IGNEOUS ROCK FROM SEVERNYI KOLCHIM (H3) CHONDRITE: NEBULAR ORIGIN.

M. A. Nazarov, Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow 117975, Russia, F. Brandstätter and G. Kurat, Naturhistorisches Museum, Postfach 417, A-1014, Vienna, Austria.

The discovery of lithic fragments with compositions and textures similar to igneous differentiates in unequilibrated ordinary chondrites (UOCs) and carbonaceous chondrites (CCs) has been interpreted as to suggest that planetary bodies existed before chondrites were formed [1-3]. As a consequence, chondrites (except, perhaps CI chondrites) cannot be considered primitive assemblages of unprocessed nebular matter. Here we report about our study of an igneous clast from the Severnyi Kolchim (H3) chondrite [4]. The results of the study are incompatible with an igneous origin of the clast but are in favor of a nebular origin - similar to that of chondrules [5].

Texture and mineralogy. The Severnyi Kolchim igneous rock has an elongated rounded shape and a size of 0.8*0.5 mm. It consists of olivine (12%), orthopyroxene (46.1%), Ca-rich pyroxene (19.5%), Ca-rich feldspar (21.8%), chromite (0.2%), and mesostasis (0.3 vol.%). The rock is relatively coarse-grained (0.1 mm) and demonstrates a distinct textural zoning (Fig.1). Rounded olivine grains (light) are concentrated in the central part of the rock and group along its elongation. These grains are surrounded by Ca-rich pyroxene (dark grey) and Ca-rich feldspar (black) which form a typical ophitic texture. The outer zone of the object is composed mainly of orthopyroxene (light grey) with rare olivine inclusions. Rare chromite grains are located at olivine/feldspar contacts. The mesostasis between feldspar laths consists of fine-grained intergrowths of Na-rich feldspar, Ca-rich pyroxene, ilmenite, and silica. On the basis of the textural and compositional characteristics this rock can be classified as olivine gabbro-norite.

Mineral chemistry. Representative analyses of the phases are given in the Table. Olivine has a limited compositional range (Fig.2) of Fo80-84, and low contents of CaO (0.05%) and NiO (<.01%), typical for olivines of H chondrites. However, three minute grains of Mg-rich olivine (Fo90-92) were found enclosed in orthopyroxene of the outer zone. These relic grains resemble those in chondrules. Orthopyroxene exibits large compositional variations (Fig.2) from En80.5 to En87.7, Wo2.4-5, Al_2O_3 0.5-2.66%, TiO_2 0.07-0.55%, Cr_2O_3 0.4-0.9%. It has a compositional zoning with the Fe/Mg ratio increasing towards the surface of the object. However, as compared to olivine orthopyroxene has an appreciable higher Mg/Fe ratio (Fig.2). The Ca-rich pyroxene shows the highest Mg/Fe ratio of all phases (Fig.2). Its composition is close to diopside (Table) but commonly depleted in Wo (31-44) with Al_2O_3 1.1-3.3%, TiO_2 0.2-1.4%, Cr_2O_3 0.4-1.0%. Similar pyroxenes (endiopsides) were described from garnet lherzolites [6] and some chondrules [7]. The Ca-rich feldspar has a composition similar to that of eucritic feldspars, i.e. An78 - An91. It, however, is unusually rich in Cr (0.3-0.8% Cr_2O_3). In contrast, the feldspars in the mesostases are Na-rich (Ab84-85, Or1-3) and comparable to those in the chondrules. The chromites (Table) have typical compositions of chromites in H chondrites.

The bulk composition of the rock (Table) was calculated on the basis of the modal data and the mineral compositions. It is compatible with compositions of cumulate rocks of the gabbro-norite suite. On the other hand this composition is indistinguishable from that of the type III ferromagnesian chondrules of carbonaceous chondrites [8].

Discussion. The ophitic coarse-grained texture, the roughly cotectic proportions of feldspar and high-Ca pyroxene, the presence of orthopyroxene, instead of low-Ca clinopyroxene, and the Ca-rich feldspar composition, as well as the absence of any metal grains distinct the object from chondrule clasts and suggest it to be formed on a differentiated parent body by igneous processes. However, the mineral chemistry data conflict with this suggestion. In fact, the olivine which should be the first liquidus phase in the melt, cannot have a Fe/Mg ratio higher than the total melt, the orthopyroxene, and the cotectic feldspar-clinopyroxene liquid. The mineral compositions rather favor a mixing of different components. In addition, the textural zoning of the object and the compositional zoning of the orthopyroxene, which is similar to the zoning of olivine chondrules [9], are not compatible with an igneous origin. The textural zoning is suggestive of an accretionary process similar to that proposed for chondrules [5]. The non-equilibrated Mg/Fe distribution between and within the phases corresponds to diffusion-controlled exchange reactions with a nebular gas [5,12]. Therefore, we have to conclude, that this igneous rock has a nebular origin. It can be suggested from the chemical similarity between the object and the type III chondrules that the latter could be produced by complete melting of a precursor material similar to the Severnyi Kolchim "igneous" object.

Summary. This study shows: (1) the chondrule precursor material should have a complicate nebular history including mixing of different nebular components and gas-solid reactions following the general model of chondrule formation proposed by [5,9,10]; (2) nebular processes can produce a material which is close in chemistry and texture to some types of igneous rocks and, therefore, the igneous origin of some lithic clasts in UOCs and CCs is doubtful; (3) our findings even support the suggesstion [5,13] that the basaltic achondrites might be of nebular rather than igneous origin.

References. [1] G.Kurat and A. Kracher (1980) Z. Naturforsch. 85a, 180-190. [2] I. Hutcheon and R. Hutchison (1989) Nature, 337, 238-241. [3] A. K. Kennedy et al. (1992) Earth Planet. Sci. Lett., 113, 191-205. [4] M. A. Nazarov et al. (1983) Meteoritika, 42, 40-47 (in Russian). [5] G. Kurat (1988) Phil. Trans. R. Soc. Lond. A325, 459-482. [6] F. R. Boyd (1973) Geochim. Cosmochim. Acta, 37, 2533-2546. [7] E. J. Olsen (1983) In "Chondrules and their Origins", E. A. King (ed), Lunar Planet. Inst.,Houston, 223-234. [8] H. Y. McSween (1983) ibid, 195-210. [9] J. A. Peck (1986) LPSC XVII, 654-655. [10] G. Kurat et al. (1985) LPSC XVI, 471-472. [11] G. Kurat et al. (1992) LPSC XXIII, 745-746. [12] M. Blander and J. C. Katz (1967) Geochim. Cosmochim. Acta, 31, 1015-1034. [13] G. Kurat (1990) Meteoritics, 25, 377-378.

Table: Representative EMP analyses.

	Ol	Opx	Cpx	Pl	Ch	Bulk
SiO2	38.5	53.8	52.9	45.6	0.72	51.4
TiO2	0.04	0.50	0.32	0.01	1.19	0.26
Al2O3	0.08	2.66	1.49	35.3	7.0	7.4
Cr2O3	0.15	0.89	0.67	0.85	56.0	0.71
FeO	16.9	6.00	1.67	0.82	30.3	6.4
MnO	0.43	0.15	0.07	0.04	1.16	0.21
MgO	44.3	31.5	22.2	0.09	3.1	25.2
CaO	0.07	2.58	17.9	16.6	0.37	8.1
Na2O	0.00	0.05	0.11	1.51	0.00	0.29
K2O	0.00	0.01	0.03	0.04	0.00	0.05
MG'	82.4	90.3	96.0		15.2	87.5

MG'= Mg/(Mg+Fe), at.%.

Fig.1 Distribution of Mg in igneous object from from Severnyi Kolchim.

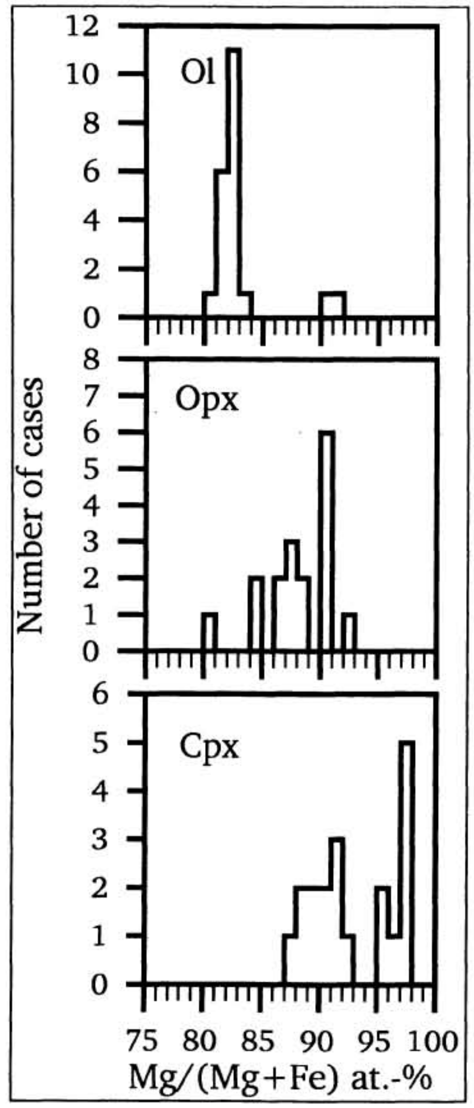

Fig.2 Mg/(Mg+Fe) ratios of olivines and pyroxenes from igneous object in Severnyi Kolchim.