FLUID PRECIPITATION OF CHROMITE AND FELDSPAR-RICH GLASS IN MARTIAN ORTHOPYROXENITE ALH84001.

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Introduction. ALH84001 is a cumulate orthopyroxenite of martian origin [1], which shows abundant evidence for fluid activities [1-5]. Trace element abundances in the bulk rock [6], apatite, and carbonates [7] strongly support that view. Textural relationships [5] and magnetite morphologies [8] additionally suggest that beside carbonates, glass, and phosphates also chromite and silica, and a variety of minor phases associated with them, precipitated from fluids. Trace element abundances have been determined so far in orthopyroxene [9], apatite, feldspar-rich glass, and carbonates [7]. Here we report on trace element abundances in feldspar-rich glasses and in chromites.

Methods. We have studied polished thin section ALH84001,141 by optical microscopy, analytical scanning electron microscopy, electron probe microanalysis, and ion microprobe analysis, following standard procedures.

Results. ALH84001 is an orthopyroxenite breccia rich in minor constituents and accessories, such as chromite, feldspar-rich glass, augite, olivine, Ca-phosphate, carbonate, a silica phase, Fe-sulfides, and Fe-sulfate. Chromite is present in three different sizes (Figs. 1, 2). Large grains (up to 0.5 mm in size) are equidimensional, birefringent, occur within and in between orthopyroxenes, and are usually accompanied by aggregates of smaller chromites (up to about 50 µm in size) and by feldspar-rich glass. The smaller chromites fill also veins (Fig. 1), where they are associated with feldspar-rich glass and Fe-sulfides (pyrrhotite and pyrite). Chromite contains 5.5 wt.% of Fe_2O_3 (the cause of its birefringence [10]), is rich in TiO_2 (2.2 %) and Al_2O_3 (8 %), has 28.3 % FeO and 0.28 % MnO, and has *mg* = 0.19. It is rich in Li, V, Co, and Nb, and has surprisingly high contents of the REEs (Fig. 3).

Feldspar-rich glass is commonly associated with chromites but also fills veins and pockets. An angular pocket (40x90 µm) within a large orthopyroxene grain (Fig. 2) consists mainly of feldspar-rich glass and silica with minor olivine, enveloped by feldspar, and Ca-phosphate. Glass has a feldspar-like composition, mostly poor in K and non-stoichiometric, but can be K-rich in places. Trace element contents (Fig. 4) are correlated with the K content and show a feldspar-like pattern in the K-poor glass and a REE-rich and LREE-enriched pattern in the K-rich glass. All glasses are rich in Be, Sr, Ba, LREEs, and Eu. The K-rich one is also rich in Th.

Discussion. The chemical composition and trace element content of chromite and feldspar-like glass from orthopyroxenite ALH84001 support previous suggestions that fluids are probably responsible for the formation of maskelynite, apatite, and carbonate [6, 7], as well as chromite [5] and most accessories associated with these phases [8].

Trace element abundances in chromites are very high by terrestrial standards (compare [11]). The REEs, when present above the detection limit have a peculiar pattern (Fig. 3), with HREEs below detection limit (judged from the Y content, they have abundances close to 0.01xCI), and the LREEs beeing enriched with respect to the HREEs, and possibly fractionated. As not all chromites do have this pattern, we suspect that a LREE-rich phase could be present as tiny inclusions. Either version, whether the REEs reside in the chromite or in a separate phase, is in favor of a fluid phase formation because a primitive melt is not likely to contain incompatible elements at the oversaturation level, and the spinel-liquid partition coefficients do not allow the chromite to accept LREEs at the level observed [12]. The high Sc content of the chromite also appears to be at odds with known mineral-liquid distribution coefficients, which are very low for spinel and > 1 for pyroxene [12], and yet it is about 0.4 times that of the bulk. Terrestrial spinels in equilibrium with pyroxenes with comparable trace element contents have much lower Sc contents (about 0.05xSc-opx, [11]).

The trace element contents of the glasses are also very high (Fig. 4). The K-poor glass has a trace element pattern which approximately follows the plagioclase-liquid distribution coefficients [13], but is very rich in LREE, indicating a fluid strongly enriched in highly incompatible elements. Such a compositional signature is also preserved in the K-rich glass which is very rich not only in LREEs, Be, Sr, and Ba, but also in Th.

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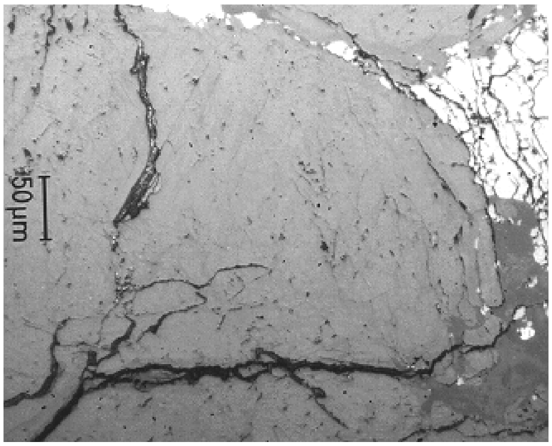

Figure 1: Portion of a large chromite (light grey) surrounded by granular chromite aggregates and feldspar-like glass (dark grey) in orthopyroxene. Note vein filled by chromite and glass. Optical micrograph, reflected light.

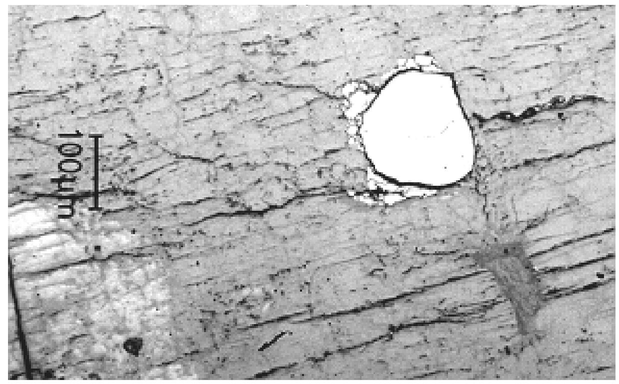

Figure 2: Large chromite and granular chromite (light grey) enclosed in orthopyroxene with adjacent angular pocket of feldspar-like glass (dark grey) which also contains K-rich glass and silica. Optical micrograph, reflected light.

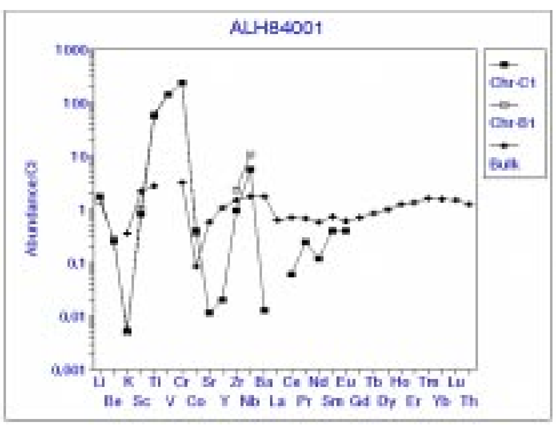

Figure 3: CI-normalized elemental abundances in large chromite (Fig. 2) compared to ALH84001 bulk composition [6].

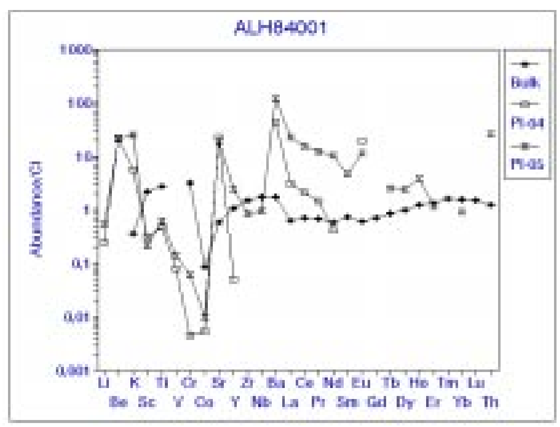

Figure 4: CI-normalized elemental abundances in a K-poor (Pl-4) and K-rich (Pl-5) glass compared to ALH84001 bulk composition [6].