UNMELTED FeNi METAL MICROMETEORITES FROM THE NOVAYA ZEMLYA GLACIER. D.D. Badjukov[1], F. Brandstaetter[2], J. Raitala[3], and G. Kurat[2], [1]V.I. Vernadsky Institute RAS, Kosygin str. 19, 119991, Moscow, Russia, badyukov@geokhi.ru, [2]Naturhistorisches Museum, Burgring 7, 1010 Wien, Austria, franz.brandstaetter@nhm-wien.ac.at, gero.kurat@univie.ac.at, [3]Astronomy, University of Oulu, PO BOX 3600, Finland, jraitala@oulu.fi

Introduction: The micrometeorite flux onto the Earth amounts to ~30,000 t/y [1] and overwhelms the meteorite flux that makes up ~53 t/y [2]. Ice of Antarctic and Arctic glaciers is a well-known collector of dust [3], part of which are micrometeorites (MMs). During the last 35 years, a huge number of MMs were collected from glaciers of Greenland and Antarctica [3]. The main fraction of MMs appears to be related to carbonaceous chondrites and ordinary chondrites seem to be rare [4,5] – as are particles of achondritic origin [6,7]. Here we report on the texture and mineralogy of two FeNi metal and one metal-chromite particles, which possibly are the first unmelted metal micrometeorites found so far.

Results: Particles NZ6-4-4,59, NZ6-4-4,10, and NZ6-2-4,20 were extracted from a cryoconite sample collected at the northern passive margin of the Novaya Zemlya glacier [8] during the 2006 field season. The sample preparation included wet sieving and a separation of >50 μm particles under an optical microscope. The operations were performed in a room where no meteorites have been handled before. After extraction, particles were mounted in epoxy resin, sectioned, and studied using routine optical, ASEM, and electron microprobe techniques.

Particle NZ6-4-4,59 consists of Ni,Co-bearing Fe-hydroxides with elongated and worm-like inclusions of kamacite and taenite (Fig.1). Taenite is more abundant than kamacite and has a low Co content compared to kamacite (Table 1). There are at least three types of iron hydroxides with low analyses totals, two of which contain NiO and CoO (Table 2). Ni-free Fe-hydroxide forms a crust at one side of the particle (Fig. 1). According to the analyses totals and the BSE image contrasts the Ni-containing oxides (1 and 2 in Table 2) have different water contents.

The metal particle NZ6-2-4,20 (Fig.2) has a scale-like shape with a notched margin. Metal is chemically inhomogeneous with Ni contents varying from 13 to 17 wt% (Table 1). The surface of the particle is enriched in Ni and the core seems to be composed of a mixture of very fine-grained Ni-rich and Ni-poor phases (kamacite and taenite?).

Particle NZ6-4-4,10 (Fig. 3) consists of chromite and Fe-Ni-Cr metal. Tiny subhedral chromite grains form a non-compact, porous aggregate. Chromite has the composition: 56.5 - 61.2 wt% Cr_2O_3, 23.9 - 28.0 FeO, 5.8 - 7.7 TiO_2, 5.6 - 6.9 MnO, 1.1 - 1.7 Al_2O_3, and < 0.1 wt% MgO. Metal (Table 3, 1) is homogeneous and contains small inclusions (Table 3, 2; bright in Fig.3) that are rich in Cu. Systematically rather low analyses totals (~ 97 %) might be due to the presence of a light element such as C, although we cannot exclude other reasons – e.g., analytical error.

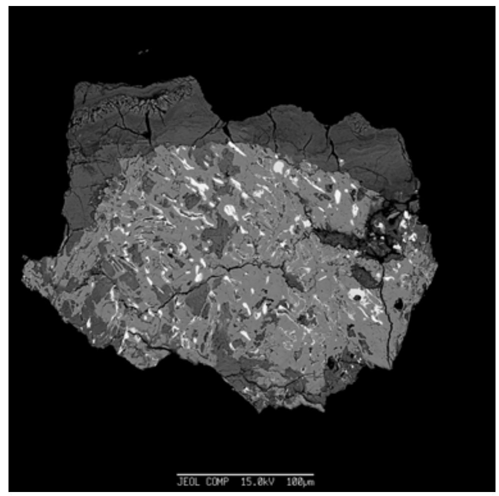

Fig.1. BSE image of particle NZ6-4-4,59 consisting of taenite and kamacite (white) embedded in Ni,Co-bearing Fe hydroxides (grey and light grey). A crust of Fe hydroxide without Ni covers the upper part of the particle.

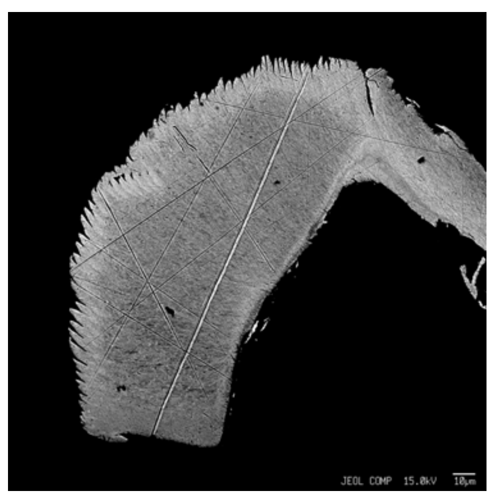

Fig.2. SEM image of all-metal particle NZ6-2-4,20. The lighter grey mantle contains more Ni and the inner part seems to consist of two phases.

Table 1: Chemical composition of metal in particles NZ6-4-4,59 and NZ6-2-4,20 (EMPA data in wt%)

	NZ6-4-4,59		NZ6-2-4,20		
	kamacite	taenite	aver.(7)	Low Ni	High Ni
Fe	**91.8**	**71.5**	**84.4**	**86.2**	**82.6**
Ni	**7.15**	**27.8**	**14.9**	**13.0**	**16.9**
Co	**0.77**	**0.35**	**0.70**	**0.75**	**0.66**
Tot.	**99.7**	**99.7**	**100.0**	**99.9**	**100.2**

Table 2: Chemical composition of hydroxides in particle NZ6-4-4,59 (EPMA data in wt%).

	SiO_2	FeO	NiO	CoO	CaO	Na_2O	Total
1	**b.d.**	**81.8**	**6.1**	**0.59**	**b.d.**	**b.d.**	**88.49**
2	**1.18**	**65.8**	**7.6**	**0.68**	**0.67**	**0.1**	**76.03**

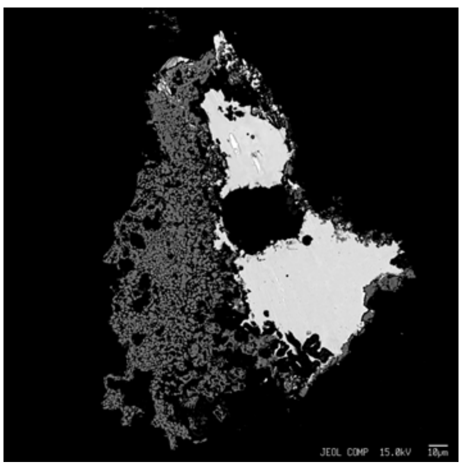

Fig.3. BSE image of particle NZ6-4-4,10. A porous aggregate of chromite (dark grey) on the left, Ni-Co-Cr metal (light grey, right) includes small precipitates of Cu-containing metal (white, upper center).

Table 3 Chemical composition (EPMA data in wt%) of metals in particle NZ6-4-4,10

	Fe	Ni	Co	Cr	Cu	Mn	total
1	**78.6**	**11.5**	**0.26**	**7.12**	**0.15**	**0.08**	**97.7**
2	**73.5**	**13.4**	**0.25**	**5.71**	**4.24**	**0.19**	**97.3**

Discussion: *Particle NZ6-4-4,10* at first sight could be considered as an artificial contaminant. However, the composition of the metal does not correspond to common stainless steels, which contain more Cr (> 15%) and Mn (~1%), are Si-bearing (≤1%) and have less Ni. Also, the particle could come from fallout of an ore processing plant. However, the structure and texture of the particle are delicate and cannot be the result of ore processing at a metallurgical plant. The aggregation structure formed by tiny subhedral chromites indicates diffusion limited aggregation [e.g., 9] of possibly condensate (subhedral) grains in a wind-free environment with exotic physico-chemical conditions. The metal composition is also distinct from typical meteoritical metal. Perhaps, particle NZ6-4-4,10 has an exotic extraterrestrial origin and presents a new type of meteoritic matter, that needs to be further investigated utilizing isotope studies.

Metal in particles NZ6-4-4,59 and NZ6-2-4,20 corresponds to meteoritic metal. The composition of coexisting kamacite and taenite in the former indicates equilibration at about 550 °C [10]. This MM was not melted during the passage through the Earth's atmosphere. Particle NZ6-2-4,20, however, could be a rehomogenized metal (Ni/Co = 21.3) which reports a heating event, possibly the atmospheric entry heating. The surface-related inhomogeneity possibly indicates partial oxidation and loss of Fe. It clearly is not a melted metal MM because they form the I-type cosmic spherules, which consist of wüstite and magnetite with Ni-rich iron metal occasionally present in their cores.

No unmelted metallic MM has been yet reported from among many thousands of MMs. This is strange, because iron cosmic spherules (melted iron micrometeoroids) are common in all MM collections, inclusive the deep sea collections. Surprisingly, also the collections from recent snow at Dome C, Antarctica, do not contain metal UMMs, although the dust was not exposed to melt ice water for a long time during its recovering from snow [11].

Sources of the metallic iron UMMs are uncertain. We can suggest that these UMM cannot originate from parent bodies of iron meteorites that experienced slow cooling. Although primary metal of particle NZ6-4-4,59 is strongly oxidized it seems that the original size of taenite and kamacite grains was not more than tens of μm, which suggests fast cooling.

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