ERG ATOUILA 001: UNIQUE ALBITITE ACHONDRITE METEORITE. C. B. Agee, A. J. Ross, M. N. Spilde, K. Ziegler, Department of Earth and Planetary Sciences and Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131, agee@unm.edu.

Introduction: Erg Atouila 001 is an albitite achondrite with one of the highest modal feldspar contents ever reported in a meteorite– comparable to lunar anorthosite meteorites, however its feldspar is an albite-orthoclase solid solution (alkali-feldspar). This albitite meteorite is also unlike other Na-feldspar-rich ungrouped achondrites such as GRA 06128/06129 [1] Almahata Sitta ALMA-A [3], NWA 11575 [4] and Erg Chech 002 [5] which have albite-anorthite solid solutions (plagioclase feldspar). When plotted on a total alkali-silica (TAS) diagram the bulk composition of this meteorite falls within the trachyte field – unique for achondrite meteorites. Given the relatively coarse grain size, equilibrated mineral phases, and inferred plutonic origin, this meteorite is a "syenite" igneous rock type.

Fig. 1. Photograph of one of the Erg Atouila 001 main masses (553 grams, top) and two views of UNM deposit sample (20.5 grams, lower) showing a saw-cut face and the exterior surface of the meteorite.

History, Physical Characteristics and Petrology: Two stones 553 g and 240 g were found in Mali in August and September 2020. Both pieces were purchased by Mohamed Aid, a Moroccan meteorite dealer who holds the main masses. The exterior of the stones is dominated by a pink to light orange color with some dark gray patches with oxidation halos, and some small green patches are scattered throughout. No fusion crust is present. Several dark-colored shock melt veinlets are visible (figure 1).

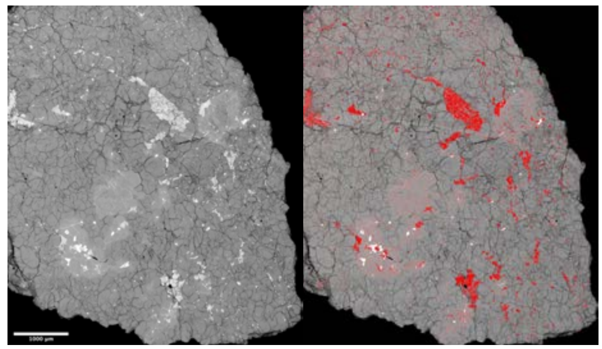

Fig. 2. BSE map of Erg Atouila 001 stitched from 57 images, Olivine, pyroxene and apatite (in red) make up 3.75% of the area of the sample. Sulfide and metal make up 0.75%, albite makes up 95.5% of the surface area in the images.

Microprobe examination and an SEM mapping show that albitic alkali feldspar makes up ~95% of the modal abundance of this meteorite (figure 2). Clinopyroxene makes up approximately 3% of the mode, phases with less than 1% modal abundance include olivine, K-feldspar, fluorapatite, merrillite, troilite, Fe-metal, ilmenite, and oxidized iron. Small poikiolitic inclusions of olivine and lamellae of K-spar are ubiquitous within the host albite. Clinopyroxene occurs primarily in centimeter-sized elongate nodules or lenses along with olivine inclusions and other minor phases (figure 3).

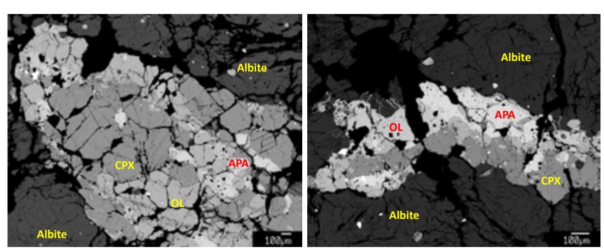

Fig. 3. BSE images of nodule domains in which augite (CPX), olivine (OL) and apatite (APA) were observed. The albite host encloses the nodules.

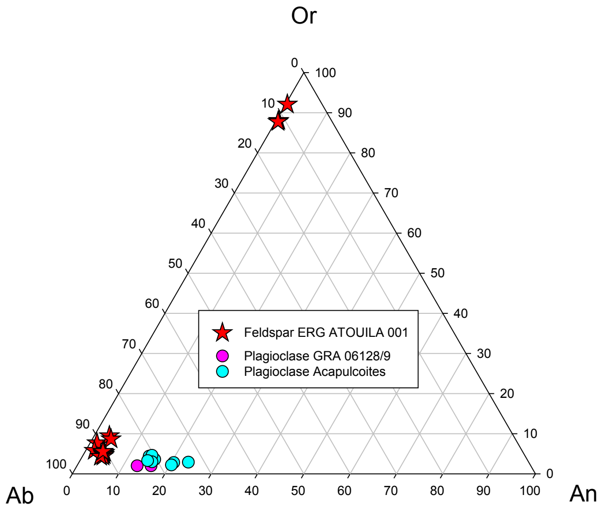

Fig. 4 Ternary diagram showing the feldspar compositions of Erg Atouila 001, red stars (n=24). Na-rich plagioclase in GRA 06128/9 [1] (pink) and in acapulcoites (cyan).

Electron microprobe results: *Albite* Ab 90.5±1.3 Or 5.8±1.3 An 3.7±1.0, n=21; *K-spar* Ab 10.2±2.3 Or 89.3±2.4 An 0.5±0.1 n=3; *augite* Fs 8.9±0.9 Wo 45.0±0.9, Fe/Mn=10±1, TiO_2=1.41±0.21, Cr_2O_3=1.07±0.22, Na_2O=1.02±0.07 (all wt%), n=29; *olivine* Fa 29.6±0.5, Fe/Mn=22±1, n=23; *apatite* F=4.24±0.71, Cl=0.11±0.09 (all wt%), n=10; *merrillite* Na=1.88±0.10, Mg=2.03±0.03, Fe=0.41±0.10 (all wt%), n=8; *troilite* FeS, n=6; *metal* Fe=99.2±1.4, Ni=0.13±0.09, Co=0.03±0.02 (all wt%), n=15. Noteworthy is the relatively high degree of chemical compositional equilibration in most phases. Augite and olivine have Fe/Mg and Fe/Mn values similar to the acapulcolite-lodranite group. Augite is rich in Ti, Cr, and Na. Apatite is F-rich and Cl-poor. Iron metal is very low in Ni-content.

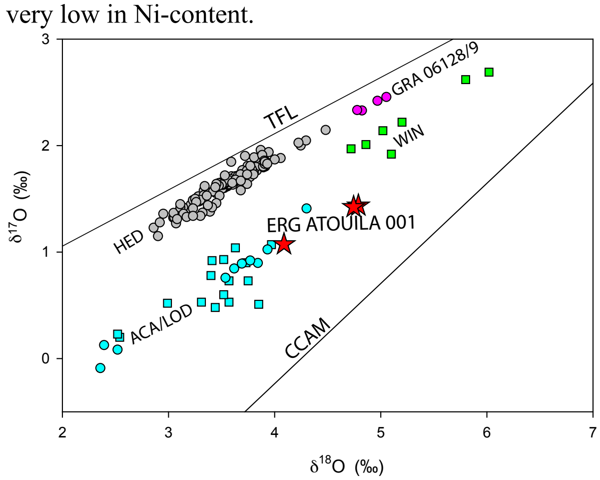

Fig. 5. Triple oxygen isotope diagram showing the values for Erg Atouila 001 (red stars). Also shown are values for acapulcoites and lodranites (cyan), HED meteorites (gray), winonaites (green), and ungrouped achondrites GRA 06128 and GRA 06129 (pink) [6]. TFL=terrestrial fractionation line, CCAM=carbonaceous chondrite anhydrous minerals.

Oxygen isotopes: Oxygen isotopes were performed at UNM on 3 acid-washed fragments analyzed by laser fluorination and gave δ18O= 4.789, 4.744, 4.088; δ17O= 1.437, 1.423, 1.074; Δ17O= -1.091, -1.082, -1.084 (linearized, all per mil, TFL slope=0.528). The measurement with the lowest δ17O and δ18O values was performed on a green pyroxene which overlaps with the higher values of the acapulcoite-lodranite field. The two measurements with higher δ17O and δ18O values were performed on feldspar-rich fragments.

Origin of Erg Atouila 001 and Comparison with other Silica-rich Ungrouped Achondrites: Erg Atouila 001(EA 001) is the first example of an albitite or synenite meteorite and based on terrestrial examples, which are relatively rare, it is likely derived from a highly differentiated source or parent body. EA 001 has similar oxygen isotopes and Fe/Mg and Fe/Mn to the acapulcoite-lodranite group, suggesting a possible, but yet unexplored genetic link. EA 001 now joins the growing number of classified silica-rich ungrouped achondrites (figure 6), all of which, with the exception of NWA 11119, are alkali-rich. Several have been shown to be formed from igneous activity in the early solar system. However based on oxygen isotopes they seem to originate from at least 5 different parent bodies, suggesting that ancient silica-rich magmatism was more common in the solar system than previously thought.

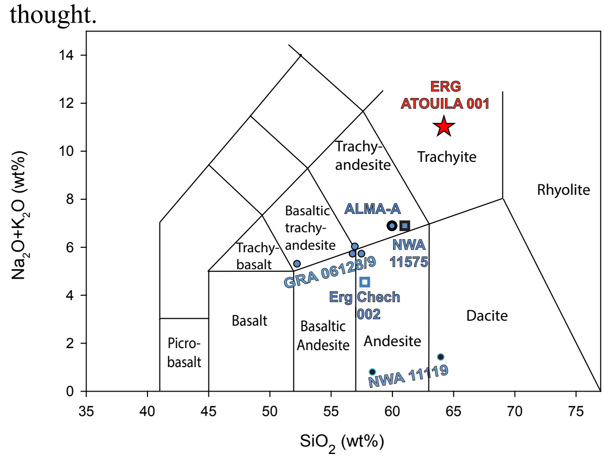

Fig. 6 Total alkalis versus silica (TAS) diagram showing the bulk composition of Erg Atouila 001 (red star) based on modal mineralogy. Also shown are values for other silica-rich ungrouped achondrites (blue) GRA 06128/06129 [3] Almahata Sitta ALMA-A [2], NWA 11119 [4], NWA 11575 [5], Erg Chech 002 [6].

References: [1] Shearer C.K. et al. (2008) *American Mineralogist* 93, 1937–1940. [2] Bischoff A. et al. (2014) *Proceedings of the National Academy of Sciences* 111, 12689–12692. [3] Agee C.B. et al. (2018) *Lunar and Planetary Science Conference*, 2226. [4] Barrat et al. (2021) *PNAS* 118 (11) e2026129118. [5] Day J.M.D. et al. (2009) *Nature,* 457, 179-182. [6] Srinivasan P. et al (2018) *Nature Communications* 9 (1), 1-8.