TAFASSASSET: THE SAGA CONTINUES

K. G. Gardner-Vandy[1], D. S. Lauretta[1,2], M. Killgore[2], I. A. Franchi[3], and R. C. Greenwood[3], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, kgardner@lpl.arizona.edu, [2]Southwest Meteorite Center, Tucson, AZ 85712, [3]Planetary and Space Sciences Research Institute, The Open University, Milton Keynes, MK7 6AA, United Kingdom.

Introduction: Tafassasset, a meteorite that consists of 26 stones found in the Tenere desert of Niger between 2000 and 2001, has yet to be definitively classified, and its dubious origin is likely due to considerable textural and compositional heterogeneities between individual stones. It appears that at least two different lithologies of Tafassasset have been studied. The first (Tafa-Paris) was classified by [1] as a metamorphosed CR chondrite based upon an oxygen isotope composition in line with the CR chondrites (Figure 1) and the presence of metal-bearing relict chondrules similar to the chondrules found in the CR chondrite Renazzo (Figure 2). The authors assert that the differences between Tafassasset and Renazzo can be explained by various degrees of metamorphism.

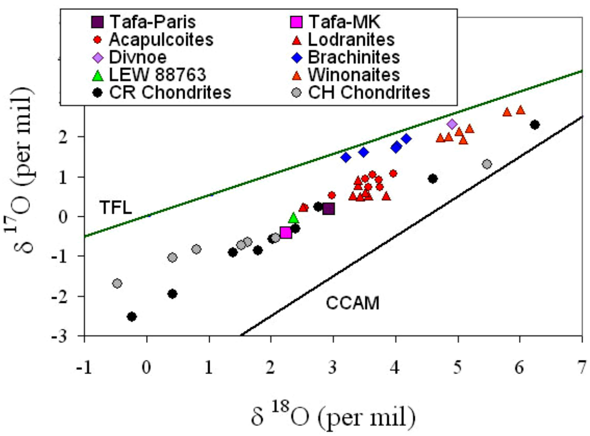

Figure 1: Oxygen Isotope Plot of Primitive Achond.

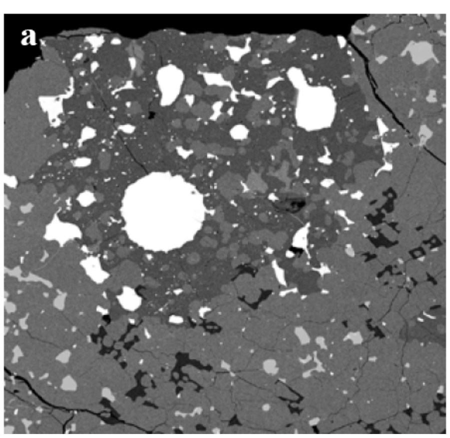

Figure 2: Figure 2a from [1] showing a relict chondrule similar to the chondrules in Renazzo

Soon after, [2] found that Tafa-Paris and another Tafassasset sample (Tafa-Freiburg) both have refractory element ratios depleted relative to the CI chondrites, with Al/Mg and Mn/Mg ratios more like those of other primitive achondrites. In the end, they exclude a relationship between the CR chondrites and Tafassasset and confirm a pairing between Tafa-Paris and Tafa-Freiburg. Likewise, [3] agrees that their sample of Tafassasset, similar in composition to Tafa-Freiburg and absent of relict chondrules, is not a metamorphosed CR and is more like Brachina, and they assert that there are two groups of brachinites in existence: one main group and another that includes Tafassasset and the anomalous LEW 88763. Finally, [4] analyze a sample of Tafassasset from Marvin Killgore (Tafa-MK) which seems analogous to that studied by [2-3]. In their study, [4] assess a relationship between Tafassasset and other FeO-rich primitive achondrites, concluding that the major mineral composition of Tafassasset ($Fa_{28.3}$ olivine and $Fs_{23.5}$ low-Ca pyroxene) is much more similar to the brachinites and other FeO-rich ungrouped primitive achondrites such as RBT 04239 than the CR chondrites.

Perhaps the most vexing issue in the Tafassasset confusion is the existence of two competing sets of information: CR-like oxygen isotope data and FeO-rich silicate composition. How can an FeO-rich, recrystallized meteorite have an oxygen isotope composition in line with the FeO-poor CR chondrites? In the following study, we obtain our own data of Tafa-Paris and compare it to previously reported data on Tafa-MK. We also supply new oxygen isotope data for the Tafa-MK sample and offer a hypothesis for the origin of the Tafassasset stones as a whole.

Analytical Techniques: Two chips of bulk Tafa-MK were sent to Open University for oxygen isotopic analysis. Two polished thin sections of Tafa-Paris were obtained from the Muséum National d'Histoire Naturelle, Laboratoire de Minéralogie in Paris, France for analysis on the Cameca SX50 electron microprobe at LPL. The conditions for the analyses on the electron microprobe were 15 kV accelerating voltage, 20 nA beam current and 1-μm beam size for olivine and pyroxene; and 15 kV, 8 nA and 10-μm beam size for plagioclase.

Initial Results: The two chips of Tafa-MK analysed here have nearly identical oxygen isotopic composition, averaging $\delta^{17}O = -0.41$ ‰ and $\delta^{18}O = 2.25$

‰ with $\Delta^{17}O$ = -1.58 (Figure 1). This is different than the compositon found by [1] for Tafa-Paris: $\delta^{17}O$ = 0.18 ‰ and $\delta^{18}O$ = 2.94 ‰ with $\Delta^{17}O$ = -1.35.

Our observations show that Tafa-Paris is texturally and mineralogically indistinguishable from Tafa-MK; each contains subhedral olivine with pyroxene and interstitial plagioclase, with chromite, metal and troilite as minor phases. Figures 3 and 4 show BSE images of typical regions in each section; note the identical relationships between the olivine and pyroxene (medium grays) to the metal and troilite (white) and interstitial plagioclase (dark gray). The composition of the olivine, pyroxene and plagioclase is also nearly identical. As reported in [4], we found Tafa-MK to have $Fa_{28.3}$ olivine, $Fs_{23.5}$ low-Ca pyroxene, and $An_{23.6\text{-}36.5}$ plagioclase. Here, we find Tafa-Paris to have $Fa_{29.1}$ olivine, $Fs_{24.1}$ low-Ca pyroxene, and $An_{23.3\text{-}45.1}$ plagioclase. We do not observe relict chondrules in either Tafa-Paris or Tafa-MK.

Despite minor olivine and pyroxene compositional differences, Tafa-MK and Tafa-Paris plot near each other on the $X_{Fs,opxn}$ versus X_{Fa} diagram shown in Figure 5. Both Tafa-MK and Tafa-Paris plot within the LL ordinary chondrite field and along an equilibrium trend with other FeO-rich primitive achondrites and highly metamorphosed ordinary chondrites. This figure emphasizes the compositional differences between Tafassasset and the CR chondrites as the latter plots much to the lower left near olivine $Fa_{1\text{-}8}$.

Discussion: In the quest to understand the origin of Tafassasset, consideration of our new oxygen isotope data is imperative. As discussed here, all of the Tafassasset stones circulating through the scientific community can be paired, yet already two of the stones have distinct oxygen isotopic compositions. To explain the oxygen isotope differences between the Tafassasset stones, we hypothesize that a parent body of FeO-rich material partially differentiated and cooled (without reaching isotopic homogeneity) in a region of the nebula with oxygen-isotopic composition similar to the CR chondrites. Further study is necessary to access a second scenario in which a CR chondrite precursor had a high concentration of FeO-rich material that then partialy melted to form stones like Tafassasset.

References: [1] Bourot-Denise M. et al. (2002) *LPS XXXIII*, Abstract #1611. [2] Zipfel J. et al. (2002) *Meteoritics & Planet. Sci., 37*, A155. [3] Nehru C. E. et al. (2003) *LPS XXXIV*, Abstract #1370. [4] Gardner K. G. et al. (2007) *LPS XXXVIII*, Abstract #2086.

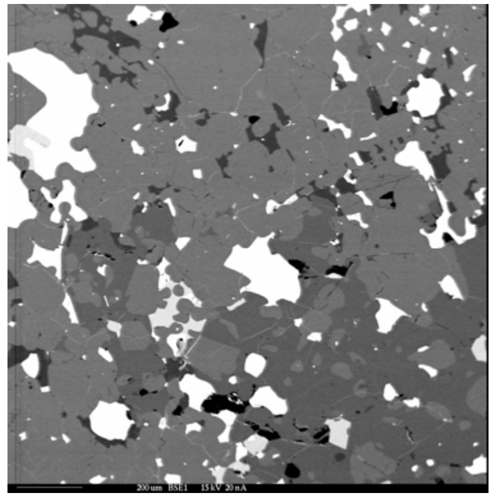

Figure 3: BSE image of Tafa-MK (1.46 mm across)

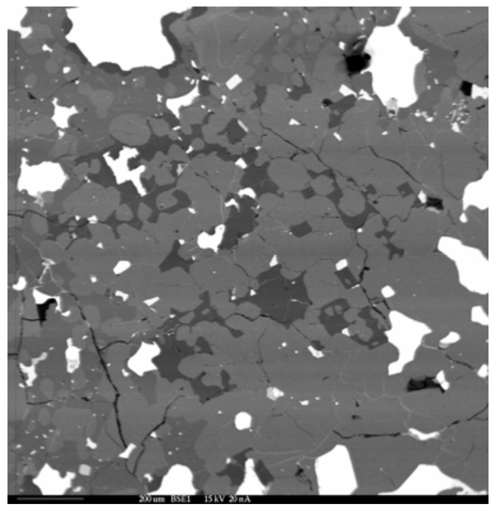

Figure 4: BSE image of Tafa-Paris (1.46 mm across)

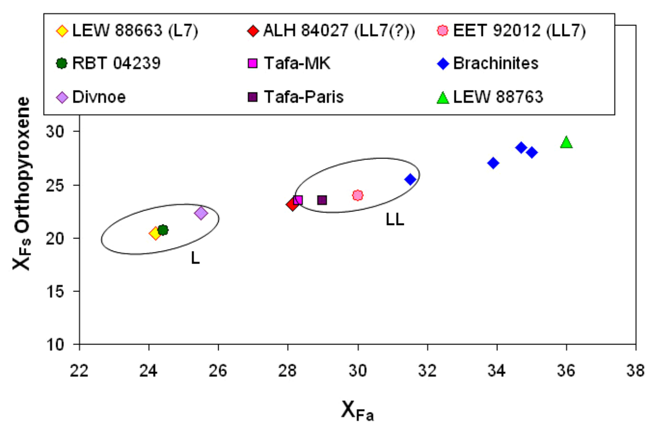

Figure 5: $X_{Fs,opxn}$ vs. X_{Fa} for Primitive Achondrites and L and LL OCs