OLIVINE INCLUSIONS IN THE FUKANG PALLASITE AND IMPLICATIONS FOR THE MAIN-GROUP PARENT BODY

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Introduction: Fukang is a Main-group pallasite that consists of semi-angular olivine grains (Fo 86.3) embedded in an Fe-Ni matrix with 9-10 wt. % Ni and low-Ir (45 ppb). Olivine grains sometimes occur in large clusters up to 11 cm across. The Fe-Ni phase is primarily kamacite with accessory taenite and plessite. Minor phases include schreibersite, chromite, merrillite, troilite, and low-Ca pyroxene.

We report the results of a study of the Fukang pallasite that includes measurements of bulk composition, mineral chemistry, mineral structure, and petrology. In particular, we focus on a variety of silicate inclusions enclosed in olivine that contain phases rarely or not previously reported in Main-group pallasites, including clinopyroxene (augite), tridymite, K-rich felsic glass, and an unknown Ca Cr-silicate.

Olivine Inclusions: Inclusions found in Fukang's olivine exhibit features that are rare in Main-group pallasites and preserve important information from the parent body. They include measurable amounts of clinopyroxene (augite), the presence of the silica phase tridymite, K-rich felsic glasses, and an unidentified Ca-Cr silicate. Below we highlight the implications from the presence of each of these inclusion phases:

1) Clinopyroxene (augite) in Main Group pallasites has not previously been observed. However, augite in the "pyroxene" pallasites has been analyzed by Boesenberg et al. (2000) and appears to be similar in composition to the augite in Fukang. Extremely uniform composition of both low-Ca pyroxene and augite in Fukang olivine inclusions suggests that the pyroxenes have equilibrated with each other, either during their formation or at a later time, and has enabled us to perform two-pyroxene thermobarometry.
2) Tridymite is an SiO_2 polymorph that crystalizes within a narrow range of low-pressure, high-temperature conditions. It can stably form at vacuum pressures and temperatures between 867 and 1470°C. Fukang was the first pallasite in which the presence of tridymite was reported (DellaGiustina 2011). It has also been reported in the Omolon pallasite by Lavrentjeva et al. (2012). Although tridymite can persist metastably at temperatures below its stability field, it cannot withstand pressures >0.4 GPa at any temperature, even for short durations. It is therefore widely recognized as a pressure indicator in terrestrial and planetary materials (Black 1954) and can be used to infer the range of pressures (shock or otherwise) experienced by Fukang.
3) K-rich felsic material is unusual in meteorites and has not been previously observed in other Main-group pallasites. The observation that K-rich felsic material co-exists with tridymite in many instances suggests that these assemblages are a trapped melt from a more evolved silicic magma and may reveal information about upper mantle regions in the pallasite parent body. These inclusions could have been overlooked in other pallasites, were rare and heterogeneously distributed, or in some cases were not trapped by them at all.
4) A Ca Cr-silicate phase that could not be identified as any known mineral phase, and may have also been observed in the Pavlodar pallasite Steele (1994).

Parent Body Size: Evidence indicates that Fukang originated deep in the interior of a differentiated parent body. Slow cooling rates inferred from the Widmanstätten pattern in the metal phase, and the lack of elemental zoning in olivine further support this conclusion. The morphology of olivine indicates that many grains formed in direct contact with one another to form nodules, most likely at the base of a magma chamber. This evidence supports formation at the core-mantle boundary of the Main-Group parent body.

Pressure constraints determined from two-pyroxene barometry of ortho- and clinpyroxene (0.39 ± 0.07 GPa), tridymite (< 0.4 GPa), and geophysical calculations that assume pallasite formation at the core-mantle boundary, provide an upper estimate on the size of the Main-group parent body from which Fukang originated. Using these constraints, we conclude that Fukang formed at the core-mantle boundary of a large differentiated planetesimal, up to 400-680 km in radius.

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