Os isotope systematics and its application to Earth sciences

Kuo-Lung WANG
王國龍
Institute of Earth Sciences, Academia Sinica, Taipei

Abstract

In the past two decades, the ^{187}Re-^{187}Os system, as other common radiogenic isotope systems, has been applied to geological issues, such as geochronology and the origin of chemically distinct reservoirs within planetary bodies. This follows a long period of limited application of the system because of analytical difficulties. The present interest in the system stems from the fact that Re and Os are highly siderophile elements (HSE), meaning that they strongly prefer metal or sulfide phases over silicate minerals. These elements were extracted nearly fully from planetary mantles into cores during core formation. Several aspects of this decay system make it particularly useful in addressing a variety of geological processes. The *first* is the siderophile/chalcophile nature of these elements, making this a useful system to address questions of core formation and ore genesis. *Second*, whereas all the other radioactive and radiogenic elements are incompatible ones, and hence enriched in melts, Os is a highly compatible element (bulk D ~ 10) and is enriched in the residual solid. This makes Os isotope ratios particularly useful in studies of the mantle. *Third*, while Os is highly compatible, Re is moderately incompatible and is slightly enriched in the melt. Thus partial melting appears to produce an increase in the Re/Os ratio by a factor of ~10^2. As a consequence, the range of Os isotope ratios in the Earth is enormous compared to other radiogenic elements, so analytical precision need not be as high as for elements such as Sr and Nd. Consequently, Re and Os can provide unique insight into certain problems compared to other long-lived radiogenic isotope systems (e.g. Rb-Sr, Sm-Nd, U-Th-Pb) that involve lithophile elements that partition into silicate rather than metal or sulfide.

Whole-rock Re-Os isotope data from mantle-derived peridotites have contributed much information on the age of the subcontinental lithospheric mantle (SCLM; [1] and references therein). However, recent studies have demonstrated that Os in these rocks is concentrated in sulfide phases and that these can be mobile within the SCLM, so that whole-rock Re-Os model ages probably reflect mixing processes, rather than single melting events [2, 3]. Recent developments in the in situ analysis of the Re-Os system in sulfide phases allow us to unravel some of this complexity and improve the interpretation of the age information contained in the mantle-derived samples [2, 3, 4].

The Os isotope compositions of sulfides in mantle xenoliths from the Penghu Islands, Taiwan Strait, reveal the presence of Proterozoic SCLM beneath the extended southeast margin of the South China block. [5] The sulfide Os model ages yield peak T_{MA} ages of 2.3, 1.8, 1.4 and 0.9-0.8 Ga, indicating significant events in the lithospheric mantle (e.g. formation/melt extraction) at these time periods. The timing of these events is remarkably consistent with those of the major crustal accretion events as recorded by U-Pb, Nd and Hf model ages of the overlying crust. The sulfide ages may actually date these metasomatic events in the underlying lithospheric mantle, and robustly reflect the timing of tectonothermal events that affected the overlying crust.

Another major field of interest regarding Os isotopes involves weathering, marine sediments, and the chemical evolution of seawater.

References:

[1] Shirey and Walker (1998). *Ann. Rev. Earth Planet. Sci*. 26, 423-500.
[2] Alard et al. (2002). *Earth Planet. Sci. Lett.* 203, 651-663.
[3] Griffin et al. (2002). *Geochem. Geophys. Geosyst.* 3(11), 1069, doi: 10.1029/2001GC000287.
[4] Pearson et al. (2002). *Geochim. Cosmochim. Acta*, 66, 1037-1050
[5] Wang et al. (2003). *Geology* 31, 709-712