NWA 2736: AN UNUSUAL NEW GRAPHITE-BEARING AUBRITE. J. J. Lowe[1], D. H. Hill[1], K. J. Domanik[1], D. S. Lauretta[1], M. J. Drake[1], M. Killgore[2]., [1]Lunar & Planetary Laboratory, University of Arizona, Tucson, Arizona 85721, [2]Southwest Meteorite Laboratory, P.O. Box 95 , Payson, AZ 85547. dhill@lpl.arizona.edu.

Introduction: Aubrites are enstatite-rich achondrites that are probably related to enstatite chondrite parent bodies. The exact link, if any, is not understood. They may have formed from melting within one or more enstatite chondrite parent bodies [1].

Description of NWA 2736: One complete stone weighing 171.51 grams was recovered from the Sahara Desert by nomads sometime before September 2004. It was completely covered with fusion crust and desert varnish. This stone is severely weathered, with caramel brown coloration throughout and calcite veins that extend into the interior of the sample (Fig. 1).

Mineral analyses were performed and elemental x-ray maps were obtained with a CAMECA SX-50 electron microprobe at the Lunar and Planetary Laboratory at the University of Arizona.

The relatively high modal abundance of albitic plagioclase, presence of euhedral graphite, depletion of troilite, and occurrence of pervasive kamacite veins (some with daubreelite) all indicate that NWA 2736 has a complex history and may sample a new region of the aubrite parent body.

Overall Texture: This meteorite is mostly composed of crystals of enstatite and plagioclase of about 50-100 microns in size. We estimate that, by volume, enstatite makes up about 60% and plagioclase about 30%. The equigranular texture appears to be igneous. A small amount of silica (<1 vol %) is observed in association with these two minerals.

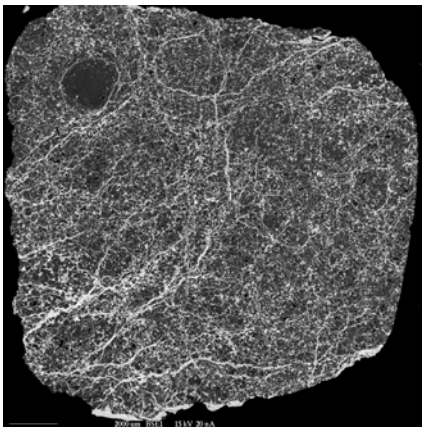

Fig. 1. BSE image of the thin section, showing the 2.5-mm diameter, "round inclusion" and network of rust veins and calcite. Sample is 1.6 cm across.

The groundmass is crosscut by an extensive network of veins that generally follow the grain boundaries of the enstatite and plagioclase crystals. These veins consist mainly of Si-bearing iron oxide as well as abundant, partially resorbed, crystals of daubreelite $(Fe_{0.9},Mn_{0.1})Cr_2S_4$. A few small grains of kamacite are also observed in the veins.

Graphite: One of the most unusual features of this meteorite is the presence of large crystals of graphite up to 500 microns long that are sparsely scattered throughout the meteorite (Fig. 2). Graphite occurs interstitially between the enstatite and plagioclase crystals and is often associated with iron oxide veins. Although anhedral graphite is reported in a few aubrites [2], large, well-formed crystals have not been previously observed in these meteorites.

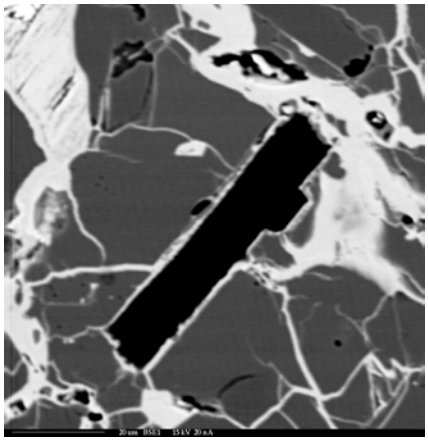

Fig. 2. Euhedral graphite crystal typical of those found throughout the specimen. Field of view is 80 microns wide.

Round Inclusion: A round silicate inclusion (Fig. 1) approximately 2.5 mm in diameter occurs in the thin section we examined. The minerals present in this inclusion are similar in abundance and composition to those found in the remainder of the meteorite. However their textures are considerably different with alternating, parallel, bands of enstatite and plagioclase that are approximately 10 microns wide. There is a higher concentration of metal and sulfides in the outer region of this object than in the center.

Results: Enstatite in this meteorite is almost pure in composition (average mg# = 99; $En_{99}Fs_0Wo_1$). The enstatite crystals contain abundant, small (</=5 micron) inclusions of kamacite $(Fe_{0.93}Ni_{0.06}Si_{0.01})$, troilite $(Fe_{0.98}Ti_{0.01}Cr_{0.01})S$, daubreelite $(Fe_{0.9}Mn_{0.1})Cr_2S_4$ and oldhamite $(Ca_{0.95}Mg_{0.03}Mn_{0.02})S$. One inclusion of alabandite $(Mn_{0.50}Mg_{0.25}Fe_{0.25})$ was observed also. Plagioclase compositions average $Ab_{79}An_{16}Or_5$ and

show no evidence of chemical zoning. Representative compositions of major minerals are shown in Table 1.

Discussion: NWA 2736 is an unusual enstatite achondrite. Pure enstatite, daubreelite, oldhamite, alabandite, Si-bearing kamacite, and troilite with Ti are almost exclusively found in aubrites or enstatite chondrites and can only form under very reducing conditions. We now examine whether NWA 2736 is a metamorphosed chondrite, aubrite, or impact melt.

Metamorphosed chondrite: The basis for classification as a metamorphosed chondrite is the presence of what may be one or more relict chondrules in the sample. The barred texture found in the "round inclusion" is often found in chondrules. The overall composition of this inclusion is very similar the host meteorite.

Graphite inclusions in metal grains are reported in the E7 chondrite QUE94204 [3]. Euhedral graphite, thought be an indicator of impact processes, is observed in the EL4 impact melt breccia QUE94368 [4, 5]. Graphite is reported in Norton County and Shallowater as well [2]. So the *presence* of graphite is not a distinguishing feature for aubrites and chondrites.

Aubrite: The igneous texture, low metal and sulfide abundance relative to E chondrites, trapped melt inclusions within both enstatite and plagioclase, and, especially an "aubrite-like" alabandite composition, suggest that NWA 2736 is an aubrite. Silicate and metal compositions tend toward EL characteristics that, as with other aubrites, suggest an EL-type parent body [6 - 8]. It has been noted that most EL6 chondrites do not have significant opaque veins [5].

Impact-effects: It is possible that the meteorite could be an impact product related to both EL chondrites and aubrites. The igneous texture, presence of possible relict chondrules, and ambiguous mineral compositions, and network of opaque metal veins that surround silicate grains, all suggest that the sample experienced impact on its parent body after formation of the original igneous aubrite. No sulfide droplets have been found in the veins, suggesting a low degree of shock.

Silicate compositions are most similar to the aubrite impact melt Happy Canyon [6]. The presence of euhedral graphite laths and euhedral silicate grains surrounded by kamacite are characteristic features of unannealed impact-melt breccias. [4, 5]. NWA 2736 is not brecciated but could have had a complex history that included impact melting.

The veins probably consisted of kamacite and daubreelite when they first formed and subsequently suffered terrestrial weathering to iron oxide. This is supported by the presence of kamacite and daubreelite grains that are altering to the iron oxide material. The veins often contain calcite indicative of terrestrial weathering. The kamacite veins that follow grain boundaries provide additional evidence for modification by impact.

Conclusion: NWA 2736 is an aubrite that experienced low shock impact. It is an unusual enstatite achondrite related to known aubrites and EL enstatite chondrites. Modal and mineral compositions point to sampling of a new region of one of the already postulated aubrite parent bodies or another aubrite parent body altogether.

References: [1] Keil K. (1989) Meteoritics 24, 195. [2] Okada A. et al. (1988) Meteoritics 23, 59-74. [3] Satterwhite C. and Righter K. (1996) Antarct. Newsl. Vol.. 19, No. 1.[4] Rubin A. E. (1997) PSC XXVIII, #1004. [5] Rubin A. E. et al. (1997) GCA 61, 847-858. [6] Watters T.R. and Prinz M. (1979) PLPSC 10th, 1073-1093.[7] Sears D. W. et al. (1982) GCA 46,597-608. [8] Fogel R. A. (1997) 60th Met. Soc. Abstr. #5170.

Acknowledgments : This work was supported by NASA grants #NNG04GF65G to D. S. L and #NAG5-12795 to M. J. D.

Table 1. Representative mineral analyses for NWA 2736

Oxide Wt%	Enstatite	Plagioclase	Wt%	Kamacite	Daubreelite	Troilite	Oldhamite	Alabandite
SiO2	58.79	64.98	Si	1.04	0.02	0.09	0.66	0.09
TiO2	0.01	0.02	Ti	0.01	0.06	0.54		0.00
Cr2O3	0.02	0.01	Cr	0.01	35.96	0.69	0.01	0.10
Al2O3	0.21	21.24	Co	0.28	0.00	0.00	0.00	0.00
FeO	0.35	0.63	Fe	92.55	16.99	61.34	0.72	17.72
MnO	0.01	0.01	Mn	0.00	2.49	0.03	1.23	33.23
MgO	39.68	0.55	Mg	0.02	0.00	0.02	0.93	7.33
CaO	0.59	3.13	Ca	0.00	0.02	0.02	51.80	0.30
Na2O	0.01	8.60	S	0.01	44.07	36.54	42.42	40.21
K2O	0.00	0.88	P	0.03	0.00	0.00	0.05	0.00
NiO	0.02	0.02	Ni	5.87	0.01	0.06	0.02	0.03
Total	99.69	100.06	Total	99.83	99.64	99.32	97.84	99.00
# of analyses	28	22		3	32	6	2	2