SHOCK-INDUCED MELT POCKET FORMATION IN NWA 4468: EVIDENCE FOR PHASE TRANSFORATION-INDUCED IMPLOSION

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Northwest Africa (NWA) 4468 is 675 g martian meteorite recovered from the Western Sahara in 2006 [1]. It is an olivine basaltic shergottite, comprising clinopyroxene, olivine, maskelynite, chromite, ilmenite, Ca-phosphates, troilite and pyrrhotite. There have been several studies of NWA 4468, including its geochronology, petrology and bulk composition, but aspects of its shock history are less well constrained. The meteorite exhibits both bulk (maskelynite formation) and localized shock effects, the latter in the form of shock veins and melt pockets that contain various high pressure and/or high temperature polymorphs, glasses and neocrystallites. This work presents new results following extensive melt pocket characterization based on analytical field emission scanning electron microscopy and micro-Raman spectroscopy. The melt pockets are typically 2-5 mm in diameter and sub-spherical. Three components are identified in the melt pockets: (1) fragmented/fractured mineral phases inherited from the bulk sample; (2) inherited mineral phases that have undergone solid-state phase transformation (e.g., olivine to ringwoodite), and (3) glasses and neocrystalline phases that originated via fusion. Metal phases (mainly Fe-Ti-Cr oxides) have undergone melting to yield disseminated clouds of immiscible spheres set within a silica-rich glass matrix. Three Ca-phosphate polymorphs have been recognized [2, 3]: α-, β- and γ- apatite (chlorapatite, merrilite and tuite, respectively), with their structures confirmed by Raman spectroscopy. Ca-hollandite and stishovite are also present. Evidence for a possible new high-pressure polymorph of low-Ca clinopyroxene is also presented and discussed. Ringwoodite is developed at the rim of the pockets, which, overall, suggest an increasing pressure gradient from periphery to core. Most if not all melt pockets are characterized by the presence of Ca-phosphate phases in their core regions. We propose that the relatively low pressure transformation of apatite to merrillite, which took place during the bulk shock event, may have provided the necessary energy for the thermal-pressure spike as a result of concomitant volume reduction and associated implosion.

References: [1] Irving A J. et al. 2007. LPSC XXXVIII, Abstr.# 1526. [2] Beck P. et al. 2007. GRL 34:L01203, doi:10.1029/2006GL028141. [3] Xie X. et al. 2002. Geochim. Cosmochim. Acta, 66:2439-2444.