Chromite-troilite distribution of Fe and Cr in highly shocked chondrite Novosibirsk (H 4-5)

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High shock is well known to result in redistribution of some elements among coexisting minerals. In that relation the most expressible element is Cr having high concentrational gradients between chromite and other minerals that favours redistribution. Since Cr is ordinary element determined under silicate annalyses its zonal distribution in silicates of highly shocked chondrites is well known.

Distribution of chromium between chromite and opaque minerals of chondrites is poorly known since Cr isn't usually determined under their analysis. It is known only scrappy data on Tsarev [1] and Preobrazhenka [2] chondrites, troilite of which contains up to some tenths of percent of Cr.

Recently under investigation of Novosibirsk (H 4-5) chondrite we have also found elevated Cr contents in some grains [3]. Among 13 grains analyzed 5 grains have elevated Cr contents (.14 - .20 wt.%) and 8 ones - normal low content (up to 0.09 wt.%). Mineralogical observations indicate that all the grains with elevated Cr content are in contact with chromite whereas the grains with normal Cr content haven't such a contact. It is appear the source of Cr supplied in the troilite was chromite. If it is so, the exchange reaction of Cr and, probably, Fe between chromite and troilite would take place. Under troilite - kamacite buffer Cr is probably divalent and may be dissolved in troilite in form of CrS. But in this case Cr^{3+} transferring from chromite to troilite must be reduced to divalent and may be an oxidant. Reducing agent may be ion Fe^{2+} which will be oxidized to Fe^{3+} entering in chromite. If this suggestion is true diffusional exchange of cations would result in Fe^{3+} zoning in chromite.

In the Novosibirsk meteorite 20 grains of chromite were analyzed and half of these was checked for chemical zoning. Among 31 analyses nine contain no calcculated Fe^{3+}. Six Fe(3+)-less analyses represent cores of large (some hundreds of um) grains, 1 - rim of large grain enclosed in metal and 2 - relatively small (some tens of um) grains. One of the grains demonstrates clear Fe^{3+} zoning: enriched in Fe^{3+} edge (0.035 f.u.) - intermediate low Fe^{3+} composition (0.007) - Fe(3+)-less core. The highest Fe^{3+} contents are observed at the edges of large grains and in the small grains.

Assuming exchange reaction between troilite and chromite an equation of this reaction may be written as:

$FeCr_2O_4$(chr) + 2 FeS(trl) = 2 CrS(ss in trl) + $FeFe_2O_4$(ss in chr)

Equilibrium constant of this reaction is :

$$K(T) = \left(X^{trl}_{CrS} \cdot \gamma^{trl}_{CrS}\right)^2 \cdot X^{Chr}_{FeFe_2O_4} \cdot \gamma^{chr}_{FeFe_2O_4} \Big/ \left(X^{trl}_{FeS} \cdot \gamma^{trl}_{FeS}\right)^2 \cdot X^{chr}_{FeCr_2O_4} \cdot \gamma^{chr}_{FeCr_2O_4}$$

Assuming activity coefficients of CrS and FeS in troilite and $FeCr_2O_4$ and $FeFe_2O_4$ in chromite are equal the equilibrium con-

FE-CR DISTRIBUTION BETWEEN CHROMITE AND TROILITE: PETAEV M.I.

stant may be written as:

$$K(T) = (Cr^{2+}/Fe^{2+})^2_{trl} * (Fe^{3+}/Cr^{3+})_{chr}.$$

Numerical values of the constant at various temperatures have been calculated based on thermodynamical properties of reacting minerals [4,5]. Results are presented at Fig.1 along with data on 5 pairs of coexisting troilite and chromite. As Fig.1 shows the equilibrium temperatures are in the range of 1500 - 1670 K. It is important that under equilibrium the Cr content in troilite will decrease with temperature decreasing. Therefore, under slow cooling troilite must content no Cr as it is observed in equilibrated ordinary chondrites. This, in turs, means that elevated Cr content in troilite represents a "frosen" high-temperature equilibrium between chromite and molten troilite as indicated by estimated temperatures. Such a conclusion is in good agreement with mineralogical observations [3] suggesting fast cooling of meteorite matter at high temperatures.

The temperatures estimated based on Cr distribution between chromite and troilite are significantly higher than ones estimated based on other thermometers: 1200 K (olivine - chromite), 890 (orthopyroxene - chromite) and 1100 (metal - troilite) [3]. This disagreement in temperatures may be partly resulted from large uncertainty of estimation which under activity ratio of 10 is about 150 K in the temperature range of 1300 - 1700 K. But and in this case "chromite-troilite" temperature is significantly higher than other estimated temperatures and consistent with silicate melting observed in the meteorite. It is probable that "frosen" equilibrium distribution of Cr between troilite and chromite is an indicator of high postshock temperatures for fast cooled chondrites.

References: [1] Migdisova L.F. et al. Meteoritika, 1982, No 41, 13-30 (in Russian). [2] Migdisova L.F. et al. Meteoritika, 1988, No 47, 32-43 (in Russian). [3] Petaev M.I. et al. Meteoritika, 1990, in press (in Russian). [4] Pankratz L.B. U.S. Bur. Mines Bul., 1982, No 672. [5] Petaev M.I., Khodakovsky I.L. In: Adv. Phys. Geochem., 1986, V. 6, 101-135.

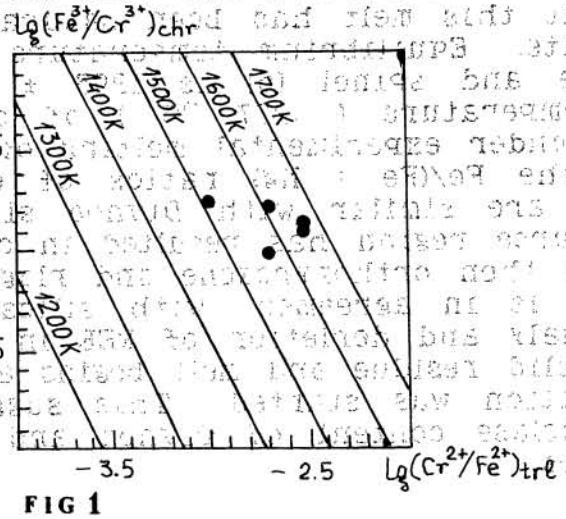

FIG 1