PETROLOGY AND MULTI-ISOTOPIC COMPOSITION OF OLIVINE DIOGENITE NWA 1877: A MANTLE PERIDOTITE IN THE PROPOSED HEDO GROUP OF METEORITES. A. J. Irving[1], S. M. Kuehner[1], R. W. Carlson[2], D. Rumble, III[2], A. C. Hupé[3] and G. M. Hupé[3], [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195 (irving@ess.washington.edu), [2]Carnegie Institution, Washington, DC 20015, [3]The Hupé Collection.

Introduction: With the discovery of NWA 1877, there are now five known olivine diogenites. All are coarse grained harzburgitic peridotites composed predominantly of olivine and orthopyroxene with accessory chromite, troilite, and very low-Ni metal. Anorthitic plagioclase is an accessory phase in four examples, but NWA 1877 is unique because of its lack of plagioclase, and it appears to be the best candidate yet for a mantle sample related to 4Vesta.

Although olivine is present as an accessory mineral in some diogenites, there is a clear distinction between such samples and those we term olivine diogenites. We propose that the term **olivine diogenite** be used only for peridotitic assemblages with greater than 30% olivine. Since modal analyses of many diogenites [1] indicate that the great majority of examples contain zero to 4.7% olivine, we suggest further that diogenitic rocks with up to 5% olivine be termed **olivine-bearing diogenites.** For any examples (so far unknown) with olivine contents between 5% and 30%, the term **olivine-rich diogenite** could be applied. If this considerable gap in olivine contents is supported by further discoveries, then the existence of a distinct *peridotitic* olivine diogenite suite, quite separate from the *orthopyroxenitic* diogenite suite, will be firmly established. The term olivine diogenite, which has already been in use in published reports since the studies of Sack et al. [2], is a petrographic designation and has no petrogenetic connotations. Like terrestrial peridotitic rocks, olivine diogenites may have formed by several different mechanisms on their parent body, and conceivably could represent primordial mantle rocks, solid residues after mantle partial melting, igneous crystal cumulates within deep crust or mantle reservoirs or conduits, or even metamorphic rocks.

There is evidence that the HED meteorites derive from 4Vesta itself [3], or perhaps from a once larger, differentiated, small planetary body of which 4Vesta is the largest remnant. Based on their very close similarities in mineral compositions and oxygen isotopic compositions to howardites, eucrites and diogenites, olivine diogenites must also represent samples related to 4Vesta. Therefore, we propose an extension of the acronym in common use for these samples, and refer to them collectively as the **HEDO group**. The current inventory includes three examples from Antarctica (ALHA77256, EETA79002, GRA98108) and two examples from Morocco (NWA 1459 and NWA 1877).

Northwest Africa 1877: A large, partly disaggregated stone with thin black fusion crust and a total known weight of at least 1.6 kilograms (and allegedly as much as 7-8 kilograms) was found in early 2003 reportedly near Irtimi, Morocco (Figure 1). The largest available portion of the fragmented specimen has been classified as NWA 1877 (934 g), with additional material as NWA 2115 (642 g).

The coarse-grained, dense rock has an overall brownish color (caused by minor terrestrial weathering) but is deep yellow-green where fresh. It is a harzburgitic peridotite composed of subequal amounts of orthopyroxene ($Fs_{22.4\text{-}23.3}Wo_{1.5}$; FeO/MnO = 25.2-29.7) and olivine ($Fa_{27.8}$, FeO/MnO = 44-50) with minor Al-poor chromite [Cr/(Cr+Al) = 0.848-0.88, Mg/(Mg+Fe) = 0.117-0.198], troilite (as abundant blebs within silicates and as inclusions in chromite), and sparse Ni-free metal (partly altered to limonite). Plagioclase is absent. From examination of three serial thin sections (see Figure 2), we estimated the modal amount of olivine to be approximately 45%, which is consistent with the moderately high density of this meteorite. As with diogenites, cataclasis produced by shock associated with impact excavation and ejection from their parent body is evident in all the olivine diogenites.

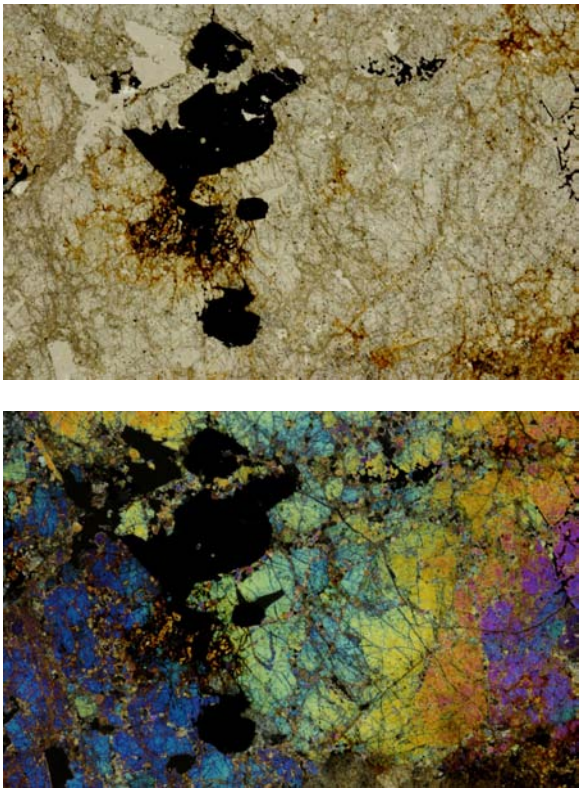

Figure 2. Plane-polarized light (top) and cross-polarized light images of NWA 1877 (width of field = 2.2 cm), showing part of a large orthopyroxene grain (left, blue), part of a large olivine grain (right), chromite and stained metal (black and orange).

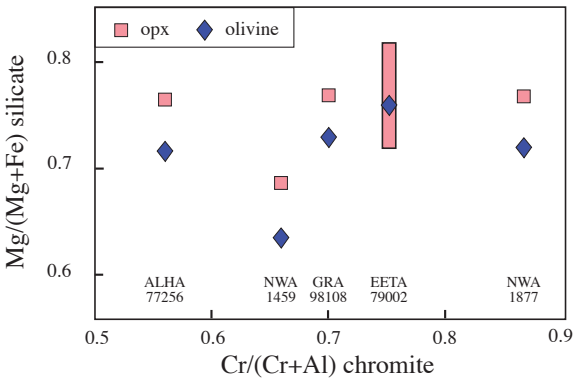

Figure 3. Mg values for olivine and orthopyroxene versus Cr value for coexisting chromite in the five known olivine diogenites.

Isotopic Compositions: Oxygen isotopic compositions of NWA 1877 measured in duplicate on acid washed mafic silicates by laser fluorination ($\delta^{17}O$ = 1.94, 1.87; $\delta^{18}O$ = 4.18, 4.04; $\Delta^{17}O$ = -0.25, -0.26 per mil, respectively) plot within the field of HED meteorites. Rhenium and osmium concentrations in NWA1877 whole rock are low (Re - 45 pg/g, Os - 2pg/g, 10-3 and 4 x 10-6 times CI abundance, respectively) indicating efficient extraction of highly siderophile elements from the HEDO mantle during core formation and limited impactor contamination. The blank-corrected measured $^{187}Os/^{188}Os$ (0.208 ± 0.009) and the $^{187}Re/^{188}Os$ (109 ± 27) translate to a model age relative to chondritic Re-Os evolution of 44 ± 13 Ma, indicative most likely of disturbance of the Re-Os system by terrestrial weathering, but possibly indicating the time of shock metamorphism. Analyses of Mg and Cr isotopic compositions on separated olivine and chromite also are in progress.

Discussion: The relatively magnesian silicate compositions in NWA 1877 are similar to those in Antarctic olivine diogenites ALHA77256 and GRA98108 [2, 5], and quite different from the more iron-rich mafic silicates in Moroccan olivine diogenite NWA 1459 [6]. However, chromite in NWA 1877 is much more Cr-rich than in any of the other examples (Figure 3), which strongly suggests that NWA 1877 is a primitive mantle sample rather than possibly a cumulate. The complete absence of plagioclase may imply that NWA 1877 comes from greater depths in the Vestan mantle than any of the other olivine diogenites (which could represent deep crustal cumulates from eucritic magmas). Clinopyroxene has not been found as discrete grains in any of the olivine diogenites, but does occur as a very minor exsolved phase in some orthopyroxene grains in NWA 1459. Such infertile, Cr-rich harzburgitic lithologies are those predicted as mantle residues from experimental melting studies on eucrites [7]. Earth-based reflection spectroscopy has established that the exposed interior of 4Vesta contains abundant olivine [8], and further confirmation of a peridotitic interior may be forthcoming from the DAWN mission.

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