A New Primitive Achondrite from Northwest Africa

Kseniya K. Androsova*
University of Calgary, Calgary, AB, Canada
kandroso@ucalgary.ca

and

Alan R. Hildebrand
University of Calgary, Calgary, AB, Canada

Summary

The winonaite and acapulcoite/lodranite meteorites constitute small groups of primitive achondrites that have experienced thermal metamorphism sometimes accompanied by varying degrees of partial melting. Petrographic and elemental abundance studies [optical microscope observations and electron microprobe analysis] have been conducted on several meteorites recovered in Northwest Africa (NWA). One meteorite has fine-grained, granulitic texture, abundant, evenly distributed metal and troilite grains, and highly reduced mineral compositions [Olivine ($Fa_{6.0\pm0.4}$), low-Ca pyroxene ($Fs_{7.5\pm0.4}$, $Wo_{1.3\pm0.2}$), high-Ca pyroxene ($Fs_{3.2\pm0.2}$, $Wo_{45.8\pm0.7}$)]. Based on these criteria it appears that the data are consistent with the sample being a winonaite. The overall textural resemblance of this meteorite to NWA 1463 and /or NWA 725 (somewhat anomalous) winonaites (both having multiple relict chondrules) may suggest that this meteorite is paired with one or both. Although, until its oxygen isotope composition is obtained the classification of this meteorite as a winonaite (vs. as an acapulcoite) remains uncertain, its primitive achondritic nature is quite evident.

Introduction

The winonaite meteorites represent a class of rare primitive achondrites (together with the acapulcoite/lodranite association) that have sometimes undergone partial melting but generally have chondritic mineralogy and composition. Winonaites can be characterized by fine- to medium-grained, mostly granulitic textures, highly reduced mineral compositions, and unique oxygen isotope signatures (Benedix et al., 1998). Although most of the winonaites lack chondrules, several have been reported to have regions containing relict chondrules. The importance of such meteorites is that they preserve an unusual transition from chondritic material to differentiated meteorites and represent a rarely sampled O isotope reservoir, as a result providing a rare snapshot of Solar-System history.

A private collector provided two fragments of the same meteorite with the initial mass of 11.01g and 16.51g for analysis and classification. Tentative hand sample observation suggested that the meteorite was likely an ordinary chondrite, as several chondrules could be observed by the unaided eye. Relatively high iron content however, raised a suspicion that the meteorite in question might be some other type. Here, we examine the textural and mineralogical data observed in this meteorite and discuss its possible classification as a winonaite.

Method

One polished thin section was obtained and examined with an optical microscope in both transmitted and reflected light. Grain size was determined by measuring twenty randomly selected grains within the matrix and averaging the values. Although grain size approximation based on such few grains resulted in a large standard deviation, it gave an adequate gross estimate of an overall grain size through out the sample. Mineral compositions were determined by a JEOL 8200 electron microprobe operated at 15 kV accelerating voltage and 20 nA beam current. Typical terrestrial mineral standards (forsterite standard for olivine, and augite standard for pyroxene) were used to calibrate the electron microprobe. Standard mineral formulae and end-member calculations were performed. Newly obtained textural, mineralogical, and compositional data were then compared with known primitive achondrites described in the literature and possible correlations were assessed.

Sample description

The exterior (in hand sample) of the meteorite has some patches of grayish brown, thin fusion crust (Fig. 1a). High abundance of metal and the presence of chondrules can be observed on the cut surface of the specimen (Fig 1b). Thin section analysis revealed that the sample is composed of a metal- and sulfide-rich mosaic of Ca-poor pyroxene and olivine grains, with an olivine/Ca-poor pyroxene ratio < 1 and rather fine-grained matrix, with an average grain size of 150 µm. Multiple grain boundaries form triple junctions at ~ 120°. Grains exhibit sharp optical extinction and irregular fractures suggesting a very weakly or unshocked stage (S1). The sample contains multiple relict chondrules, up to 2.3 mm in diameter, encased in a recrystallized groundmass (Fig. 2a, Fig. 3), texturally similar to a type 5 chondrite. Overall, metal and troilite are abundant and distributed evenly throughout the sample as blebs (up to ~ 600 µm in diameter) rather than veins (Fig. 2b). Preliminary electron microprobe analysis reveals the following mineral compositions: Olivine ($Fa_{6.0\pm0.4}$), low-Ca pyroxene ($Fs_{7.5\pm0.4}$, $Wo_{1.3\pm0.2}$), high-Ca pyroxene ($Fs_{3.2\pm0.2}$, $Wo_{45.8\pm0.7}$).

Conclusions

Based on all the features observed it appears that the data are consistent with the sample being a winonaite (Benedix et al., 1998), rather than an ordinary chondrite. Furthermore, presence of multiple relict chondrules, overall texture, and mineral compositions suggests that the meteorite could be paired with NWA 1463, officially classified as winonaite (Benedix et al., 2003). It could also be paired with NWA 725 (Floss et al., 2008), which was originally classified as an acapulcoite, but recent oxygen isotope analysis put the material within a winonaite field and suggested a possible pairing with NWA 1463 (Floss et al., 2008). However, based on the limited petrographic and electron microprobe data in hand, it is not yet evident if the meteorite is paired. The set of potential pairs amongst previously classified NWA meteorites is larger than NWA 725 and 1463, and the pairing of previously described NWA primitive achondrites remains in a state of flux complicated by the common lack of recovery location information. Classification of this sample as a winonaite also remains somewhat uncertain, until its oxygen isotope composition is obtained. Regardless of the uncertainties, the unusual nature of this meteorite is quite evident suggesting that one more meteorite could be joining a small group of primitive achondrites.

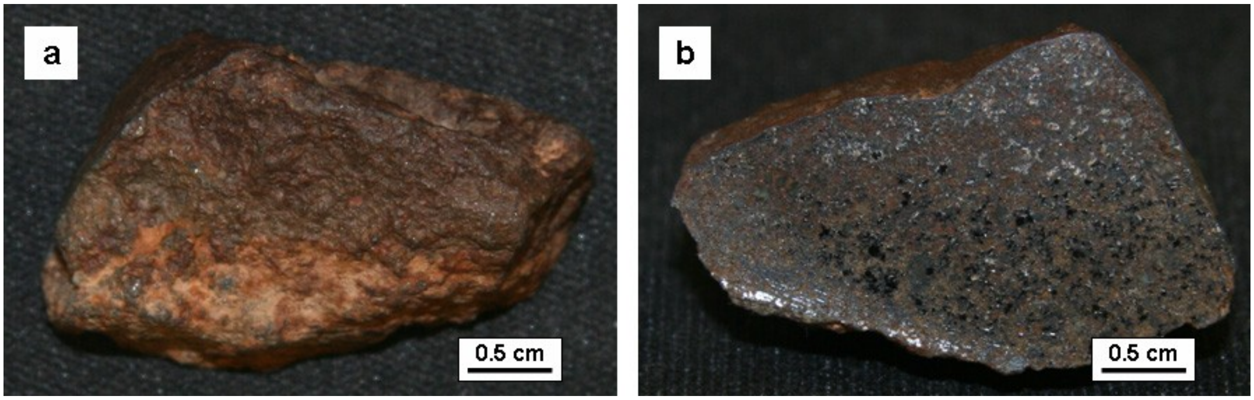

Figure 1: Hand sample photos of the meteorite: (a) Exterior of the meteorite with a typical grayish brown fusion crust in places, (b) Cut and polished surface showing abundant metal.

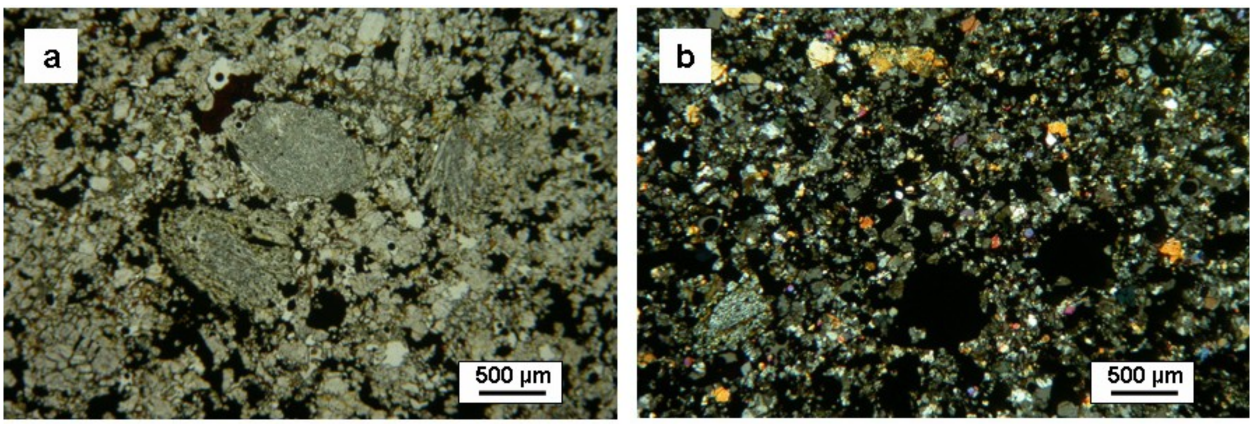

Figure 2: Transmitted light (plain polarized – left, cross polarized – right) photomicrographs of the meteorite in thin section at two different locations: (a) Relict chondrules (in the center) encased into recrystallized matrix, (b) Fine-grained equigranular texture, with considerably coarser metal grains (bottom right).

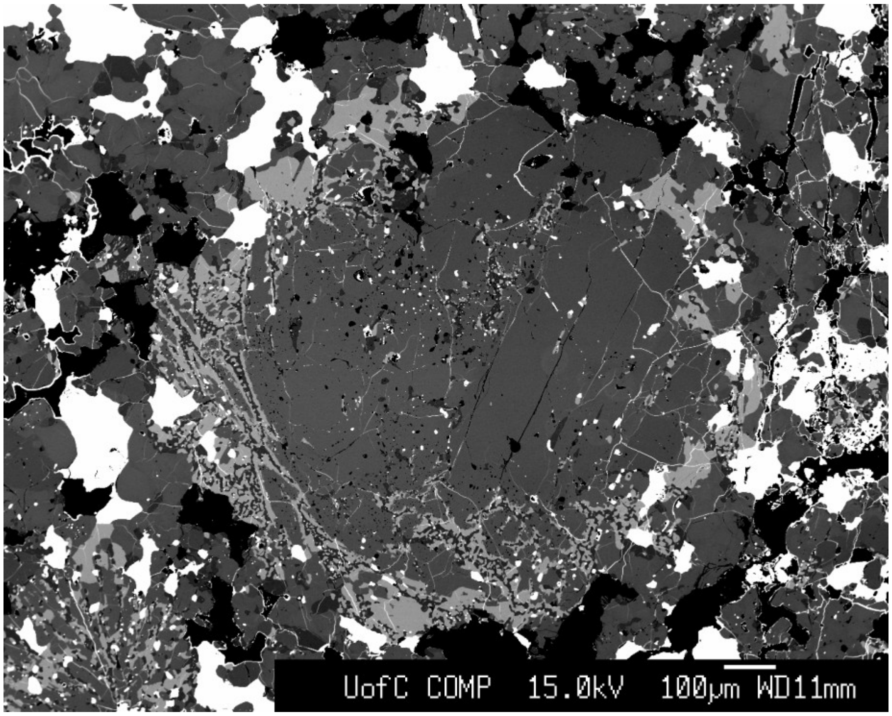

Figure 3: Back-scattered electron image of a rimmed relict chondrule (in the center)

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References

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