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LOW-Ca PYROXENES IN THE NWA 998 NAKHLITE METEORITE: REACTIVE PRODUCTS OF OLIVINE-PLAGIOCLASE MINERAL ASSEMBLAGE.

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Introduction: NWA 998 is a unique nakhlite meteorite as it has the texture and mineralogy typical of terrestrial gabbro [1]. It is fully crystallized with abundant augite and olivine forming the framework of the rock and an inter-cumulus assemblage comprised of plagioclase and K-feldspar, low-Ca pyroxene, Ti-magnetite, Cl-apatite and Fe-sulfide [2].

Another characteristic of NWA 998 is the significant presence of low-Ca pyroxenes, most of which are in chemical and textural disequilibrium with the other igneous minerals [3]. The formation of low-Ca pyroxenes in some of the nakhlites is poorly understood but may contain a record of re-equilibration reactions in response to changing physico-chemical conditions during late and/or post igneous processes [4].

Methods: Polished surfaces of slices of NWA 998 were examined using a Carl Zeiss Sigma analytical SEM with Oxford microanalysis for back-scattered electron imaging, energy dispersive X-ray element mapping and quantitative mineral analysis.

Results and discussion: Petrographic observations provide evidence that low-Ca pyroxenes developed along olivine-plagioclase grain boundaries and have progressively intruded into olivine, plagioclase and adjacent augite. Remnants of both olivine and plagioclase and inclusions of apatite are commonplace within large (up to 100 μm long) low-Ca pyroxene grains. The crystallization of low-Ca pyroxene has locally erased the primary texture and structure of the rock. Their reactive textures reflect a return of mineralogical equilibrium from early stable mineral associations.

The low-Ca pyroxene crystals display compositional variations according to their petrological settings suggesting some degree of chemical interdependency between the reactant hosts and their associated products. The low-Ca pyroxenes topographically replacing olivine correspond to “pure” orthopyroxene (with or without vermicular magnetite), while those replacing plagioclase are pigeonite with augite lamellae.

Conclusions: The crystallization of low-Ca pyroxene resulted from mineralogical instability between the formerly juxtaposed olivine and plagioclase feldspar grains. This instability may have been caused by changes in temperature or oxygen fugacity (solid-state transformation) or because of the presence of a reactive silicate melt along grain boundaries. The residual melts in NWA 998 show enrichment trend towards more silica and alkali rich compositions, as underlined by the occurrence of both K-feldspar and “frozen” alkali-silica-rich material filling corner pores. Silicate melt droplets may have triggered the reactions, which need to be quantified through volume mass balance calculation. However, petrographic observations suggest that solid-state (sub-solidus) reactions have been the main mechanism for the development of low-Ca pyroxene within the reactive zone.

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