**HIGHLY SIDEROPHILE ELEMENT ABUNDANCES AND RHENIUM-OSMIUM ISOTOPE SYSTEMATICS OF CHONDRITIC COMPONENTS.** G. J. Archer[1], R. J. Walker[1], and E. S. Bullock[2]. [1]Department of Geology, University of Maryland, College Park, MD 20742 (garcher@umd.edu). [2]Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560.

**Introduction:** Chondrites are primitive meteorites consisting of variable proportions of three major, diverse components: refractory inclusions, chondrules, and matrix. Calcium-aluminum-rich inclusions (CAIs) are the most refractory and likely the oldest of these components [1-4]. They are typically made of mixtures of minerals that condense at higher temperatures, such as corundum and melilite. Chondrules are mainly composed of olivine and pyroxene, and formed as melted droplets soon after CAI formation [1,5]. Matrix is composed primarily of very fine-grained silicates, and typically contains the least refractory materials in chondrites [6]. Chondritic components preserve key evidence for the earliest conditions of the solar system, as well as evidence for secondary processes on chondritic parent bodies.

The highly siderophile elements (HSE), including Re, Os, Ir, Ru, Pt, and Pd have condensation temperatures that overlap with those estimated for chondritic components. Further, the Re-Os isotopic system, in which $^{187}$Re decays to $^{187}$Os ($\lambda$=1.666 x $10^{-11}$a$^{-1}$), has the potential to constrain the timing of secondary processes that affected the HSE in chondritic components [7].

Several previous studies have shown that group I, III, V, and VI CAIs have suprachondritic concentrations of all HSE, except for Pd, which is one of the most volatile HSE. Palladium is instead present in nearly chondritic abundances in these groups. Group II CAIs, in contrast, are typically characterized by subchondritic concentrations of all HSE, most likely reflecting fractional condensation [e.g., 8].

Abundances of HSE in other chondritic components differ considerably from CAIs. Horan et al. [9] described HSE patterns of components separated from ordinary chondrite chondrules, and reported that a metallic component was characterized by an unfractionated, suprachondritic HSE pattern. A non-magnetic component was characterized by subchondritic HSE abundances patterns with both Re and Pd depletions, relative to other HSE. Few measurements of HSE in chondrite matrix have been reported.

Rhenium-Os isotopic data for chondritic components would be expected to plot on a primordial Re-Os isochron, if the system remained closed from the time of component formation until the present [10]; however, [7] investigated Re-Os systematics of Allende CAIs and found that many Allende CAIs don't plot on a primordial isochron. They also reported that multiple fragments of one CAI defined a secondary errorchron with an age of ~1600 Ma.

**Methods:** In order to characterize HSE and Re-Os systematics in chondritic components, the components were separated from Allende and crushed into powders, which were then combined with isotopic spikes enriched in $^{190}$Os, $^{185}$Re, $^{99}$Ru, $^{194}$Pt, $^{191}$Ir, and $^{105}$Pd. Powders, spikes, and ~3 mL 2:1 concentrated $HNO_3$ + HCl were combined in Pyrex Carius tubes [11] and heated to 260°C for three days. After digestion, Os was removed via solvent extraction using $CCl_4$ and back extraction into HBr [12], and then purified by microdistillation [13]. All other HSE were purified using anion exchange chromatography. Purified Os was then analyzed by N-TIMS using a *VG Sector 54*. Rhenium, Ru, Pt, Ir, and Pd were analyzed by MC-ICP-MS using a *Nu Plasma*.

**Results:** Consistent with previous studies, Allende non-group II CAIs have suprachondritic abundances of the refractory HSE, and depletions in Pd. Allende group II CAIs are depleted in all HSE [Fig. 1a]. In contrast to non-group II CAIs, Allende and Chainpur (LL3.4) chondrules have much lower abundances of the refractory HSE, generally closer to bulk chondritic abundances. Most, however, are characterized by Pd depletions relative to the more refractory HSE [Fig. 1b]. Allende matrix fractions have HSE patterns that are very similar to bulk Allende [Fig. 1c]. Most of the Allende CAIs, chondrules, and matrix plot beyond analytical uncertainties of a primordial isochron. Instead, many of the chondritic components plot along the linear array described by [7] that defines an age of ~1600 Myr (Fig. 2).

**Discussion:** Calcium-aluminum-rich inclusion HSE abundance data are consistent with previously published results [e.g., 14]. Non-group II CAIs are enriched in the most refractory HSE, consistent with high temperature condensation, as has been previously suggested [14]. The Pd depletions are consistent with its greater volatility compared to the other HSE measured here. The Pd depletions suggest that either non-group II CAIs (or their precursor constituents) condensed at temperatures above which Pd condenses (1324 K at $10^{-4}$ bar), or that Pd was lost from the CAIs via one or more evaporation events.

We offer two possible explanations for the flat HSE abundance patterns coupled with Pd depletions in chondrules. The first is that refractory (CAI-like) precursor materials were incorporated into those aggregates that eventually melted to form chondrules. We speculate that these refractory precursor materials had HSE abundance patterns similar to CAIs.

A second possibility for the HSE patterns of chondrules is related to the HSE patterns of the metallic and nonmetallic components of ordinary chondrite chondrules described by [9]. Ordinary and carbonaceous chondrite chondrules have similar HSE patterns (Fig. 1b), and therefore it is likely that their HSE patterns were established by similar processes. Thus, chondrules in carbonaceous chondrites likely contain the HSE components (or their remnants) found in ordinary chondrite chondrules. Mixing the metallic, unfractionated HSE component with the nonmetallic, Pd-depleted HSE component could result in a HSE pattern similar to those of chondrules.

There are several explanations for why some chondritc components do not plot on a primordial Re-Os isochron. These include early solar system processes, such as intense interactions with cosmic rays, and late-stage open system behavior. The normal stable isotopic compositions of Re and Os indicate that early-formed isotopic heterogeneites in the early solar system are not responsible for the observed nonisochronous behavior. The most likely explanation is that the Re-Os system was disturbed by late-stage open system behavior. The data remain consistent with the interpretation of [7] that the open-system behavior occurred on Allende within the last 2 Ga.

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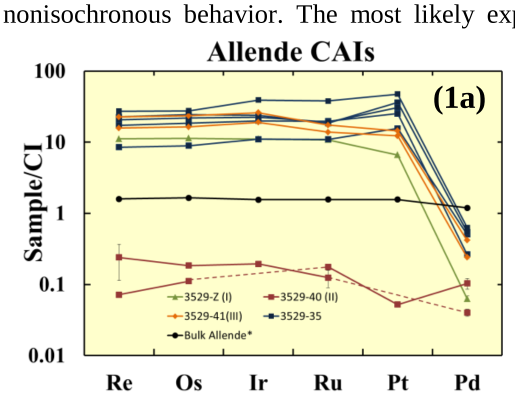


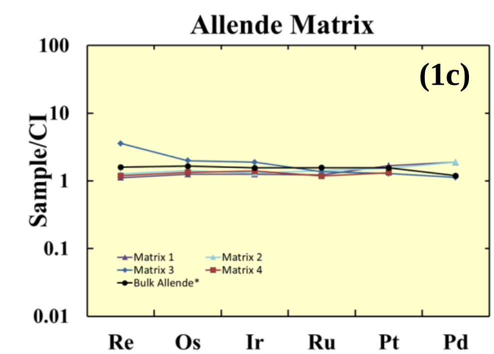


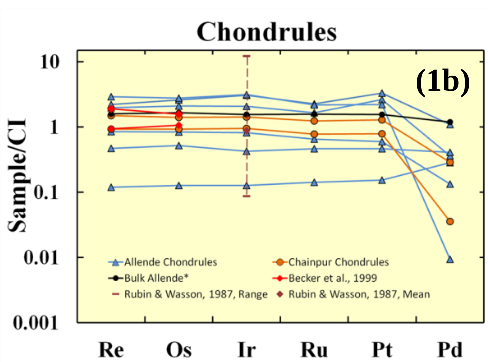


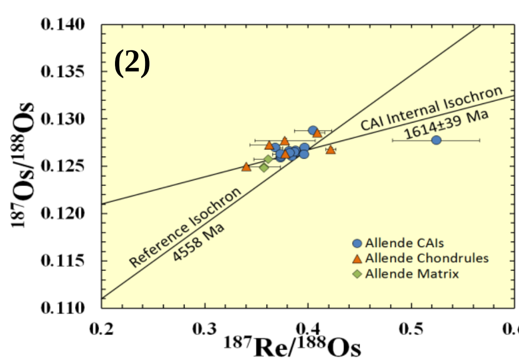


**Figure 1:** HSE abundances of (a) CAIs, (b) chondrules, and (c) matrix normalized to CI chondrites. Roman numerals indicate the REE group classification of CAIs. HSE abundances of fractions of the same CAIs have the same symbols. Most samples are from Allende, but two chondrules are from Chainpur.

**Figure 2:** $^{187}Re/^{188}Os$ vs. $^{187}Os/^{188}Os$ isochron plot for Allende chondritic components analyzed by this study. CAI internal isochron from [7].