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THE METEORITE OF JUNE 30, 1908, IN CENTRAL SIBERIA*

By L. A. KULIK

Lomonossoff Institute, Russian Academy of Sciences, Moscow, U.S.S.R.

ON JUNE 30, 1908, at 7:00 a. m., in mild weather and a cloudless sky, a large bolide or fireball rushed along in the general direction from south to north over the basin of the River Yenissei in Central Siberia. The fall of the mass onto the Earth was completed by the appearance of a column of fire raised over the taiga [virgin forest] —and observed from a distance of 400 kilometers at Kirensk—by three or four powerful thunderclaps and a crash, recorded at a distance of more than 1,000 kilometers from the center of the fall, and by powerful air waves. To distances of some scores of kilometers around the center of the fall these waves blew down the trees of the taiga in an eccentric-radial direction, tops outward, and were so powerful that they set into motion the baromicrographs of Western Europe as well as those of North America and other countries. These waves went around the world and were recorded a second time in Potsdam, Germany. Seismographs all over the world (at such widely separated stations as, e. g., Irkutsk, Tashkent, Tbilissi, Jena, Washington and Java) recorded powerful Earth

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waves which, as just stated, twice encircled the globe, as a result of the explosive action of the meteorite on the Earth's crust. The epicenter of this disturbance was located behind [the] Podkamennaya Tunguska, in the region of the factory [of] Vanovara. Huge masses of the finest substance, sprayed by the meteorite in its flight through the atmosphere and raised by the explosion in the Earth's crust (due to the cosmic speed of the impact of the meteorite), caused a heavy blanket of dust in the upper layers of the atmosphere, and the formation, at a height of from 83 to 85 kilometers, of "silvery clouds" (light clouds), and dust screens on the "ceiling" and in the lower layers of the stratosphere. Thus were produced those remarkable phenomena called "night dawns," which were of incomparable beauty. These were observed on the day of the fall, from the place of its occurrence as far as Spain, and from Fenno-Scandia to the Black Sea. During the night of June 30 to July 1 and the next few days, these "dawns" gradually became weaker.

The first information concerning the fall of the meteorite was gathered by the writer's expedition, which had been equipped for work in Siberia in 1921 by A. V. Loonatcharsky, People's Commissary for Public Instruction. The official scientific circles at that time did not, however, regard the accounts of this phenomenon as sufficiently trustworthy to warrant an investigation of it. In 1925-26, the writer's opinion was confirmed by new data about the fall; first, from information concerning the seismic waves, furnished by A. V. Vosnessensky, Director of the Irkutsk Observatory, and second, from other evidence supplied by S. V. Obrootcheff, a geologist, and I. M. Soussloff, an ethnographer. Finally, in 1927, the writer had

the opportunity to go to [the] Podkamennaya Tunguska to examine the place of this sensational fall. The investigation brought to light a continuous, eccentric, radial "windfall" in a huge area, of radius about 30 kilometers, which extended on some of the hills to a distance of 60 kilometers and even farther. Observers relate that individual trees were thrown down on the hills in the neighborhood even of Vanovara. The exceptional power of these air waves is evidenced further by the fact that in Kirensk (distant 400 kilometers), fences were overturned; in Kejma, people carrying grain-sacks were knocked down; and in Kansk (600 kilometers distant), workers were thrown from rafts into the river, while at a distance of even 700 kilometers to the south of Kansk, horses could not stand on their feet!

The probable figure of this "windfall," in consequence of the presence of many hills around the center of the fall, in plan reminds one of the meteorological graph called the "wind-rose." It is difficult now, of course, to estimate the dimensions of the whole area of this "windfall" without a survey. The outer fringe of the "windfall" (about 20 kilometers from the center) bears traces of a continuous burn from above. Moreover, the branches of the fallen trees, as well as those which still remain standing, are, as a rule, broken and destroyed. Especially characteristic is the fact that every surface of a break bears a little bit of charcoal, i. e., a trace of the burn. There is "no break without a burn." The central area of the "windfall" lies on permanently frozen, hilly peat mosses, which alternate with swamps among the hills of the mountain watershed. This central area is surrounded by burned trees, still standing, but totally devoid of branches. The continuous "windfall"

begins a little farther from the center, at a distance of one-half to one kilometer.

Pronounced meteoritic craters were not discovered in the course of the first expedition into this region. But another trip, taken in 1928 with a cinema operator, gave the writer an opportunity to explore the area of the "windfall" for a considerably greater distance, to film the "windfall" and to obtain, with a small theodolite, an instrumental determination of the direction of the fallen trees and of the props [meaning upright trees or stumps?] in the center of the "windfall," as well as to discover, in some of the depressions, the "rock flour" typical of meteoritic craters—i. e., fine, sharp-edged, crushed material of the surrounding rocks. Moreover, at the same time, the question was raised regarding the origin of some round excavations [depressions?] in the hilly peat mosses, about 50 meters in diameter and from 4 to 6 meters deep. A preliminary magnetic exploration of these hollows failed because of the presence of magnetic rocks (Siberian traps) in the area.

The striking picture recorded on the film and the necessity of a more detailed exploration, warranted the writer's expedition of 1929, undertaken for the purpose of making a thorough examination of this country. L. V. Schoumiliva, a geo-botanist [paleo-botanist?], and E. L. Krynoff, a scientific worker, took part in this trip. A small group of workers of variable number (from two to seven) proceeded for eighteen months, by surveying, excavating, constructing trenches in the frozen peat mosses, boring, etc., to make a comparative study of the permanently frozen hilly peat mosses, and to obtain climatological data, in order to ascertain the extent of the permanently frozen area as well

as to discover the optimum conditions for aerophotography. Accordingly. in the center of the "windfall" a hamlet was built and a small meteorological station was established. The observations secured there showed that, at the beginning of January, the region of the winter snows and the area of permanent congelation [permanently frozen ground] were everywhere co-extensive. Thus was refuted the notion that the southern limit of the region of permanent congelation was located and that underground water bubbles and funnel-shaped gaps could be found here. Moreover, it was discovered that the end of May, when there is no snow, but as yet no leaves on the trees, is the best time for the aerophotography of the "windfall."

In 1929, at the request of members of the expedition, S. I. Belych, an astronomer-geodesist, determined the geographical co-ordinates of the astroradio points located on Mount Farrington and Mount Schakrama (25 kilometers to the south), and at the factory [of] Vanovara (about 90 kilometers to the southeast). In this same year, a round depression (the so-called "Funnel of Soossloff"), 200 meters to the west of the foot of Mount Stoikovitch, was specially investigated. At the southern border of this hollow, a 40-meter trench was excavated for the drainage of the water. This cut showed great folds (up to 1.5 meters) in the peat mosses and in the underlying blue clay—evidently the result of the enormous lateral pressure of the explosion gases which emanated from the meteorite. At the northern border of this asymmetric funnel, a blue, half-transparent, silica glass, containing traces of nickel, was detected in the projecting clays. In the center and at the northern and southern borders of the funnel, three pit holes were bored to a depth of 31.5 meters with a 4-inch

rotary shock borer of the "Empire" type. These holes showed that permanent congelation existed there at a depth of 25 meters, and they terminated at a sand aquifer. In no other place were borings made.

All the valley locations in the central area of the "windfall" bear traces of a huge flood. Furthermore, the "south marsh" contains [or exhibits] a remarkable example of a concentric surge in the floating turf—characteristic evidence of the intensive subsidence of the water. Taking into account all of these facts and the configuration of the site, we can readily understand the testimony of the natives of the taiga when they relate that at the place where "it" [the meteorite] fell, water flowed out from the Earth for a time. Obviously, separate masses of the meteorite pierced the 25 meters of permanently frozen ground and released artesian waters, which partially destroyed the permanently frozen hilly peat mosses.

According to available data, confirmed by the direction of the fallen trees, the center of the fall of several individual meteoritic masses is located on the northern border of the "south marsh." Here, amid the continuous marshy turf, islands of frozen hilly peat mosses remain, one of which (the eastern one) has a round funnel. This was the object of an investigation by the writer's expedition of 1929-30. Near this formation samples of material were taken, at a depth of 5 meters, from the bottom of the marsh. These showed, under the microscope, minute globules of nickeliferous iron and fused aggregates of quartz grains. Finally, in 1930, native Tungus actually visited the expedition on the site of the fall of the meteorite and reported that, immediately after it fell, they found in the neighborhood of the center of the fall, pieces of brilliant native iron!

It is necessary to complete the factual account of this fall by conclusions of a theoretical nature, based on considerations of matters of vital interest. We know that on June 30, 1908, behind [the] Podkamennaya Tunguska, an enormous iron meteorite fell. We may imagine that this body broke into pieces, first in the air and then in the Earth's crust, which it penetrated as a number of discrete fragments, and that there (in the crust) these fragments burst into still smaller pieces under the action of the escaping incandescent gases which were produced at the time. We should expect to encounter, at a depth of hardly less than 25 meters, crushed masses of this nickeliferous iron, individual pieces of which may have a weight of one or two hundred metric tons. We estimate that the whole mass of the original iron meteorite, before its encounter with the Earth's atmosphere, was probably as much as several thousands of metric tons, but hardly as much as several tens of thousands.

The writer is now engaged in an attempt to obtain an aerophoto-plan of the site of the fall of this meteorite.

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