OLIVINE-BEARING DIABASIC SHERGOTTITE NORTHWEST AFRICA 5990: PETROLOGY AND COMPOSITION OF A NEW TYPE OF DEPLETED MARTIAN IGNEOUS ROCK. A. J. Irving[1], S. M. Kuehner[1], C. D. K. Herd[2], M. Gellissen[3], D. Rumble, III[4], T. J. Lapen[5], S. Ralew and M. Altmann [1]Earth & Space Sciences, University of Washington, Seattle, WA 98195 (irving@ess.washington.edu), [2]Earth & Atmospheric Sciences, University of Alberta, Edmonton, AB, [3]Institut für Geologie, Ruhr-Universität Bochum, Germany, [4]Carnegie Institution, Washington, DC, [5]Earth & Environmental Sciences, University of Houston, TX.

Discovery: A very fresh 59 gram Martian meteorite, partly coated by black fusion crust and flight-oriented, was found on Hamada du Drâa, Morocco in 2009. It is a new type of olivine-bearing diabasic igneous rock related to the depleted Mars mantle source, and has chemical and isotopic affinities with mafic olivine-free diabasic shergottite QUE 94201 [1].

Figure 1. *Whole NWA 5990 stone*

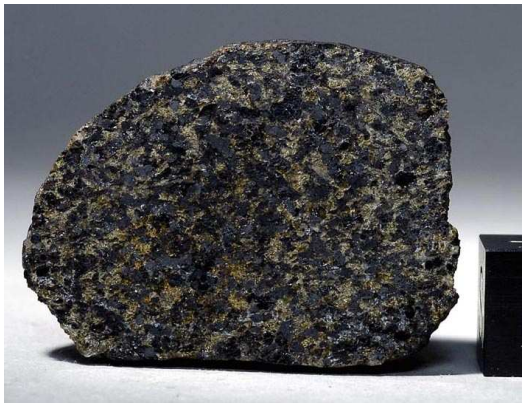


Figure 2. *Polished slice, showing subophitic texture; maskelynite is white, clinopyroxene is beige and olivine is black. Scale cube is 1 cm © S. Ralew.*

Petrography: The specimen is medium-grained (up to 1.1 mm) with a subophitic texture, and resembles a terrestrial diabase. It is composed mainly of clinopyroxene (35 vol.%, $Fs_{28.3\text{-}33.1}Wo_{7.8\text{-}12.5}$ and $Fs_{19.9}Wo_{29.9}$, FeO/MnO = 24.1-30.0), plagioclase (35 vol.%, $An_{64.3\text{-}65.2}Or_{0.2\text{-}0.1}$) and olivine (25 vol.%; core $Fa_{40.7}$, rim $Fa_{46.9}$, FeO/MnO = 52.0-53.5) with accessory chromite, ilmenite, pyrrhotite, Na-Mg-bearing merrillite and rare magnetite. Shocked plagioclase is in part maskelynite, and in part vesicular, spherulitic aggregates of birefringent blades (presumably representing quenched melt). The major silicate minerals exhibit very limited compositional zoning. Chromite compositions range from $Chr_{49}Mt_7Sp_{24}Usp_{20}$ to $Chr_{12}Mt_3Sp_5Usp_{79}$. A preliminary estimate of magmatic log fO_2 is ~IW+2, based on olivine, pyroxene and melt inclusion chromite.

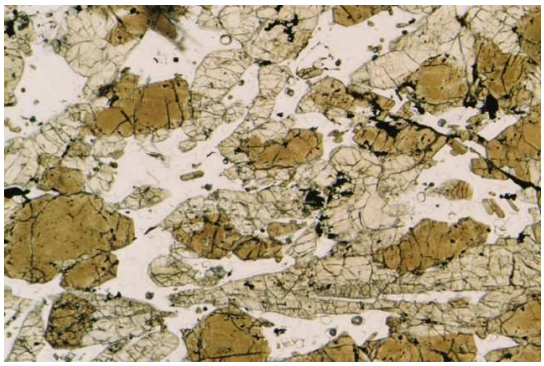


Figure 3. *(***above***) Plane polarized light image; olivine (brown), clinopyroxene (beige), plagioclase (white), Fe oxides and shock glass (black). (***below***) Partially cross-polarized light image. Widths 9 mm © T. Bunch.*

Oxygen Isotopes: Analyses of two acid-washed whole rock subsamples by laser fluorination gave, respectively: $\delta^{18}O$ = 4.15, 4.21; $\delta^{17}O$ = 2.41, 2.47; $\Delta^{17}O$ = 0.226, 0.253 per mil. The dispersion in replicate values is less than for many other shergottites [2].

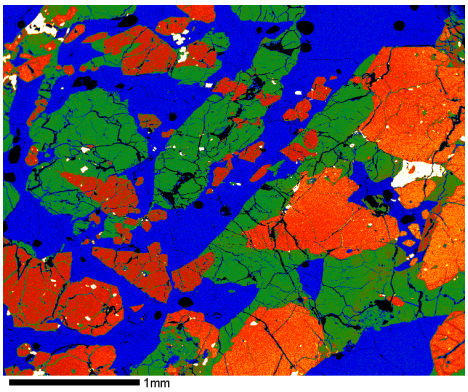
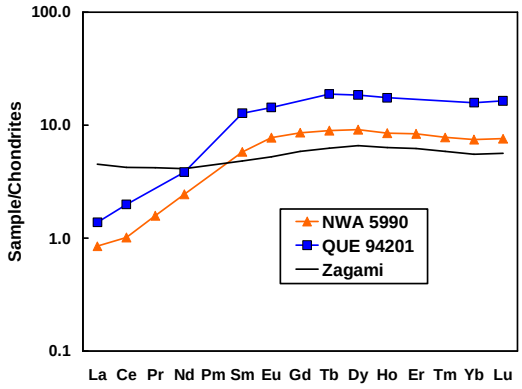


Figure 4. *BSE image, showing clinopyroxene (green), olivine (red/orange), plagioclase (blue, with marginal vesicles), chromite and ilmenite (both white)*

Bulk Elemental Composition: Clean representative dust totaling 2.3 grams obtained during cutting of the specimen was analyzed by XRF and ICP-MS. We also report a fused bead microprobe analysis (courtesy of R. Zeigler at WUSL) of fusion crust from unrelated "intermediate" mafic shergottite NWA 4480 - see [3].

	NWA 5990	***4480***		***5990***
SiO_2	42.26	45.22	Ni	146
TiO_2	0.72	1.44	La	0.27
Cr_2O_3	0.41	0.13	Ce	0.83
Al_2O_3	6.94	12.53	Pr	0.193
FeO_T	22.06	19.82	Nd	1.50
MnO	0.46	0.45	Sm	1.16
MgO	17.09	6.24	Eu	0.59
CaO	6.54	9.44	Gd	2.30
Na_2O	0.79	1.98	Tb	0.44
K_2O	0.02	0.13	Er	1.81
P_2O_5	0.99	1.62	Yb	1.65
SUM	98.26	99.00	Lu	0.25
Mg/(Mg+Fe)	0.580	0.359	Hf	1.47



Neodymium Isotopes: TIMS analysis of the whole rock powder gave $^{143}Nd/^{144}Nd = 0.515463 \pm 6$, or a modern day ε_{Nd} value of +55.13. Both the REE pattern and Nd isotopic ratio are consistent with derivation from the depleted Mars mantle source.

Classification and Affinities: Using the combined bulk chemical and textural classification scheme of [4], NWA 5990 is a permafic olivine-bearing diabasic shergottite. Among the 54 known unpaired Martian

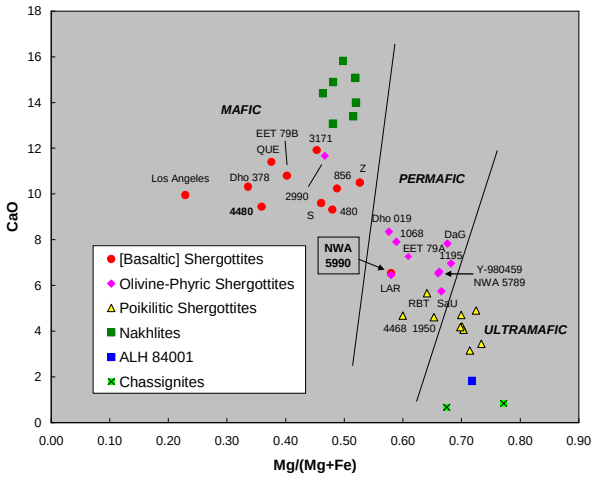


Figure 5. *Bulk compositions of NWA 5990 and NWA 4480 relative to those of other Martian meteorites [4]*

meteorites, the most similar specimen is QUE 94201, although that Antarctic mafic meteorite lacks olivine. The relative compositional homogeneity of mafic silicates in NWA 5990 (see Figure 4) is unusual, since nearly all other shergottites (of all types) show "chaotic" compositional zoning in their pyroxene. If such irregular zoning patterns are indicative of assimilation of altered crustal components as discussed by [2], then the NWA 5990 parent magma evidently was not subject to such interactions, perhaps because it was located in the interior of a deeper feeder dike.

Non-Diversity of Martian Meteorite Samples: The discovery of NWA 5990 emphasizes the possibility that other types of Mars rocks may be found or recognized as meteorites. Even so, the fact that all of the Martian meteorites found so far are igneous rocks, and related to just three mantle sources (*except* for NWA 2990 [5]), points up the likelihood [6] that many specimens may be launch-paired, and derived from as few as seven separate regions on or near the Martian surface.

References: [1] McSween H. et al. (1996) *GCA* **60**, 4593-4569; Warren P. et al. (1999) *GCA* **63**, 2105-2122 [2] Rumble D. and Irving A. (2009) *Lunar Planet. Sci.* **XL**, #1480 [3] Irving A. et al. (2007) *70th Met. Soc. Mtg.*, #5127 [4] Irving A. et al. (2010) *Lunar Planet. Sci.* **XLI,** this conference [5] Lapen T. et al. (2010) *Lunar Planet. Sci.* **XLI**, this conference [6] Nyquist L. et al. (2009) *GCA* **294**, 345-348.

Educational Website: A comprehensive website with information about Martian meteorites can be found at: http://www.imca.cc/mars/martian-meteorites.htm.