Synthetic melt inclusion and quartz-trap methods for determining Pt solubility in a mafic mineral – Halide melt system at 750°C, 400 bar

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The solubility of platinum in a hydrous salt melt (S-free; ~ 75 wt% $CaCl_2$+$MgCl_2$, 25 wt% H_2O) was investigated at conditions consistent with the post-cumulus metamorphism of layered intrusions that host platinum-group element deposits. The salt melts were reacted with metallic Pt or Pt-$PtAs_2$ (sperrylite) in Pt capsules using conventional Rene 41 cold seal vessels which buffer fO_2 at FMQ-1. The activities of relevant metal-complexing species (e.g., HCl^0) were buffered by the assemblage tremolite-diopside-enstatite-quartz. Salt melts were trapped (simultaneously) in the matrix of a quartz trap (granulated natural quartz partially isolated in a smaller gold capsule) and in synthetic melt inclusions trapped in pre-fractured quartz. After quenching, the melt inclusions and quartz trap material were analyzed by laser ablation ICP-MS.

Platinum solubility is in the low ppm range. Analysis of different portions of the quartz traps using a 90 µm pit size yielded relatively consistent platinum concentrations of 14.4 ± 6.7 ppm (2σ, n=6; Pt metal source), and 4.6 ppm ± 1.9 ppm (2σ, n=6; Pt-$PtAs_2$). Based on the consistency of the metal concentrations from different parts of the trap, it is considered that these concentrations are most representative of metal solubility at run conditions and that the laser sampling size sufficiently overcomes local heterogeneity in the distribution of Pt quench products. By contrast, Pt concentrations in hydrosaline melt inclusions from different areas of a 3 mm x 10 mm quartz cylinder range from below detection limits (~0.1 ppm) to 14.4 ppm (n=28; Pt) and to 6.6 ppm (n=31; Pt-$PtAs_2$). The range in observed metal concentrations in this trapping medium increases with the number of inclusions analyzed, and varies between different areas in the quartz cylinder. This confirms observations that saline inclusions trapped in pre-fractured quartz heal quickly (as early as several hours) at elevated temperatures, and may trap disequilibrium metal concentrations in mineral- or melt-buffered systems (Hanley *et al*., 2005); thus, they are suitable only for qualitative evaluation of trace metal solubility.

The data demonstrates that Pt is highly soluble at conditions consistent with post-cumulus metamorphic activity in layered intrusions, and that salt melts may significantly modify primary metal concentrations in layered intrusions and redistribute these metals. Additionally, Pt solubility in the hydrosaline melt was reduced by a factor of ~ 3 in the presence of a platinum arsenide phase.

References

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~560 Ma and ~300 Ma Re-Os ages constrain Neoproterozoic glaciation and record Variscan hydrocarbon migration on extension of Oslo rift

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The Moelv tillite, exposed in the Lower Allochthon of the Scandinavian Caledonides represents the Neoproterozoic Varanger glaciation, which is generally correlated with the ~580 Ma Gaskiers glaciation in Laurentia. To refine a 620 ± 14 Ma maximum age for the Moelv tillite based on detrital zircons [1], Re-Os data were collected from a C-rich shale horizon in the Biri Formation underlying the tillite.

East of the town of Biri, the weakly deformed Biri shale contains a significant silt component, minor but ubiquitous fine-grained pyrite, and an average TOC of 0.7%. Exposures in a steep bedrock stream channel (Djupdalsbekken) show little bleaching or oxidation. Here, where the Biri shale is separated from the Moelv tillite by the Ring conglomerate, two localities were sampled. Seven analyses of four samples taken about 50 m below the Biri-Ring contact yield a statistically tight Re-Os age of ~560 Ma, with an initial $^{187}Os/^{188}Os$ (Os_i) near 1. Four additional samples, taken ~48 m below the contact, scatter slightly, but all samples regressed together still yield an age within uncertainty of 560 Ma. Re-Os data from samples taken ~3 m below the Biri-Ring contact scatter about a reference line of 600 Ma with Os_i = 1.0. Scatter may result from minor Re and lesser Os loss during recent oxidative weathering. Thus, there is some true geologic variation in the data, but the results clearly support an age close to that of the ~580 Ma Gaskiers glaciation.

A second Biri locality near Øvre Rendal lies on the northern extension of the ~300 Ma Oslo rift. Here, the shale shows strong cleavage, has an average TOC of 2.7%, contains lenses of pyritic sandstone, is unusually thick, and directly underlies the Moelv tillite. Road-cut exposures are locally rusty, but fresh, black samples were obtainable. Ten analyses from six samples taken in a 1-m stratigraphic interval scatter about a reference line of 300 Ma with Os_i = 1.1. Greenschist-facies, dynamic metamorphism does not disturb the Re-Os system in shales [2,3]. We therefore propose that heat from the ~300 Ma rifting event induced hydrocarbon maturation and migration, and that the organic material analyzed was isotopically homogenized (or introduced) during this event.

References

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