INVESTIGATING A COMMON SOURCE FOR BRACHINITES AND GRAVES NUNATAKS 06128 AND 06129 METEORITES USING HIGH PRECISION CHROMIUM ISOTOPES. M. E. Sanborn[1] and Q.-Z. Yin[1], [1]Department of Earth & Planetary Sciences, University of California at Davis, One Shields Avenue, Davis, CA 95616 USA (E-mail: mesanborn@ucdavis.edu)

Introduction: The brachinites are a unique group of ultramafic, olivine-rich meteorites thought to potentially represent partial melt residues [1] or igneous cumulate rocks [2] of chondritic parent bodies. A similar group of meteorites, known as "brachinite-like" meteorites, bear strong affinities to the brachinites in terms of overall mineralogy and their oxygen isotopic composition, but differ based on the more magnesian-rich composition of their silicate phases [3]. Possibly related to both of these groups is an ungrouped pair of achondrites Graves Nunataks (GRA) 06128 and 06129. These unique achondrites have a high modal abundance of plagioclase (>80%) with the remaining mineralogy composed of olivine and pyroxene and have an oxygen isotopic composition similar to that of the brachinites and brachinite-like samples [4]. Both Brachina (the type specimen of the brachinites) and GRA 06128/06129 represent some of the oldest evidence for planetesimal melting and differentiation processes with a Mn-Cr age of Brachina of 4564.5±0.9 Ma [5] and a model Al-Mg age of GRA 06129 of 4564.9±0.2 Ma [6]. While the mineralogy of GRA 06128 and 06129 is quite distinct from the Brachinites, based on oxygen isotope compositions [3,7], bulk chemistry [3], and contemporaneous ages [5,6], a genetic link to brachinites has been proposed. In order to establish a robust model for the formation processes occurring on the brachinite parent body to generate these different samples, it is helpful to constrain as many parameters as are available to clarify genetic relationships between the brachinites and GRA 06128/06129.

We have shown previously [8] the utility of using high precision Cr measurements ($\varepsilon^{54}Cr$) coupled with oxygen isotopic compositions ($\Delta^{17}O$) as a forensic tool to investigate the genetic relationships between various samples and examine possible petrologic links. Here we apply this same tool to further investigate similarities in the source material from which the brachinites and GRA 06128 and 06129 formed by determination of high-precision Cr isotopic compositions for GRA 06128, GRA 06129 and the brachinites Brachina and NWA 3151.

Methods: An interior, fusion crust-free chip of each sample was powdered using an agate mortar and pestle and 20-30 mg of the resulting powder used for dissolution. The sample powders were sealed in PTFE capsules with a 2:1 mixture of concentrated HF-HNO_3 and placed in stainless steel Parr bombs. The samples were heated in the acid mixture at 190°C for 96 hours. After the samples were dissolved, Cr was separated using a 3-part column chromatography procedure based on [9]. The purified Cr fractions were loaded onto outgassed W filaments (the total Cr load split among four filaments) and each set of sample filaments bracketed with two filaments loaded with a similar amount of terrestrial Cr standard before and after. The Cr isotopic composition was measured on a Thermo *Triton Plus* thermal ionization mass spectrometer at the University of California at Davis. The measured $^{53}Cr/^{52}Cr$ and $^{54}Cr/^{52}Cr$ ratios are reported in ε-notation (parts per 10,000 deviation from the terrestrial standard). The $^{55}Mn/^{52}Cr$ ratios were measured on a Thermo *Neptune Plus* inductively coupled plasma mass spectrometer at UC Davis.

Results and Discussion: The results for Brachina, NWA 3151, GRA 06128, and GRA 06129 are shown in Figures 1 and 2.

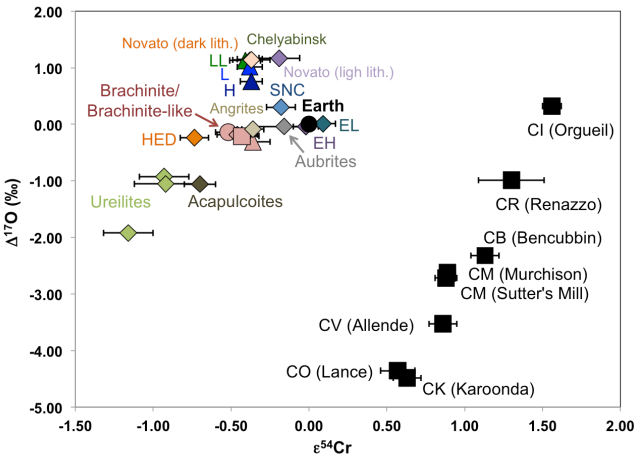

Figure 1. $\Delta^{17}O$-$\varepsilon^{54}Cr$ diagram showing the composition of Brachina, NWA 3151, GRA 06128, and GRA 06129 in comparison with other achondrite and chondrite groups. Literature data for $\varepsilon^{54}Cr$ are from [10-18] and $\Delta^{17}O$ from [16-22].

Previous studies investigating the variability of Cr isotopic composition among achondrites have not reported any measurements for brachinites. As such, the values for Brachina and NWA 3151 reported here are

the first examples of the ε^{54}Cr isotopic composition and variation observed in the brachinites. Both Brachina and NWA 3151 have negative ε^{54}Cr values (as is seen in a majority of other achondrite groups) and their ε^{54}Cr composition is identical within error with a ε^{54}Cr of -0.52±0.08 and -0.36±0.11, respectively. While limited to two samples, thus far the data indicates that the ε^{54}Cr composition within the main brachinite group is homogenous.

The Cr isotopic composition of GRA 06128 and GRA 06129 are identical within error, with ε^{54}Cr values of -0.43±0.11 and -0.46±0.13, respectively. These values are also consistent with the measured ε^{54}Cr composition for Brachina and NWA 3151. The similarity in the ε^{54}Cr composition among all four samples provides additional support for a common isotopic reservoir from which they formed, providing additional evidence for the existence of a genetic relationship.

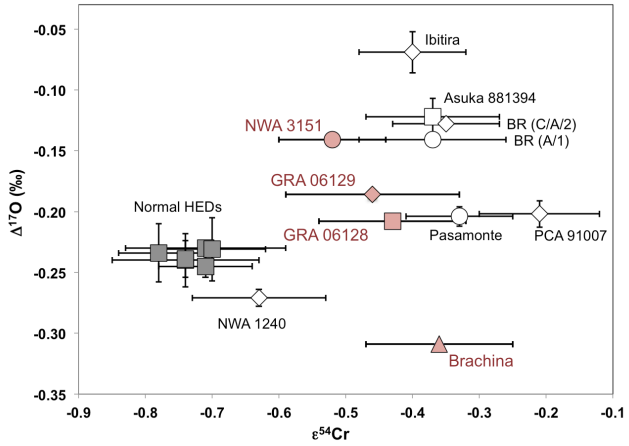

Figure 2. $\Delta^{17}O$-$\varepsilon^{54}Cr$ diagram of the brachinites, GRA 06128, and GRA 06129 in comparison with the normal HEDs and anomalous eucrites (BR = Bunburra Rockhole). Literature data for eucrites are from [8,23] and references therein.

The brachinite and brachinite-like meteorites are not isolated in $\Delta^{17}O$-ε^{54}Cr space from other achondrites. In fact, Brachina, NWA 3151, GRA 06128, and GRA 06129 all plot in a similar region to that of anomalous eucrites analyzed previously (Fig. 2). At present, there is no clear genetic relationship established among these planetary materials. However, the overlap in ε^{54}Cr values indicate that the isotopic reservoir from which the brachinites, brachinite-like meteorites, and anomalous eucrites formed may be related, or in close proximity in the solar nebula.

Acknowledgements: This study was funded by NASA Grant NNX14AM62G and UC Lab Fees Award ID# 12-LR-237921 awarded to Q.–Z. Yin

References: [1] Nehru C. E. et al. (1983) *JGR, 88,* B237-244. [2] Warren P. H. and Kallemeyn G. (1989) *LPS XIX,* 476-486. [3] Day et al. (2012) *GCA, 81*, 94-128. [4] Shearer C. K. et al. (2008) *American Mineralogist, 93,* 1937-1940. [5] Wadhwa M. et al. (1998) *LPS XXIX*, Abstract #1480. [6] Wimpenny J. et al. (2011) *LPS XLII*, Abstract #2473. [7] Ziegler K. et al. (2008) *LPS XXXIX,* Abstract #2456. [8] Sanborn M. E. and Yin Q.-Z. (2014) *LPS XLV*, Abstract #2018. [9] Yamakawa A. et al. (2009) *Anal. Chem., 81,* 9787-9794. [10] Trinquier A. et al. (2007) *ApJ, 655*, 1179-1185. [11] Yamakawa A. et al. (2010) *ApJ, 720,* 150-154. [12] Ueda T. et al. (2006) *MAPS, 41*, 5178. [13] Qin L. et al. (2010) *GCA, 74,* 1122-1145. [14] Yin et al. (2009) *LPS XL,* Abstract #2006. [15] Shukolyukov A. and Lugmair G. W. (2006) *LPS XXXVII,* Abstract #1478. [16] Jenniskens et al. (2012) *Science, 338,* 1583-1587. [17] Popova O et al. (2013) *Science, 342,* 1069-1073. [18] Jenniskens P. et al. (2014) *MAPS, 49,* 1388-1425. [19] Clayton et al. (1991) *GCA, 55,* 2317-2337. [20] Clayton R. N. and Mayeda T. K. (1996) *GCA, 60,* 1999-2017. [21] Clayton R. N. and Mayeda T. K. (1999) *GCA, 63,* 2089-2104. [22] Greenwood R. C. et al. (2005) *Nature, 435*, 916-916. [23] Benedix G. K. et al. (2014) *LPS XLV*, Abstract #1650.