Pt solubility in silicate melts: Centrifuging nanonuggets to decipher core formation processes

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Understanding the partioning of highly siderophile elements (HSE) between silicate and metallic melt is a key issue for models of core/mantle equilibria and for core formation scenarios. However, this task has proven challenging, due to the presence of metallic particules ("nanonuggets" [1]) in silicate glasses produced at fO_2's relevant for core formation. Whether these nanonuggets are considered equilibrium or quench phases (and thus re-integrated into the bulk concentration) results in orders of magnitude of variation in partition coefficients for HSE [1].

If the nanonuggets are present at high P and T, they can be centrifuged out of the silicate glass. We thus performed a series of experiments using Pt/graphite double capsules to investigate the solubility of Pt in a natural basaltic melt at 1.0 GPa and fO_2 of IW-2 to IW+2 [2]. Experiments were either run in a static piston-cylinder or (after static equilibration) in a centrifuging piston-cylinder [3], in which the sample is accelerated at the experimental conditions up to 1450 g for up to 12 h ("dynamic" experiments). Pt concentrations in glasses were then analyzed by femtosecond LA-ICP-MS.

Silicate melts from static experiments are heterogeneous, and the LA-ICP-MS signal highly noisy, indicating submicron-scale heterogeneities (Pt "nanonuggets" [1]). In contrast, the bulk of the dynamic samples show a very smooth LA-ICP-MS signal without any evidence for nanonuggets and much lower time integrated concentrations. Nanonuggets are thus not formed upon quench, but are present at high temperature and can effectively be sedimented out of the silicate melt. Our dynamic technique allows to measure accurate Pt partition coefficients, which are in reasonable agreement with the lowest average solubilities defined by the nanonugget-corrected data of [1].

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S-cycling and sulfurization processes at the Lost City Hydrothermal Field

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Near the Mid-Atlantic Ridge at 30°N, the Lost City Hydrothermal Field (LCHF) hosts numerous carbonate-brucite chimneys, that are venting alkaline (pH 9-11), low-temperature (28-90°C) and metal-poor hydrothermal fluids with high concentrations of H_2 (up to 14.4 mmol/kg) and CH_4 (1-2 mmol/kg) related to serpentinization reactions in the underlying mantle peridotites [1, 2]. Within this system, a wide range of mineral compositions and sulfur species have been identified, which reflect large variations in redox conditions, fluid fluxes, and likely sulfur-related microbial activity [3]. In addition, microbiological studies have identified both sulfate reducing and sulfur oxidizing microbial communities, indicating that microbial cycling of sulfur is an important biogeochemical process in this environment [4].

In this study, we have analyzed organic sulfur compounds in carbonate-brucite samples from various sites of the LCHF, collected in 2005 to better understand S-cycling in these systems. Because of the presence of a diversity of sulfur species, temperature and redox states, many pathways for sulfur incorporation into the organic matter can be envisaged. C_{27} and C_{29} steroid thiols were identified and provide evidence for sulfurization processes involving incorporation of reduced inorganic sulfur species into functionalized biosynthetic lipids at Lost City. Knowing the predominant sulfur species in the sampled areas [4], we can evaluate the state in which the sulfur is incorporated into the organic matter. Moreover, the selectivity of the detected sulfurized organic compounds may reflect a particular pathway of sulfur incorporation, possibly involving microbial activity [5]. $\delta^{34}S$ measurements of elemental sulfur are in progress and are expected to provide additional constraints on the mechanisms influencing the cycling of sulfur at LCHF.

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