CHAUNSKIJ: THE MOST HIGHLY METAMORPHOSED, SHOCK-MODIFIED AND METAL-RICH MESOSIDERITE

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The 1990 g Chaunskij meteorite was found in 1985 and classified as an anomalous ungrouped iron [1]. It contains ~10 vol.% mono- and polymineralic troilite-phosphate-silicate inclusions, microns to centimeters in size. In [2] we proposed its affinity with mesosiderites; here we present mineralogical, chemical and isotopic data establishing that Chaunskij is the most highly metamorphosed, shock-modified and metal-rich of the mesosiderites. The most striking manifestation of metamorphism in Chaunskij is the presence in it of a cordierite-bearing assemblage substituting for basalt lithology.

STRUCTURE AND MINERALOGY. Metal in Chaunskij displays mesosiderite structure, and shows unusually high levels of shock damage in the kamacite. Tetrataenite borders 5-10 μm wide enclose large regions of cloudy taenite, which, in turn, sometimes enclose martensitic regions. Much of the tetrataenite apparently has been disordered by shock. Schreibersite occurs as occasional very small precipitates at tetrataenite borders, and infrequently as larger masses at grain boundaries. Shock-affected troilite in moderately large globules (up to several mm) and rounded phosphate inclusions are irregularly distributed. Silicate areas in the polymineralic inclusions are, as a rule, irregular in shape. In larger inclusions, these areas are usually surrounded by phosphate rims.

Two dominant silicate lithologies have been found in the inclusions. One, making up a large inclusion (Fig.1), consists of a fine-grained (20-30 μm) aggregate of anhedral pyroxene, subhedral plagioclase laths and silica, minerals characteristic of HED meteorites and mesosiderites. Their compositions match those of mesosideritic pyroxene and plagioclase. Whitlockite is minor. Textures vary from microophitic or subophitic to xenoblastic, and are similar to the textures of highly-recrystallized and impact-melted mesosiderites such as Simondium and Hainholz [3]. This 'igneous' lithology contains relatively large (100 - 200 μm) porphyritic grains of pyroxene and (rarely) plagioclase having irregular edges, suggestive of reaction with the groundmass. Some of the porphyritic pyroxene grains have chromite-rich cores like those found in pyroxene phenocrysts in highly recrystallized mesosiderites [4]. The 'igneous' lithology also contains rare primary clasts enriched in Px, whose boundaries are almost unresolvable from the groundmass in transmitted light.

The second, 'metamorphic', lithology forms as separate small inclusions and as larger areas in intimate contact with the igneous lithology in the large inclusion (Fig.1). This lithology is a fine-grained (typically 30-50 μm) xenoblastic intergrowth of low-Ca pyroxene, whitlockite, and cordierite, with rare larger porphyritic grains of the first two minerals. Porphyritic pyroxene grain edges are generally irregular, indicative of reaction with the groundmasss. Plagioclase is present only as a rare accessory mineral.

Silicate areas also contain metal-phosphate veins and rare pockets or veins of impact glass saturated with Fe-Ni-S globules, mineral fragments, and clasts of the 'igneous' and 'metamorphic' lithologies. Minor minerals in both lithologies are SiO_2, kamacite, taenite, troilite, chromite, ilmenite and rutile. The chromite and ilmenite vary in MgO, MnO, and Al_2O_3 contents. Rare grains of pyrophanite, zircon, alabandite, native copper, stanfieldite, and a graftonite-farringtonite mineral are also present.

OXYGEN ISOTOPES. Oxygen isotope data for three different inclusions - one 'igneous' and two 'metamorphic' - plot on the same fractionation line, indicating fractionation during metamorphism (Fig.2). Data for the 'igneous' lithology falls exactly within the HED - mesosiderite field, leaving no doubt as to the mesosideritic affinity.

BULK CHEMISTRY. A chemical analysis of the large inclusion is shown in the Table 1, and REE contents of whitlockite and pyroxene by ion microprobe analysis are shown in Fig.3, along with the estimated bulk REE content. Recalculated to the silicate fraction only, the composition is very close to those of eucrites and mesosiderites except for minor enrichment in Al and depletion in Fe and Mn. The most important difference between Chaunskij and HED-Mes members is a large enrichment in P and volatile chalcophiles in Chaunskij. Table 2 shows that petrographic modes and chemical norms are in good agreement. Both major element and REE chemistry and bulk mineralogy point to a cumulate eucrite as the precursor of the silicate inclusions. This precursor was apparently slightly fractionated during the remelting event inferred by the structure of the 'igneous' lithology. Similar gabbroic clasts have been found in mesosiderites [5,6].

DISCUSSION. Mineralogical, chemical and O-isotopic data strongly suggest a relationship of Chaunskij to mesosiderites. However, the silicates in Chaunskij are not mixed as intimately with metal as those in mesosiderites, but form discrete inclusions like those in irons with silicate inclusions. This is the only major difference between Chaunskij and known mesosiderites. Nevertheless, while Chaunskij formally corresponds to the 'irons with silicate inclusions' group on the basis of the proportion of metal and silicates, we classify it here as a metal-rich mesosiderite. Other differences between Chaunskij and mesosiderites fall on simple extensions of the mineralogical and chemical trends observed in mesosiderites. Prograde metamorphism, causing recrystallization of mesosideritic silicates and an increased content of phosphates, resulted in the formation of a true metamorphic cordierite-pyroxene assemblage in Chaunskij. In this sense, Chaunskij is the most metamorphosed member of the mesosiderites. The presence of impact glass in silicates and ε-structure in kamacite, atypical for mesosiderites, makes Chaunskij also the most shock-modified mesosiderite.

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Table 1. Chemistry of inclusions

	Silicates	Bulk		
	wt.%			*ppm*
SiO_2	49.47	40.95	Co	244
TiO_2	0.42	0.35	Ga	5.99
Al_2O_3	14.00	11.59	Se	10.7
Cr_2O_3	0.57	0.47	Zn	8.31
FeO	14.04	11.62	Cd	6.01
MnO	0.36	*0.30*		*ppb*
MgO	9.70	8.03	Te	570
CaO	8.84	7.32	Ag	539
Na_2O	0.36	0.26	Au	81.8
K_2O	0.02	0.02	Sb	49
P_2O_5	2.26	1.87	Bi	10.6
H_2O^+		1.07	Tl	3.12
H_2O^-		0.28	In	0.83
Fe_{met}		2.26	Rb	727
Ni		1.80	Cs	45.5
Co		0.02	U	36.2
FeS		10.80		
C		0.02		
Total		99.01		
Fe_{tot}		17.87		

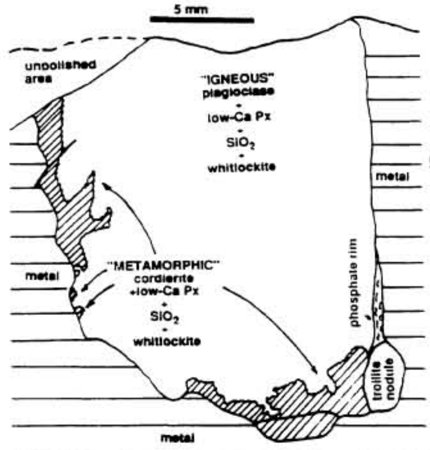

Fig. 1. Map of the large inclusion.

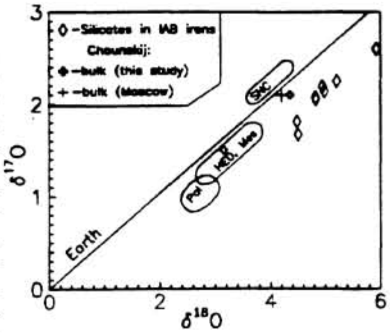

Fig. 2. Oxygen isotopes in the Chaunskij inclusions

Table 2. Mineralogy of inclusions (wt.%)

Mineral	Norms	Modes
Pyroxene	39.8	39
Plagioclase	29.5	29
Cordiertite	3.5	6
Whitlockite	4.4	4
Silica	6.5	5
Chromite	0.7	1
Ilmenite	0.7	0.8
Metal	4.0	*
Troilite	10.8	15*

*Metal + troilite

Fig. 3. REE in Chaunskij minerals.