 1999.

size and alternating laminated and massive intervals. Water content is high in all cores. Cores collected from shallow-water areas show laminations throughout their length. The sediment is mainly sandy mud (pelite ranges from 60 to 80% d.w.) with organic matter ranging from 5 to 16 % d.w. The mineralogical composition is rather constant in different cores, showing predominant quartz, plagioclases, K-feldspar and clay minerals, mostly a smectite. Cores collected from the lake center display a more complex stratigraphy, i.e., two different facies: an upper, laminated and a lower massive units, in agreement with the seismo-stratigraphic observations. Within the upper unit the sandy component is larger (up to 60%). Analyses of several biological proxies (e.g. diatoms, pollen, algal pigment) are being carried out in order to understand the environmental significance of the two facies.

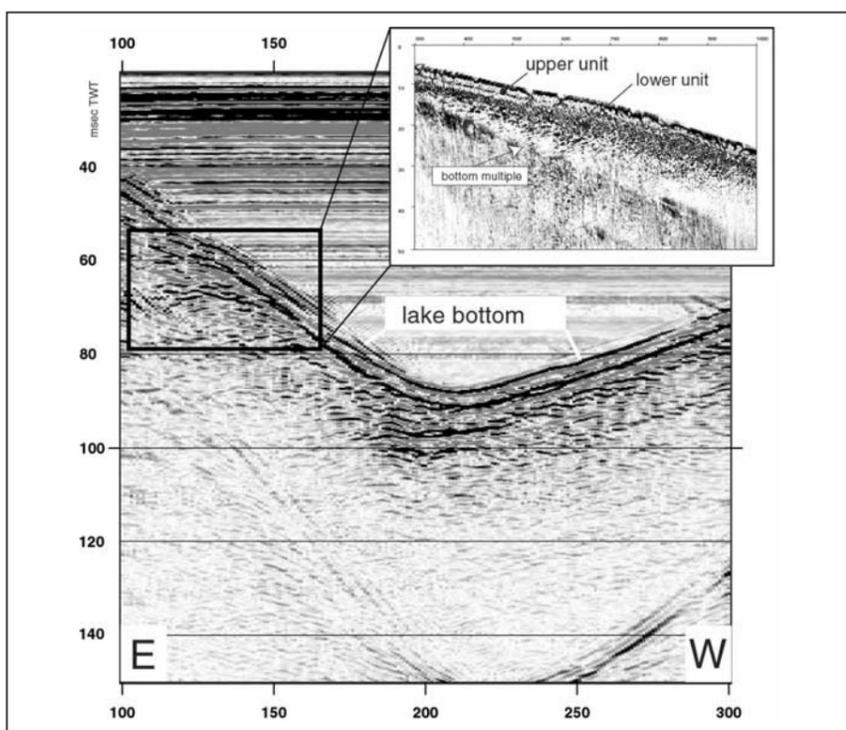


Figure 2. Example of E-W seismic reflection profiles across the lake center. The higher resolution profile (close-up) clearly shows the contact between the two main seismic units: the upper, finely laminated and the lower, chaotic.

The time frame, derived from  $^{137}\text{Cs}$  and  $^{210}\text{Pb}$  activity-depth profiles, identifies the interval corresponding to the 1908 event at different depths in cores. The average depth of this level is from 20 to 40 cm in the shallow-water cores, and between 60 and 80 cm in the cores collected near the lake's center. Preliminary biological investigations suggest that the lake pre-existed the 1908 event, because similar assemblages of lacustrine organisms were found above and below the 1908 event layer. The shallow-water cores do not show important facies changes close to the 1908 event, although an increase in the grain size occurs. Deep-water cores record instead important sedimentological changes below the event: larger organic remains (larch cones, leaves, herbs or moss, wood fragments), massive or oblique laminated layers and higher C/N ratios. All these occurrences can be interpreted as an increase in the energy of the sedimentary processes within the lake, as well as disturbances in the drainage basin, around the level corresponding to the 1908.

A preliminary analysis of the geophysical data and of some sediment cores indicate that the Lake Cheko is a young feature and its sedimentary infill record a major change in the environmental conditions, from 0.2 to about 1 m below the lake floor. Although the morphology of the lake is compatible with an impact origin, several sedimentological and biological proxies indicate that its formation pre-dates the 1908 event. The isotopic composition of the organic matter and the sediment geochemistry (major and trace elements), will help define the nature of the cosmic body that caused the 1908 Tunguska event.

## References:

- Fast, V.G. 1967: Statisticheskij analiz parametrov Tungusskogo vyvala. *Problema Tungusskogo Meteorita, Part 2*, 40-61. Izdatel'stvo Tomskogo Universiteta, Tomsk.
- Florenskij, K.P. 1963: Predvaritelnyje rezultaty Tungusskoj meteoritoj kompleksnoj ekspeditsii, 1961. *Meteoritika* 23, 3-29.
- Kolesnikov, E.M., Boettger, T. & Kolesnikova N.V. 1999: Finding of probable Tunguska Cosmic Body material: isotopic anomalies of carbon and hydrogen in peat. *Planetary and Space Science* 47, 905-916.
- Longo, G., Serra, R., Cecchini, S. & Galli, M. 1994: Search for Microremnants of the Tunguska Cosmic Body. *Planetary and Space Science* 42, 2, 163-177.
- Sapronov, N.L. 1986: Drevnije vulkanicheskiye struktury na jube tungusskoj sineklizy. *Nauka* 3, 25-81, Novosibirsk.