Thermo-chemical plumes generated by core formation processes in Venus and Earth interior differentiation

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The Venus highlands and large volcanic plateaus represent large magmatic events but lack significant crater densities and are thus suggested to have a relatively young age of formation. However, the analogous continental rocks on Earth display a similar elevated topography and lack of crater density but indicate ages of 4.1 Ga and older. A non-tectonic origin for these large magmatic events is required in the early stages of evolution due to the lack of tectonic activity on Venus and recent geochemical studies indicating the onset of plate tectonic subduction may have been delayed on Earth initiating around 3.2 Ga. We suggest a large source of surface volcanism may have been generated by thermo-chemical plumes formed during core formation processes and interior differentiation of terrestrial rocky planets. We use laboratory fluid experiments to study core formation processes using liquid metal gallium and high viscosity glucose syrup which provide the buoyancy ratios expected for planetary interiors and low Reynolds number flow dynamics. Preliminary results indicate that the physical process of sinking metal diapirs form trailing conduits that may drag low density surface magmatic material to the base of the mantle. The low density material collects, grows at the base of the box, and rises back to the surface. We compare two cases of a pond made of 1) liquid metal emulsion and 2) a smooth coalesced metal pond. We find that emulsion experiments entrain greater amounts of low density fluid to the base of the box. Once the metal diapir reaches the base, conduit material exhibits flow reversal to return buoyantly to the surface. In the case of coalesced liquid metal diapirs, low density conduit material returns to the surface through the pre-established conduit. In the emulsion diapir case, we observe the formation of a new thermo-chemical buoyant plume that grows, exits the conduit, and travels along a new pathway to the surface. Metal plume descent velocities are faster than predicted by Stokes theory and must be adjusted to consider the mass of an overlying magma ocean, and reduced drag from a trailing conduit. Estimates of metal-silicate plume sinking time and thermo-chemical plume rise time for terrestrial planetary interiors are provided. Thermo-chemical plumes formed by core formation processes are dependent on meteorite impacts, iron ponding and descent to the core and will necessarily postdate the heavy bombardment period. These unique plumes are nonetheless a source for large magmatic events at the surface and can explain thick crustal melting events as well as repeated melting and fractionation to produce plateau structures, highland features on Venus and perhaps pre-tectonic proto-continental formation on Earth, all of which lack significant crater densities.