NEW INSIGHTS INTO THE GENETICS OF PLANETARY BUILDING BLOCKS. K.R. Bermingham[1], E.A. Worsham[1,2], R.J. Walker[1]. [1]Department of Geology, University of Maryland, College Park, Maryland, 20742, USA, (kberming@umd.edu). [2]Institut für Planetologie, University of Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany.

Introduction: The relative contributions of isotopically (genetically) diverse materials to the building blocks of terrestrial planets remains poorly constrained. A promising way to identify the composition of accretionary materials is to contrast the nucleosynthetic genetic signatures of different meteorites to those of terrestrial samples. Molybdenum and Ru isotopes are well suited to this application because both elements have documented nucleosynthetic isotope anomalies among a wide selection of meteorite groups [1-4]. These isotope anomalies are generally considered to be a result of the heterogeneous distribution of *s*-process rich materials in the solar nebula.

The Mo and Ru isotope anomalies of different meteorite groups have previously been found to correlate strongly. This correlation is consistent with predictions from *s*-process nucleosynthetic theory, and has been termed the Mo-Ru cosmic correlation [1]. The Mo-Ru compositional estimate of the Earth's mantle broadly lies at one end of the correlation. This is striking because the Mo and Ru budgets of the bulk silicate Earth (BSE) were likely established during different stages of planetary accretion. The Mo budget of the BSE was likely primarily set through high pressure metal-silicate partitioning, mainly during the final ~10-20 % of terrestrial accretion [1,5-7]. The Ru budget was more likely primarily established during the final ~0.5-1 % of Earth's accretion [1,5-7]. If this relative timing scenario is accurate, the fact that the Earth lies on or near the correlation implies there may have been no major change in the feeding zone of accreting materials during the final ~10-20 % of accretion [1].

This study refines the Mo-Ru cosmic correlation with the addition of new high precision Mo and Ru isotope data for 25 different meteorites. The goal is to determine if the correlation remains robust, to more precisely assess how Earth relates to the correlation, and to constrain the composition of contributors of genetically diverse materials to Earth during later stages of its accretion. This study is the first to collectively analyze Mo, Ru, and Os (determined as a dosimeter of cosmic ray exposure, CRE, [8]) from the same sample dissolutions to define the correlation. Effects of CRE vary with depth in a meteorite, so it can be critical to analyze these elements from the same meteorite piece.

Samples and Methods: Molybdenum, Ru, and Os data were mainly collected for magmatic and non-magmatic iron meteorites, many which have not been analyzed previously for these isotopes. Between 2 to 4 meteorites were used to define the isotopic composition of a group. All samples were provided from the Smithsonian Institution NMNH.

Iron meteorites were digested in 8M HCl. Complete dissolution was achieved after ~48 hrs. After dissolution, the solutions were divided into separate aliquots for Mo, Ru, and Os isolation and purification [9,10]. Molybdenum and Ru were separated and purified from matrix using a combination of cation, anion and micro-distillation (in the case of Ru and Os) techniques.

The isotope data were collected using a *Thermo Fisher Tritons* thermal ionization mass spectrometers operated in negative mode at the Department of Geology, University of Maryland. Oxygen isotope compositions were measured *in situ* using 10^{12} ohm and 10^{13} (for Ru and Mo) ohm resistors in two amplifiers to allow for accurate corrections for in-run oxygen isotope variations and oxide interferences. This correction is critical because significant variations in the oxygen isotopic composition from run to run, and during the course of a run can adversely affect analytical precision of the Mo and Ru isotope ratios of interest [9,10]. Data are corrected for instrumental mass fractionation using the exponential law and ^{98}Mo/^{96}Mo, ^{99}Ru/^{101}Ru, or ^{192}Os/^{188}Os as the relevant normalizing ratio. Replicate analyses of *Alfa Aesar* standards define an external precision of ±6 ppm (2σ SD) for ^{100}Ru/^{101}Ru; ±5 ppm (2σ SD) for ^{97}Mo/^{96}Mo; and, ±5 ppm (2σ SD) for ^{189}Os/^{188}Os. These precisions are significantly improved relative to previous studies [1-4].

Results: Isotopic data are reported here as μ^{97}Mo and μ^{100}Ru, which are the deviations in parts per million of the isotopic composition relative to terrestrial standards. We determined the isotope compositions of meteorites from the IAB, IIAB, IIIAB, IVA, IVB, IC, as well as 4 ungrouped iron meteorites. Although data for these iron meteorite groups have been reported previously, we significantly expanded the number of data for meteorites comprising each group.

After CRE correction, all meteorites, except for the IAB (main group and sLL subgroups) and ungrouped iron meteorite Gebel Kamil, display resolved negative μ^{100}Ru and μ^{102}Ru isotope anomalies, concurring with [3,4]. There are no resolved anomalies in μ^{96}Ru, μ^{98}Ru, or μ^{104}Ru. CRE corrected Mo isotope compositional data for the same samples show variations in μ^{92}Mo, μ^{94}Mo, μ^{95}Mo, μ^{97}Mo, and μ^{100}Mo for all meteorites except again, for the IAB (main group and sLL subgroups) and Gebel Kamil. These results are in general agreement with published data and have been interpreted as *s*-process deficits [1,2].

Discussion: Using the refined dataset, a general linear correlation persists between μ^{97}Mo and μ^{100}Ru for meteorite groups and individual meteorites (**Fig. 1**). However, analytically well-resolved scatter about a linear trend is evident, a finding which concurs with earlier work [4; although this study utilized Mo and Ru data obtained from different digestions and did not correct the Mo isotopic compositions for CRE effects]. For example, although group IIAB and IIIAB irons have essentially identical μ^{97}Mo values, their μ^{100}Ru values differ by at least 10 ppm.

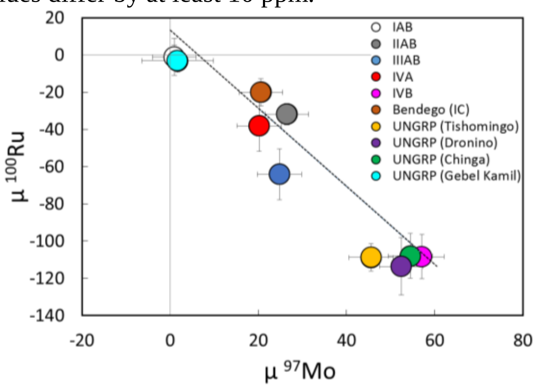

Fig. 1. The μ^{97}Mo and μ^{100}Ru for meteorite groups and individual meteorites from this study. All data are CRE corrected, except for Bendego (IC). The dotted line is defined by magmatic groups IIAB, IVA, IVB and represents a mixing line between s-process Mo and Ru. Error bars represent the 2SD associated with the measurement campaign, or 2SE internal error associated with a single measurement (whichever is larger).

The scatter indicates that the relative degree of *s*-process variability in Mo and Ru is not solely responsible for isotopic variability between these two elements. The moderately heterogeneous distribution of Mo and Ru isotopes about a linear trend may be due to a fractionation in the relative contributions of presolar components to the precursor materials. Alternately, they may reflect a variable contribution from the *r*-process. Notably, the groups that are clearly resolved in Mo-Ru isotopes (e.g., IIAB and IIIAB) are not the same groups as have been shown to have dichotomous Mo isotope compositions [11].

Given the deviations from linearity in the Ru-Mo isotopic compositions of the iron meteorite groups, it is concluded that simple, two component mixing of putative endmember nucleosynthetic components is no longer a viable model for these siderophile elements. The uncertainty in the position of the cosmic correlation also means that the Mo and Ru isotope compositions of Earth may no longer be required to have originated from the same genetic building blocks, as was previously suggested, based on a less well defined correlation [1].

The genetic characteristics of late accretionary contributors to Earth's mantle can potentially be constrained by contrasting the Ru isotopic composition of meteorites within different terrestrial mantle domains. Collisional models [e.g., 12], together with ^{182}W isotopic heterogeneity preservation in the mantle suggest that, if present, some level of nucleosynthetic heterogeneity in Ru may be preserved in the terrestrial rock record. To examine this we have collected high precision Ru isotope data from 8 different mantle domains which sample the terrestrial convecting upper mantle. Our data indicate that the upper mantle has a relatively uniform Ru isotopic composition (**Fig. 2**). The average of these materials is well resolved from all meteorites studied, except for IAB iron meteorites and Gebel Kamil. The search for primordial isotope signatures will continue with a focus on those mantle domains documented to have preserved primordial isotope anomalies.

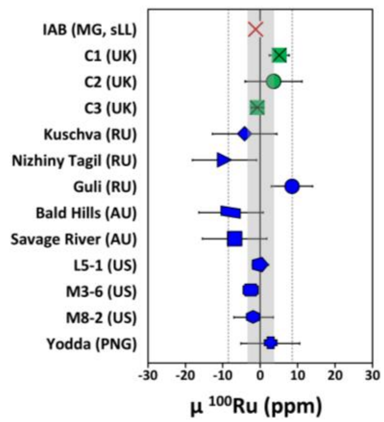

Fig. 2. μ^{100}Ru for individual Os-Ir-Ru alloy grains and chromitites. IAB data are an average of Main Group and the sLL subgroup. Error bars represent the 2SD associated with the measurement campaign for single measurements or the 2SE for multiple measurements (n>3) of a single sample. The 2SD and 2SE external precision are indicated by the dotted lines and grey field, respectively, for repeated measurements of an *Alfa Aesar* Ru standard.

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