ANORTHITE-RICH ACHONDRITE WAN ZAWATIN 001: EXPANDING THE RANGE OF DIOGENITIC CUMULATE ROCKS BEYOND NORITIC AND TOWARDS THE FIELD FOR ANORTHOSITES.

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Introduction: It is widely agreed that diogenites represent cumulate igneous assemblages from mafic parent magmas on a differentiated parent body [e.g., 1]. Although the "classic" examples are composed almost entirely of orthopyroxene, more recent finds have expanded the mineralogic diversity to include assemblages with significant modal contents of olivine (harzburgites, dunites), as well as others richer (up to at least 20 vol.%) in anorthitic plagioclase (norites) [2 ,3, 4]. Such assemblages are very much analogous to those of cumulate rocks in terrestrial layered intrusions (e.g., Skaergaard, Stillwater, Bushveld), but unlike those occurrences diogenitic rocks composed predominantly of plagioclase (anorthosites) or chromite (chromitites) have not been recovered as meteorites until recently.

Here we describe a unique anorthite-rich achondrite which has mineralogic and oxygen isotopic affinities to diogenites, although not so plagioclase-rich as to be termed an *anorthositic* diogenite.

Petrography: Even in its macroscopic appearance, Wan Zawatin 001 is striking because of its overall almost pure white color and pale greenish, translucent fusion crust (see Figure 1 below).

This meteorite is a relatively coarse grained monomict breccia (mean grainsize ~0.7 mm), and is composed of fairly closely-packed mineral clasts plus some polymineralic fragments within a sparse finer grained matrix (see Figure 2). The major mineral phases are anorthite (76 vol.%, $An_{95.4-95.6}Or_{0.1-0.2}$) and orthopyroxene (24 vol.%, $Fs_{24.5-25.2}Wo_{2.3-2.6}$, FeO/MnO = 26-28), together with minor accessory low-Ti chromite and troilite. Because of the simple and homogeneous mineralogy of this meteorite, it was possible to compute a reasonably accurate mineral mode from bulk rock XRF results and mineral compositions determined by EMP analysis.

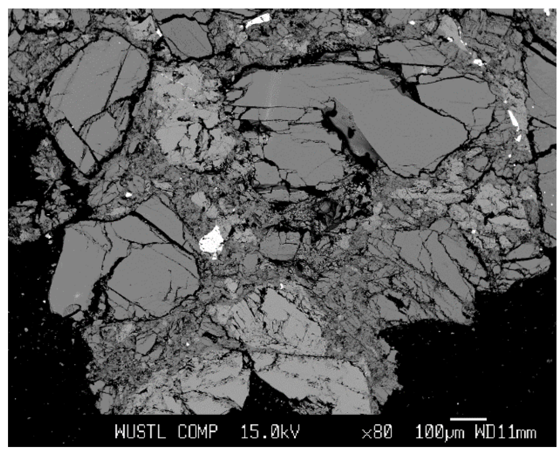

Figure 2 *Back-scattered electron image showing anorthite (darker gray), orthopyroxene (lighter gray) and chromite (bright)*

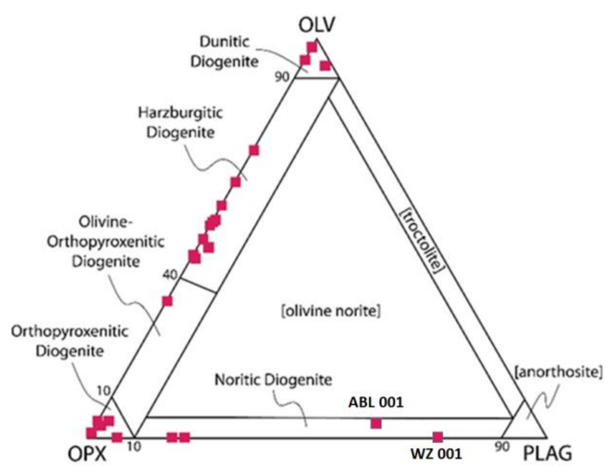

***Figure 3**. Modal mineralogy of diogenites*

Bulk Elemental Composition: XRF analysis of fresh interior material gave (in wt.%, normalized to 100 without Na_2O or P_2O_5): SiO_2 46.95, TiO_2 0.08, Al_2O_3 27.73, Cr_2O_3 0.27, FeO 5.59, MnO 0.22, MgO 3.05, CaO 15.99, K_2O 0.12; FeO/MnO = 25.

Oxygen Isotopes: Analysis at CEREGE by laser fluorination of a 1.5 mg aliquot from acid-washed powder produced by crushing a 85 mg bulk sample gave $\delta^{17}O$ 1.774, $\delta^{18}O$ 3.821, $\Delta^{17}O$ -0.236 per mil (for a TFL slope of 0.526). This isotopic composition plots within the broad field for diogenites (see Figure 4).

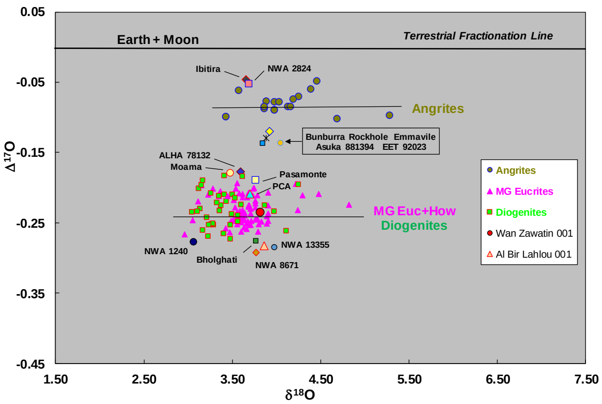

Figure 4. *Oxygen isotopic compositions of Wan Zawatin 001, typical diogenites and other achondrites. PCA = PCA 91007. Data sources include [5], [6], [7], [8] and a compilation from other literature.*

Discussion: By analogy with terrestrial igneous rocks of similar mineralogy, diogenites are best understood to be hypabyssal or plutonic cumulate igneous rocks from unknown relatively Mg-rich mafic parent magmas. We have previously described feldspathic diogenites with <10 vol.% anorthitic plagioclase and noritic diogenites with up to ~20 vol.% anorthitic plagioclase [4]. Now Wan Zawatin 001 extends the mineralogic range in diogenites to very plagioclase-rich assemblages (see Figure 3), and holds the promise that anorthositic diogenites containing >90 vol.% anorthite should be expected to exist.

Another unusual achondrite with some petrologic similarities to Wan Zawatin 001 is Al Bir Lahlou 001 [8] and a paired stone we have studied (containing ~60 vol.% anorthitic plagioclase plus ~35 vol.% orthopyroxene and minor olivine). However, the oxygen isotopic composition of this meteorite [8] plots to more negative $\Delta^{17}O$ values than for typical diogenites and Wan Zawatin 001, although in the vicinity of compositions for anomalous eucrites NWA 1240, NWA 8671 and NWA 13355 (see Figure 4).

Experimental phase equilibrium studies [9] have established that the parent magma(s) for diogenites cannot be as ferroan as typical eucrites, and would have to be much more magnesian in composition (perhaps like rare crystallized igneous eucrite clasts in a few achondritic breccias). The evidence of brittle deformation (cataclasis) exhibited by many (but not all) diogenites also serves to set them apart from eucrites, and suggests that these two groups of achondrites may derive from separate parent bodies with different shock histories.

If that is true, the overlap in oxygen isotopic compositions between diogenites and some (but significantly not all) eucrites may be only fortuitous. It is evident from Figure 4 that oxygen isotope differences actually preclude any genetic relationship between diogenites and other eucrites such as Ibitira, NWA 2824, Bunburra Rockhole, Emmaville, Asuka 881394 and EET 92023. The presence of clasts of both diogenites and eucrites in achondritic breccias (polymict eucrites, polymict diogenites and howardites) may mean only that the diogenite clasts represent exotic impactor materials accumulated onto some airless eucritic parent bodies, but it need not imply a common origin or genetic connection with any eucrites. In fact diogenites have more mineralogical and isotopic attributes in common with mesosiderites than with typical eucrites.

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