ISOTOPE FORENSICS UTILIZING $\Delta^{17}O$-$\varepsilon^{54}Cr$ SYSTEMATICS PROVIDE SUPPORTING EVIDENCE FOR DIFFERENTIATED PARENT BODIES OVERLAIN BY CHONDRITIC VENEERS: A CASE FOR THE CR PARENT BODY. M. E. Sanborn[1], Q.-Z. Yin[1] and A. J. Irving[2]. [1]Dept. of Earth & Planetary Sciences, University of California at Davis, One Shields Avenue, Davis, CA 95616 USA (E-Mail: mesanborn@ucdavis.edu), [2]Dept. of Earth & Space Sciences, University of Washington, Seattle, WA 98195

Introduction: The meteorite group known as the CR chondrites, until recently, had been almost entirely comprised of samples of petrographic grades 1 and 2 (e.g., [1-2]). However, the recent recovery of several new, unique samples from Northwest Africa has indicated a possibility that there may be samples from the CR chondrite parent body recording metamorphic conditions [2-3] and igneous differentiation [3-5]. Several new samples in particular may record such conditions: NWA 2994 and 3100 are highly equilibrated and metasomatized CR6 chondrites; Tafassasset contains poikiloblastic aggregates interpreted as former chondrules and can be described as a CR7 chondrite

In contrast, NWA 8054 is a coarse-grained stone comprised primarily of olivine, orthopyroxene, and clinopyroxene completely lacking any evidence of chondrules [3]. NWA 011 and paired specimen NWA 2976 [3-5] are plutonic igneous rocks, once thought to be eucrites. They all have oxygen isotopic compositions that plot directly within the CR chondrite trend (Fig. 1) [2-5]. Meteorites from two very different groups (e.g., chondrites versus achondrites) exhibiting similar isotopic compositions (Figs. 1 and 2) has led to a hypothesis of a layered, differentiated parent body overlain by chondritic veneer [3]. Such a hypothesis has been proposed before to explain the possible CV chondrite-Eagle Station pallasite connection (Fig. 2) [9].

Here we extend and further develop the hypothesis for the CR parent body (CRPB) presented in a separate abstract [3]. We argue that directly relating this group to the same parent body as CR chondrites best explains the unique petrographic features and some chemical diversities between these samples and the CR2 chondrites [2-3]. We demonstrate the "forensic" power of the paired $\Delta^{17}O$-$\varepsilon^{54}Cr$ isotope systematics in establishing petrogenetic relationships among meteorites [8,10], as petrographic and oxygen isotope data alone (Fig. 1) can be demonstrably deceiving. For this purpose, we acquired high precision Cr isotopic data for NWA 3100, 2994, Tafassasset, and NWA 8054 to investigate any similarities to CR chondrites, and compare and contrast with NWA 011/2976.

Whether the unique (paired) achondrites NWA 6704 and NWA 6693 are related to the CR parent body remains to be fully evaluated, but we include data points for these specimens in the plots below.

Analytical Methods: Fusion crust-free (~35 mg) chips from each of the meteorites were powdered using an agate mortar and pestle. The sample powders were placed in Teflon capsules with a 3:1 mixture of concentrated HF and HNO_3 and sealed in stainless steel Parr bombs. Each sample was placed in an oven at 190°C for 96 hours for complete dissolution of refractory phases. Chromium was separated from the matrix using the 3-column chemistry procedure described by [11]. High precision Cr isotopic measurements were made using the Thermo *Triton Plus* thermal ionization mass spectrometer at University of California at Davis. The separated Cr fractions were loaded onto degassed single W filaments. Total Cr loads for each filament were 3 µg with a total of 4 filaments measured for each sample (bracketed by two terrestrial standard filaments before and after the sample filaments). The $^{54}Cr/^{52}Cr$ ratios are expressed in ε-notation (parts per 10,000 deviation from a terrestrial standard).

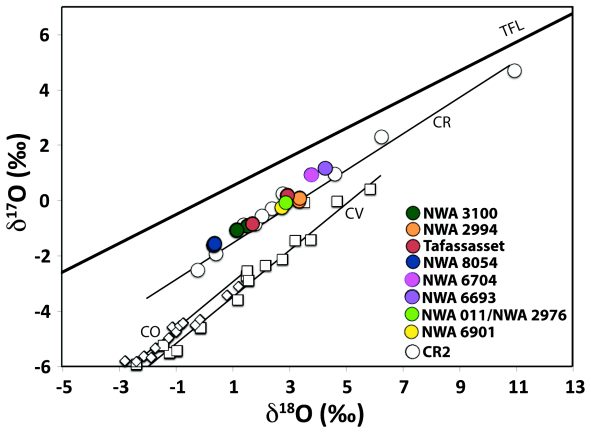

Figure 1. Oxygen isotopic composition of NWA 3100, 2994, 6901, 8054 and Tafassasset, NWAs 011/2976, 6704/6693, [2-3,5-7] in comparison to the ranges for CR, CO, and CV chondrites [12].

Results and Discussion: The ^{54}Cr isotopic results for the highly equilibrated CR chondrites NWA 2994, 3100, Tafassasset, and for NWA 8054 are provided in Table 1 and their relative positions in terms of $\Delta^{17}O$ versus $\varepsilon^{54}Cr$ are shown in Fig. 2. The highly metamorphic group of CR6 (NWA 3100, 2994) and CR7 (Tafassasset) have positive $\varepsilon^{54}Cr$ values. Together with NWA 011/2976, [4-5,13], these samples plot in a tight cluster in $\Delta^{17}O$-$\varepsilon^{54}Cr$ space near CR chondrites (Fig. 2). NWA 6901, thought to be paired with the group

[3,14], plots slightly off the field in terms of ε^{54}Cr, requiring verification in our future work. NWA 8054, on the other hand, has a negative ε^{54}Cr value and plots in a unique position in Δ^{17}O-ε^{54}Cr space distinct from any established meteorite group.

Table 1. Cr isotopic results.

Sample	Δ^{17}O [2-3]	ε^{54}Cr (±2SE)
NWA 2994	1.728	1.31±0.10
NWA 3100	1.101	1.50±0.11
Tafassasset	1.587	1.44±0.08
NWA 8054	1.763	-0.44±0.08

Cr Isotopic Evidence for Single Parent Body for CR2, CR6, and CR7 chondrites. The similar oxygen isotopic composition and bulk geochemical composition have led to the idea that NWA 2994, NWA 3100, and Tafassasset may be related to the CR chondrites, possibly from the same parent body [3]. The ε^{54}Cr for all three of these samples are identical within error and the same within error as the CR chondrite Renazzo. In addition, the igneous plutonic group (NWA 011 and NWA 2976) also has a similar ε^{54}Cr and Δ^{17}O (Fig. 2). These observations point towards the possibility of a common parent body for all of these samples.

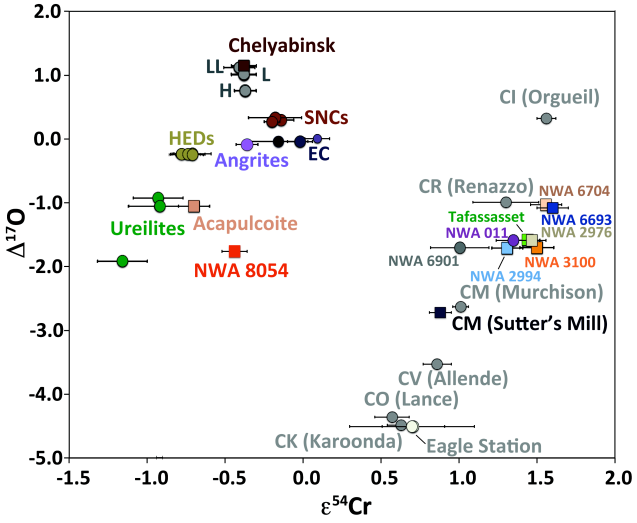

Figure 2. Δ^{17}O vs. ε^{54}Cr plot. Oxygen data for these four samples are from [2-3]. ε^{54}Cr data other than reported here are the literature values are from [8,13-21] and Δ^{17}O data are from [2-3,5-7,12,18-19,22-25].

Distinct Parent Body for NWA 8054. Unlike NWA 2994/3100 (CR6), and Tafassasset (CR7), NWA 011/2976 (igneous plutonic group) that yield positive ε^{54}Cr values similar to the values observed in Renazzo, NWA 8054 is markedly different. While nearly identical in terms of Δ^{17}O, the negative ε^{54}Cr of -0.44 in NWA 8054 indicates its source is clearly separate from that of CRPB. In fact, NWA 8054 plots in its own region in Δ^{17}O-ε^{54}Cr space. This appears to indicate that it is originating from a new, distinct parent body that has not previously been associated with any other known materials in the Solar System. In addition to NWA 8054, the recent measurement of NWA 7325 [8] also point towards yet another previously unknown parent body not sampled by other meteorite groups.

Importance of Cr Isotopes in Deciphering Petrogenetic Relationships. The evolving picture on the evolution of the CR parent body demonstrates the increasing utility of coupling Cr isotopes with other geochemcial and petrologic information. From the CR2 chondrites that have historically encompassed nearly all of the CR group, we now have additional geochemical constraints to possibly connect not only highly equilibrated and metamorphosed samples (CR6-7), but also stones of igneous texture that petrographically are difficult to associate with the other CR chondrite samples. Establishing such relationships is made much more difficult without the use of the Δ^{17}O-ε^{54}Cr systematics. The expanded use of combined oxygen and chromium isotopes in sample classification will undoubtedly reveal many more possible petrogenetic links that might otherwise remain ambiguous.

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