79th Annual Meeting of The Meteoritical Society
7-12 August 2016
Berlin, Germany

El Médano 301: a New Forsterite Chondrite

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BACKGROUND & OBJECTIVE

Dark chondritic clasts with reduced olivine ($Fa_{0.08-3.66}$) and pyroxene ($Fs_{0.07-14.5}$) compositions have been described inside Cumberland Falls aubrite [1] (Figure 1). It was suggested these clasts are the fragments of an otherwise unsampled F-chondrite parent body which upon a collision with the aubrites parent body has led to the formation of Cumberland Falls breccia [1]. Another interpretation suggests that the reduction of a LL chondritic component in presence of highly reduced aubritic host could form clasts with the observed composition [2]. The latter model is supported by the occurrence of less reduced chondrites (defined as low-FeO ordinary chondrites) formed during thermal metamorphism and the reduction of chondritic clasts (defined as HH chondrites) inside IIE iron meteorites. Acfer 370 [3] and NWA 7135 [4] (Figure 2) are two recently described chondrites that show affinities with Cumberland Falls clasts. El Médano 301, an ungrouped chondrite that also shares characteristics with these two meteorites and with the Cumberland Falls chondritic clasts was found in 2013 by our team during a search for meteorites in the Atacama desert (Chile). Here we report the preliminary results on the petrography, mineral chemistry, trace element and oxygen isotopic compositions, and IR spectroscopy of this meteorite. Comparison of El Médano 301 with the previously known meteorites, can give insights into the existence and origin of F chondrites and their relationship with the ordinary chondrites and reduced ordinary chondrites.

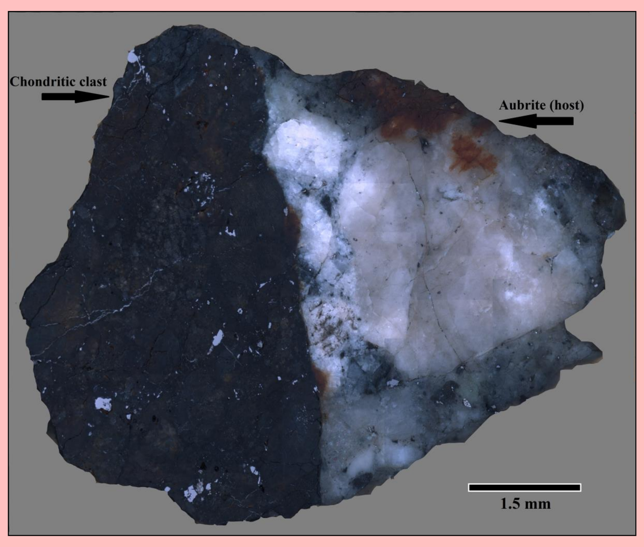

Figure 1: Cumberland Falls aubrite, contains dark chondritic clasts (mosaic picture prepared under combined reflected and plane-polarized transmitted light). Sample: MNHN-2840-2.

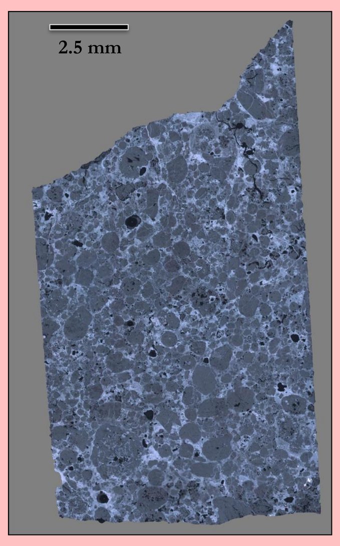

Figure 2: NWA 7135 shows a well-preserved chondritic texture (mosaic picture prepared under reflected plane-polarized light).

TEXTURE & MINERALOGY

El Médano 301 is composed of two pieces totaling ~17 g. There is no trace of fusion crust and cut surfaces show a dark brown interior. It presents a well-preserved and closely packed chondritic texture (Figure 3). Main minerals are Mg-rich olivine and Ca-poor pyroxene, diopside, chlorapatite, chromite, troilite, kamacite and taenite (Figure 4). Metal and sulfides have been extensively (>90%) replaced by weathering products. Different minerals (specially olivine) show sharp optical extinction and some random fractures, which indicates a low shock degree (S1-S2). Average apparent chondrule diameter is 500 ± 320 µm (n=99). Average olivine (n=10) and orthopyroxene (n=11) compositions are Fa3.9 ± 0.4 (PMD = 5.5%) and Fs13.1±5.7 (PMD = 40%), respectively, which suggest a petrologic type of 3 (leaning to 4). Average Co content of kamacite is 0.13 (n=8). The magnetic susceptibility is log χ = 4.62 (χ in 10^{-9} m^3/kg). The infrared reflectance spectrum of El Médano 301 was obtained on a powdered sample leached with HCl to remove weathering products (oxyhydroxides) that otherwise dominate the spectrum. The spectrum reveals the presence of two strong absorption around 0.92 µm and 1.9 µm. The position of these bands as well as their relative intensity points toward the presence of an Mg-rich and Ca-poor pyroxene. From a spectral point of view, El Médano 301 is therefore closer to Vesta (V-type) than S-type asteroids.

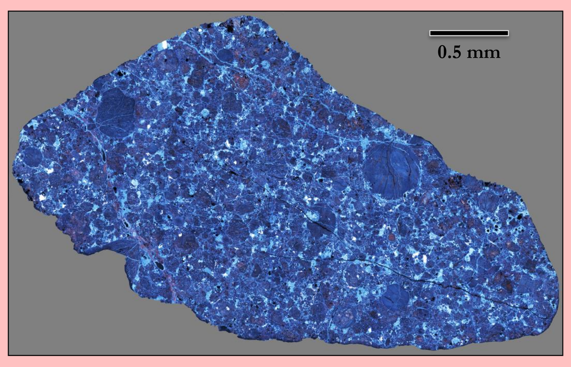

Figure 3: El Médano 301 shows a well-preserved chondritic texture (mosaic picture prepared under reflected plane-polarized light).

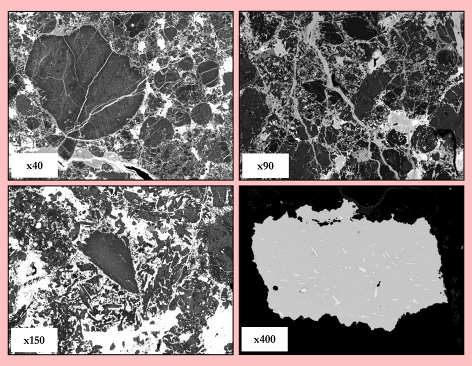
Figure 4: SEM pictures of different El Médano 301 components.

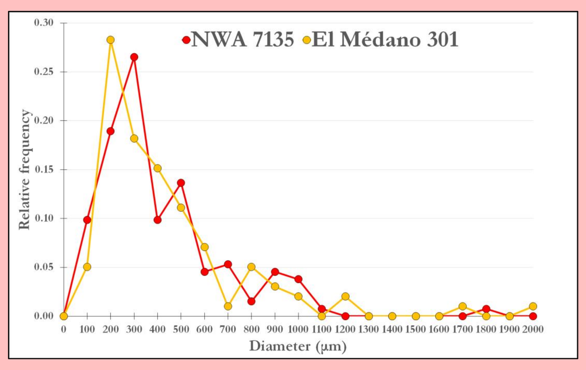

Figure 5: Diameters and size-frequency distributions of El Médano 301 and NWA 7135.

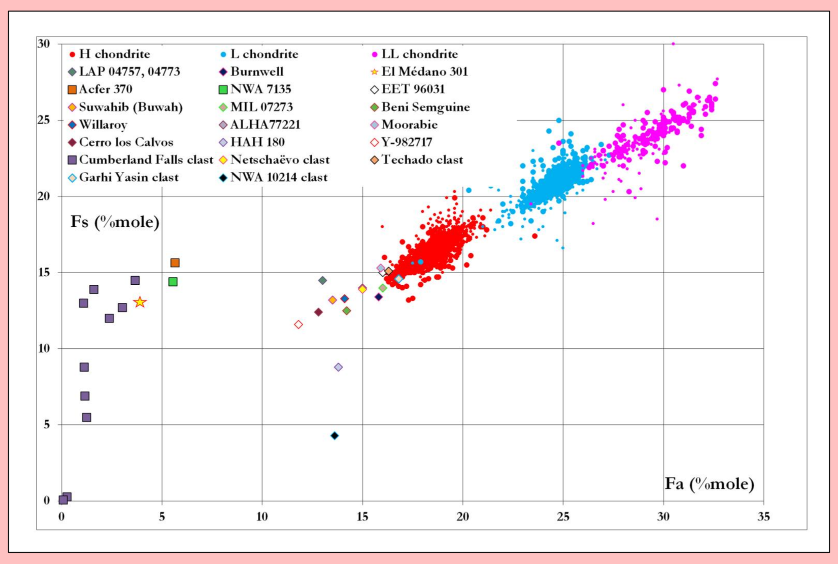

Figure 6: Average olivine and orthopyroxene compositions of ordinary chondrites, and reduced ordinary chondrites and the "related" chondrites. Data source: Meteoritical Bulletin.

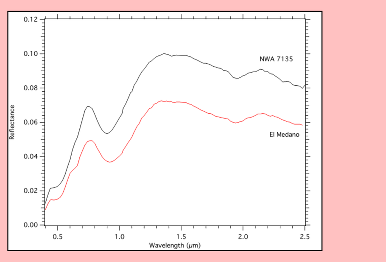
Figure 7: The IR spectra of NWA 7135 and El Médano 301.

CHEMISTRY & OXYGEN ISOTOPES

Mean-CI normalized ICP-MS analysis results show an elevated amount of Ba (× 43.6), Sr (× 3.2) and LREE (up to × 2.4 for La), which are indicative of terrestrial weathering. Keeping in mind these effects, the trace elements contents (comprising REEs) are in the range of mean ordinary chondrites (Figure 8). Oxygen isotopic composition from analysis of two acid-washed 1.5 mg aliquot of a powdered 200 mg bulk sample by laser fluorination is δ17O = +3.61, +3.58‰, δ18O = +5.38, +5.39‰ , Δ17O = +0.79, +0.76‰ (linearized, slope 0.5247, analytical uncertainties 0.08‰, 0.12‰, 0.03‰ respectively) (Figure 9).

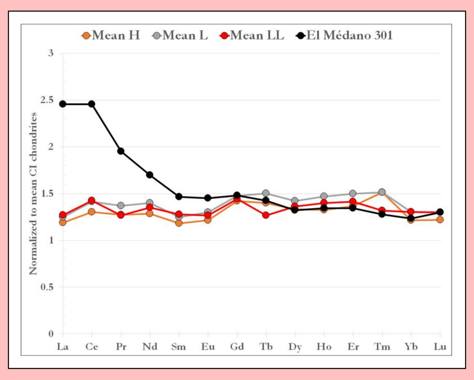

Figure 8: REE composition of El Médano 301 and different ordinary chondrites. Data source: [5].

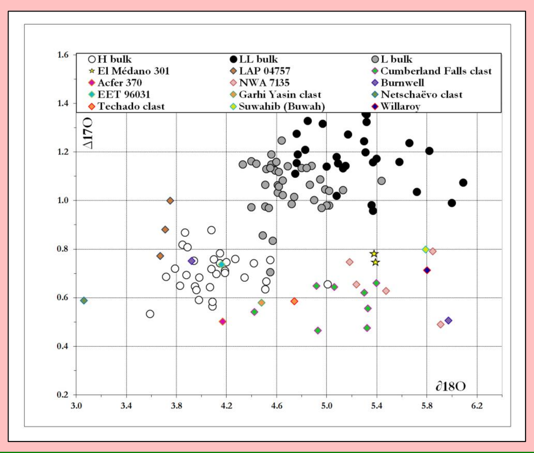
Figure 9: Oxygen isotope composition of El Médano 301 and different ordinary and reduced chondrites . Data source: [6].

DISCUSSION & CONCLUSIONS

The average apparent chondrule size of El Médano 301 and NWA 7135 (480 ± 270 µm, n = 132), is intermediate between values for H [7] and L [8] chondrites, but significantly smaller than LL chondrites. This precludes a formation by reduction of a LL chondrite precursor as suggested for the chondritic clasts of Cumberland Falls [2]. Trace element composition shows the affinity of the meteorite with ordinary chondrites. However, the olivine and pyroxene compositions of El Médano 301 are far from the defined ranges for H, L, LL and low-FeO chondrites. Cobalt content of kamacite is also much lower than the reported amount for the ordinary chondrites [9]. Together with Cumberland Falls clasts, NWA 7135 and Acfer 370, it forms a well-separated cluster. Similarly, the oxygen isotope compositions of these meteorites form a cluster separated from other ordinary chondrites.

El Médano 301 is a chondrite containing olivine and pyroxene with Mg-rich compositions of $Fa_{3.9 \pm 0.4}$ and $Fs_{13.1 \pm 5.7}$ that are intermediate between other ordinary and enstatite chondrites. Its oxygen isotope composition is different from other ordinary chondrites and it is similar to the chondrite clasts in Cumberland Falls. All these characteristics suggest that El Médano 301 has a close relationship to these clasts, NWA 7135, and Acfer 370, strengthening the case for the occurrence of a "F chondrite" class of ordinary chondrite.

REFERENCES

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