



Mantle highly siderophile element concentrations were not established through high-pressure metal-silicate equilibration in a deep magma ocean - New experimental data for Ru, Rh, Pd, Re, Ir, Pt.

Ute Mann (1), Daniel J. Frost (2), Harry Becker (3), Andreas Audétat (2), and David C. Rubie (2)

(1) Institut für Geochemie und Petrologie, ETH Zürich, CH-8092 Zürich, Switzerland (ute.mann@erdw.ethz.ch/Fax +41(0)446321636), (2) Bayerisches Geoinstitut, Universität Bayreuth, D-95447 Bayreuth, Germany, (3) Institut für Geologische Wissenschaften/Geochemie, Freie Universität Berlin, D-12249 Berlin, Germany

The 'highly siderophile' elements (HSE) Ru, Rh, Pd, Os, Ir, Pt, Re, and Au are known to have extremely high metal-silicate partition coefficients of > 104 at 1 bar and they should have consequently been completely removed from the silicate fraction of the Earth during metal-silicate equilibration in a magma ocean. However, they are present in the Earth's mantle in much higher concentrations than these 1 bar partition coefficients would predict and in approximately chondritic proportions. The main theory to explain the HSE inventory of the mantle pictures the late accretion of a highly oxidized, chondritic material after core/mantle differentiation had ceased that mixed a small concentration of these previously strongly depleted elements back into the mantle. Alternatively, it has been discussed, that high pressures and temperatures (e.g. 30-40 GPa, > 3000 K), as expected in a silicate magma ocean, might drastically lower the HSE partition coefficients to levels where metal-silicate partitioning alone would account for their abundances in the Earth's mantle.

In this study metal - silicate partitioning data for Ru, Rh, Pd, Re and Pt have been determined by equilibrating liquid HSE-Fe-alloy (40 wt%) and molten peridotite (60 wt%) at 3-25 GPa and 2150 - 2500°C using multianvil technique. In most experiments the HSE's were added as a chip of previously alloyed metal to silicate and Fe-powder mixtures contained in MgO single crystal capsules. The bulk HSE concentration in the Fe-alloy was varied from 50 to 90 wt% which resulted in oxygen fugacities of -1.5 to +2 log units relative to the iron wüstite buffer (ΔIW). Metal compositions of the run products were determined with the electron microprobe while analyses of the quenched silicate liquid were carried out with laser ablation ICP-MS.

Partitioning data were corrected for the fact that large concentrations of HSE were present in the metallic phase of our experiments, i.e. to the level of infinite dilution. Corrected metal-silicate partition coefficients linearly decrease with increasing oxygen fugacity, which is a good indicator that analyzed concentrations in the silicate do not reflect the presence of undissolved nuggets. From data regression of these trends valencies of the HSE in the silicate melt of 1+ (Pd, Pt, Rh) and 2+ (Ru, Re) could be determined. All studied HSE become less siderophile with increasing P and T. In addition to an overall negative pressure trend there may be a change from a strong decrease of the partition coefficients < 6 GPa to a much weaker decrease between 6 and 18 GPa that seems to flatten off on extrapolating to higher P. Therefore, temperature, rather than pressure, seems to be the dominating parameter that influences HSE partitioning. However, at 18GPa and redox conditions of -2 ΔIW it would require $T > 3500-4500$ K in order to produce partition coefficients of Pd, Pt and Rh that are consistent with their observed core/mantle ratios. For Re, Ru and Ir, $T > 6000$ K would be required. Considering the weak effect of pressure above 6 GPa, it is unlikely that significantly higher pressures (40-60 GPa) would be sufficient to explain the HSE mantle abundances by metal-silicate equilibration in a deep magma ocean. Therefore, a process such as the accretion of an undifferentiated late veneer seems to remain the more plausible explanation for mantle HSE abundances.