New Insights to Earth History Provided by Short-lived Radiogenic Isotope Systems

RICHARD J. WALKER[1] & ANDREA MUNDL-PETERMEIER[2]

[1]Department of Geology, University of Maryland, College Park, MD USA 20742

[2] Department of Lithospheric Research, University of Vienna, Althanstraße 14, 1090 Vienna, Austria

Short-lived radiogenic isotope systems provide important information about processes that occurred in early Earth history, as well as possible locations of isotopically anomalous reservoirs in the modern Earth. Two complementary short-lived systems, ^{182}Hf-^{182}W and ^{146}Sm-^{142}Nd, have half-lives of ~9 and 103 Myr, respectively. In silicate systems, Hf, W, Sm and Nd all behave incompatibly and parent-daughter fractionations are broadly similar. In systems in which metal is present, however, the siderophile W is strongly fractionated from the lithophile Hf. Ancient and modern terrestrial rocks exhibit both positive and negative ^{142}Nd and ^{182}W anomalies, relative to presumed ratios for bulk silicate Earth. In modern rocks the magnitude of ^{142}Nd anomalies is greatly attenuated relative to anomalies present in Archean rocks. By contrast, ^{182}W anomalies in modern rocks are as large as found in Archean rocks. Processes proposed to generate the anomalies in one or both systems include initially grainy late accretion (W), disaggregation and uneven mixing of late accreted bodies (W), early differentiation inclduing magma ocean processes involving metal-silicate equilibration (W) or silicate-silicate crystal-liquid fractionation (W, Nd), and core-mantle interactions (W). In rare instances, ^{142}Nd and ^{182}W anomalies appear correlated, however, in most lithologies they are not. No single process can be invoked to account for the observed isotopic variability, hence, Earth has apparently retained a record of several different early-Earth processes. For example, the rare instances of positive correlations between ^{182}W and ^{142}Nd anomalies in some Archean rocks likely implicates the involvement of silicate crystal-liquid fractionation in an early, large mantle domain. By contrast, the observation that ^{182}W anomalies negatively correlate with ^{3}He/^{4}He but not ^{142}Nd in several modern ocean island basalt systems may suggest that at least some OIB sources include materials derived from a primordial deep mantle domain that obtained its negative ^{182}W anomaly through core-mantle isotopic equilibration.