A new unified catalogue and a new map of the 1908 tree fall in the site of the Tunguska Cosmic Body explosion

Giuseppe Longo [1], Mario Di Martino [2], Gennadv Andreev [3]
John Anfinogenov [4], Larissa Budaeva [3], Evgeny Kovrigin [3]

[1] Dipartimento di Fisica, Universita' di Bologna, Bologna, Italy
[2] INAF - Osservatorio Astronomico di Torino, Pino Torinese, Italy
[3] Tomsk State University, Tomsk, Russia
[4] Tungussky State Natural Reserve, Vanavara, Evenkija, Russia

Introduction

The 1908 tree fall is the principal source of information on the Tunguska Cosmic Body (TCB) explosion. The data on forest devastation give information on the energy emitted and on the height of the explosion. The directions of flattened trees make it possible to calculate the coordinates of the wave propagation centre(s) and to obtain information on the so-called epicentre(s) of the explosion. From the azimuth distribution of flattened trees, the final trajectory of the TCB, defined by its azimuth *(a)*, the trajectory inclination *(h)* over the horizon and the height *(H)* of the explosion, can be obtained.

Fast map and catalogues

Though Kulik discovered the radial orientation of fallen trees since 1927, systematic measurements of fallen tree azimuths were begun only during the two great post-war expeditions organized by the Academy of Sciences in 1958 and 1961, and during the Tomsk 1959-1960 expeditions. Under the direction of Fast, with the help of Boyarkina, this work was continued for two decades during ten different expeditions from 1961 up to 1979. A total of 122 people, mainly from Tomsk University, participated in these on site measurements. The data collected have been published in a catalogue in two parts [1-2]: the first

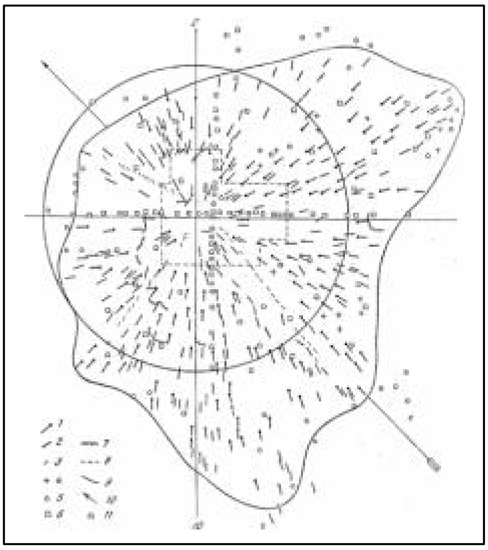

Fig. 1 - Fallen tree distribution (1961) [3-4].

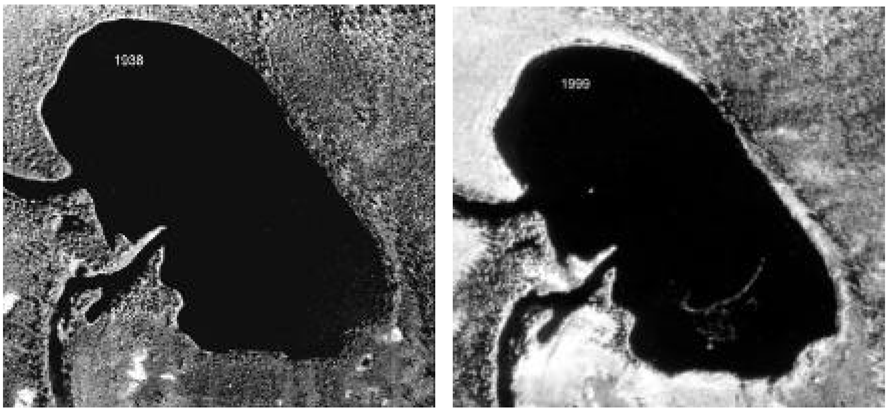

Fig. 2 – The lake Cheko in Kulik’s APS *(left)* and in Tunguska99 APS *(right)*.

one contains the data obtained by six expeditions (1958-1965), which include the fallen tree azimuth averaged on trial areas equal to 2500 or 5000 m^2, chosen throughout the whole devastated forest. In the second part, the data collected by the six subsequent expeditions (1968-1976) were given. Unfortunately, a map containing all the data [1-2] has never been published. In the last 40 years, the map of fallen tree azimuths used for comparison with theoretical models [e.g. 5-6] was the one constructed by A. Boyarkina, V. Fast and co-workers [3-4]. This map, reproduced in Fig. 1 contains only the data on the azimuths measured in 1958-1961.

Analysing the data on flattened tree directions from the first part of his catalogue [1], Fast obtained the epicentre coordinates 60°53’09’’ ± 06’’ N, 101°53’40’’ ± 13’’ E (single explosion). Subsequently [2], Fast found a trajectory azimuth a = 99° and Bronshten analyses gave a height of the explosion H = 7.5 ± 2.5 km and a trajectory inclination h = 15°.

The new map and catalogue

We have used three datasets to construct the new map of fallen tree directions: 1) revised Fast data [1-2], 2) data from Kulik 1938 aerophotosurvey, 3) the data collected in 1967 by Anfinogenov group. To analyse the 1938 aerophotosurvey (APS) and to link its photos to the ground, the Tunguska99 expedition carried out a new APS. The 1999 APS [7-8] covered a ~300 km^2 surface 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, corresponding to an area a little larger than that of the 1938 APS (dashed line in Fig.1). Finally, we carried complementary on-site measurements in July 1999 and 2002 to obtain the coordinates of different reference points in the same area. These data allowed us to recognise ground elements on the aerial pictures and to connect them to the regional topographic net. Photos of the lake Cheko shot in 1938 and in 1999 are shown in Fig. 2. Minor changes can be seen on the shores near the ingoing/outgoing Kimchu river.

The correspondence between the "kilometre coordinate system" used by Fast and the standard geographical coordinates has never been published. In the new unified catalogue, for each Fast azimuth we give its kilometre and geographical coordinates. The last ones have been obtained by using reference points recognised on the ground. Though part of Fast trial areas data was not used due to the rather

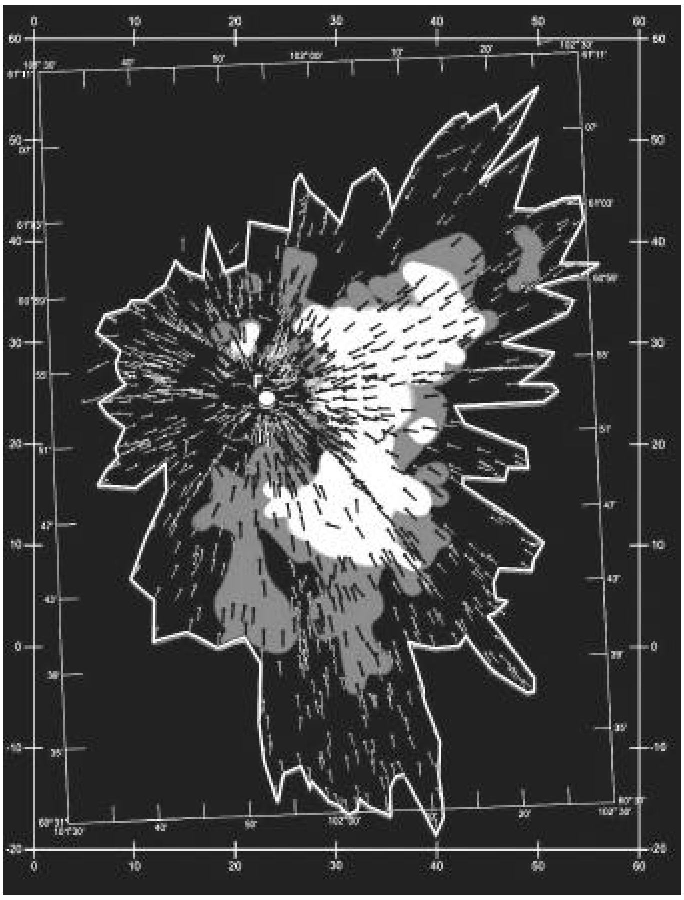

Fig. 3 – The unified map of fallen tree azimuths.

poor statistics, the new catalogue includes 1165 azimuths extracted from Fast data [1-2] and published here after the introduction of the necessary corrections. To these data, 80 Anfinogenov azimuths and other 350 obtained from the digitalized photos of the 1938 APS have been added. Thus, the data we used are several times larger than those in Fig. 1 or those considered by Fast to obtain the mentioned TCB trajectory parameters. We have introduced a reliability degree for each trial area averaged azimuth. In Fig. 3, the white, gray and black areas correspond to a high, medium and low reliability, respectively. In the figure, the external frame represents the kilometer coordinates, while the inner - the geographical ones.

From the data on fallen tree directions in our new unified catalogue, we obtain a single body trajectory azimuth $a = 110° \pm 5°$. The same data are compatible with the hypothesis that the cosmic body was composed by at least two bodies, falling independently but very close one to the other, with a trajectory azimuth ~135 ° and an inclination of the total combined shock wave axis between 30° and 50°. The first body, with a greater mass, emitted the maximal energy at a height of about 6-8 km. The second, of minor mass, flew a little higher, on the right side and behind the first body, following the azimuth ~135° in the direction of the lake Cheko.

List of references

1. Fast V. G., A. P. Boyarkina and M. V. Baklanov, *Problema Tungusskogo meteorita,* part 2, 62-104, Izdatelstvo Tomskogo Universiteta, Tomsk, 1967.
2. Fast V. G., N. P. Fast and N. A. Golenberg, *Meteoritnyje i meteornyje issledovanija*, 24-74, Nauka, Novosibirsk, 1983.
3. Florenskij K.P., *Predvaritelnyje rezultaty Tungusskoj meteoritnoj kompleksnoj ekspeditsii 1961 g*., Meteoritika 23, pp. 3-29, 1963.
4. Boyarkina A.P., Diomin D.V., Zotkin I.T., Fast V.G., *Izucheniye udarnoj volny Tungusskogo meteorita po vyzvannym yeyu razrusheniyam lesa*, Meteoritika, vol XXIV, pp. 112-140, 1964.
5. Korobeinikov V.P., Chushkin P.I., Shurshalov L.V., Tungusskij Fenomen: gazodinamicheskoje modelirovanije. In: *Sledy Kosmicheskih Vozdejstij na Zemlju*, Nauka, Novosibirsk, pp 59-79, 1990.
6. Boslough M.B.E. and Crawford D.A. (1997), Shoemaker-Levy 9 and Plume-forming Collisions on Earth, in *Near-Earth Objects*, Vol. 822 of the Annals of the New York Academy of Sciences, pp. 236-282, 1997.
7. Longo G., Di Martino M., Recalculation of the Tunguska Cosmic Body parameters on the basis of the 1938 and 1999 Aerophotosurveys. In *Asteroids, Comets, Meteors 2002*, (Warmbein B., ed.), ESA-SP 500, pp. 843-846, 2002
8. Longo G., Di Martino M., Remote Sensing Investigation of the Tunguska Explosion Area. In: *Remote Sensing 2002*, (Manfred O., D'Urso G., eds.), Washington: SPIE Press (United States) 4879, pp. 326-333, 2003.