NORTHWEST AFRICA 12869: PRIMITIVE ACHONDRITE FROM THE CR2 PARENT BODY OR MEMBER OF A NEW METEORITE GROUP? C. B. Agee, H. Aikin, K. Ziegler, Department of Earth and Planetary Sciences and Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131, agee@unm.edu.

Introduction: We report here the classification of a new primitive achondrite, Northwest Africa (NWA) 12869, which is a plagioclase-bearing harzburgite with oxygen isotopes similar to CR2 chondrites, however the high Fa- and Fs-content and Fe/Mn of its olivines and pyroxenes appear to be inconsistent with a direct genetic link to CR2. Instead, NWA 12869 shows petrologic and geochemical resemblance to about a dozen other primitive achondrites or highly recrystallized chondrites which have been linked to the CR2 parent body because of similar oxygen and chromium isotopes [1,2]. An alternative interpretation is that these meteorites are not derived from the CR2 parent body, but instead represent a separate new meteorite group.

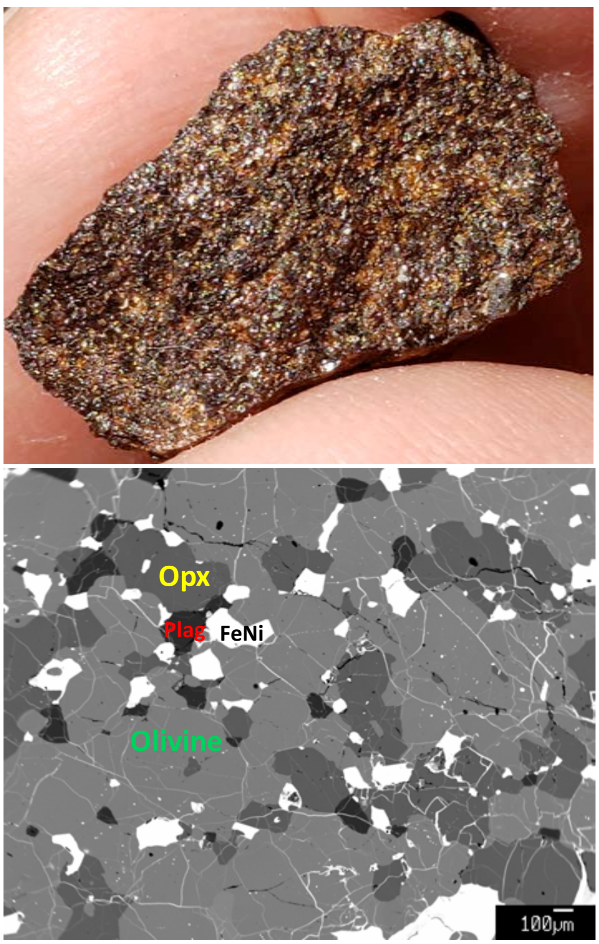

Fig. 1. Top, photograph of a chip of NWA 12869 used for microprobe analysis (~2x1 cm). Bottom, BSE image showing texture and major phases present.

History, Physical Charateristics, Petrology: NWA 12869 was purchased by Abdelhadi Aithiba in Taoudenni, Mali, 2019. The main mass of NWA 12869 was a single stone of 4300 grams. It has a dark brown, desert-weathered, irregular shaped exterior. Broken surfaces show dark brown, green, and honey-colored grains (fig. 1) Electron microprobe analyses were performed on a polished probe mount taken from the classification deposit sample at the Institute of Meteoritics (UNM). The estimated modal mineral abundances by area are: 70% olivine, 20% low-Ca pyroxene, 5% plagioclase, and 10% kamacite+troilite. Fine crosscutting Fe-oxide veinlets were seen throughout. No chondrules were observed. (fig. 1).

Electron microprobe results: *Olivine* Fa34.7 ± 0.2, Fe/Mn = 86 ± 5, n = 10; *low-calcium pyroxene* Fs26.2 ± 1.3 Wo3.6 ± 0.4, Fe/Mn = 58 ± 8, n = 6; *plagioclase* An47.4 ± 0.5 Ab51.5 ± 0.5, n = 4. Figure 2 illustrates the Fa and Fe/Mn values of NWA 12869 olivines compared to CR2 chondrites, CR6 and 7 chondrites, and primitive achondrites having oxygen and chromium isotope values similar to CR2.

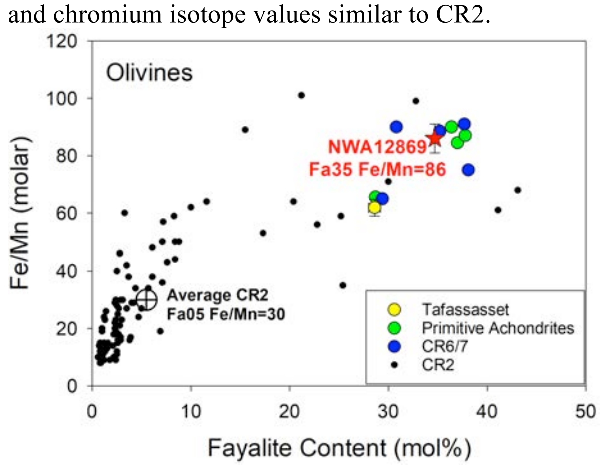

Fig. 2. Average olivine Fe/Mn and Fa-content in NWA 12869 (red star) compared to random chondrule olivine analyses for CR2 chondrites (90 black dots, NWA 7655, NWA 8725, NWA 12197, NWA 12698), average CR2 olivine (circle with cross) n=90, Tafassasset [3], Primitive Achondrites (NWA 2994, NWA 3100, NWA 3250, NWA 6901), CR6 chondrites (NWA 6921, NWA 7317, NWA 11561) and CR7 chondrites (NWA 7511, NWA 12455). All data except CR2 and Tafassasset are from the MetBull.

Oxygen Isotopes: NWA 12869 is classified as a primitive achondrite not belonging to a known group, however oxygen isotopes indicate that it has similar values to CR2 chondrites, Tafassasset, some primitive achondrites and CR6/7 listed in figure 2, ungrouped basaltic achondrite NWA 011 (and pairs), and orthopyroxenites (NWA 6693, NWA 6704, NWA 8054). Figure 3 shows our results for laser fluorination analyses of three acid-washed fragments of bulk sample with values of $\delta^{17}O$= 0.225, 0.170, -0.072; $\delta^{18}O$= 3.668, 3.584, 3.181; $\Delta^{17}O$= -1.712, -1.722, -1.752 (all linearized, permil). The values for NWA 12869 coincide with several primitive achondrites, CR6/7, and NWA 011, and fall on the fairly tight trend defined by these meteorites and Tafassasset. NWA 12869 values also coincide with a few CR2 values, however the CR2 trend spans an much larger range of $\delta^{17}O$ and $\delta^{18}O$ values and has apparent slope that is slightly steeper. Oxygen isotope values for NWA 6693/6704 plot higher in figure 3 than both trends.

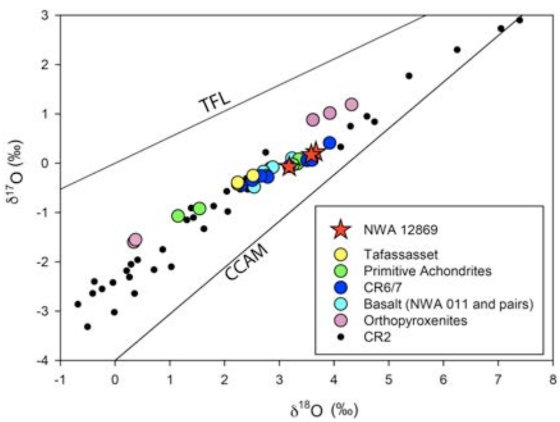

Fig. 3. Triple oxygen isotope diagram showing the values for NWA 12869 (red stars). Also shown are values for CR2 chondrites (black dots) and other primitive achondrites, CR6-7, and ungrouped achondrites (colored dots).

Is the CR2 parent body a source for type 6-7 chondrites, primitive achondrites, basalts, and orthopyroxenites? The evidence that CR2 chondrites and NWA 12869 (and the other PAC, type 6-7, and ungrouped meteorites discussed here) shared the same or a similar oxygen isotope reservoir in the early solar system seems very compelling. This has led some [1,2] to conclude that the CR2 parent body is a disrupted layered, differentiated body and the source of not only CR2 chondrites, but also the petrologically diverse collection of meteorites that share similar oxygen and chromium isotope values. On the other hand, coincidence of oxygen (or chromium) isotope values does not prove that two or more different types of meteorites or planetary rocks are from the same parent body. An obvious example where coincident oxygen isotope values are not due to a common parent body would be for terrestrial rocks, lunar rocks, aubrites, and enstatite chondrites. These all have oxygen isotopes that plot on, or near, the terrestrial fractionation line but come from four different parent bodies, and are petrologically and geochemically distinct from each other. Therefore, in addition to oxygen (chromium) isotopes, other independent lines of evidence such as petrology and geochemistry are required to prove a common parent body. In the case of the parent body hypothesis linking CR2 and the other PAC, type 6-7, and ungrouped meteorites discussed here, these additional lines of evidence are for the most part lacking. As originally noted by Gardener-Vandy et al. [3] in their study of Tafassasset, the lion's share of olivines in CR2 chondrites are in type-I chondrules which are Fa-poor with relatively low Fe/Mn values. In contrast, Tafassasset olivines are much more ferroan with relatively high Fe/Mn values. This is also true of NWA 12869 and the other PACs, as well as the CR6 and 7, all shown in figure 2. This large geochemical difference imposes a daunting challenge to derive these meteorites from a CR2 precursor. These extreme Fa and Fe/Mn mismatches and other geochemical constraints led Gardener-Vandy et al. to exclude the possibility that Tafassasset formed by partial melting of a CR2 chondrite. Until a plausible petrologic connection between CR2 and these meteorites is identified, the common parent body hypothesis remains far from proven.

New Meteorite Group? An alternative interpretation is that these meteorites are not derived from the CR2 parent body, but instead represent a separate new meteorite group. Included in this group would be the following:

- *Primitive achondrites:* Tafassasset, NWA 2994, NWA 3100, NWA 3250, NWA 6901, NWA 12869.
- *CR6:* NWA 6921, NWA 7317, NWA 11561.
- *CR7:* NWA 7531, NWA 12455.
- *Ungrouped achondrites*: NWA 6693, NWA 6704, NWA 8054; NWA 011 (and pairs).

Possible names for this new group could be *Tafassassetites* or *Ténéréites*. "*Tafassassetites"* would be appeling because of Tafassasset's early discovery and geographical name. On the other hand, it could be more appropriate for the new meteorite group to be named "*Ténéréites"* after the Ténéré desert in the south-central Sahara, stretching from Niger to Chad, where Tafassasset was supposedly found. Unfortunately coordinates for the numerous pieces of Tafassasset were originally withheld by the finder and are not officially cited in Meteoritical Bulletin, making the name *Tafassassetites* perhaps less appropriate because of the uncertain find locations within the Ténéré desert.

References: [1] Sanborn M. E. et al. (2014) *45th LPSC,* abstract 2032. [2] Irving A. J. et al. (2014) *45th LPSC,* abstract 2465. [3] Gardener-Vandy K. G. et al. (2012) *Geochimica et Cosmochimica Acta* 85 142–159.