UNIQUE ULTRAMAFIC SHERGOTTITE NORTHWEST AFRICA 4797: A HIGHLY SHOCKED MARTIAN WEHRLITE CUMULATE RELATED TO ENRICHED BASALTIC (NOT "LHERZOLITIC") SHERGOTTITES. A. J. Irving[1], T. E. Bunch[2], S. M. Kuehner[1], R. L. Korotev[3] and N. C. Classen [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195 (irving@ess.washington.edu), [2]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011, [3]Dept. of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130.

Discovery: A small (15.0 gram), partially fusion crusted stone found near Missour, Morocco is an unusual type of ultramafic shergottite with dramatic shock features (perhaps predating its ejection from Mars).

Figure 1: NWA 4797 stone showing fusion crust.

Petrology: This fresh specimen consists of peridotite transected by several shock injection veins (Figure 2). The primary lithology comprises olivine chadacrysts (up to 1.5 mm; $Fa_{31.3-32.7}$, FeO/MnO = 49.3-53.0) and clinopyroxene oikocrysts (up to 9 mm; zoned from subcalcic augite: $Fs_{14.6-16.0}Wo_{35.3-29.9}$, FeO/MnO = 23.8-26.2 to pigeonite: $Fs_{25.2-26.3}Wo_{14.8-7.9}$, FeO/MnO = 27.8-31.8) with interstitial regions (originally intercumulus) now consisting of vesicular glass (Figure 4a) containing sparse, tiny microlites of birefringent plagioclase ($An_{56.8}Or_{0.8}$). Accessory phases are titanian chromite, Mg-ilmenite (with tiny baddeleyite inclusions), merrillite and pyrrhotite. Maskelynite is absent.

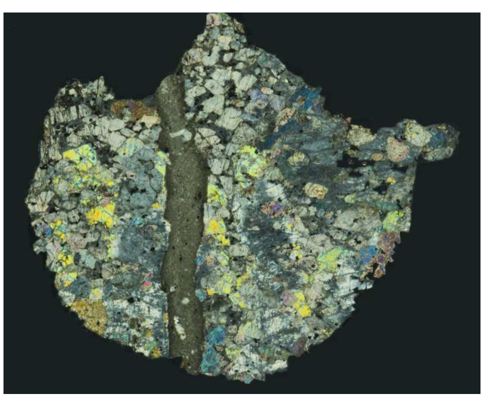

Figure 2: Cross-polarized optical thin section image showing coarse chromite wehrlite wallrock crosscut by shock injection vein. Rock area is 120 mm x 100 mm.

One shock injection vein (see Figure 3) contains reacted xenocrysts and polycrystalline fragments of the peridotite material enclosed in a vesicular aggregate of fine grained (5-10 microns) interlocking *phosphoran* olivine ($Fa_{23.7-28.7}$, FeO/MnO = 39.5-48.0, P_2O_5 = 0.28-0.46 wt.%), augite ($Fs_{14.3-16.3}Wo_{41.4-36.4}$, FeO/MnO = 24.7-26.7) and glass (average of 6 analyses, in wt.%: SiO_2 58.7, TiO_2 1.4, Al_2O_3 14.3, FeO 6.5, MnO 0.22, MgO 2.1, CaO 11.8, Na_2O 2.7, K_2O 0.12, P_2O_5 1.8, SO_3 0.17, Cl 0.05). Both margins of the vein exhibit even finer grained (< 2 microns), quenched selvedges against the peridotite wallrock (see Figure 4b).

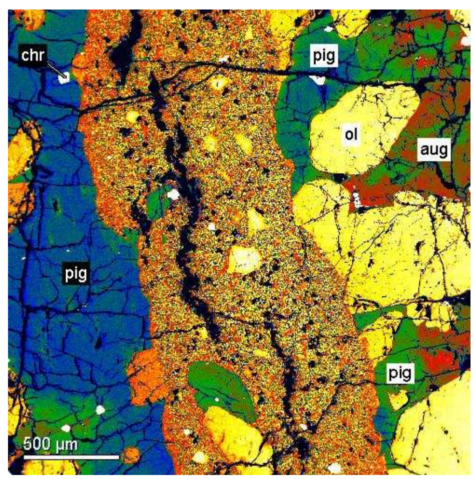

Figure 3: BSE image of shock vein cutting wehrlite. Note engulfed clasts and elongate vesicles in vein.

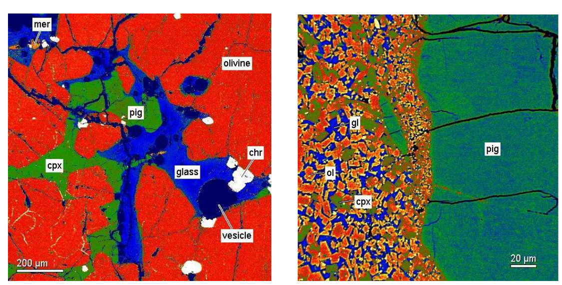

Figure 4a (left): Interstitial vesicular glass in wehrlite lithology; **Figure 4b (right):** Detail of selvedge of shock vein against pigeonite in wallrock wehrlite.

Chromite in interstitial melt pockets and chromite xenocrysts in the injection vein are partially replaced by fine polycrystalline eskolaite (with evidence of plastic flow), and ilmenite grains have irregular rutile rims. These effects in the primary oxide minerals are indicative of decomposition in a very high temperature melting event. Vesicles in shock veins appear to be empty, but some in interstitial glass in the wehrlite contain subhedral daughter crystals of pyrrhotite (see Figure 5).

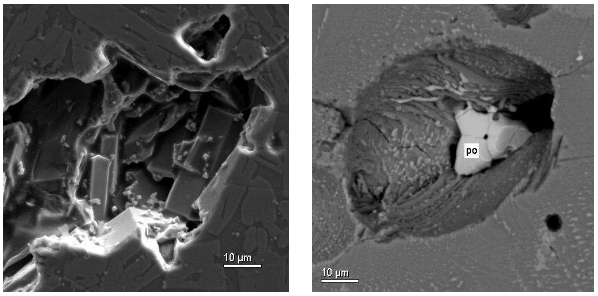

Figure 5: Scanning electron images of vesicles within shock vein (left) and within interstitial glass (right, with vapor-deposited(?) daughter crystal of pyrrhotite).

Bulk Composition: Three 30 mg aliquots of coarsely ground material (clean fusion crust plus portions of attached peridotite) were analyzed by INAA. The mean composition is: (in wt.%) FeO 19.6, Na_2O 0.40; (in ppm) Cr 6620, Ni 330, Sc 26.3, La 0.69, Sm 0.52, Eu 0.18, Tb 0.19, Yb 0.57, Lu 0.080, Hf 0.55, Th 0.10. The chondrite-normalized rare earth element pattern is subparallel to that for "enriched" basaltic shergottites, but at one third to half of the absolute abundances, and there is a small negative Eu anomaly.

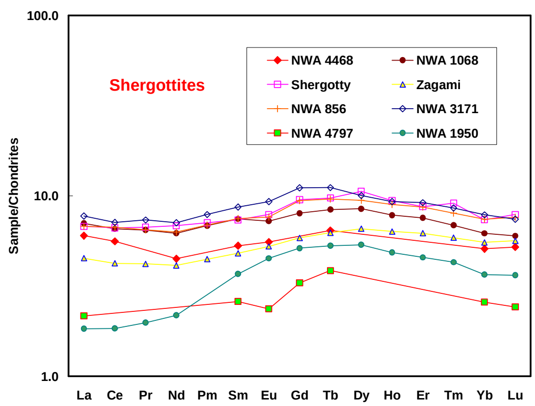

Figure 6: Chondrite-normalized REE abundances of NWA 4797 compared with abundances for "enriched" basaltic shergottites [1] and "lherzolitic" shergottite NWA 1950 [2].

Igneous Petrogenesis: The peridotite lithology in NWA 4797 differs from so called "lherzolitic" shergottites in several ways. It does share a poikilitic texture, with olivine and chromite enclosed by clinopyroxene oikocrysts. However, there is no primary plagioclase, although it likely was present as an intercumulus phase before the shock melting event that produced the interstitial vesicular glass. Compositionally NWA 4797 is quite distinct from "lherzolitic" shergottites in having a much lower Sm/Nd ratio similar to that of "enriched" basaltic shergottites like Shergotty and Zagami. This can be seen clearly by the crossing REE patterns of peridotites NWA 4797 and NWA 1950 (in Figure 6). The lower absolute REE abundances in NWA 4797 coupled with its negative Eu anomaly are consistent with this being the first known wehrlite or plagioclase wehrlite cumulate from a basaltic shergottite parent magma. Such cumulates are not unexpected given the existence of highly fractionated basaltic shergottites such as Los Angeles and NWA 2800 [3].

Super Shock: The shock effects exhibited in NWA 4797 are unique among Martian meteorites and are estimated to be at level S6. Based on [4], this entire specimen has experienced very high shock pressures (probably in excess of 80 GPa) and transient temperatures above 1500ºC. Features such as solid-state recrystallization of many pyroxene and olivine grains, dissociation of oxide phases, (re)melting of intercumulus assemblages, solid solution of phosphorus in olivine, and apparent vapor-deposition of remobilized sulfides imply that NWA 4797 is possibly the most highly shocked Martian rock yet discovered, even more so than NWA 2737 [5]. It remains uncertain whether the shock effects and injection of high temperature melt veins occurred during the meteorite ejection event, or during a potentially more energetic, earlier impact into the Martian peridotite target lithology.

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