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MICROMETEORITES IN THE DUST COLLECTED ON KOZUF MOUNTAIN (REPUBLIUC OF NORTH MACEDONIA)

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Abstract

About 40,000 tons of space-derived material fall to Earth every year. The largest part of this interplanetary dust is the result of the collision of meteorites from the meteorite belt or from the melting of ice from bodies in the Solar System.

These interplanetary dust particles collide with the Earth's atmosphere and are further fragmented and fall to Earth as micrometeorites, measuring less than 2 μm. Significant amounts of micrometeorites have been found in deep sea sediments, on snow-capped mountains, and in the ice of the polar regions.

This paper presents the investigations using the SEM-EDS technique on the dust collected on Kozhuf Mountain. From the tests carried out, it can be concluded that in the collected dust two grains were found that have the shape of a micrometeorite, while the chemical analysis shows a composition that corresponds to the composition of some micrometeorites.

Key words: *interplanetary dust, collision, particles, micrometeorites.*

INTRODUCTION

Interplanetary dust particles are the smallest meteorite particles (micrometeorites) available for laboratory testing [1-3]. Their dimensions are less than 10 μm while their mass is several nanograms [4]. They mainly consist of crystalline phase aggregates and amorphous phase aggregates, and the dimensions of the grain size materials are usually in the order of 100 μm or smaller. Their overall composition is chondritic. Some research shows that these particles orbit the Sun for an average of about 104 years [5].

Micrometeorite dust is usually collected in the stratosphere, at an altitude of 20 - 25 km using a stratospheric aircraft. This dust that collects in the stratosphere is divided into two groups: hydric and chondritic and anhydrous or chondritic smooth. Hydride micrometeorites are generally massive objects with plate shapes and fibrous surface textures. Their structure is dominated by minerals that contain water, mostly clay (smectite) and a smaller amount of serpentine and silicate glass, as well as small amounts of diopside, forsterite, Fe-Ni sulfides, magnetite, chromite, and carbonaceous matter. Anhydrous micrometeorites are extremely fine-grained, highly porous (up to 70%) and have a low density (0.3 - 0.6 gr/cm^3). They are heterogeneous in their composition, mainly rich in anhydrous minerals (mainly enstatite, forsterite, sulfides rich in Fe, Ni), carbon dust and nano diamonds. Micrometeorites are very relevant evidence for the planetary sciences and astrophysics as well as for the geology of the Solar System. Micrometeorites can be distinguished from meteorites themselves [6-8] because the mechanisms of their formation are different, they are not only collisions between interplanetary fragments, but the phenomena of evaporation of ice-containing bodies that can also produce micrometeorites, in which case their transport to earth is controlled by radiation rather than gravity [9]. Furthermore, the micrometeorite flux provides information related to the geochemical contribution of extraterrestrial matter to Earth materials as well as questions related to the origin of life on Earth [10-16]. Knowledge of the physical and geochemical properties of micrometeorites provides elements for modeling the origin and evolution of cosmic dust in near-Earth space, as well as assessing the potential hazard of near-Earth space dust activity. Micrometeorites have been collected from various environments, mainly from deep-sea sediments [17-19], lake sediments of Greenland, as well as from Antarctic ice [20]. The collection of micrometeorites from different environments provides information related to different geological as well as micrometeorite flux [21-24].

CLASIFICATION OF MICROMETEORITES (According to Folco and Cordier, 2015), Citation:

Some 40,000 tons of micrometeoroids enter the Earth's atmosphere each year [25], dominating the annual mass influx of extraterrestrial material accreting on our planet. Micrometeoroids are microscopic particles, typically less than a few millimeters in size, moving in the interplanetary space of the Solar System [4]. They are mainly produced by collisions among solid bodies and by surface evaporation of icy bodies in the Solar System, including asteroids, comets, and possibly terrestrial planets and their moons.

Micrometeoroids that survive hypervelocity impact with the Earth's upper atmosphere and are collected at the Earth's surface are called micrometeorites [26]. They range in size from 10 µm to 2 µm [4], with many 0,500 µm. They are broadly classified according to the degree of melting experienced during atmospheric entry as melted micrometeorites or cosmic spherules, unmelted or angular micrometeorites, and partially melted or scoriaceous micrometeorites (Fig.1). Although most micrometeoroids impacting the Earth's atmosphere are lost through melting and evaporation, micrometeorites constitute the principal source of extraterrestrial material that can be recovered to the Earth's surface [27, 28]. Extraterrestrial particles smaller than 10 µm are usually collected in the stratosphere and are known in the literature as Interplanetary Dust Particles, IDPs [2, 3].

MATERIAL AND METHODS

On Kozhuf Mountain, at an altitude of 1,200 meters, a sedimentator has been installed to collect dust. The sedimentator has dimensions of 1 meter in length and 1 meter in width and with a depth of 5 centimeters. After one year, the sediment was collected from the sedimentator and brought to the laboratory. A separation was made using a magnetic separator and a magnetic fraction was obtained for further investigations using the SEM-EDS technique.

For the determination of the phase and mineralogical content of the collected materials Cambridge-style SEM stubs using double sided carbon tape, and graphite coated to prevent charging were used. The coated samples were analyzed by Quanta 650F SEM, fitted with a back-scattered electron detector (BSED) and a Bruker 5030 X-ray detector. The Esprit Quantax 1.9 EDS Analysis System was used to determine the elemental composition of particulate matter. Point Analysis was used to characterize the samples in high-vacuum mode, using an accelerating voltage of 15 kV and a spot size of 6. BSE images of selected fields of view were taken to examine the SEM-based characteristics.

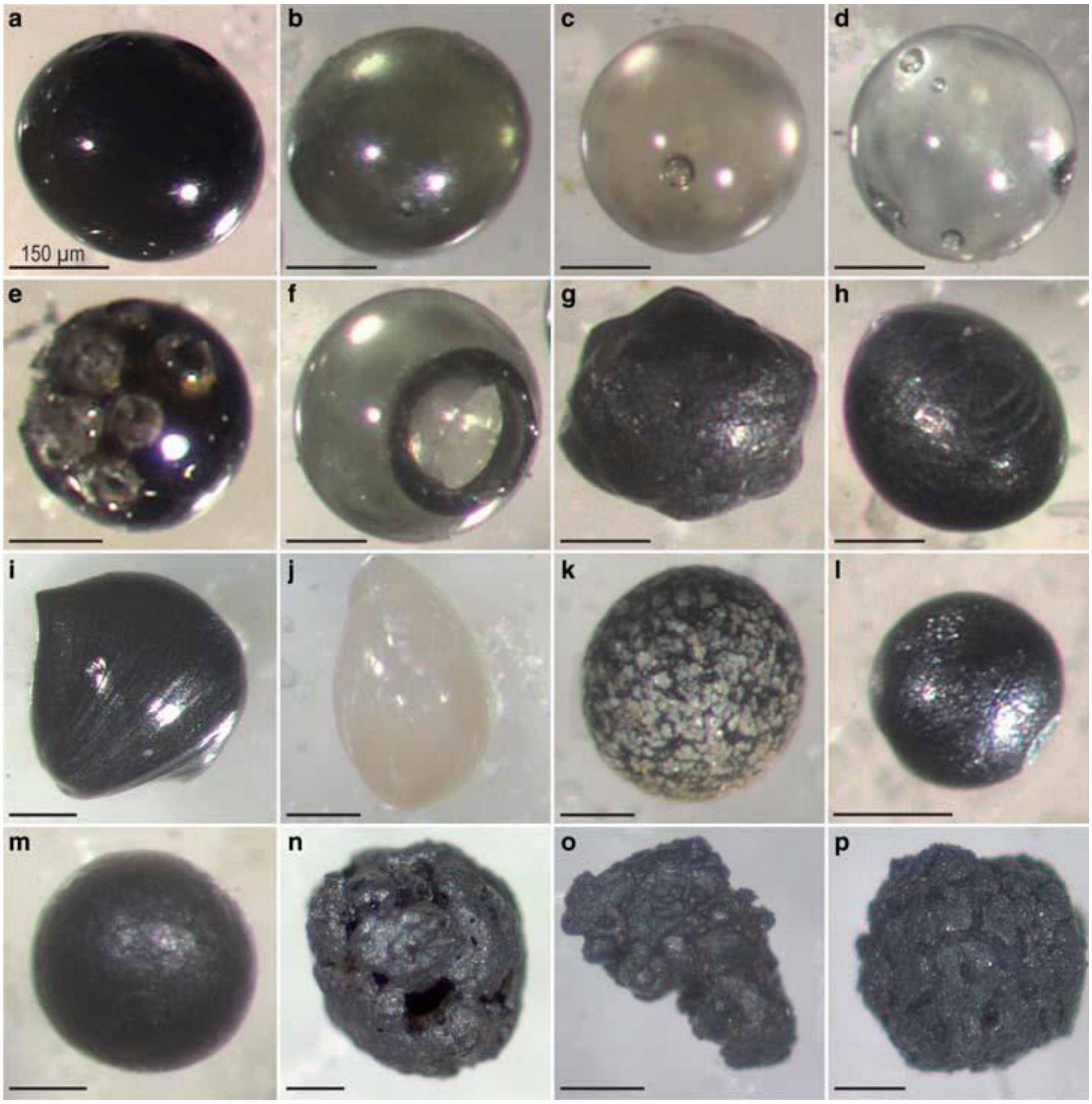

Figure 1. Stereomicroscopic images of various classes of micrometeorites. The types are defined in Table 1. (a–f) Glass cosmic spherules showing the most common range of colors and variable vesicularity. (g) Cryptocrystalline cosmic spherule with characteristic turtle-back (polyhedral-like) morphology. (h–i) Barred olivine cosmic spherules showing characteristic striations. (j) CAT cosmic spherule with its characteristic milky white color. (k) Porphyritic cosmic spherule. (l) I-type cosmic spherule with its characteristic metallic luster. (m) G-type cosmic spherule. (n) Partially melted micrometeorite with characteristic scoriaceous structure. (o–p) Unmelted micrometeorites with characteristic angular to sub-angular shapes. Scale bars j 150 mm. All micrometeorites are from the Transantarctic Mountain collection [29],

RESULTS AND DISCUSSION

The micro meteorites that were found in the collected dust from the sedimentator were processed using the SEM-EDS technique and the results are shown in Fig. 2 and Fig. 3. From the results shown, it can be seen that the dimensions of the micrometeorites are about 3 microns (these are extremely small dimensions) and, based on these dimensions, it can be concluded that it is interplanetary dust. The SEM-EDS analysis shows that in one particle the elements (Fe, Mg, Ca, Si) are present (Fig. 2), while in the other particle the elements (Fe, Ni, Cr, Ca, Mg, Si) are present (Fig. 3).

Based on the obtained results, the micrometeorite void can be classified as [29].

Iron (I) Spheroids consisting almost entirely of iron oxides. They often contain Fe, Ni metal beads.

G-type (G) Spheroids consist almost entirely of nearly equal amounts of Fe oxide dendrites and silicate glass. They often contain Fe, Ni metal beads.

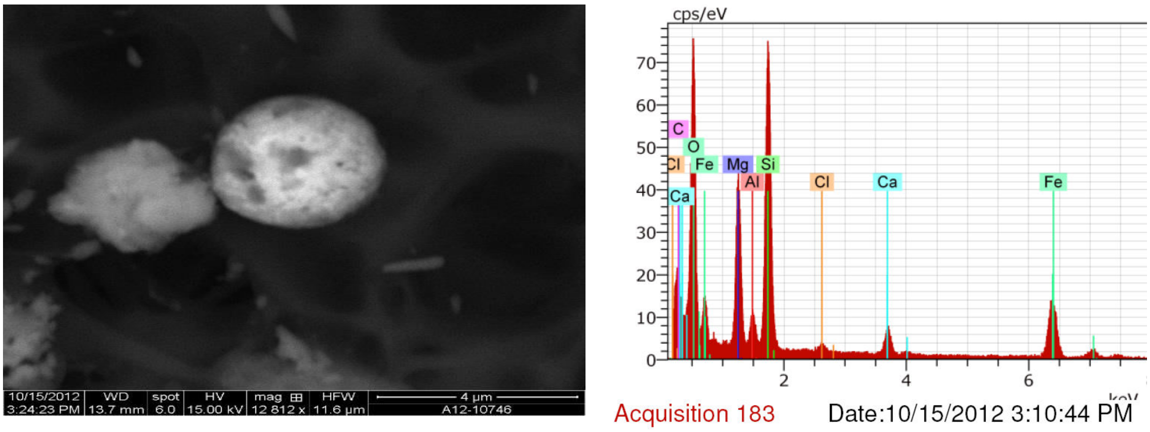

Figure.2. SEM-EDS analysis of **Iron (I)** type of micrometeorites

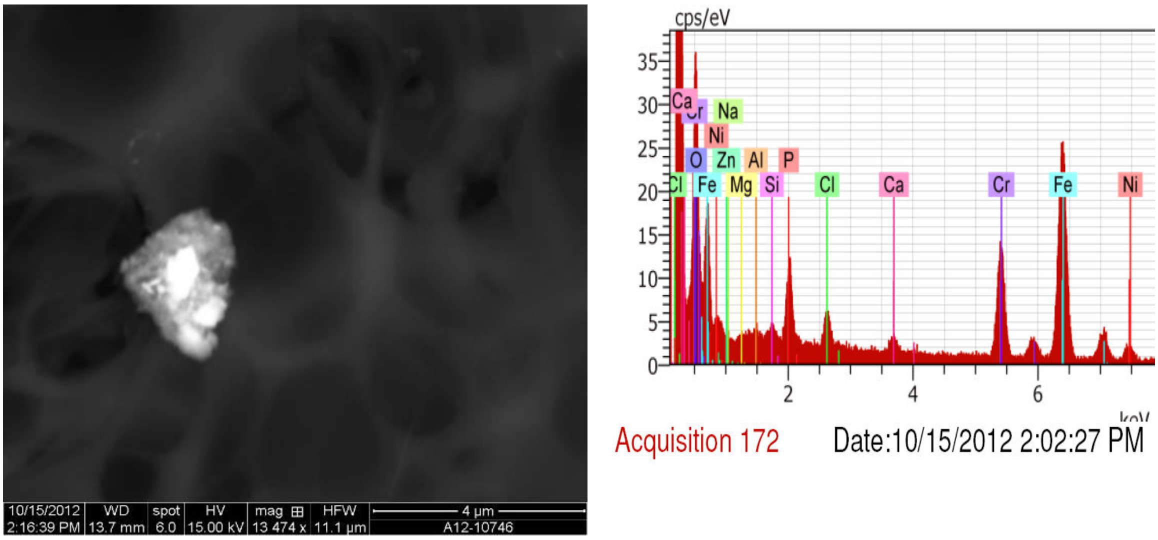

Figure 3. **G-type (G)** type of micrometeorites

CONCLUSION

Fragments were found in the dust samples collected in the Kozhuf Mountain sedimentary, which according to their chemical composition and morphology correspond to micrometeorite dust. The following elements are present in the composition of the fragments that have a spherical shape: Mg, Fe, Ca, Ni, Si, Cr). The presence of these elements implies that in the mineral composition of the fragments there is the presence of Fe-Ni oxides (magnetite, chromite) as well as the presence of pyroxenes and olivine.

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МИКРОМЕТЕОРИТИ ВО ПРАШИНА СОБРАНА НА ПЛАНИНАТА КОЖУФ (РЕПУБЛИКА СЕВЕРНА МАКЕДОНИЈА)

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Резиме

На Земјата паѓаат околу 40 000 тони материјал кој е со потекло е од вселената секоја година. Најголемиот дел од оваа интерпланетарна прашина е резултат на судирот на метеоритите од метеоритскиот појас или пак од испраувањето на мразот од телата во Сончевиот Систем.

Овие честички од интерпланетарна прашина се судруваат со атмосферата на Земјата, дополнително се уситнуваат и како микрометеорити, со димензии помали од 2 мм, паѓаат на Земјата. Значајни количини на микрометеорити се најдени во длабоките морски седименти, на планините покриени со снег и во мразот на поларните области.

Во овој труд се прикажани испитувањата со примена на SEM-EDS техниката на прашина која е собрана на Кожуф Планина. Од спроведените испитувања може да се заклучи дека во собраната прашина има најдено две зрна кои имаат форма на микрометеорит, додека хемиската анализа покажува состав кој одговара на составот на некои микрометеорити.

Клучни зборови: *интерпланетарна прашина, судрување, честички, микрометеорити.*