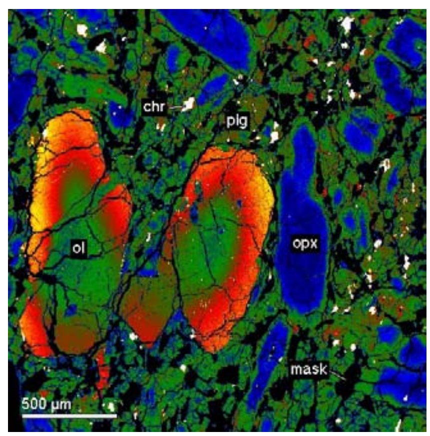
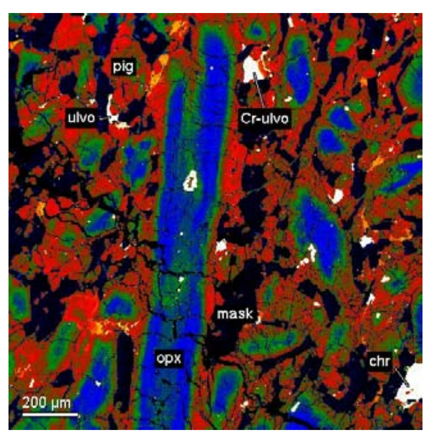
OLIVINE-ORTHOPYROXENE-PHYRIC SHERGOTTITES NWA 2626 AND DaG 476: THE THARSIS CONNECTION. A. J. Irving[1], T. E. Bunch[2], J. H. Wittke[2] and S. M. Kuehner[1], [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195 (irving@ess.washington.edu), [2]Dept. of Geology, Northern Arizona University, Flagstaff, AZ 86011.

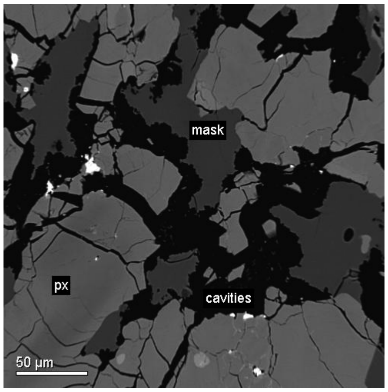
Petrology of NWA 2626: A 31.07 gram crusted stone (Figure 1) purchased in Morocco in November 2004 is an olivine-orthopyroxene-phyric shergottite. Unlike similar specimens we have studied [1], NWA 2626 has cross-cutting glass-rich veinlets and pockets (Figure 2), probably produced by shock during ejection from Mars. Inside a thin weathering rind, the dark greenish specimen is composed of euhedral to subhedral olivine phenocrysts and preferentially-oriented, prismatic low-Ca pyroxene phenocrysts in a groundmass of zoned pigeonite ($Fs_{26.4}Wo_{12.4}$ to $Fs_{34.1}Wo_{12.4}$), maskelynite ($An_{66.0-71.0}Or_{0.4}$), olivine ($Fa_{43.6-47.3}$), Ti-chromite (Cr/(Cr+Al) = 0.72-0.79, 9.2-19.8 wt.% TiO_2), chromite (Cr/(Cr+Al) = 0.71-0.86, 0.7-2.0 wt.% TiO_2), merrillite, ilmenite, ulvöspinel and pyrrhotite. Olivine phenocrysts are zoned from $Fa_{16.7}$ cores to $Fa_{43.3}$ rims, and pyroxene phenocrysts have irregular cores of orthopyroxene (as magnesian as $Fs_{17.9}Wo_{2.4}$, with ~0.03 wt.% TiO_2 and ~0.4 wt.% Al_2O_3) mantled by pigeonite ($Fs_{25.4}Wo_{4.4}$ to $Fs_{37.0}Wo_{12.7}$) with minor subcalcic augite ($Fs_{21.7-24.0}Wo_{30.8-31.1}$) - see Figures 3 and 4.

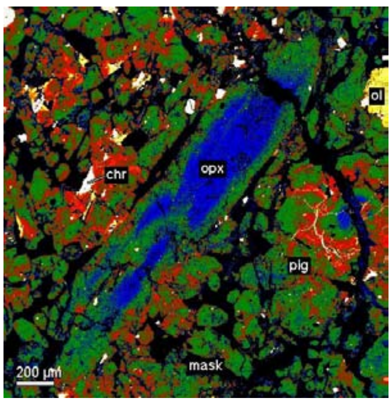
Although textures and mineral compositions are similar to those in olivine-orthopyroxene-phyric shergottites NWA 1195 and NWA 2046 [1], in our judgement none of these specimens are terrestrially paired. Olivine phenocrysts in NWA 2626 have less magnesian cores than those in NWA 2046 ($Fa_{15.7}$), yet both olivine and pyroxene are zoned to less ferroan rim and groundmass compositions than the corresponding phases in NWA 2046 ($Fa_{47.9}$, $Fs_{49.1}Wo_{10.9}$). NWA 1195 (with Fa_{19} olivine cores) is a complete stone from a different, well-documented location near Safsaf, Morocco. Merrillite habits also are distinctive, with the more abundant merrillite in NWA 2626 and NWA 1195 appearing to partially replace groundmass plagioclase. Another unusual feature of NWA 2626 is the presence of enigmatic "moats" (as observed in thin sections) around the edges of maskelynite grains (see Figure 5) that may signify former soluble salts or softer alteration assemblages, perhaps of Martian origin.

Reassessment of DaG 476: Examination of a new specimen of Libyan shergottite DaG 476 (loaned by A. Hupé) leads us to propose that it too is an olivine-orthopyroxene-phyric shergottite. We have found orthopyroxene as cores in prismatic pyroxene phenocrysts displaying the same habit as the more









abundant orthopyroxene grains in NWA 1195 and NWA 2046 (see Figure 6). Opinions vary about whether orthopyroxene cores and at least some of the olivine macrocrysts (Fa_{20}) in DaG 476 and paired specimens are phenocrysts or xenocrysts [2], but we contend that the morphologies and compositions of both phases are consistent with their precipitation as phenocrysts from the same or a closely related magma, possibly with subsequent partial magmatic resorption during mixing (see also [3]). Perhaps because of its less primitive bulk composition, DaG 476 contains fewer orthopyroxene phenocrysts than the other samples, and preferred alignment of either pyroxene or olivine crystals is not evident.

Are Most Shergottites Samples From Tharsis?: Despite its unique textural and mineralogical characteristics, it can be argued that NWA 2626 and most, if not all, of the other 17 known unpaired olivine-phyric to basaltic shergottites may represent samples ejected in a small number of impacts from the large shield volcanoes in the Tharsis region of Mars. Although these specimens range from very primitive (Y 980459) to highly evolved (Los Angeles) and their formation ages span from 575 to 165 Ma, they could have been excavated from a large, long-lived magmatic province by as few as four impacts (at 20, ~2.7, ~1.2 and 0.73 Ma). A terrestrial analogy might be to imagine a single large impact into the (much smaller) Columbia Plateau in Washington, which could in principle eject basalt specimens with an age formation span from 17 to 6 Ma and a wide range of source trace element enrichment characteristics [4]. Tharsis (and Olympus Mons in particular) may be the only region on Mars with a long-term history of relatively low viscosity “basaltic” magmatism producing multiple flows, possibly up until as recently as <10 million years ago [5], as well as a large, active subsurface plumbing system capable of multiple magma evolution and mixing. Perhaps also bolides in low-angle trajectories needed for efficient ejection of samples as meteorites might be more likely to encounter the slopes of very high shield volcanic mountains, and furthermore impact modeling suggests that young terranes are the most likely sources of Martian meteorites [6].

One important aspect requiring explanation in this hypothesis is the existence among the shergottite samples of three distinct mantle source characteristics [e.g., 7]: depleted (Y 980459, NWA 1195, DaG 476, SaU 005, Dhofar 019, QUE 94201), Bulk Mars (NWA 480/1460, EETA79001) and enriched (NWA 1068, NWA 856, Zagami, Shergotty, Los Angeles). Even though the basalts from different volcanoes associated with the much smaller Hawaiian hotspot vary chemically, they all possess similar moderately depleted OIB source characteristics [e.g., 8]. It would be difficult then to imagine that Olympus Mons, Ascraeus Mons, Pavonis Mons and Arsia Mons would each have magmas confined to just one mantle source type. Instead it may be more plausible that each of these gigantic magmatic systems is underlain by heterogeneous mantle containing regions of variable volume and trace element depletion/enrichment, perhaps as a function of depth or even laterally, ultimately as a result of crystallization of an ancient magma ocean [as in the models of 7].

References: [1] Irving A. J. et al. (2002) *MAPS*, *37*, A69; Irving A. J. et al. (2004) *LPS XXXV*, #1444. [2] Zipfel J. et al. (2000) *MAPS*, *35*, 95; Folco L. et al. (2000) *MAPS*, *35*, 827; Wadhwa M. et al. (2001) *MAPS*, *36*, 195; Mikouchi T. et al. (2000) *MAPS*, *36*, 531. [3] Shearer C. K. et al. (2005) *LPS XXXVI*, *this volume*. [4] Carlson R. W. (1984) *GCA 48*, 2357. [5] Hartmann W. K. et al. (1999) *Nature*, *397*, 586; Neukum G. et al. (2004) *Nature*, *432*, 971. [6] Head J. N. et al. (2002) *Science*, *298*, 1752. [7] Borg L. E. and Draper D. S. (2003) *MAPS*, *38*, 1713; Herd C. D. K. (2003) *MAPS*, *38*, 1793. [8] Basaltic Volcanism Study Project (1981) Chapter 1.2.6, Pergamon.