Title: Insights into growth of continental arcs: a xenolith perspective

Abstract:
How the continents formed is one of the central questions in earth science. A prevailing view is that continental crust is differentiated from juvenile island arc "building blocks", but the processes responsible for such differentiation are still debated. One feature that distinguishes mature continental arcs from their juvenile predecessors is that the former tend to have thicker crust and lithosphere than the latter. Lithospheric thickening has several effects on the evolution of continental crust. For instance, thicker lithosphere promotes fractionation of high-pressure phases such as garnet and clinopyroxene over olivine, and may therefore influence the composition of primitive magmas early in their differentiation history. Another consequence of thickened lithosphere is the stabilization of dense garnet cumulates, which may founder back into the mantle and thus drive the crust to its evolved composition.

Here, I investigate how and when thickening occurs in continental arcs using lower crustal and mantle xenoliths from the classic Cordilleran Sierra Nevada arc in California, USA. Mantle xenoliths indicate initial shallow and hot melting that left behind spinel harzburgite residues, which were subsequently compressed and cooled into the garnet stability field. Refertilization, i.e., re-addition of basaltic melt, affected the entire mantle lithosphere but is most pronounced in deeper equilibrated garnet peridotites, where up to 30% melt was added back. Olivine LPOs are consistent with a transition from the "A" type fabric typical of mantle peridotites to girdle distributions of A and C to "B" type fabric. Water contents measured by ion microprobe in olivine are too low to account for this fabric transition. Instead, the observed olivine LPO is similar to experiments where melt + peridotite are deformed, as well as natural examples of melt-infiltrated peridotite. Rapid cooling of the peridotites from 1200 C to 700 - 800 C preserved this P-T-X history (mineral disequilibria, chemical zoning). Al-diffusion modeling of garnet exsolution in pyroxene indicates cooling occurred within 5 Ma, and coupled Lu-Hf/Sm-Nd isochron ages of garnet websterites constrain the timing of cooling to 90 Ma, coeval with the peak of Sierran arc magmatism. Thus, thickening of lithosphere is associated with arc magmatism. I propose that the rapid cooling of the thick arc root was caused by impingement of the thickening root on a normally-dipping Farallon slab which resided beneath the Sierras between 220 to 40 Ma. This hypothesis challenges the widely held view that shallowing of the slab caused arc termination.