THE RECLASSIFICATION OF NORTHWEST AFRICA (NWA) 2900 FROM CV3 TO CK3 CHONDRITE.

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Introduction: Northwest Africa (NWA) 2900, a single 1375 g stone, was found in the North African Sahara in 2004. Although this meteorite was classified as a Vigarano-like carbonaceous chondrite of petrologic type 3 (CV3) [1], we present data demonstrating that NWA 2900 is instead a Karoonda-like carbonaceous chondrite of petrologic type 3 (CK3).

The criteria used for the classification of chondrites into different classes include their petrography and mineralogy [e.g., 2], bulk element abundances [e.g., 3], and oxygen isotope compositions [e.g., 4]. The carbonaceous chondrite class is divided into distinct groups based on bulk composition and petrographic characteristics such as the relative sizes and modal abundances of chondritic components (e.g., chondrules). Certain groups, such as CV and CK chondrites, show similarities so substantial that they are considered to be clans that may represent distinct parent bodies that originated in close proximity to one another in the solar nebula [2]. Due to their similarities, these two chondrite groups are especially prone to misclassification. Nevertheless, it is important to accurately classify CV and CK chondrites to properly compare the properties of the two groups and to rigorously test the single parent body hypothesis proposed by [5].

The CV chondrites are characterized by their high matrix abundances, large chondrules, and high abundances of large calcium-aluminum-rich inclusions (CAIs) [2]. CV chondrites are further subdivided into oxidized (CV_{ox}) and reduced (CV_{red}) subgroups based upon modal metal/magnetite ratios and the Ni content of metal. The oxidized subgroup is subdivided into the Allende-like (CV_{oxA}) and Bali-like (CV_{oxB}) subgroups based on petrologic characteristics such as secondary alteration [6, 7]. The CK chondrites are highly oxidized, characterized by high fayalite contents of their olivine (~$Fa_{16–37}$) and abundant magnetite [8, 9, 10]. While all CV chondrites are classified as petrologic type 3 (i.e., are unequilibrated), CK chondrites cover the entire petrologic range from type 3 to 6, and those of petrologic type <4 show many similarities to CV_{ox} chondrites [5]. In particular, the CK3 and oxidized CV3 chondrites exhibit a similar range of bulk oxygen isotope compositions [5].

The similarities between CV and CK chondrites led [5] to suggest that the two groups may represent samples from a single thermally stratified parent body. This single parent body model was challenged by [10], who argued that the compositional differences between magnetite in these two chondrite groups could not be achieved by a single metamorphic sequence and further suggested that magnetite compositions could instead be used to distinguish between CV and CK chondrites. Subsequently, several new criteria for distinguishing between CV and CK chondrites were provided by [11], including chondrule olivine compositions, matrix olivine compositions, and chondrule abundances. In this study, we reevaluate the classification of NWA 2900 using the latest criteria established by [11] and demonstrate that this meteorite should be reclassified as a CK3 chondrite.

Methods: An epoxy-mounted 1-inch round thick section of NWA 2900 was initially characterized using an optical microscope. Backscattered electron (BSE) and X-ray element maps were obtained with the JXA-8520F electron probe microanalyzer (EPMA) in the Eyring Materials Center at Arizona State University (ASU) (operating conditions: 20 kV, 30 nA). These maps were used to identify phases for further study and to determine the modal abundances of the major chondritic components. High-resolution images were obtained for select, representative phases using the same instrument. Major and minor element abundances (Na, Si, Mg, Al, P, Ca, K, Mn, Ti, Fe, Cr, and Ni for silicates; Mg, Si, Al, Ti, Ca, Cr, Fe, Co, and Ni for magnetite) were determined quantitatively with the Cameca SX-100 EPMA at the Lunar and Planetary Laboratory (LPL) at the University of Arizona (operating conditions: 15 kV, 20 nA). An overlap correction was applied to the magnetite analyses to account for the Cr Kβ peak overlap with the Mn Kα peak. Only magnetite and stoichiometric silicate analyses with totals between 98 and 101 wt.% were considered of high quality and are presented here.

Results and Discussion: The interior of NWA 2900 has a grayish appearance and contains large chondrules (~13 vol.%; average size = 1.11 mm, n = 25), CAIs (~5 vol.%), magnetite (~4 vol.%), and coarse-grained interchondrule matrix (~78 vol.%) (Fig. 1). The chondrule abundance is similar to the ~20 vol.% abundance reported in CK chondrites, and significantly less than the chondrule abundance of ~40 vol.% reported for CV chondrites [e.g., 9].

Chondrule olivine compositions for NWA 2900 are in the range of $Fa_{1–35}$, compared to $Fa_{16–37}$ for CK chondrite olivines and highly variable Fa content for CV chondrite olivines [2, 8–10]. Matrix olivine is well equilibrated with $Fa_{33–36}$, similar to matrix olivine in CK chondrites ($Fa_{32–37}$) [e.g., 9, 10]. The Cr_2O_3 vs. FeO compositions of chondrule olivines in NWA 2900 are shown in Fig. 2, and most data plot within the field of previous CK3 chondrite data.

All measured magnetite compositions approach or exceed the lower limits for Cr_2O_3, TiO_2, NiO, and Al_2O_3 abundances required for classification as a CK3 chondrite based on the criteria of [11]. For example, the MgO vs. Cr_2O_3 compositions of magnetite are shown in Fig. 3; most data plot near or within the field of previous CK3 chondrite data.

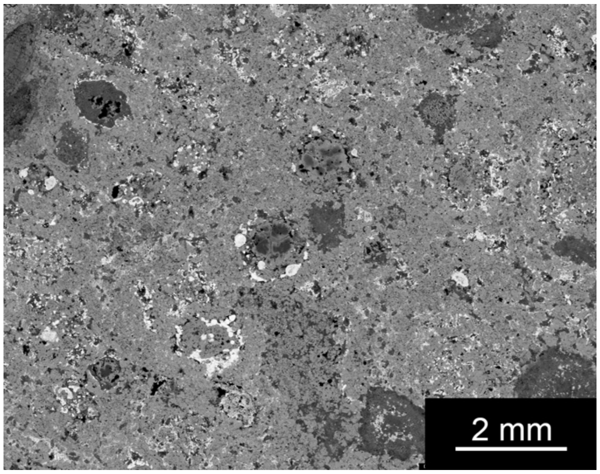

Fig. 1. BSE map of NWA 2900. Brightest regions are magnetite, darkest regions are remnant chondrules and CAIs.

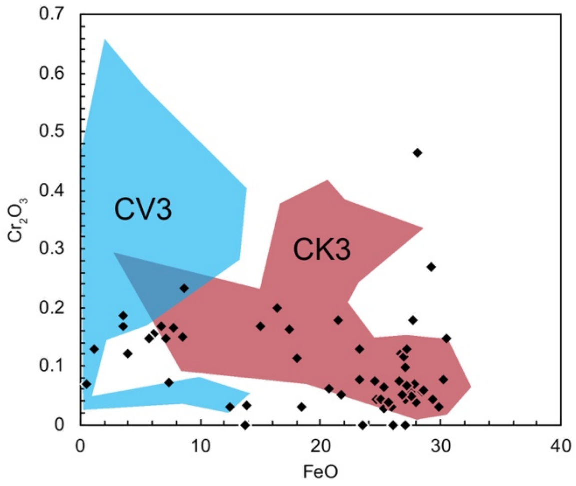

Fig. 2. Chondrule olivine compositions from NWA 2900 (black diamonds) and from literature data (colored fields) for CV3 chondrites [11–14] and CK3 chondrites [10].

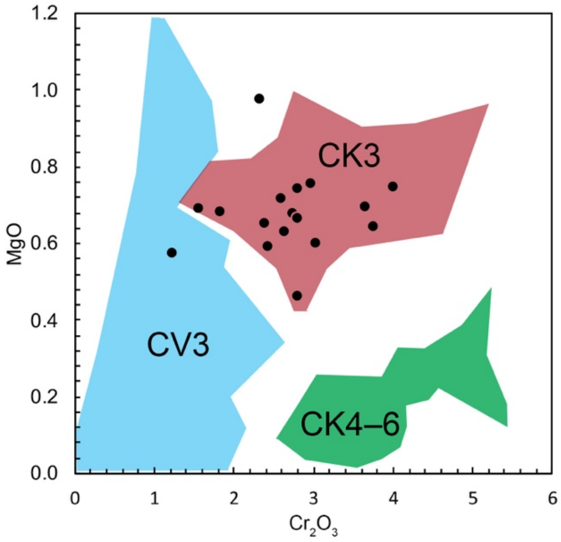

Fig. 3. Magnetite compositions from NWA 2900 (black circles) and from literature data (colored fields) for CV3 chondrites [5, 12, 15, 16], CK3 chondrites [5, 10], and CK4–6 chondrites [5, and references therein].

Conclusions: Based on the criteria established by [11], including magnetite compositions, chondrule olivine compositions, matrix olivine compositions, and the abundance of chondrules, NWA 2900 should be reclassified as a CK3 chondrite.

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