V11D-3209 Integrating Experimental Investigations, Computational Modeling, and Petrochemical Data of Igneous Rocks: Quantifying Open-System Processes in Magma Storage and Transport Zones (Invited)

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Documenting the processes and timescales of magma formation and diversification and defining the locations, shapes, volumes, and phase states of magma storage and transport zones rely on data produced by novel analytical techniques and state-of-the-art experimental methods. Computational modeling effectively links these critical tools. The Magma Chamber Simulator (MCS) is an internally consistent thermodynamic open system model that uses experimental constraints from rhyolite MELTS (Gualda et al. 2012, Ghiorso & Gualda, 2015) to compute paths of open system magmas that evolve via processes including crystallization, magma mixing, cumulate/mush entrainment, and host-rock assimilation. MCS results yield elemental, isotope, mass, and thermal characteristics of melt ± crystals ± volatiles in “resident” magma, crustal wallrock (melt and solids), recharge magma, and entrained material. To model the petrochemical evolution of igneous rocks related by open-system processes, one typically runs 200+ models that vary initial compositions, pressures, and temperatures of magma, wallrock, etc. Comparison of model results with whole rock, mineral, and melt inclusion chemical data and other constraints (e.g., thermobarometry) yield interpretations about igneous processes at a range of scales—from how crust forms and evolves to processes responsible for *in situ*geochemical records of crystals—and allows assessment of epistemic and aleatoric uncertainties. Two examples of computational studies will illustrate MCS’s utility and flexibility. (1) Modeling of historical basalts at Mt. Etna (Italy) provides evidence for variable degrees of melting of metasomatized mantle, followed by magma recharge and assimilation of partial melts of carbonate-flysch crust. (2) MCS models reproduce whole rock and mineral data of plagioclase-rich basalts at Steens Mountain (USA) through entrainment of gabbroic mush that likely formed in early stages of Columbia River Basalt magmatism. To enhance understanding of trans-lithospheric

magma systems, future work on MCS will prioritize (i) building a post-processing environment that utilizes select statistical methods to inform “best-fit” models and to quantitatively assess uncertainty, and (ii) increasing modeling efficiency by adding automated modeling capabilities.