Exploring the site of the Tunguska impact

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The Tunguska event is the largest cosmic calamity caused by the impact of an interplanetary body with the Earth atmosphere that happened during historical times. A two-week scientific expedition (Tunguska99, http://www-th.bo.infn.it/tunguska/) to the impact site has been carried out starting from 14 July 1999 by the Department of Physics of the University of Bologna, in collaboration with researchers of the Turin Astronomical Observatory and of the Institute of Marine Geology (CNR Bologna). A camp was built in the taiga, at some hundred kilometers from the nearest roads. Personnel and researchers, mainly from Tomsk (Russia), provided local support. The participants and the equipment were transported from Italy to Krasnoyarsk by a Russian *Iljushin IL-20M* aircraft of the GosNIIAS Institute and from Krasnoyarsk to Tunguska by a Russian *MI-26* helicopter. The main goal of the expedition was to carry out a systematic exploration of the impact site, in order to assess the nature of the body that caused the devastation, felling more than 80 million trees. The explosion occurred at a height of 5-10 km, releasing energy between 10 and 20 million Megatons. Neither macroscopic fragments of the cosmic body, nor a typical signature of an impact, like a crater, have been found. In spite of the vast amount of theoretical and experimental work done up to now (Vasilyev 1998 and references therein), the nature and composition of the cosmic body and the dynamics of the event have not yet been clarified. Some, but no conclusive, data were acquired by the first Italian 1991 expedition (Longo et al. 1994, Serra et al. 1994). The "Tunguska99" expedition (Amaroli et al. 2000) was organized in order to give an answer about the origin of the Tunguska event, and a contribution to the international research programs aiming at the study of cosmic impacts with the Earth. The main tasks of the "Tunguska99" expedition were: 1) to study the structure and sediments of the lake Cheko; 2) to carry out a multispectral (from visible to medium infrared) aerial photosurvey of the explosion site; 3) to collect peat, rock and wood samples; 4) to monitor gamma rays during the flights Italy–Siberia–Italy and in Tunguska. The samples and data collected during the expedition are now under examination in different Italian laboratories. The aim of these analyses is to deduce important characteristics of the Tunguska event and to refine, verifying their accuracy, the mathematical models concerning the impacts with atmosphere of cosmic bodies having different composition and dimensions.

The results of the geophysical/sedimentological study of the Lake Cheko will make it possible to understand its origin and to find whether the lake stores information on the Tunguska body. What obtained up to now is summarized in a second contribution to the present Workshop (Gasperini et al. 2001) and is here omitted.

The expedition Tunguska99 differed from all the previous ones by the fact that the investigations were performed simultaneously by water means on the Lake Cheko, by ground means and by aerial remote sensing, in collaboration with GosNIIAS. Many aspects of the Tunguska event can be studied by comparing the aerophotosurvey of the explosion site made in 1938, with the new one performed during the Tunguska99 expedition. The possibility to analyse the 1938 aerophotosurvey is of fundamental importance because it was carried out only 30 years after the event, when the tree trunks overthrown by the shock wave were still easily recognizable on the ground. This will allow us to locate the fallen trees and to determine accurately their directions. Krinov, referring to the 1938 survey, states: "It is a unique scientific document authenticating the only radial forest devastation of its kind in existence and caused by the explosion of a meteorite" (Krinov 1966). The 1938 photographic material, never completely analysed, could release important information on the fallen tree distribution and on the location of possible secondary "epicentres" produced by the explosion of some large fragments coming from the principal cosmic body, as reported by several witnesses of the event and subsequently deduced by some researchers. A more accurate determination of the forest area destroyed by the explosion will allow us to estimate with higher precision the energy released and could shed light on the impact dynamics. The 1999 aerophotographic survey

Figure 1. Photograph (from 26 July 1999) from the point usually called the "epicentre" of the explosion

covered a surface of more than 250 km^2 between the latitudes 60° 50' 00" N and 60° 58' 30" N and between the longitudes 101° 45' 00" E and 102° 05' 00" E. The photos have been taken in the scale 1:8000 and 1:14000 with coverage of 60% (long.) and 30% (lat.). In parallel, a line scanner made simultaneously a survey in 6 spectral bands, from optical to thermal infrared: 0.43-0.51 μm, 0.50-0.59 μm, 0.61-0.69 μm, 0.76-0.90 μm, 1.5-2.5 μm and 8.0-12.5 μm. Fig. 1 shows the western part of the Southern swamp photographed on 26 July 1999. Kulik's analysis (Kulik 1939, 1940) has indicated in this area the possible presence of two secondary centers of wave propagation (see Serra et al. 1994).

During the flight, the aircraft position was continuously monitored with a GPS system and the geographic coordinates were linked to the photographs. Contemporarily, we measured on ground the coordinates of different reference points in the same area. These data will allow us to recognise ground elements on the aerial pictures and to connect them to the regional topographic net.

Peat, wood and rock samples from the impact site have been collected. A piece of peat (50 x 20 x 80 cm) has been taken at about 500 m from the SE border of the Lake Cheko. Isotopic analysis and pollen examination have been carried out to find indications on the composition of the cosmic body and on vegetation changes due to the 1908 impact. In the layer corresponding to the year 1908 a variation of the ^{13}C and ^{15}N content is clearly observed (see Fig. 2 reproduced from Kolesnikov et al. 2001). Wood samples from trees surviving the 1908 explosion have been collected at different distances from the epicenter, in order to further the investigation carried out by the first Italian expedition in 1991. Pieces of the so-called "John rock" have been collected. SEM observation of these samples has confirmed the rock sedimentary origin.

Gamma rays have been continuously monitored both during the flights Italy-Siberia-Italy and during the two-week stay in the Tunguska Natural Reserve (Longo et al. 2000) by using a detector of the VRC group of the University of Bologna. In the past similar detectors have been used to study gamma ray variation in dependence of solar activity, of the geomagnetic field, and of the environmental conditions in Italy, Antarctica, Svalbard islands, Himalayas, and during the sea trips voyages Italy-Antarctica-Italy. The new in-flight measurements indicate significant cosmic ray flux variation due to the solar activity. At the base camp, gamma rays from cosmic and environmental radiation have been continuously monitored (at 60° 57' 49" N and 101° 51' 22" E) on time scale of 15 minutes, in the 0.05-3 MeV and in the 3-10 MeV energy bands. Daughter radionuclides from the ^{238}U and ^{232}Th chains have been recorded close to the lake Cheko. The data are being processed to find other natural or man-made radionuclides. As previously observed in other places, the measurements in Tunguska confirm the existence of sporadic radonic storms in connection with rain washout.

Our field research can be strengthened by theoretical studies and modelling. A first step in this direction has been achieved and an 83% probability for an asteroidal origin of the Tunguska cosmic body has been obtained (Jopek et al. 2001).

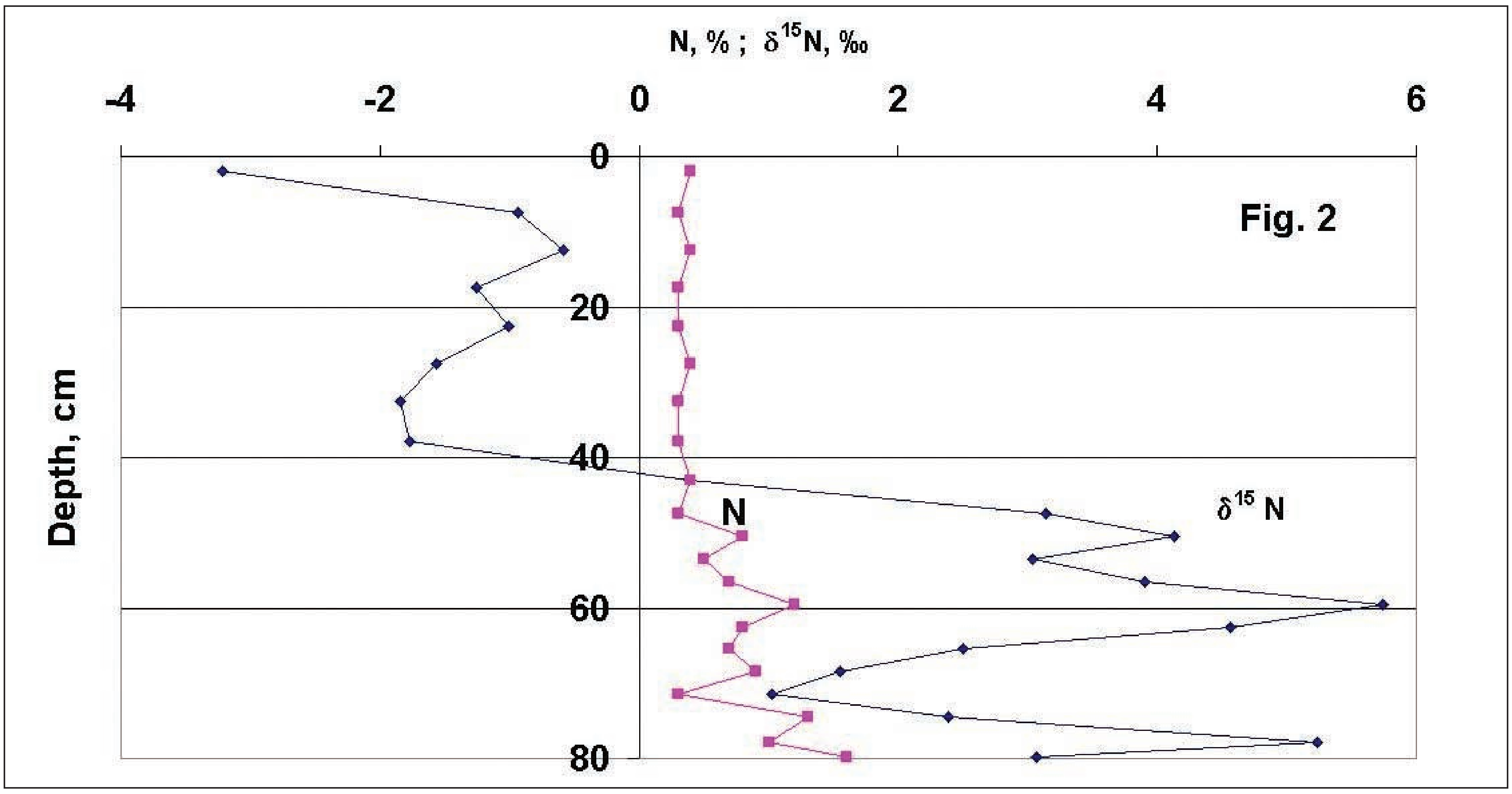

Fig. 2. Content and isotopic composition of nitrogen in peat column taken near Lake Cheko during the Tunguska99 Expedition.

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