Compositional heterogeneity within the Yellowstone magma reservoir: Insight from zircon age, trace-element, and Hf-isotopic analyses

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Introduction

The Yellowstone Plateau (USA) hosts one of the largest Quaternary magmatic systems in the world, with caldera forming eruptions at 2.059 ± 0.004 Ma, 1.285 ± 0.004 Ma, and 0.639 ± 0.002 Ma, as well as numerous intracaldera and extracaldera eruptions between caldera-forming events [1]. The most recent eruptive episode at Yellowstone caldera produced the Central Plateau Member (CPM) of the Plateau Rhyolite, which erupted intermittently between ~170-70ka with a cumulative volume ≥600km^3, thereby approaching the ≥1000km^3 (dense rock equivalent) of rhyolite erupted during the preceding caldera forming eruption of the Lava Creek Tuff [1]. Thus, the CPM rhyolites provide snapshots of an evolving large silicic magma reservoir though time.

In this study we examine the degree of compositional heterogeneity ca. 100ka in the Yellowstone magma reservoir by comparing sub-crystal-scale SIMS age, SIMS trace-element, and LA-MC-ICPMS Hf-isotopic data from zircons hosted in three CPM rhyolites erupted at different locations within the caldera during the 100-120ka time period, as well as an ~118ka extracaldera rhyolite. Linking the age, trace-element, and Hf-isotopic compositions of zones within individual zircons provides a robust method for recognizing distinct crystal populations and magma compositions within the CPM reservoir, and monitoring the evolution of the magma reservoir over time using crystal zoning patterns. Comparing crystal populations in coeval rhyolites erupted from different parts of the caldera furthermore allows for assessment of whether the rhyolites have similar crystal populations and provides insight into the degree of compositional heterogeneity within the magma reservoir at ~100ka.

Results and Conclusions

Age, trace-element, and Hf-isotopic data for zircons from the intracaldera West Yellowstone flow, Solfatara Plateau flow, and Hayden Valley flow as well as from the extracaldera Gibbon River flow document the presence of multiple zircon populations within the CPM magma reservoir. Hf-isotopic compositions of zircons in the CPM rhyolites vary from -8.5 εHf to 1.2 εHf, with individual grains displaying large (>4 εHf) Hf-isotopic variations. These data document that the CPM reservoir experienced mixing and crystal exchange with multiple magmas prior to eruption, and place constraints on the degree of compositional heterogeneity in the Yellowstone magma reservoir ca. 100ka.

[1] Christiansen *et al.* (2007) *Geol. Sur. Open File Rep*, **1071**, 1-98.

Temporal variation of sulfur and iron metabolisms within composite tailings and overlying sand cap at Syncrude's Mildred Lake property

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In accordance with provincial regulations, the Alberta oil sand companies must reclaim mined areas and composite tailings (CT) deposits produced as a by-product of bitumen extraction. Syncrude, the largest operator in the Alberta oil sands is currently building the first pilot fen reclamation project overtop of CT. Dewatering of CT associated with reclamation activities at Syncrude's Mildred Lake property (Fort McMurray, AB), has resulted in unexpected incidents of H_2S gas release from CT dewatering wells, identifying the need for in depth biogeochemical characterization of these materials and identification of the potential roles of microbial activity in H_2S generation. The objectives of this field and experimental research are to establish the existence of Fe- and S- respiring bacteria within CT porewaters and their potential linkages to H_2S release over seasonal and spatial scales within the CT deposit. An operationally defined sequential extraction procedure was used to quantify biologically accessible pools of amorphous Fe and S substrates within the sand cap overlying the CT, an important interface between the CT pore-water brine and the developing fen. Results show high concentrations of bioavailable Fe (124 μmol/g) and S (48 μmol/g) in the reducible ("amorphous and crystalline oxyhydroxides") and the oxidizable ("organic/sulfide") sediment fractions respectively. Porewater wells within CT and the overlying 10 m sandcap on which the fen is currently being constructed were sampled 4 times from June 2010 to October 2011. H_2S was detected in all wells and at all sampling dates, the highest concentration detected was for a well within the sandcap of 183 μmol/L. Enrichments for S and Fe oxidizing and reducing bacteria from samples collected in June and September 2010 and July 2011, have shown positive growth for S- and Fe- oxidizing and reducing bacteria in well water from the location of reported H_2S_g release, consistent with the involvement of these microbes in S- cycling and H_2S production in CT. Experimental mesocosms with targeted Fe and S metabolisms are currently being assessed for H_2S generation to identify key metabolic pathways involved. Select field and laboratory results, including 16S rRNA sequencing of environmental enrichments and the bulk well water community, along with the results of experimental mesocosms will be discussed.