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MODELS OF H CHONDRITES GENESIS AND EVOLUTION: NEW FINDINGS

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INTRODUCTION:

Markovka chondrite (H4) under investigation was a small fragment 1·2·5 cm — part of the large meteorite fall at 1967 near Markovka village, east Siberia. It was stone rain of fragmented chondrite body with the size ca. 1 m as whole. Relative fresh and unweathered sample allows us to collect detailed Raman spectra of mineral phases with Witec Alpha 300 System, DLR. The resulting chemical composition of the main minerals (olivine, pyroxenes, plagioclases etc.) was refined by the SEM-EDX method, Dept. Chemistry, Moscow State University. Also, the presence of numerous FeNi grains allowed for metallographic analysis of nickel diffusion across the grain boundary. As is well known [1], the rate of diffusion of nickel is determined by the temperature of the environment and due to the concentration' gradient the cooling history could be confidently estimated.

The basic model of H parent body assumes an onion-shells structure, where H6 corresponds "core", H5 — "low mantle", H4 — "upper mantle" and H3 — "outer crust" [2]. Generally, it reflects a negative correlation between the petrologic type and the cooling rate, that is, the deeper the layer, the slower it cools. But, there are a number of exceptions where positive correlation is present. For some cases, two stage (with impact excavation) cooling model provides T – t path consisted with Hf – W age of peak metamorphism and constraints imposed by the Pb–Pb ages of the phosphates and Ar – Ar ages of the feldspars vs. their respective closure temperatures [3]. Also, alternative model was developed in which maximum metamorphic temperatures are reached in km-sized planetesimals and slow cooling through 700 K occurs in larger bodies that accreted from these planetesimals [4].

Using new findings at Markovka' mineralogical composition we will try to remove some of the contradictions between different models of H chondrites' parent bodies.

COMPOSITION:

Raman spectra of Markovka contain lines as of main silicate groups (olivine, pyroxene, etc.) as Fe-oxides (maghemite, goethite, etc.) presented on Figure 1. Measurements of the characteristic line shift provide important information concerning chemical content and deformation state of the chondrite' rocks [5].

Olivine shows its characteristic doublet peak (DB) between 818–825 1/cm (DB1) and 847–856 1/cm (DB2). Its exact position depends on Fe–Mg concentrations vary primarily as a function of Mg/(Mg + Fe) and may be used to estimate the Fo content of the olivine. A tighter correlation was found between the DB2 peak positions Fo values for magnesian olivine

(Fo > 50), which provides Markovka' olivine composition as $Fo_{80}Fa_{20}$ From another side, the structural difference of ortho- and clinopyroxene results in a doublet for orthopyroxene between 660–680 1/cm and a weak peak at approximately 235 1/cm, where clinopyroxene shows only a single peak and no peak around 235 1/cm, respectively. So, Raman spectra of Markovka' pyroxene with peaks at 1008, 336, 232 1/cm and double peak at 680 1/cm provides clear indication of transition from low–Ca pyroxene to orthopyroxene with composition as $En_{80}Fs_{20}$. The similar Mg/Fe content of the above silicates indicates the thermal equilibration.

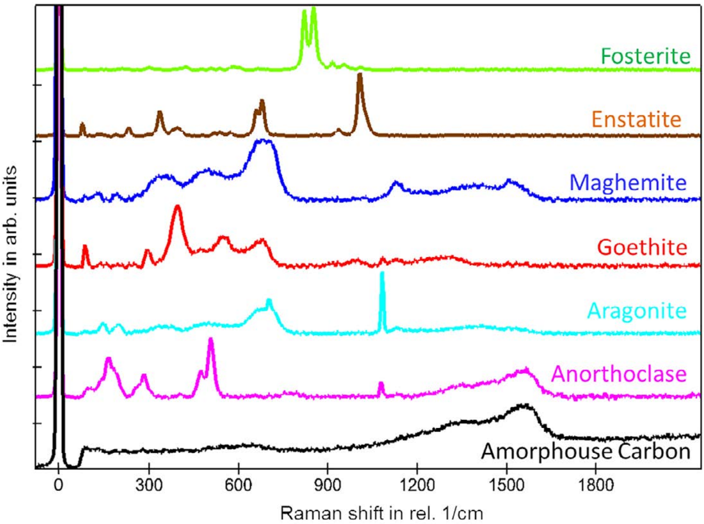

Fig. 1. Raman spectra of mineral phases of Markovka (H4) meteorite

Carbonates ($CaCO_3$) mineral' polymorphs could be identified using the positions of some of their minor Raman bands: calcite has bands at 282 and 713 1/cm and aragonite has minor bands at 207 and 704 1 / cm, respectively [6]. Markovka's spectra has characteristic peaks at 703 and 196 1/cm which indicates aragonite presence. It is high-pressure polymorph of calcite and, according its phase diagram (Figure 2), is stable starting 3 kbar, only.

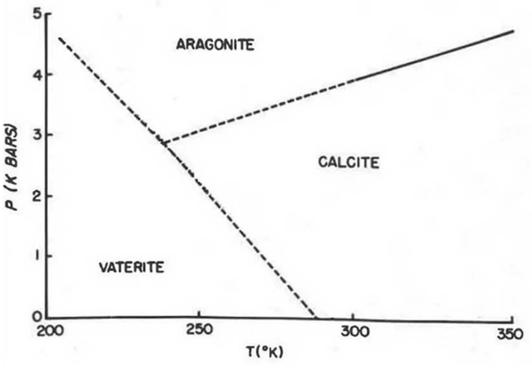

Fig. 2. Phase diagram Calcite-Aragonite-Vaterite

RESULTS AND DISCUSSION:

Aragonite presence could be explained twofold. First, huge size of the Markovka' parent body. With mean density of chondrites as 3–4 g·cm^{-3}, needed pressure as 3 kbar is possible for body with radius ca. 400 km. Current accretion models suppose quite short time interval of ca. 1–2 Mio. years (since CAI formation) and planetesimals with limited size ca. 50–200 km (in radius). Second, aragonite could be precipitated from a saturated solution under certain conditions. The Mg:Ca ratio at which the calcium carbonate mineral that has pseudohomogeneously precipitated from seawater changes from calcite to aragonite was experimentally determined as a function of temperature. Results indicate a dramatic change in the critical Mg:Ca ratio over a relatively small temperature range. So, Markovka provides new constraints on evolution processes at the early Solar system and worth for the further detailed mineralogical and geochemical analysis.

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