THERMOBAROMETRY OF MARTIAN NAKHLITES AND A LHERZOLITE - A COMPARISON

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Introduction:. Based on mineralogy and texture, Martian clinopyroxenites (nakhlites) and the lherzolitic ALH77005 are plutonic rocks from the interior of Mars. We have studied the thermal history, geothermobarometry and oxygen fugacity indicators of the nakhlites Nakhla, Lafayette, Y000593, NWA998 and the lherzolite ALH77005.

Thermometry: Minimum temperatures range from 1000 to 1150 °C for the cores of the large augites of all nakhlites studied, using the phase diagram of Lindsley [1]. Pyroxene thermometry for ALH77005 give significantly higher temperatures of up to as 1200 to 1300 °C. Both, the pyroxene cores in nakhlites and in ALH77005 are chemically homogeneous and must have cooled rapidly, as indicated by the lack of exsolution lamellae.

Oxygen fugacity: A new determination of the fO_2 of Lafayette, based on Fe-Ti-oxides, is with QFM 0.1 ± 0.6 in good agreement with earlier results on other nakhlites [2]. Estimates for ALH77005, based on Fe^{3+} in chromite [3], give a much lower fO_2 of QFM –3.3 ± 0.7 in agreement with results of Goodrich [4].

Barometry: Application of the single clinopyroxene barometer of Nimis [5] give a crystallization pressure of 1.2 – 2.4 ± 1.0 kbar for ALH77005 corresponding to a depth of ~ 18 km in Mars. The method is not applicable to nakhlites.

Discussion: The significantly higher fO_2 recorded by nakhlites when compared to ALH77005 is surprising. A possible explanation is extensive reaction of nakhlites with an oxidized crustal reservoir, a model suggested by Herd [6] to explain the large fO_2 variations among shergottites. The untypical high enrichment of light REE in nakhlites supports this model, at least qualitatively. In addition, evidence for reaction of nakhlite augites with an oxidized environment is provided by the microstructure of these meteorites. The FeO-rich rims in Nakhlite augites show extensive exsolutions [7], and with increasing FeO-content the width of the exsolution lamellae increase which is opposite to the trend expected from experimental data [8]. We concluded earlier that the nakhlites experienced a two stage evolution [7]. After formation and thermal equilibration of the augites above 1150 °C, the pyroxene crystals were rapidly transported to a location close to the surface of planet Mars, where they reacted with a highly oxidized melt or fluid enriched in light REE. Cooling of FeO-rich pyroxenes under these conditions may lead to the observed extensive exsolution phenomena.

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