Melt evolution in a calc-alkalic batholith recorded in silicate and oxide mineral assemblages

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The Big Bear Lake Intrusive Suite is a concentrically zoned, granodioritic to granitic calc-alkalic suite that intruded the Paleoproterozoic Laurentian craton. Cation exchange and trace element thermometers indicate melt evolution occurred between 800 and 660°C, consistent with experimental phase relations in oxidized, hydrous granodioritic-granitic systems. Pl-hbl pairs from granodiorite yield T=725-660°C and P increasing from 3 to 4.7 kb southward, consistent with field evidence that the batholith is tilted up to the south. Euhedral, strongly zoned titanites in granodiorite yield a very similar apparent T range, ~740-665°C ($aSiO_2$=1, $aTiO_2$=0.5), consistent with textures suggesting early crystallization of (hem-rich)ilm+mt+hbl and late ttn+mt+hbl+qtz. Late rims have abruptly increasing Eu/Eu* at apparent near-solidus temperatures, suggesting a rapid change in oxidation state. Zircons from both granodiorite and granite yield T=800-690°C ($aSiO_2$=0.9, $aTiO_2$=0.4), consistent with zircon saturation T=800-740°C and most zircon growth prior to crystallization of titanite. Rare apparently magmatic zircon cores record T as high as 900°C. The presence of these high T magmatic cores and the abundance of premagmatic zircons in all analyzed samples suggests melts similar to those at the level of final emplacement were either never above ~800°C, or experienced transient heating episodes too brief to fully digest older zircons. Zircon εHf supports this observation; Proterozoic zircon cores were overgrown by magmatic rims growing in both isotopically primitive and evolved melts. Late magmatic zircons converge on a more restricted range of εHf, suggesting homogenization of diverse individual magmatic batches during final ascent and emplacement. Trace element data for magmatic zircon and titanite also suggest that compositionally diverse melts were present during early growth of these minerals, and that melt homogenization progressed rapidly, but relatively late in the crystallization history. These observations are consistent with generation and homogenization of diverse melts below the current level of exposure, and late mineral-melt fractionation during development of the concentrically zoned map pattern.

Size dependent adsoprtion behavior of hematite nanoparticles

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Iron (hydr)oxide nanoparticles are widespread in the environment, often affecting trace metal bioavailability and cycling. Research is increasingly demonstrating that such particles may have different properties and reactivities than larger analogous materials. This research compared the adsorption of Pb (II) in the presence and absence of a microbial ligand to nanoparticulate hematite (α-Fe_2O_3) samples as a function of particle size. Hematite particles were synthesized with mean diameters of 3.6nm, 8.6nm and 40nm, and characterized by a wide range of techniques, including TEM, BET surface area, XRD and XPS. Batch sorption studies were conducted using Pb (II) and the hydroxamate siderophore desferrioxamine B (DFOB). In the absence of DFOB, Pb sorption data suggested size resolved differences in Pb (II) binding across a range of pH values due at least in part to increased Fe hydroxylation at and near the surfaces of the smaller particles. The Pb adsorption edges were shifted to lower pH for the smaller particles. Also in Pb adsorption edge experiments, DFOB decreased maximum sorption (which occurs at pH > 6) onto the 40nm particles by 20% but did not affect maximum Pb (II) sorption on the other particles appreciably. DFOB sorption decreased with increased Pb (II) concentration in the system, which may be due at least in some measure to changes in DFOB solution speciation upon binding to Pb. Characterization of the molecular structure of Pb (II) surface species by EXAFS combined with thermodynamic modelling is ongoing. Overall, this research demonstrates that the size of (nano)particles may impact the speciation and partitioning of metals in the presence of organic ligands, which may help to refine reactive transport and sequestration models.