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The sublithospheric origin of batholiths

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Temperatures required for the generation of granodiorites and tonalites are on the order of 1000 ˚C, far from the peak temperatures measured in regional migmatites that, with exception of very local situations, rarely overpass 800-850 ˚C. These values are around the breakdown of hydrous silicates in crustal rocks, namely biotite (pelitic migmatites) and hornblende (amphibolites), and thus they impose a buffer for thermal anomalies within the continental crust. Furthermore, melts derived from these peeritectic reactions do not math the composition of silicic magmas that give rise to calc-alkaline rocks. Many important magmatic structures in calc-alkaline batholiths are the result of gravitational instabilitities developed as a consequence of reversely stratified magma chambers. These strucutures strongly suggest that granodiorites and tonalities were crystal-poor magmas when they were emplaced into the continental crust and behaved as nearly-newtonian systems. This rheological state implies temperatures of the order of 1000 ˚C for the intrusion of these magmas, being the temperatures of generation possibly higher. Geochemical features of these silicic rocks, mainly based on trace elements and Sr-Nd-O isotopes, clearly support a hybrid origin, with crustal (recycled sediments) and mantle (peridotite and its melting products like oceanic crust) involved in variable proportions. Taken into account on one hand the difficulty for magma mixing due to differences in viscosities and rheological behaviour between basalts (mantle melts) and granites (crustal melts), and, on the other hand, the usually observed liquid-liquid relations denoting clearly immiscibility between silicate melts with compositions not very different, it seems more plausible that a composite source, having mantle and crust components, is the parent rock for these hybrid melts and magmas. Experimental data are in favour of these composite sources for the generation of calc-alkaline melts of silicic composition (granodiorites and tonalites), satisfying mayor elements relations and trace elements abundances and isotopic ratios, as determined by constraints imposed by phase equilibria at different depths.

Conditions for melting of mixed source are encountered in the mantle wdge in supra-subduction settings. Fertile sources with appropriate composition are introduced into depth as part of the subduction channel. These may form mixed cold plumes that can transport the fertile subducted crustal materials towards hotter zones of the supra-subduction mantle wedge leading to the formation of silicic melts. We investigate magmatic consequences of this plausible geodynamic scenario by using experimental approach. Melt compositions, fertility and reaction between silicic melts and the peridotite mantle (both hydrous and dry) were tested by means of piston-cylinder experiments at conditions of 1000 ˚C and pressures of 2.0 and 2.5 GPa. The results indicate that silicic melts of trondhjemite and granodiorite compositions may/might be produced in the ascending mixed plume megastructures. Our experiments show that the formation of an Opx-rich reaction band, developed at the contact between the silicic melts and the peridotite, protect silicic melts from further reaction in contrast to the classical view that silicic melts are completely consumed in the mantle. The mixed, mantle-crust isotopic signatures which are characteristic of many calc-alkaline batholiths are also expected from this petrogenetic scenario.