# Monazite as a monitor of melting, garnet growth, and feldspar recrystallization in continental lower crust

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The presence or absence of partial melt may be particularly critical for controlling the relative strength or weakness of crust. Thus, developing petrologic monitors for constraining the timing, composition, and degree of melting are essential. Monazite is a common accessory phase in felsic granulite ribbon mylonites exposed in the Upper Deck domain of the Athabasca granulite terrane, western Canadian Shield. Pseudosection modeling in the NCKFMASHT ($Na_2O$-CaO-$K_2O$-FeO-MgO-$Al_2O_3$-$SiO_2$-$H_2O$-$TiO_2$) system supports the hypothesis that the garnetiferous felsic granulites represent the restitic products of *UHT*-melting in thickened continental crust. Monazite inclusions in garnet are predominantly depleted in Y, Sm, and Gd and linked to fluid-absent melting of biotite + plagioclase + quartz at $P$>1.5 GPa. Yttrium-depleted, Th-rich monazite domains (ca. 2.61-2.55 Ga) represent growth in the presence of melt, garnet, ternary feldspar, and orthopyroxene at $T$>1000°C. Low Th-rims depleted in Ca and enriched in Eu are linked to growth of grossular-rich garnet at the expense of recrystallized plagioclase and orthopyroxene during crustal thickening and lower crustal flow at 2539 ± 21 Ma (2σ). Over 650 m. y. of lower crustal residence was followed by syn-kinematic growth of LREE-enriched (La + Ce) monazite (concurrent with recrystallization of feldspar) during dextral transpressive reactivation at c. 1.9 Ga. Nearly all monazite grains in this study are marked by positive Eu-anomalies relative to chondrite. A direct link is implied between Y, Sm, Eu, and Gd in monazite and garnet and plagioclase, two of the major phases in continental lower crust. Europium-anomalies in lower crustal monazite associated with modally-abundant garnet appear directly related to depletions of Y, Sm, and Gd during garnet growth and loss (or removal) of plagioclase. These links permit tighter constraints on the evolution of continental lower crust during melting, crustal flow, crustal thickening, and strain partitioning.

# Passive cell wall biomineralization: A universal phenomenon?

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A number of metal-phosphate minerals exhibit very low solubilities, and phosphorus soil amendments have been proven effective at immobilizing several contaminants, such as U, Pb, Hg, Cd, and Co, through phosphate mineralization. In uranyl-phosphate systems, passive bacterial cell wall biomineralization, or non-metabolic precipitation nucleated by cell wall binding sites, affects both the size and the extent of precipitation of uranyl phosphates (Dunham-Cheatham *et al*. 2010). Here, we determined whether the passive cell wall biomineralization that was observed by Dunham-Cheatham *et al*. (2010) in uranyl-phosphate systems also occurs in systems supersaturated with respect to Ca- or Pb-phosphate phases. We conducted precipitation experiments, with and without bacteria. Initial log molalities of dissolved Pb and Ca were -4.20 and -3.00, respectively, and the initial log molalities of dissolved P were -4.50 to -3.50 for the Pb system, and -5.00 to -2.00 for the Ca system. We used non-metabolizing cells of *Bacillus subtilis*, a gram-positive aerobic soil bacterial species, with a cell concentration of 0.124g/L dry mass. The pH of the experimental systems was kept constant at 6.00 and 8.00 for the Pb and Ca systems, respectively. The systems were allowed to react for 2 hours, then were centrifuged to separate the solid and aqueous phases. The extent of precipitation was determined by analyzing the supernatant for remaining aqueous Pb or Ca and P by ICP-OES. The solid phases were characterized by TEM and XRD to determine the relationship between bacterial cells and the precipitate that formed in all experiments.

We discovered that the presence of bacteria in the Pb system has little effect on the extent of precipitation of Pb and has no effect on the extent of precipitation of Ca in the Ca system. Although TEM results show that mineralization in the Ca system is not located within the bacterial cell wall, the precipitates appear to be nucleated by the cells, and XRD results indicate that the presence of the cells changes the morphology of the precipitate from a crystalline Ca hydroxyapatite, which forms in abiotic Ca systems, to an amorphous Ca phosphate phase in the biotic systems. Our experimental results indicate that the conditions that lead to passive cell wall biomineralization may be element specific, perhaps relating to binding mechanisms, and that bacteria can exert a range of effects on precipitating mineral phases.