ON THE ORIGIN OF THE CARBON-RICH AGGREGATES IN THE ORDINARY CHONDRITES:

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The isolated inclusions and clasts rich in carbon have been discovered in the unequilibrated ordinary chondrites and ordinary-chondrite regolith breccias [1,2]. The clasts are millimeter-sized objects with up to 13 wt.% C, where carbon-rich matrix predominates in the interstices (15-35 vol%) between chondrules and chondrule fragments. It also fills fissures at the edge of chondrules, and a number of heterogeneous olivines and pyroxenes are enclosed by carbon-rich aggregates [2]. It was concluded that the clasts are presenting a new kind of type 3 chondrite. Carbon-rich matrix with chondrules, Fe,Ni-metal and Huss-matrix are considered as main components of unequilibrated ordinary chondrites. The isolated inclusions vary in size from dozens of micron to millimeters and are composed by submicron-micron sized grains. It is supposed the inclusions have been formed from clasts [1,2]. The first investigations of the mineralogy of these aggregates showed the main minerals to be graphite and magnetite, and in some clasts (from Semarkona, Ngawi, Allan Hills A77278)- carbides, magnetite and metal [1-3]. However, more detailed studies [4,5] allowed to establish that in the "graphite-magnetite" aggregates the graphitic phase is highly disordered (poorly graphitized carbon) and enriched in Fe or associated with Fe,Ni-metal in the examined aggregates. Small amounts of magnetite, troilite, pentlandite and chromite are also observed.

Ne-E was also found in the acid-resistant residues (rich ih carbon) from Dimmitt, and it was proposed an interstellar origin of the "graphite-magnetite" aggregates [6]. However,this suggestion was not confirmed by more detailed research on isotopic composition of the rare gases [4,7]. The carbon-reach aggregates were believed to be formed by low temperature oxidation of the Fe,Ni-metal with the gas phase of the preplanetary nebula (PPN) [1,2].

In the present work we attempted to simulate the interaction of Fe,Ni-metal with the PPN gases taking into account the thermodynamics and kinetics of the reactions. The Fe-Cr-H-O-C-N-S multisystem with 19 solids and 11 gases was considered. The calculations of the equilibrium composition of solids and gases were carried out by the Gibbs energy minimization method. The programme allows to calculate the mineral composition (vol%) and composition of the gas phase. The results of the simulation with the solar system abundances of H, O, C, N, S, Fe and Cr [8] and with the abundances from the mean bulk composition of the carbon-rich matrix of the clasts PV1 and DT1 [2] are shown in the table 1 and 2, respectively. The pressure in the PPN was assumed to be 0.0001 bar. One can see from the table 1 that the first mineral formed by interaction of the Fe,Ni-metal with the PPN gases are troilite. It condenses at T=680K followed by the formation of chromite and magnetite at lower temperatutes ($T < 400K$). When $C/O > 1$ elemental carbon is stable in the wide range of temperatures. Low abundances of troilite in the carbon-reach aggregates could be assumed to result from the low rates of the sulphurization of metal. We have estimated the rate of the reaction and it was concluded that there are no kinetic constraints on this process. It can be seen from the table 2 the calculated composition of solid phases is near to the assemblages observed in the matrices of the clasts PV1 and DT1 (see [4,5]). However, it seems that the variations in the chemical composition and mineralogy of the clasts (not only between various meteorites, but in one meteorite also) [2,4,5] cannot be explained by the reactions of Fe,Ni-metal and C-bearing gases in the PPN. These differences reguire a wide range Fe:C:O:H ratios in the PPN region where the ordinary chondrites were formed. It is interesting to simulate the interaction of Fe,Ni-metal and the PPN gases in the system opened in respect of C-bearing gases and to take into account kinetic constraint on the hydrogenation of CO in the PPN [9,10]. In this case CO and CO_2 concentration higher than equilibrium values may be expected and more effective carbonisation of metal would take place in the various parts of the nebula with the different ratios Fe:C:O:H. However, it seems more plausible that the carbon-reach clasts were formed in the parent bodies of the chondrites. Carbon monoxide released from the chondritic matterial (e.g. organic matter) due to heating caused by shock events (most of the meteorites with carbon-reach inclusions and clasts are either regolith breccias or shocked chondrites) can react with metal and troilite and transport Fe,Ni in the form of carbonyls. The decomposition of carbonyls followed by the interaction of metal and CO can result in carbon, oxides and carbides by the reactions: $15Fe + 4CO = Fe_3O_4 + 4Fe_3C$;

$3Fe + 4CO = Fe_3O_4 + C$; $3Fe + 2CO = Fe_3C + CO_2$; $2CO = C + CO_2$

The relation of the clasts with organic matter were also assumed by [5].

TABLE 1

T,K solids	1000	900	800	700	600	500	400	300
Fe	97.049	97.049	97.049	97.049	30.123	22.676	21.795	
Cr_2O_3	2.952	2.951	2.951	2.951	1.724	1.588		
FeS					68.153	75.736	76.031	61.452
$FeCr_2O_4$							2.174	1.757
Fe_3O_4								36.791

TABLE 2

C	95.081		91.352	91.358	91.359	91.359	91.339	91.204
FeS	0.431		0.399	0.399	0.399	0.399	0.262	
Fe	4.064							
Cr_2O_3	0.423		0.392	0.391	0.391	0.391	0.391	0.390
Fe_3O_4			7.857	7.852	7.851	7.851	8.008	
Fe_2O_3								8.146
FeS_2								0.261
C	80.566		70.829	70.853	70.857	70.858	70.841	70.661
FeS	1.329		0.997	0.997	0.996	0.996		
Fe	17.845							
Cr_2O_3	0.261		0.196	0.196	0.196	0.196	0.195	0.192
Fe_3O_4			27.978	27.955	27.951	27.950	28.311	
Fe_2O_3								28.503
FeS_2							0.653	0.644

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