HIGHLY POROUS AGGREGATES WITHIN THE SARATOV (L4) AND GALKIV (H4) CHONDRITES

A. L. Girich and V. P. Semenenko. Institute of Environmental Geochemistry NAS of Ukraine, Palladina 34a, Kyiv-142, 03180 Ukraine

Three highly porous (HP) silicate fragments were found in the chondrite Saratov [1, 2]. An additional search showed that HP aggregates are common in the unequilibrated chondrites Saratov and Galkiv [3].

Here we present mineralogical data for two HP aggregates from Galkiv and four from Saratov. They are arranged within a matrix of the chondrites and vary in size from 0.4 × 0.7 mm to 3.0 × 4.3 mm. One of them is surrounded by a fine-grained, dense silicate rim. The rest show diffusional boundaries with the matrix. Mineralogically, the aggregates resemble each other and differ from a host of the chondrites by unusually high porosity (up to 65 vol%), uniform fine-grained texture, and a very low content of metal and troilite. In contrast to the HP aggregates from Galkiv, those in Saratov contain rare porphyritic chondrules and their clasts.

A scanning electron microscopy study displays that HP material is composed of a friable aggregate of rounded and anhedral silicate grains and euhedral crystals of submicron and micron sizes.

The major mineral phases for HP aggregates from both Galkiv and Saratov are olivine ($Fa_{17.1–18.2}$ and $Fa_{22.2–26.3}$, respectively) and Ca-poor pyroxene ($Fs_{14.5–17.6}En_{77.8–83.4}Wo_{0.4–7.7}$ and $Fs_{6.8–22.8}En_{76.8–92.9}Wo_{0.2–2.8}$, respectively). The minor are Ca-rich pyroxene ($Fs_{4.9}En_{47.9}Wo_{47.2}$ and $Fs_{4.3–17.6}En_{53.0–73.2}Wo_{9.3–40.7}$, respectively) and feldspar ($Ab_{43.2}An_{56.3}Or_{0.5}$ from Saratov). Rare phases are Fe-Ni-metal (33.3–44.6 wt% Ni and 0.15–0.34 Co in taenite and 3.82–5.3 wt% Ni and 0.74–1.15 Co in kamacite from Saratov), troilite, merrilite (45.8–46.9 wt% CaO; 42.6–48.4 P_2O_5; 3.42–3.62 MgO; 2.49–2.81 Na_2O; 0.54–1.61 FeO and 45.9–47.0 wt% CaO; 42.5–45.4 P_2O_5; 3.22–4.39 MgO; 2.56–2.74 Na_2O; 1.21–1.4 FeO, respectively), and chromite (59.0–61.8 wt% Cr_2O_3; 27.7–28.4 FeO; 5.35–5.43 Al_2O_3; 2.55–2.76 MgO; 1.1–1.54 TiO_2; 0.85–0.89 V_2O_3 and 59.4–61.9 wt% Cr_2O_3; 29.1–30.3 FeO; 3.53–3.99 Al_2O_3; 1.36–1.6 MgO; 0.89–1.85 TiO_2; 0.5–0.66 V_2O_3, respectively). Single spinel grains and copper inclusions in taenite grain were found in the largest HP aggregate from Saratov. On the whole, a compositional variation of the minerals within HP aggregates is identical with those within the chondrites host.

The HP aggregates and the chondrites host are characterized by the same grade of metamorphic processing, which testifies to their metamorphism in situ during or after accretion of the chondrites parent body.

Conclusions: The porosity, structure, and mineralogical composition of the HP aggregates are similar to those of some particles of interplanetary dust [4] and, to a lesser extent, to the lunar breccias and agglutinates [5]. This allows us to suppose a similar accretional mechanism for friable aggregates from the chondrites and interplanetary dust. Some of the HP aggregates collected a fine-grained dust that resulted in formation of a dense silicate rim. The HP aggregates, as separate highly porous bodies or their fragments, were subsequently mixed together with typical unequilibrated ordinary chondrite material. All these constituents accreted to form the meteoritic parent body.

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REE GEOCHEMISTRY OF PALLASITE PHOSPHATES

Weibiao Hsu. Purple Mountain Observatory, Nanjing 210008, China. E-mail: bxu@pmo.ac.cn

Introduction: Previous studies revealed that pallasite phosphates exhibit distinct REE patterns with highly variable abundances [1, 2]. Interpretations for this diversity include REE equilibrium partitioning between olivine and phosphates under subsolidus conditions, crystallization of phosphates from interstitial residue melts, and the late-stage products during crystallization [1]. Here, we report an ion probe study of REE distributions in phosphates from Albin, Eagle Station, Imilac, and Springwater with a goal to better understand the process(es) that led to the formation of pallasites.

Results: In Albin, we found four whitlockite grains, ranging from 100 to 500 µm. One whitlockite grain and eight stanfieldite grains were found in Eagle Station; they are generally small (30 to 100 µm) and in irregular shapes. Three whitlockite grains (200 to 500 µm) found in Imilac are extensively fractured with numerous iron oxide veins. Springwater farringtonite is relatively large (up to 1.5 mm). The round boundary of farringtonite grains indicates that this mineral was initially present as molten droplets. Phosphates tend to occur interstitially between olivine and metal.

The four whitlockite grains in Albin have essentially the same REE pattern that is highly enriched in Sm, Eu, and HREEs (~50 × CI), but relatively depleted in La to Nd (~1 × CI). In Eagle Station, the whitlockite grain has a flat LREE with depleted abundances (~0.1 × CI), a large positive Eu anomaly, and a sharp increase from Gd (0.1 × CI) to Lu (70 × CI). The other five stanfieldite grains analyzed have a similar REE pattern to that of whitlockite but with much lower REE abundances by a factor of 10–100. Whitlockite in Imilac is enriched in HREEs (10 to 80 × CI) and relatively depleted in LREEs (0.1 to 1 × CI). Springwater farringtonite grains have relatively low REEs (0.001 to 1 × CI) with a highly fractionated HREE-enriched pattern (CI-normalized Lu/La ~100). Although the phosphates among the pallasites studied display distinct REE abundances and patterns, they tend to have the same REE pattern within a given meteorite. REEs are homogeneous in a given grain but vary significantly from grain to grain by a factor of up to 100.

Discussions: Pallasite olivine commonly displays minor element zoning (e.g., Ca, Ti) [3]. This indicates that minor elements such as Ca did not fully equilibrate between olivine and phosphates under subsolidus conditions. REEs are expected to have much lower diffusion rates than Ca in olivine. Thus, equilibrium partitioning of REEs between olivine and phosphates under these conditions may be ruled out to account for the HREE-enriched pattern observed in pallasite phosphates. It is also hard to see any igneous processes which could have fractionated REEs in the phosphates.

The metallic phase of pallasites is chemically related to IIIAB irons. That pallasites might have formed through mixing of IIIAB-like molten metal with an olivine layer has even been suggested [4]. IIIAB irons usually contain small amounts of phosphates [5]. Therefore, it is possible that pallasite phosphates were incorporated into pallasites from IIIAB-like molten metal during mixing with an olivine layer. Once mixed, phosphate grains remained isolated from one another during the subsequent rapid cooling period. Each phosphate grain would have distinctive REE abundances and patterns which reflect characteristics of a previous history.

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