

Combined ^{182}W , $^{186,187}\text{Os}$ and $^{142,143}\text{Nd}$ Constraints on Terrestrial Differentiation and Mantle Mixing

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Collectively applied, the ^{182}Hf - ^{182}W , ^{190}Pt - ^{187}Re - $^{186,187}\text{Os}$, and $^{146,147}\text{Sm}$ - $^{142,143}\text{Nd}$ radiogenic isotope systems are potentially useful for exploring early planetary processes ranging from metal-silicate segregation (via Hf-W and Re-Pt-Os), to crystal-liquid fractionation in silicate domains (via Hf-W, Pt-Re-Os and Sm-Nd). For example, study of the 2.8 Ga Kostomuksha komatiites of NW Russia revealed a mantle source that was ~ 15 ppm enriched in ^{182}W , relative to ambient terrestrial W [1], and also modestly enriched in ^{186}Os and ^{187}Os [2], relative to chondritic references. However, the ^{142}Nd and ^{143}Nd isotopic compositions of these rocks are generally consistent with those of the contemporary ambient mantle [3,4]. Accounting for these isotopic characteristics is challenging. The necessary magnitude of fractionations of Hf/W, Pt/Os, and Re/Os could have been generated as a result of metal-silicate segregation at high temperatures and pressures. Such process would not have affected the initial chondritic Sm/Nd. Thus, these komatiites may, in part, have tapped a mantle domain that formed within the first ~ 30 Myr of the Solar System history, as required by the 8.9 Myr half-life of ^{182}Hf . The Kostomuksha komatiite source, however, had abundances of highly siderophile elements (HSE) within the range of estimates for the primitive mantle, so the dominant Os isotopic signature, as well as the HSE abundances, must have been inherited from ambient mantle that had acquired its HSE budget via late accretion. It is equally plausible that the necessary fractionations occurred as a result of crystallization and overturn in transient magma oceans, although the effects of such processes on Pt/Re/Os systematics at present are poorly constrained. Further, diverse, 3.8 Ga rocks from Isua, Greenland [5] have also been shown to have comparable ^{182}W enrichments, yet are also enriched in ^{142}Nd . Consequently, it is clear that there is no single mantle domain that can account for the variations that are now known for ^{182}W , ^{186}Os , ^{187}Os , and ^{142}Nd in ancient rocks. Numerous, important implications can be drawn from these findings. For example, the requirement for very early formation of the sampled mantle domain means that the putative giant impact that led to creation of the Moon > 50 Ma following Solar System formation [6], could not have resulted in the complete melting and mixing of the mantle. In addition, long-term preservation of such early-formed mantle domains means that materials added to the mantle by late accretion might also still be preserved in the mantle and identified by diverse nucleosynthetic signatures. A new era of study of early-Earth chemical geodynamics, utilizing combined short- and long-lived radiogenic isotope systems, has begun.

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Assessing the Release of Bioactive Trace Elements from Coal Fly Ash into Natural Fresh Waters

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Introduction

Each year a significant amount of coal fly ash enters the environment, where it can potentially cause adverse effects by releasing a range of bioactive trace elements. In this context, environmental studies have largely focused on the leaching of trace elements from the coal ash in landfills by rainwater and groundwater, while there has been relatively little study of the release of bioactive trace elements from coal fly ash deposited in natural fresh waters such as rivers and lakes. Furthermore, the batch leaching methods that have been used to study the interaction of rainwater and groundwater with coal ash in landfills are not readily extrapolated to rivers and lakes, where the solution to particle ratio is typically high. To address this problem, we have adapted a flow-through leaching protocol that has been used to estimate the fractional dissolution of trace elements from mineral aerosols in ocean waters. We argue that this rapid leaching technique more closely resembles the interaction of coal ash with fresh waters, thus allowing us to assess the release of coal fly ash constituents into rivers and lakes.

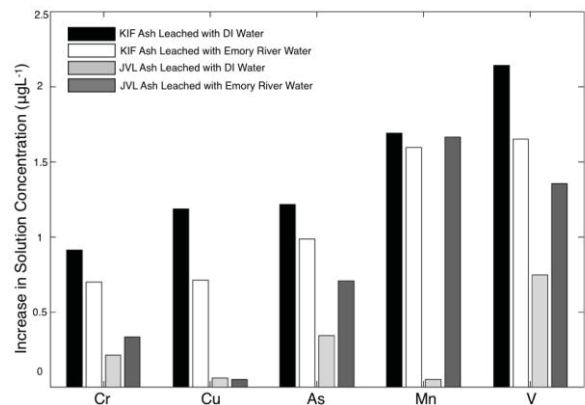


Figure 1. Increase in solution concentration of bioactive trace elements in Emory River water leach solutions.

Results

We have performed a series of flow-through leaching experiments using fresh coal ash and fresh waters collected from rivers and lakes in the southeastern U.S. A suite of bioactive trace elements have been analyzed in the resulting leach solutions and in acid digests of the bulk coal ash, using high-resolution plasma-source mass spectrometry. Our preliminary data (Fig. 1) suggest that significant fractions of a number of bioactive trace elements in coal ash are readily soluble in natural fresh waters.