SEARCH FOR DEBRIS OF THE TUNGUSKA METEOR: ANALYTICAL STUDY OF SPHERULES FROM THE EXPLOSION SITE. C. Jéhanno[1], D. Boclet[2], J. Danon[3], E. Robin[1], R. Rocchia[1]. [1] Centre des faibles radioactivités, Laboratoire mixte CEA-CNRS, 91190, Gif-sur-Yvette, France; [2] Service d'astrophysique, CEN-Saclay, 91191 Gif-sur-Yvette, France; [3] Observatorio Nacional, Rio-de-Janeiro, Brasil.

The Tunguska event, which occurred as an enormous explosion in 1908 in Central Siberia (1), has not yet received a satisfactory explanation (2). A cosmic collision is suggested by the eye-witness accounts. However, the numerous expeditions on the siberian site have never found any crater. This indicates that the bolide exploded in the atmosphere and that its material was spread over a wide area. Gravimetric and magnetic separations from large soil samples collected at several ten kilometers from the epicenter, allowed the extraction of spherules (3) with a relatively high iridium content, consistent with a cosmic origin. The mass of this material would not exceed 2 tons over an explored area of 20000 km^2 (4). A uniform extrapolation to the entire Earth leads to a maximum dispersed mass of 50000 tons, about five times the annual micrometeoroid infall (5). Consequently, a significant contamination of the siberian site by the steady cosmic dust flux cannot be excluded. On the other hand, from the finding of an iridium anomaly in an Antarctic snow-ice core, attributed to the 1908 explosion, Ganapathy estimated that the weight of the Tunguska meteor was more than 7 million tons (6). These inconsistent budgets prompted us to carry out new analyses on the available material collected at the explosion site and in Antarctic snow as well.

Careful measurements of the iridium content of a well dated snow core from Antarctica gave negative results and did not confirm Ganapathy's results (6): the Tunguska event does not show in the Antarctic snow. The meteor mass and the importance of the global scale dispersion of the smallest size debris seem to have been largely overestimated. If so, the origin of the presumed extraterrestrial material collected in the vicinity of the explosion site can also be questionned.

To clarify this point, we have investigated a sample of 80 small iron-rich spherules (80 to 150 microns) and fragments of spherules collected close to the explosion site and which had been previously studied by other authors with the scanning electron microscope (8). We have compared them with the various families of iron micrometeorites recovered in deep sea sediments (9,10) and over Greenland ice cap (11,12,13).

While Zbik (8) distinguished 5 types of spherules on morphological considerations, surface analysis with a dispersion energy X-ray spectrometer permitted the identification of only 3 groups: a first one very rich in Ni (5 spherules, Ni >1%), another one with a low Ni content (3 spherules, $0.01\% < Ni < 0.1\%$) and a third group with no Ni content. The three groups were irradiated for 72 hours in a neutron beam of 2.10^{14} $n.cm^{-2}.sec^{-1}$. at the Laboratoire Pierre Süe in Saclay, and analysed by γ-spectrometry. Individual spherules were embedded in epoxy resin, then polished and analysed at the scanning electron microscope. The weight of each spherule was determined from its iron content, by X-ray analysis and γ-spectrometry. Neutron activation analyses confirm the existence of three groups (Table):

<u>Group A.</u> Polished sections of the five spherules from this group exhibit the well known structure of the Fe-Ni spherules from the permanent micrometeorite flux (9,10,11). These spherules, consisting of two iron oxyde phases, wüstite and magnetite (plate I), have their platinum metals assembled in a Ni core (plate II) or in a nugget. Their annual accretion rate being a few 10^4 particles km^{-2} (12,13), it is not surprising to find them abundantly at places where good storage conditions exist. The large areas of peaty soils explored during the various expeditions on the Tunguska site offer such conditions.

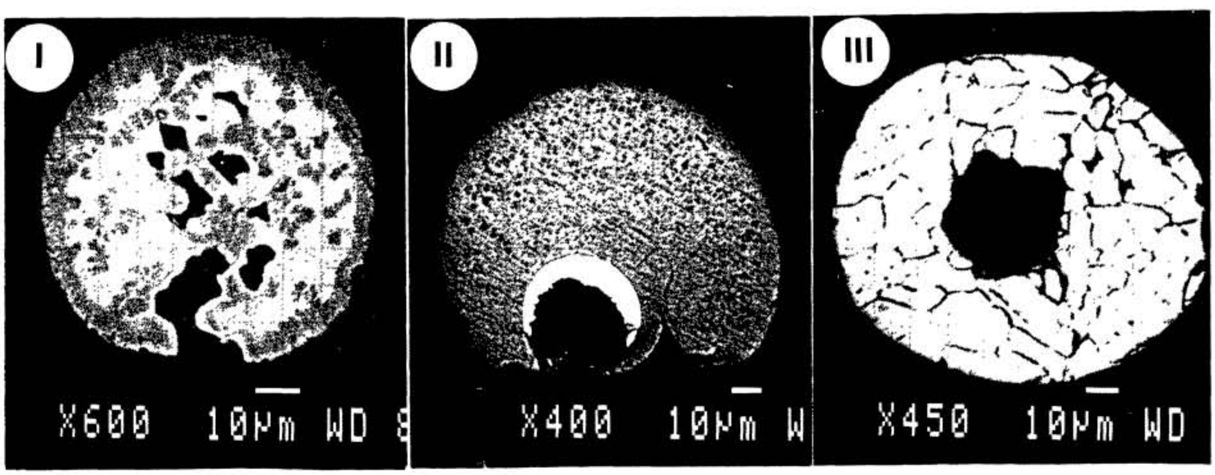
<u>Group B.</u> The three spherules of this group, compared with group A, have low Ni and Ir contents ($\approx$100 $ng.g^{-1}$) but the Ir/Ni ratio is nearly chondritic. Polished sections reveal a single iron oxide phase (plate III). Iridium is homogeneously distributed. A single oxide phase is also found in one family of the Greenland micrometeorites (10,11) but with different composition (sulfur resulting from the partial decomposition of troilite and pentlandite, higher Ir and Ni content: respectively 400 $ng.g^{-1}$ and 6600 $\mu g.g^{-1}$) and structure. Group B spherules are markedly different from the single-oxide Greenland micrometeorites (11,13). However, because of their iridium content, they must be considered as likely extraterrestrial bodies.

<u>Group C.</u> This group with various structures and shapes represents about 90% of our total sample. All the spherules consist of iron oxide and their iridium content is very low. A high precision

analysis, carried out on a set of 14 objects with a γ-γ spectrometer, yielded an average value of 5.7 ± 0.3 $ng.g^{-1}$ of iridium (Table). Individual Ir contents are found up to 40 $ng.g^{-1}$ making the boundary with group B somewhat fuzzy. Spherules of this kind do not exist in the micrometeorite populations. Their significant but low iridium content far below the chondritic value but also much higher than the average Earth crust concentration, does not indicate a clear origin. Generally, industrial iron oxide spherules do not contain iridium in excess of 1 $ng.g^{-1}$ but several tens $ng.g^{-1}$ are found in some peculiar steels. Consequently, an industrial origin is suspected for group C.

From the three groups of spherules found on the Tunguska site, the most abundant one (group C) has probably a purely terrestrial origin. Another one (group A) is definitely identified with Fe-Ni micrometeorites. The least abundant one (group B) has a likely cosmic origin. With its unusual characteristics, it is a possible relic candidate for the 1908 explosion. Since this population represents less than 5 % of our set of samples, the real mass of the Tunguska meteor debris spread around the explosion site and previously estimated to 2 tons over 20000 km2 (4) should be reduced by at least a factor twenty.

Group	Spherule	Fe %	Ni µg/g	Co µg/g	Cr µg/g	Ir ng/g
A	TK1B	63	83060±180	4528±11	1778±30	14190±150
B	TK2C	67	1450±145	1000±3	14±3	122±6
C	14 TK	67	470±50	203±1	34±3	5,7±0,3



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