Astronomy

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Abstract

Full Text

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SIZE DISTRIBUTION OF COSMIC SPHERULES FROM THE REGION OF THE TUNGUSKA FALL

(Presented by Academician V. G. Fesenkov, 26 XII 1963)

In 1958-1962, expeditions of the Committee on Meteorites of the Academy of Sciences of the USSR undertook a study of the soil in the region of the fall of the Tunguska meteorite, with the aim of isolating from it particles of cosmic origin.

The samples consisted of the surface layer of soil; the sampling depth did not exceed 2-3 cm. The average weight of a sample was 20-25 kg, and the sampling area was 2 m^2. After preliminary screening—either dry or wet—according to particle size, each sample was placed on a vibrating table (fraction less than 0.25 mm, sometimes less than 1 mm). In this way there was separated

Fig. 1. Magnetite spherules isolated from the soil at the site of the Tunguska meteorite fall. 50×.

the so-called narrow strip, into which the greater part of the magnetite passed. The narrow strips were subjected to magnetic enrichment, and the magnetic fractions were examined under a binocular microscope. Magnetite spherules with diameters from tens of microns to hundreds of microns were found (Fig. 1). The magnetite spherules are represented by porous, hollow, and, more rarely, dense varieties, owing to which their density is substantially lower than the density of the mineral magnetite (4.9-5.2 g/cm^3). Silicate spherules of the same sizes were encountered in the nonmagnetic fraction.

Magnetite spherules were first studied in detail for the region of the fall of the Sikhote-Alin meteorite, which fell in 1947. The meteoritic nature of the origin of these spherules is beyond doubt ([1]). Such spherules have repeatedly been found in settling aerosols ([2]), and also in Antarctic ice ([3]). In these cases,

Figure 2

Figure 2: Figure 2

however, the possibility of contamination by particles of industrial origin is not excluded. Morphologically identical, but smaller, spherules have been captured at altitudes of more than 100 km with the aid of sounding rockets ([4]).

The results of the processing of soil samples for the region of the fall of the Tunguska meteorite made it possible to establish an increased concentration of magnetite spherules in the northwestern direction from the epicenter of the explosion, in the form of a plume–

tail, which extends for more than 150 km (^5). In all probability, the cloud of spherules (droplets) formed during the powerful explosion-like destruction of the meteoritic body moved in the direction of the wind, gradually settling to the ground. The morphological features of the spherules confirm their origin during a process characterized by rapid heating, melting, and cooling of particles of matter. This, in particular, is indicated by the presence of silicate and magnetite spherules fused together.

For 7 samples located along the plume, all magnetic fractions were processed, including the fine-size fractions. From them all the detected magnetite spherules with diameters of 10 μ and greater were manually extracted. The diameters of the spherules were measured with an ocular micrometer under a binocular microscope.

Fig. 2. Size distribution of 516 spherules from 7 samples. The mass scale is constructed assuming a density of 1 g/cm^3

The enrichment method used did not make it possible to obtain the number of silicate spherules necessary for statistics.

Figure 2 shows the distribution of the number of magnetite spherules as a function of diameter D, constructed from more than 500 measurements. Along the abscissa are plotted the logarithms of the diameters of the spherules; along the ordinate, the logarithms of the number of spherules in a diameter interval of 10 μ. As can be seen from the graph, the distribution has the form

$$N(D) = \frac{N(1)}{D^k},$$

where $k \approx 1.5$. Consequently, the law of distribution of the spherules by masses M also has a power-law character

$$n(M) \sim \frac{1}{M^s},$$

where $3s-2=k$, whence $s \approx 1.2$. The proportionality coefficient—the number of particles of unit mass (or diameter)—remains undetermined with the described enrichment method, since there is no certainty that all particles contained in the sample were completely isolated.

Thus, for the magnetite spherules separated from the soil, with masses from 10^{-8} to 10^{-5} g, a power-law distribution with exponent $s = 1.2$ is valid; i.e., a dependence apparently characteristic of all meteoritic matter. Indeed, visual observations of the number of meteors give $s = 1.5 \div 2.5$ for $10^{-4} < M < 10^{2}$ g; radar registration of the number of meteors gives $s = 2$ for somewhat smaller masses; spherules from aerosols give $s = 1$ for $10^{-9} < M < 10^{-6}$ g; registration of impacts on satellites gives $s = 1.7$ for $10^{-10} < M < 10^{-7}$ g; and collection of particles on a sounding rocket gives $s = 1.1$ for $10^{-14} < M < 10^{-9}$ g (⁀2, ⁀4, [6]-8). Absolute estimates of the number of particles, obtained by such fundamentally different methods, also generally confirm the power-law distribution, although they are less reliable than determinations in each of the indicated mass intervals.

At the present time there is a sufficient number of facts allowing one to assert that the Tunguska meteorite was the nucleus of a small comet, which underwent explosive disintegration while moving in the atmosphere at an altitude of about 10 km (⁀9). The distribution law found for the magnetite spherules is yet another fact testifying to their cosmic origin. It may be assumed that the spherules are re-

···the result of melting (or evaporation and condensation) of refractory particles (or substances) that were part of the comet' s nucleus, i.e., they have a common origin with the particles that form meteor streams during the dissipation of comets.

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Note: Figure translations are in progress. See original paper for figures.