Deciphering the origins of chemical and isotopic trends at continental hotspot volcanoes with high-resolution thermomechenical modeling

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We present recent high-resolution magmatic-thermomechanical models which successfully replicate the isotopic and geochemical trends in erupted magmas from the large intracontinental volcanic systems of the Yellowstone hotspot track. Recent studies there have shown that erupted rhyolites there progress from having normal mantle-like $\delta^{18}O$ values to lower $\delta^{18}O$ values indicative of the melting and hybridization of shallow hydrothermally altered crust, and that the earliest magmas from each center frequently have radiogenic isotope compositions characteristic of ancient Precambrian crust, while later eruptions show little sign of ancient crustal melting.

We combine thermomechanical models of the intrusion and eruption of magmas generated in continental crust over a steady-state mantle plume with a method for tracking the evolving compositions of magmas as they form, mix, and eventually cool or erupt. These models produce a prominent gabbroic sill complex at a depth of 10-25 km, which releases rhyolitic fractionates as it cools, and also heats and melts the surrounding crust. The crustal composition which is melting is not fixed throughout the lifetime of the system. First, caldera collapse from repeated eruptions brings the uppermost crust down towards the hottest part of the magmatic system at 5-10 km depth, where it melts and replaces deeper crust as the source of crustal melting. Second, as the sill complex develops and thickens, new intrusions tend to accumulate at its top, which means that the heat source becomes increasingly separated from the lower crust by juvenile intrusions as the system evolves. This shift from mid-lower to upper-crustal melting produces the trend towards more isotopically juvenile and low-$\delta^{18}O$ erupted magmas observed on the hotspot track.