MINERALOGY AND OXYGEN ISOTOPIC COMPOSITION OF EXOTIC F6 CHONDRITE CLASTS IN THE CUMBERLAND FALLS AUBRITE. S. M. Kuehner[1], J. H. Wittke[2], K. Ziegler[3] and A. J. Irving[1] [1]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA (irvingaj@uw.edu), [2]Geology Program, SESES, Northern Arizona University, Flagstaff, AZ, [3]Institute of Meteoritics, University of New Mexico, Albuquerque, NM.

Introduction: The 1919 Cumberland Falls, Kentucky aubrite fall is well-known for containing black inclusions which were deemed to be a new class of reduced chondrite [1]. More recently two other meteorites from northwestern Africa (Acfer 370, NWA 7135) have been recognized to be examples of the same rare F chondrite class [2, 3]. We have re-examined the clasts in a specimen of Cumberland Falls to augment previous work on their features, and we also present new oxygen isotope data.

Figure 1. *Cumberland Falls slice showing two black F chondrite inclusions within the whiter aubrite matrix. The clast at the bottom is CF#1.*

Petrography: The chondrite clasts in the studied specimen evidently are so dark because of the presence of opaque phases distributed throughout very magnesian silicates, and they show evidence of having been shock-melted. The main silicate phases are forsterite ($Fa_{0.7}$), enstatite and diopside, but rare sodalite was also found. Accessory phases include kamacite, troilite, taenite, schreibersite, daubreelite and alabandite, all with irregular grain geometries indicative of melting (see Figures 2, 3, 4). Round objects which appear to be recrystallized chondrules are rare, and therefore we conclude that these particular clasts are shocked F6 chondrites. The lack of Si in kamacite, lack of Ti or Cr in troilite, and the presence of Fe in silicates all imply that the oxygen fugacity under which these F chondrite clasts crystallized was not as far below that of the IW buffer as for enstatite chondrites and aubrites.

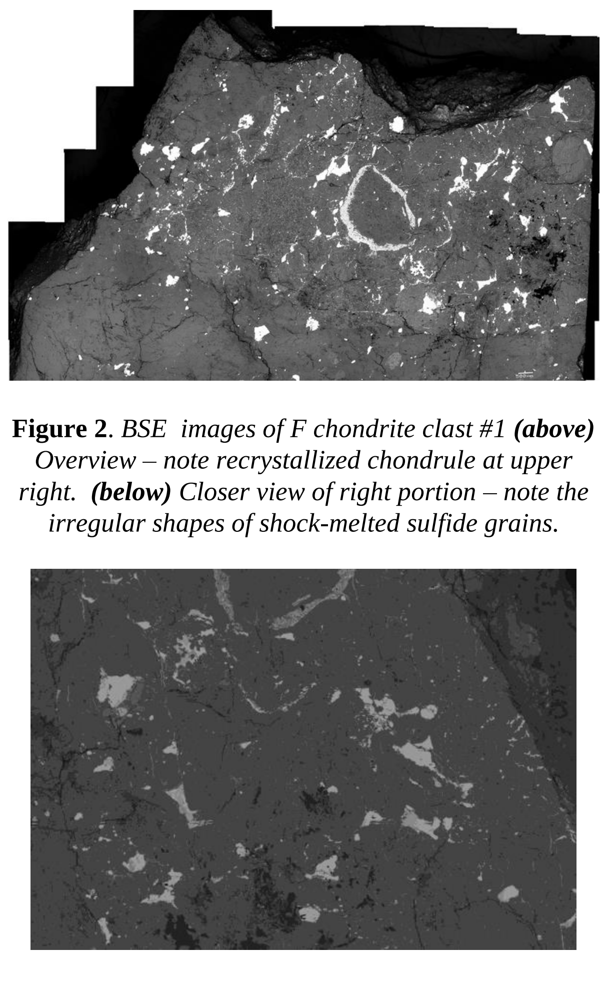

Figure 2. *BSE images of F chondrite clast #1* ***(above)*** *Overview – note recrystallized chondrule at upper right.* ***(below)*** *Closer view of right portion – note the irregular shapes of shock-melted sulfide grains.*

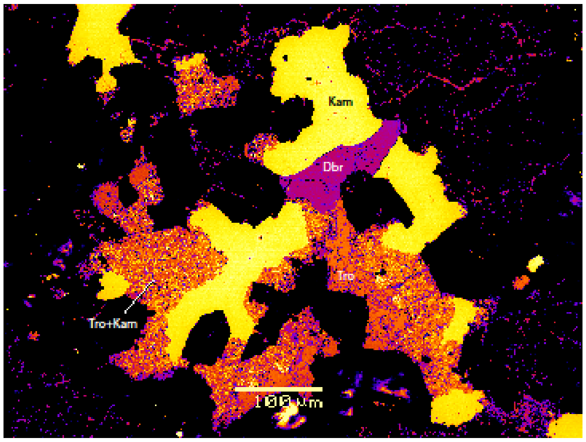

Figure 3. *False-color BSE image of accessory sulfides (troilite and daubreelite) intergrown with metal. Magnesian silicates appear black.*

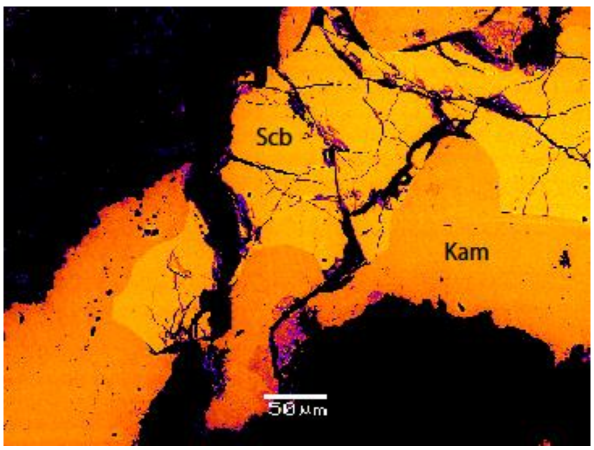

Figure 4. *False-color BSE image of accessory schreibersite with kamacite.*

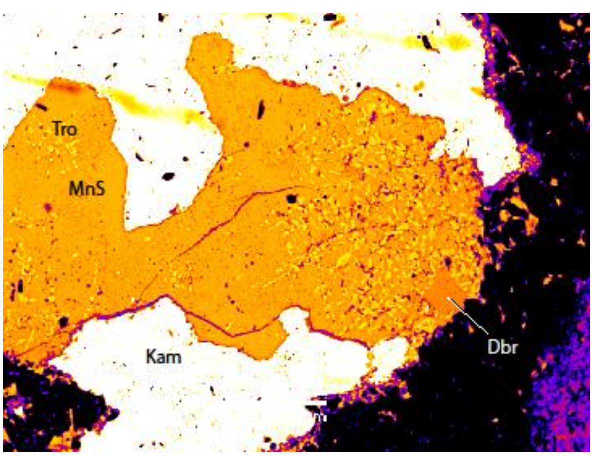

Figure 5. *False-color BSE image of accessory alabandite, troilite and daubreelite with kamacite.*

Oxygen Isotopes: A small fragment removed from clast #1 was gently crushed and washed in HCl until acid remained clear prior to laser fluorination. Results of eight replicate analyses are respectively:

$\delta^{17}O$ 3.467, 3.276, 3.243, 3.327, 3.028, 2.841, 3.377, 3.206
$\delta^{18}O$ 5.396, 5.061, 5.322, 5.328, 4.928, 4.422, 5.300, 4.917
$\Delta^{17}O$ 0.618, 0.604, 0.433, 0.514, 0.426, 0.506, 0.579, 0.610

It is apparent from Figure 6 that the oxygen isotopic composition of the fresh Cumberland Falls clast overlaps with those for the NWA 7135 specimen, establishing that the results for the latter have not been compromised by desert weathering effects (and effectively removed by our acid washing procedures).

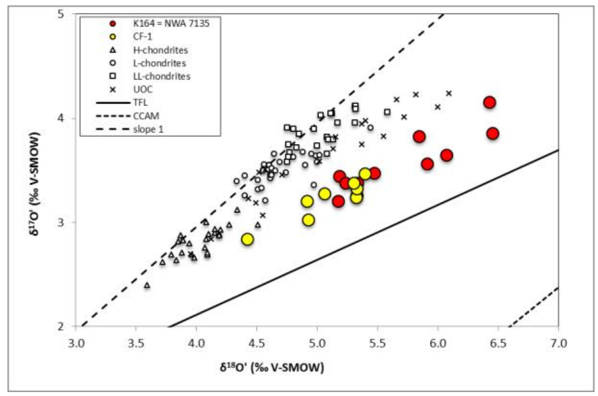

Figure 6. *Oxygen isotopic compositions for F chondrites compared with those for ordinary chondrites [4, 5].*

Discussion: The Cumberland Falls chondrite clasts (at least in the specimen studied) differ from their Northwest African counterparts in being more equilibrated and also more shocked. Other examples studied previously [1] also appear to have similar characteristics. Well formed chondrules are present in both Acfer 370 and NWA 7135, which are regarded as F3/4 chondrites, whereas the clasts in Cumberland Falls are shocked F6 chondrites. It is possible that the latter experienced higher shock during collision of F chondrite impactors onto the aubrite parent body.

Acknowledgement – The slice of Cumberland Falls studied here was generously loaned to us by John Curchin.

References: [1] Verkouteren R. and Lipschutz M. 1983 *GCA* **47**, 1625-1633 [2] Moggi-Cecchi V. et al. 2009 *72nd Meteorit. Soc Mtg.*, #5421 [3] Irving A. et al. 2015 *Lunar Planet. Sci.* **XLVI**, #2230; Kuehner S. et al. 2015 *78th Meteorit. Soc Mtg.*, #5238 [4] Clayton R. et al. 1991 *GCA* **55**, 2317-2337 [5] Ziegler K. et al. 2014 *Lunar Planet. Sci.* **XLV**, #2468.