THE EVIDENCE OF MULTISTAGE ORIGIN OF THE FINE-GRAINED REFRACTORY INCLUSIONS IN THE CARBONACEOUS CHONDRITES.

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Results of studying 38 fine-grained refractory inclusions suggest that they formed by condensation from the gas which had different degree of depletion in ultrarefractory elements. Textural relationships of objects indicate that they underwent through the stages of melting and recrystallization. The two-stage model of FGIs and AOAs formation were proposed.

The fine-grained refractory inclusions (FGIs) in carbonaceous chondrites consist of relatively small mineral phases (commonly less 3-5 um) and have specific texture (Fig. 1), which looks like the aggregate of numerous concentrically-zoned microbodies. Amoeboid olivine aggregates (AOAs) and FGIs have the similar textural features but they have different mineralogical and chemical compositions.

We studied 38 FGIs and AOAs in Efremovka, Allende (both CV3), PCA-91082 and Kaidun (both CR) by scanning electron microscopy with EDS. They were divided into 6 groups for FGIs and 2 groups for AOAs on the ground of chemical and mineralogical composition. Also were discovered 7 nodules. Several minerals (pyroxene - Ti-Al-diopside and fassaite, spinel, melilite, anorthite, olivine, hibonite, feldspatoids, perovskite, ilmenite, andradite) were studied in the fine-grained objects.

The bulk composition of the individual objects (and they groups) satisfactorily follows to the condensation or volatilization trends (Fig. 2), however the enrichment of the most FGIs by the light isotopes of Mg and Si [1] shows what the role of the volatilization in the origin of these objects was very small. We used thermodynamic calculations of equilibrium condensation from [2] and our calculations using the program PHEQ [3] and volatilization trends from [4]. Condensation trends for the system which were depleted in ultra-refractory components (88 % Al were removed from the system of solar composition) most satisfactorily describe AOAs bulk compositions. The correctness of the such model was caused with character of REE spectrums for most AOAs (group II, [5]) and with depletion of the most AOAs in refractory major elements (Ca, Al, Ti). Such depletion in ultra-refractory components can be realized by formation from gas in which early condensation products were removed from the system.

Zoning structure of studying inclusions usually comply with the model of partly melting and volatilization of the outer layers of the objects.

Textural relationships of the minerals in microbodies of FGIs and AOAs clearly indicate to non-possibility of their formation in the condensation process, because sequence of mineral formation in the process of equilibrium condensation (melilite-spinel-pyroxene-anorthite at pressure 10^{-3}-10^{-5} bar) is not coincide with observed relationship (spinel-melilite-anorthite-pyroxene for FGIs (Fig. 3) and olivine-anorthite-pyroxene for AOAs). Our data suggested that in the most cases the sequences of mineral formation are very similar to the predicted by melting model; most of FGIs compounds situated in spinel field in the CaO-MgO-Al_2O_3-SiO_2 system and AOAs - in forsterite field.

We consider that microbodies of fine-grained objects were formed independently by the condensation process, later were melted in local thermal event and recrystallized.

The processes of secondary metasomatic alteration of inclusions took place more later, and for our meteoritic collection, is observed the different degree of secondary alteration. This process probably took place both in the solar nebula and in meteorites parents bodies.

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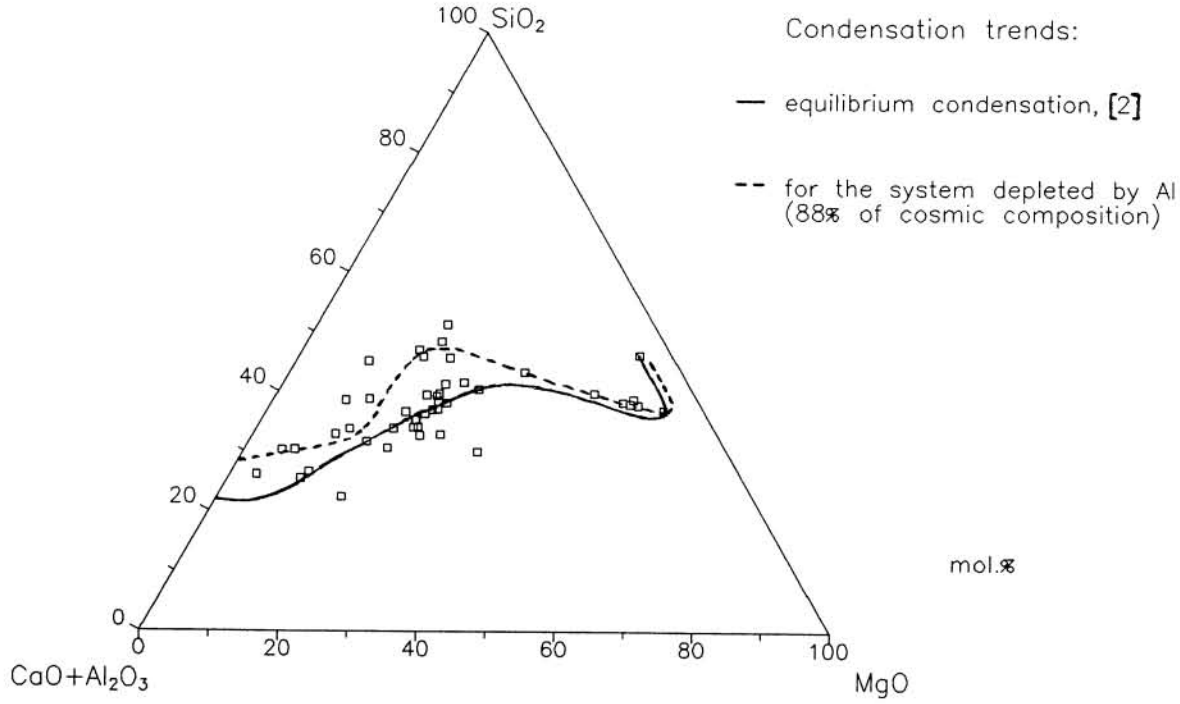

Fig 2. Bulk composition of the fine-grained objects with condensation trends.

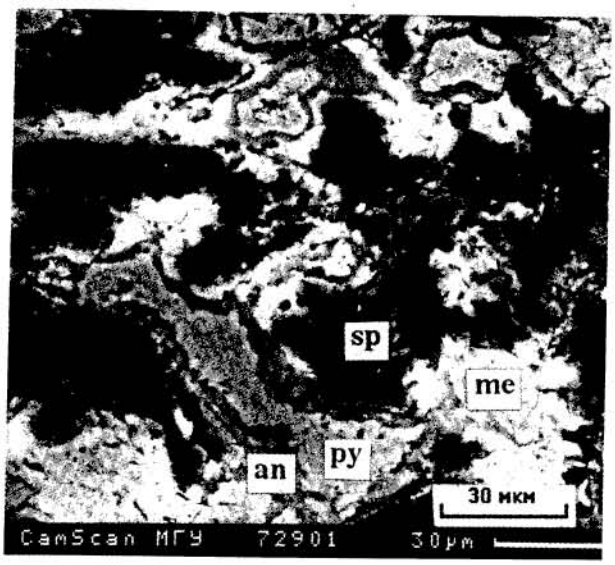

Fig. 3. Textural relationships of minerals in FGI E63A.

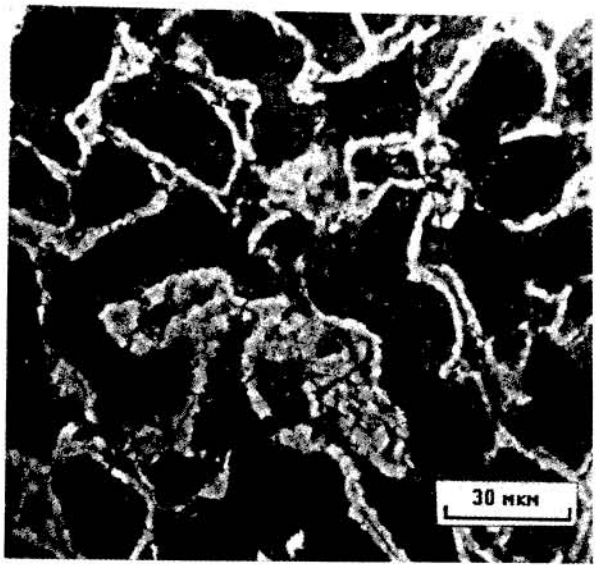

Fig. 1. Compound texture of FGI.