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Redox-induced tungsten isotope anomalies in the deep Earth

MAO TANG

INST of Geochemistry, CAS

Presenting Author: 645824531@qq.com

Tungsten (W) isotopes are commonly used as an important tracer for studying the early Earth and chemical geodynamics of mantle due to its unique chemical differentiation behaviour accompanying by chronologic information. The tungsten isotope anomalies (in term of ^{182}W) in various mantle rocks were found from several to 25 ppm including positive and negative values, explained as the results of ^{182}Hf decay or the involving of differentiation between silicate and metal during the first ~60Ma of the accretion of Earth. This explanation leads to an extremely heterogeneous mantle of today. Here we find that, except for a few extremely large anomalies, the major part of W isotope anomalies can be simply explained by a weakly temperature dependent isotope effect, i.e., the nuclear field shift. This effect can produce several to tens of ppm ^{182}W anomalies or mass-independent fractionations at 2000 or even higher temperatures, which can cover the distribution of observations including positive or negative anomalies. This effect can be confirmed by comparing other types of W isotope anomalies (e.g., ^{180}W and ^{183}W) because there are unique relationships between W isotope anomalies if they are caused by the nuclear field shift effects. This work opens a new door to use W isotope data to determine redox changes in deep mantle. Nuclear field shift isotope effect will be a unique tracer for the studying redox changes of mantle in future.