High P and T partitioning of Au: constraints on core formation

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Introduction and Objective

One hypothesis to explain the “excess” abundance of siderophile elements [1] observed in the Earth’s mantle is that metal-silicate equilibrium partitioning was reached at depth in a magma ocean. We are investigating the effect of pressure on Au partitioning between metal-sulfide and silicate liquids.

Experimental and Analytical Technique

Experiments were carried out at P=3-13.5 GPa, T=1800-2000 °C (held at superliquidus for 4-10 minutes) in a Walker-type multi-anvil device. Au_2S (1.18 wt%) was added to Richardton H-chondrite (7 wt% S in metal) starting material and placed in a graphite capsule. Au in metal-sulfide quench products was measured using a Cameca SX-50 electron microprobe. Secondary ion mass spectrometry (SIMS) was used to measure Au in the quenched silicate liquid [2].

Results

$D_{Aumet/sil}$ ranges from $1x10^3$ to $6x10^2$ from 9 to 13.5 GPa, respectively, compared to $D_{Aumet/sil}$ Earth ≅ $3x10^2$. Dissolved Au in silicate quench crystals and micron-sized metal blebs between quench crystals contribute to the total Au in silicate measured. These micronuggets are so small and finely disseminated that we are unable to exclude them from our SIMS depth profile analyses. We are investigating the origins of the Au micronuggets in order to determine their relationship to the silicate quench. Micronuggets are commonly thought to be artefacts of incomplete mechanical separation of immiscible metal-sulfide liquid from silicate liquid. However, micronuggets exsolved from silicate liquids during quench can’t be ruled out. The silicate quench products are crystalline, usually olivine and aluminous-calcic pyroxene. The textural relationship between these silicate crystals and the micronuggets suggests a complex crystallization history during quench.

Conclusions

Au from micronuggets is thought to lower D’s by at least an order of magnitude. Including the Au micronuggets in the silicate analyses yields a match to Au observed in the Earth’s mantle at P<15 GPa, whereas removing micronuggets analyses may require higher P for a match. The former corresponds to a minimum magma ocean depth of ≅ 330 km, shallower than the 650 km depth proposed by [3].

References

[1] Ringwood A.E. (1966) GCA,, 30, 41–104. [2] Danielson et al. (2001) 11th V.M.G.C. [3] Righter et al. (1997) PEPI 100, 115-134.

Inflation of komatiite lava flows and the origin of spinifex textures

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Maps of the ca. 3.5 Ga Komati Formation and outcrops show three types of komatiite lava flows (24-32% MgO) -- massive (62%), vesicular (2%), and spinifex (36%). Vesicular and spinifex flows have many features diagnostic of inflation of an upper crust, and this mode of emplacement has important implications for interpreting mineral and whole rock chemistry.

Vesicles are concentrated in upper crusts, 2-15 m thick, and provide direct evidence for magmatic volatiles in komatiites [see Parman]. A komatiite tumulus, 100 m wide and with 20 m of relief above the flow surface, has an upper vesicular crust (15-m thick). Originally vertical vesicle lineations in the upper crust document block rotations (45 deg.) that accommodated doming of the crust. The interior spinifex zone is lenticular, 1 to 25 m thick, and crystallized after rotation of the upper crust. This example of spinifex growth beneath a 15-m thick crust indicates that 1) rapid cooling is not the decisive factor in spinifex growth [see Grove] and 2) spinifex growth follows inflation of the flow surface.

The tumulus was buried beneath a compound flow unit of spinifex komatiite flow lobes. The spinifex flows have upper spinifex zones with megacrystic blades of olivine (< 50 cm). Lenticular flow lobes have distinctly pointed lateral margins with concave upper surfaces marking a gradient of increasing inflation toward the interior of the lobes. Local topography controlling the position of flow lobes was inverted. Low effusion rates and laminar flow facilitated settling of olivine, variably enriching flows in liquid, and creating phenocryst-free upper zones where spinifex textures developed.