New Calibration of the Al-in-Hornblende Geobarometer: Evidence for Lower-Crustal Fluid Saturation in Porphyry Copper Magmas

Gonzalo J. Henríquez[1], Robert R. Loucks[1], Marco L. Fiorentini[1]
[1]Centre for Exploration Targeting, The University of Western Australia, Crawley, Australia

Al-in-hornblende geobarometry provides a useful tool to understand emplacement depth and magmatic evolution of granitoids. It was empirically calibrated by Hammarstrom and Zen (1986) and re-calibrated by other investigators over the years. Currently, the calibration by Mutch et al (2016) appears to be the most reliable in the 0.8-5 kbar range, suitable to retrieve pressures equivalent to upper-crustal levels, but it tends to yield large under-estimates in the 8-15 kbar range, which relates to lower crust – upper lithospheric mantle depths. Experiments that report hornblende compositions synthesised on calc-alkalic, metaluminous granitoid melts at 650 to 950°C, 5 to 15 kbar, provide the basis for our re-calibration. Using the total Al (a.p.f.u) content in hornblende synthesised in 91 experiments from 10 published studies, linear regression yields the equation log P(kbar) = –0.2351 + 0.5082 × Al(tot); R^2 = 0.90, with a standard error ±16% (e.g., ±1.6 kbar at 10 kbar). We have applied this calibration to calculate crystallisation pressures of hornblende phenocrysts in ore-forming intrusions parental to major porphyry-type and high-sulphidation epithermal Cu(-Au-Mo) ore deposits worldwide. Plots of P by our calibration versus wt % H_2O dissolved in the melt (using Ridolfi et al, 2010), indicate onset of fluid exsolution at 8-12 kbar in many cases, as very hydrous granitoid melts begin ascent from storage chambers near the base of the crust in orogenic segments of magmatic arcs. Published experiments indicate the fluid/melt partition coefficient of CuCl is ~10 times higher at 10 kbar than at 1 kbar. Therefore, high-pressure fluid segregation from exceptionally hydrous melts as magmas begin their trans-crustal ascent from Moho depths yields efficient Cu extraction and resolves the Cu supply problem. This new Al-in-hornblende geobarometer can be used as an exploration tool by relating high-Al content in hornblende to high pressure volatile exsolution and Cu-metallogenic fertility.