ISSN 1028-334X, Doklady Earth Sciences, 2010, Vol. 431, Part 2, pp. 441–444. © Pleiades Publishing, Ltd., 2010.
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GEOLOGY

Metallic Microspheres and Microparticles in Lower Cenomanian Sediments of the Crimea: Evidence for the Cosmic Dust Event

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Presented by Academician Yu.G. Leonov April 1, 2009

Received May 26, 2009

DOI: 10.1134/S1028334X10040069

Recently, significant attention has been paid to sedimentary rocks enriched in cosmic matter. Such interest in similar objects is connected with study of the problem concerning the influence of cosmic phenomena on the Earth and its biosphere: scientists want to know to what degree this influence may be catastrophic. These objects also represent carriers of information on cosmic matter (its morphology, chemical composition), which has been falling on the Earth during its entire existence. The study of cosmic particles allows atmospheric processes, owing to which compositionally different particles acquire different morphological features, to be better understood. Recently, some researchers have seen in such objects a tool for superaccurate stratigraphic correlations [1].

Previous studies revealed that the distribution of cosmic matter in sedimentary sections is extremely irregular at different stratigraphic levels [2, 3].

This communication is dedicated to one such formerly unknown level. Materials collected and analyzed during field works of 2008 served as the basis for this work.

Thorough study of the upper Albian–lower Coniacian section (over 200 samples were taken in total) outcropping on the southern slope of Mount Kremennaya in the Bakhchisarai area of the Crimea (*N* 44°046'589", *E* 033°058'755", $h = 327 \pm 7$ m) revealed abundant metallic microspheres and microparticles of cosmic origin in the bed of basal Cenomanian greenish gray incoherent silty marl together with the typical lowermost Cenomanian planktonic (*Globigerinelloides ultramicrus, Clavihedbergella* (?) *simplex, Thalmanninella greenhornensis* (=*brotzeni*), *T. appenninica, T. gandolfi*) and benthic (*Tritaxia pyramidata, Ataxophragmium bykovae*) belonging to the *Thalmanninella greenhornensis* (=*Rotalipora brotzeni*) Zone.

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In the course of the study of these foraminifers in residues, it appeared that both foraminiferal tests and particles of preserved rocks are highly magnetic. This stimulated further more thorough examination of host rocks.

Thus, the study of samples from the lowermost Cenomanian section of the Crimea revealed abundant morphologically variable microspheres and particles of cosmic origin (Fig. 1). The table presents data on their chemical composition.

The following varieties are defined among the microspheres found (figure).

Microspheres of magnetite composition:

(1) 30–50 μm across, with fractured prismatic structural surface (figure: 1);

(2) 40–60 μm across, with elements of the crystallographic faceting (let us call them crystaspheres) (figure: 2);

(3) 40–50 μm across, with irregularly oriented roughly hummocky structural surface (figure: 3);

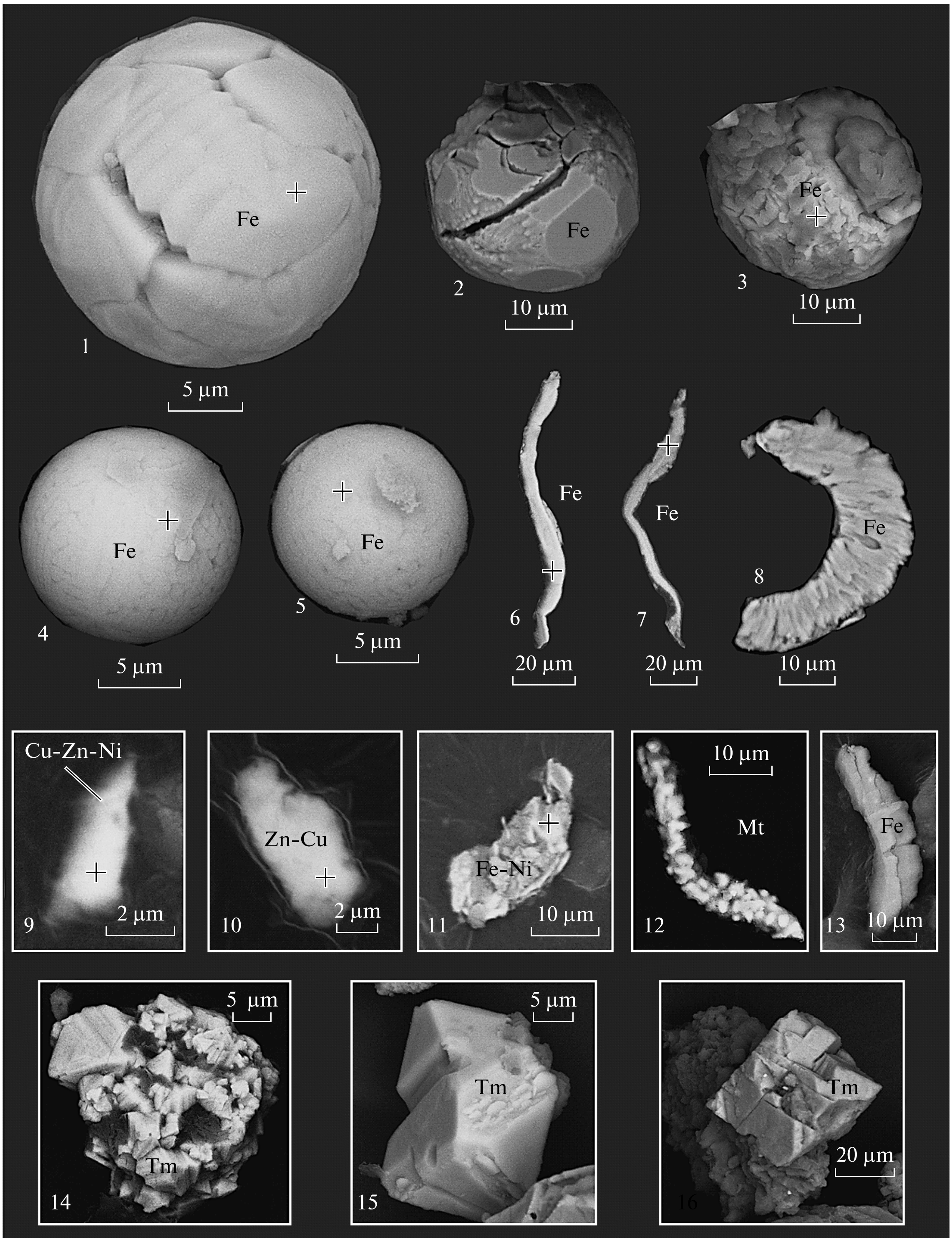
(4) 1–2 to 30 μm across, with the even “takyr”-like surface (figure: 4, 5), most abundant among microspheres.

In addition to abundant size-variable microspheres with different ornamentation of the surface, the extracted magnetic fraction also contained various iron and alloy particles.

Filiform iron represented by elongated, ribbonlike, occasionally twisted structures composed of pure (figure: 6) or partly oxidized (figure: 7) iron. Such structures are up to 100–130 μm long.

Platy iron with transverse furrows are relatively large particles up to 100 μm across, of elongated or isomeric shape, and distinct surface ornamentation in the form of ribs and furrows (figure: 8).

Spiral hummocky–crystalline iron with a fritted surface is represented by aggregate composed of oxidized iron or fritted magnetite (Mt) crystals twisted into a spiral (figure: 12).



Microspheres and microparticles of cosmic origin and accompanying mineral grains from the lower Cenomanian section of the Crimea (Bakhchisarai area, southern slope of Mount Kremennaya, Topolevaya Balka section). Images are obtained in reflected electrons (SM BSE). Crosses show sampling sites.

Irregularly shaped elongated iron particles with an even surface (figure: 13).

The microspheres, crystaspheres, and particles of meteoritic iron are accompanied by very small irregularly shaped to, occasionally, acute-angled or fritted alloy particles.

Cu–Zn–Ni alloy is represented by small isometric particles with a partly fritted surface (figure: 9, 10).

Composition of microspheres, microparticles, and mineral grains (wt %)

Element	Structure												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**15**	**16**
Fe	74.29	74.6	65.98	76.69	77.73	100	71.47	73.2	–	–	82.97	71.83	68.44
Ni	–	–	–	–	–	–	–	–	7.84	–	7.61	–	–
Mn	–	–	1.97	–	–	–	–	–	2.14	–	–	–	–
Zn	–	–	–	–	–	–	–	–	25.71	71.52	–	–	–
Cu	–	–	–	–	–	–	–	–	43.13	2.4	–	–	–
Ti	–	3.2	4.06	–	–	–	–	–	–		–	3.8	4.39
Mg	–	1.6	1.67	–	–	–	–	–	–		–	–	0.59
O	23.37	20.6	24.71	22.35	22.27	–	22.77	26.8	20.27	20.92	–	23.47	24.69
Others (Al, Ca, Si et al.)	2.34		1.6	0.96			5.75	–	0.9	5.15	9.42	0.9	1.56

Note: Numbers of structures correspond to numbers in Fig. 1.

The Fe–Ni alloy is represented by medium- to large-sized isometric or elongated particles with fritted edges (figure: 11).

It is remarkable that the magnetic fraction contains particles composed of pure Fe (table; figure: 6) and the Fe–Ni alloy without oxygen (table; figure: 11), as well as an admixture of Ni in some particles, which undoubtedly indicates their cosmic origin. The examined magnetic fraction also includes abundant semispheric titanomagnetite (Mt) aggregates with partly fritted crystals (figure: 14) and individual magnetite and titanomagnetite crystals with fritted facets (figure: 15, 16). It should be emphasized that there are no reliable indications that such structures resulted from impact events. At the same time, noteworthy is the fact that titanomagnetite grains were previously registered at other stratigraphic levels corresponding to impact meteoritic events such as the Cretaceous–Paleogene boundary [2] or Late Cambrian [3]. It is conceivable that some titanomagnetite aggregates (figure: 12) are of bacterial origin; i.e., they could have resulted from bacterial activity during weathering of rock fragments or meteoritic particles.

Comparison and conclusions. Generally speaking, iron microspheres are relatively abundant in different geological objects. In addition to possible cosmic origin, they may be of volcanic nature or related to metamorphism or bacterial life activity. According to recent views, iron microspheres of cosmic origin are usually lacking a Ti admixture, while the latter is relatively high in their volcanic counterparts (>10%) [4, 5]. It is also believed that cosmic microspheres are characterized by a perfect spherical shape, while microspheres of volcanic origin are usually tear-shaped and true spheres are extremely rare among them. Cosmic microspheres are usually enriched in Ni, while microspheres of meteoritic origin are composed of magnetite and characterized by an uneven hummocky surface, which is atypical of volcanic microspheres [4, 5, 7].

Thus, the lack of the notable Ti admixture (>10%) in microspheres, as well as their ornamented surface and practically ideal spherical shapes provide evidence for the cosmic origin of these structures [4, 5]. The occurrence of native iron and the Fe–Ni alloy without oxygen among the examined microparticles provide grounds as well for the assumption of their cosmic origin. The lack of a notable Ni admixture in microspheres likely indicates their meteoritic nature and inclusion in the category of cosmic dust, while Fe and alloy particles are attributed to categories of either meteoritic iron or micrometeorites [4, 6, 7].

The striking fact is that in their abundance and morphological diversity, microparticles of cosmic origin found in Cenomanian sediments of the Crimea are comparable with their counterparts that were recorded only at the Cretaceous–Paleogene boundary [2].

Both the lower Cenomanian section of the Crimea and the Cretaceous–Paleogene boundary succession in Gams (Eastern Alps, Austria) contain abundant metallic microspheres with smooth, "takyr"-like, and hummocky surfaces. In addition, both these sections enclose particles of different exotic alloys (Fe–Ni, Cu–Zn–Ni, Cu–Zn) and metallic iron of different morphological types such as iron plates with a transverse–hummocky structural surface and metallic iron in the form of spiral thread. Both levels are marked by finds of crystaspheres.

At the same time, dissimilar to the Cretaceous–Paleogene boundary sediments, no hollow microspheres are found in the lower Cenomanian section of the Crimea. The latter is also lacking particles composed of an alloy such as Cu–Sn–Ni, particles with Mo admixture, as well as microspheres with Cr admixture, Ni spinel, and microdiamonds, which serve as direct indicators of a meteoritic impact event.

Consequently, the significant compositional and morphological similarity of microspheres and microparticles of iron and alloys found in the lower Cenomanian sediments of the Crimea with their counterparts from the Cretaceous–Paleogene boundary clays, where they occur together with different indicators of a large meteorite fall such as microdiamonds, Ni spinel, Ni spheres, and mausonite, serves as indirect evidence for their extraterrestrial origin as well.

Does this similarity between microspheres and particles from the lower Cenomanian section of the Crimea and Cretaceous–Paleogene boundary sediments in Gams mean that the early Cenomanian was marked by a cosmic catastrophe comparable with that at the Cretaceous–Paleogene transition?

It was recently assumed that Oman hosts a crater dating back to the Albian [9]. Another meteoritic crater (Avak) is known on the Arctic slope of Alaska. Its age is estimated to be approximately the terminal Albian (100 ± 5Ma) or even the Cenomanian–Late Pliocene [10].

Inasmuch as the age of these meteoritic craters is ambiguous and there are no reliable criteria for their correlation, the relation between cosmic particles found in the lower Cenomanian section of the Crimea with the above-mentioned raters remains problematic.

Thus, the occurrence of metallic microspheres and particles of cosmic origin in lower Cenomanian sediments of the Crimea may either be related to the intensified flux of particles from the cosmic space or have resulted from the fall of a large cosmic body to the Earth at the beginning of the early Cenomanian. I propose to term similar events reflected in elevated concentrations of cosmic matter in sedimentary rocks as a "cosmic dust event."

Future studies should include the search for similar structures in other sections for estimating the scale of this event and obtaining a stratigraphic reference level.

ACKNOWLEDGMENTS

I am grateful to A.F. Grachev (Institute of Physics of the Earth, Russian Academy of Sciences), V.G. Ganelin (Geological Institute, Russian Academy of Sciences), and S.E. Borisovskii (Institute of Geology of Ore Deposits, Petrography, Mineralogy, and Geochemistry, Russian Academy of Sciences) for fruitful discussions and valuable advice. This work was supported by Program no. 15 (Origin of the Biosphere and Evolution of Geobiological Systems) of the Presidium of the Russian Academy of Sciences.

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