PETROLOGY AND OXYGEN ISOTOPIC COMPOSITIONS OF ANOMALOUS ACHONDRITE NWA 011. P. Prompratedi[1], L. A. Taylor[1], Mahesh Anand[1], D. Rumble III[2], E. V. Korochantseva[3], M. A. Ivanova[3], C. A. Lorentz[3], and M. A. Nazarov[3], [1]Planetary Geosciences Institute, University of Tennessee, Knoxville, TN 37996 (prinya@utk.edu), [2]Geophysical Laboratory, Carnegie Institute, Washington, DC 20015, [3]Vernadsky Institute of Geochemistry and Analytical Chemistry, Moscow 119991, Russia.

Introduction: Northwest Africa (NWA) 011 is a single stone of 40 g and has been discovered in the Moroccan Sahara desert in 1999 [1]. This pyroxene-plagioclase meteorite was classified as noncumulate eucrite, on the basis of petrography and geochemistry [1]. However, certain characteristics of this meteorite such as the high Fe/Mn values in pyroxene (~65) and particularly the bulk-rock oxygen isotopic compositions ($\delta^{18}O$ = +2.54, $\delta^{17}O$ = -0.48) are not of typical eucrites and may suggest a new type of basaltic meteorite [2]. In an attempt to resolve this issue, we have investigated mineral chemistry and oxygen isotopic compositions on portions of NWA 011. Trace-element chemistry and Ar-Ar age is presented in a companion paper [3].

Petrographic Description: Petrographic study of 2 polished thin-sections reveals that the sample is fine-grained monolithic, unbrecciated achondrite [1]. The absence of primary breccia texture (i.e., relic plagioclase and augite grains [2]), even in our larger section (3 cm^2), suggests that NWA 011 may not be a recrystallized breccia. Modally, the sample consists mainly of pigeonite (58.50%) and plagioclase (39.56%), with minor amounts of opaque (0.71%), silica (0.67), and phosphate (0.54) minerals. Pigeonite (0.2-0.8 mm) is commonly subhedral and often has curve boundaries at the contacts with plagioclase (Fig. 1). All pigeonite grains contain exsolution lamellae of augite, usually a few microns wide but sometimes reach ~10 µm. Plagioclase (up to 0.1 mm) is anhedral and usually forms crystal aggregates (up to 2 mm) or straddles along grain boundaries or fractures of pigeonite grains. This texture may indicate recrystallization, possibly as a result of thermal metamorphism. Opaque minerals, occurring as small clusters, include ulvöspinel, ilmenite, and small Fe metal-sulfide intergrowths (2-5 µm). Baddeleyite inclusions have also been found in some ilmenties. Olivine usually occurs in the same aggregates as oxides (Fig. 1). Ca-phosphates (whitlockite and Cl-apatite) are common but not evenly distributed.

Mineral Chemistry: Compositions of pigeonite ($Wo_{5.7-6.5}Fs_{63.2-65.1}$; Mg# = 32-33) and its lamella augite ($Wo_{36.1-39.2}Fs_{35.2-38.3}$; Mg# = 38-43) are similar to those of Nuevo Laredo Trend eucrites (Fig. 2) [4] and some lunar metabasalts [5]. However, the Fe/Mn ratios (Pig = 67, Aug = 65) are significantly higher than those of typical eucrites (Fig. 3). Plagioclase is bytownite and low in K_2O contents ($An_{80.2-87.7}Or_{0.7-0.2}$). Olivine is Fe-rich and its composition varies in a restricted range ($Fa_{79.5-81.4}$). In ulvöspinel, FeO and TiO_2 contents are 55.3 and 24.2 wt%, resp.; ilmenite contains 45.1 and 52.7 wt%, resp.

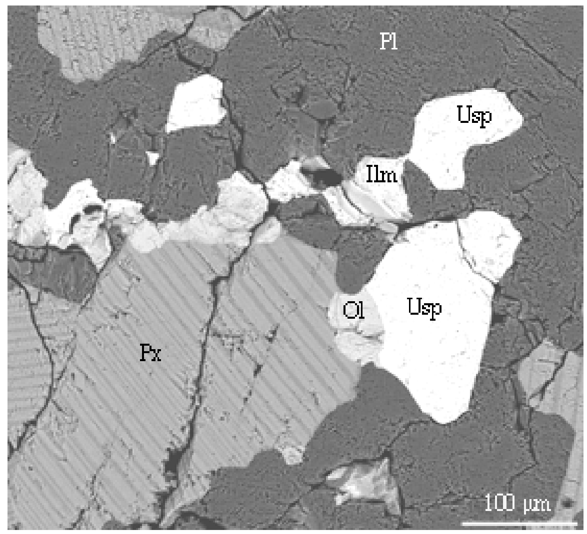

Figure 1. BSE image of meteorite NWA 011.

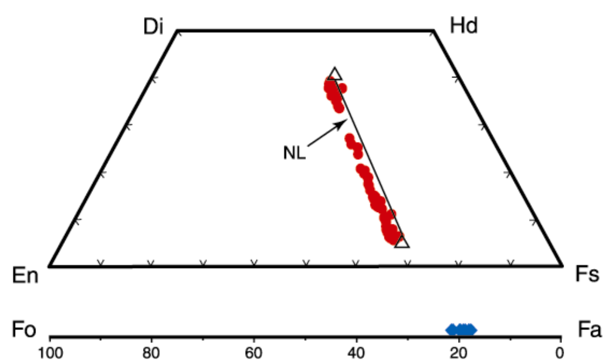

Figure 2. Pyroxene and olivine compositions of NWA 011. The pyroxene compositions are comparable to those of Nuevo Laredo Trend (NL) eucrites [4].

Oxygen Isotopes: Oxygen isotope analyses have been performed on two separate portions (2 aliquots for each) of NWA 011, using a high-precision laser-fluorination technique [6]. Results are shown in Table 1. The newly obtained oxygen data (Fig. 4) is far removed from the known eucrite region (within HED shaded field), with $\Delta^{17}O$ = -1.58 vs. -0.25 of eucrites

[7]. The results confirm the unusual oxygen isotope compositions of NWA 011 observed previously [2].

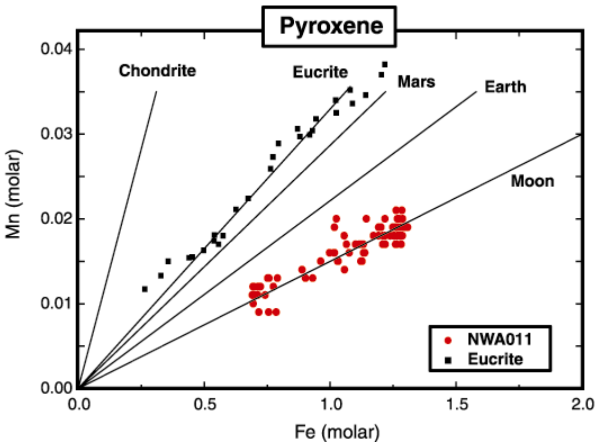

Figure 3. Plot of Fe vs. Mn in pyroxenes of NWA 011 illustrating the unusually high Fe/Mn values in NWA 011 when compared with other eucrites.

Table 1. Oxygen isotopic data of NWA 011

Aliquots	$\delta^{18}O$	$\delta^{17}O$
A1	3.23	0.10
A2	2.84	-0.10
B1	2.88	-0.08
B2	2.71	-0.17
Average	2.92	-0.06
Std. Dev.	0.22	0.12

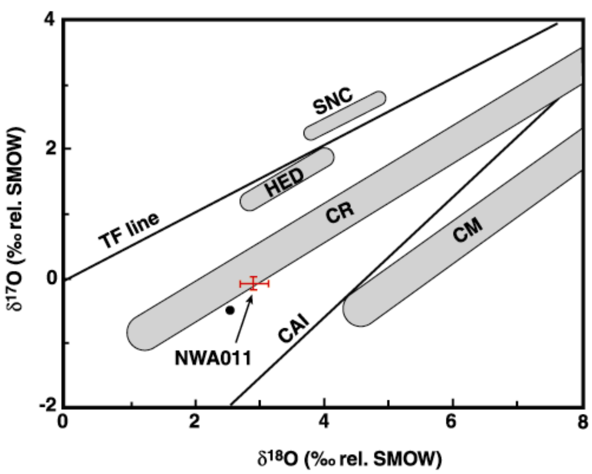

Figure 4. Oxygen isotopic compositions of meteorite NWA 011 shown with error bars. The data confirm the anomalous O-isotope values (filled circle) observed previously [2].

Crystallization Relationship: Bulk compositions from this study and [2] (Table 2) have been used for crystallization modeling, using the MELTS program at an fO_2 of IW. Figure 5 shows the following order of equilibrium crystallization resulted from our bulk composition: Pig + Pl → Sp → Ol → Aug → Whit → Ilm → Silica. The model closely reproduces phases and their compositions as observed in the sample, suggesting that post-crystallization processes did not significantly alter the original composition of NWA 011. Composition of [2] yields slightly different order of crystallization, with the absence of Ilm and silica mineral, and the olivine with Fo_{62}, which is significantly higher than that obtained from our composition. These differences may indicate the inhomogeneity of the sample.

Table 2. Bulk compositions of NWA 011

	This Study	[2]
SiO2	48.22	45.63
TiO2	0.85	0.92
Al2O3	12.86	13.12
Cr2O3	0.19	0.24
FeO	19.95	21.13
MnO	0.29	0.40
MgO	6.05	6.66
CaO	10.76	11.11
Na2O	0.54	0.45
K2O	0.03	0.03
P2O5	0.22	<0.02

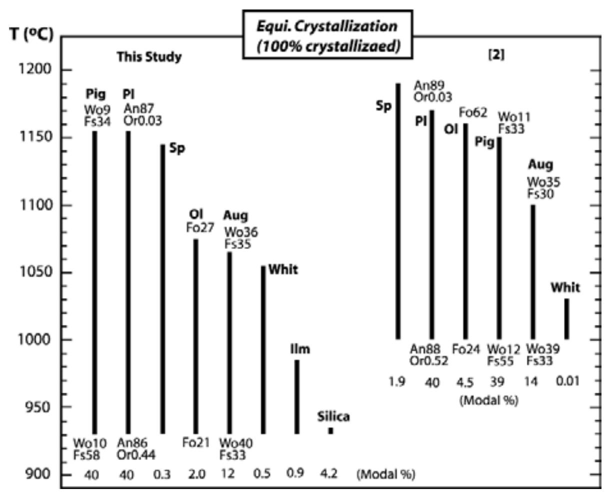

Figure 5. Crystallization modeling of NWA 011.

Discussion: NWA 011 resembles noncumulate eucrites on the basis of texture, mineralogy, and certain chemistry. However, there are 2 major differences: NWA 011 has anomalous O-isotopic compositions and higher Fe/Mn values (Figs. 3&4, resp.). Therefore, the sample possibly represents a new type of achondritic basaltic meteorite, with no apparent genetic relationship with eucrites. Its parent body could have formed in a different region of solar nebula than that of the HED parent body.

References: [1] Afanasiev S. V. et al. (2000) *MetSoc 63rd*, A19. [2] Yamaguchi A. et al. (2002) *Science 296,* 334–336. [3] Korochantseva E. V. (2003) this volume. [4] Warren P. H. and Jerde E. A. (1987) *GCA 51*, 713-725. [5] McSween H., Jr. et al. (1977) *LSI 304*, 118-120. [6] Wiechert U. et al. (2001) *Science 294*, 345-348. [7] Clayton R. N. and Mayeda T. K. (1996) *GCA 60*, 1999-2017.