Zircon as magma monitor: Robust partition coefficients from surface, rim, and glass measurements from natural systems

L.L. CLAIBORNE[1*], C.F. MILLER[1], G.A.R. GUALDA[1], M.A. FLEMING[1], A.K. COVEY[1], J.L. WOODEN[2], AND T.L. CARLEY[1,3],

[1]Vanderbilt Univ, Earth & Environmental Sci, Nashville, USA, g.gualda@vanderbilt.edu (*presenting author)

[2]USGS, Menlo Park USA (retired), geowooden@gmail.com

[3] Geol & Env Geosci, Lafayette College, Easton USA, carleyt@lafayette.edu

Zircon crystals, with reliable Kds, can elucidate the compositions of melts from which they have grown even when no other record of their host magmas exists. However, robust Kds have proven elusive: experiments are conducted with materials that do not reflect natural compositions and/or with durations that are too short for growth and equilibration of analytically tractable crystals, and most Kds from natural materials are hampered by the fact that melt compositions from which zircons grew are unknown. Natural mineral/host glass analyses provide the best means to determine robust Kds applicable to natural conditions.

We have analyzed zircon rims (SHRIMP-RG) and glasses (LA-ICPMS) in 14 tholeiitic, calc alkaline, and alkaline samples from diverse settings (continental extension, AZ-NV, USA [1] ; hot spot/spreading center, Iceland; continental arc, Mount St. Helens, WA, USA). Samples are dacites and rhyolites; glasses (72-79 wt% SiO_2, A/CNK 0.96-1.12) have Zr concentrations of 60-800 ppm and zircon saturation Ts (T_{Zr} [2]) of 660-940°C.

Kds span more than an order of magnitude (Nd 0.01-0.12; Yb 25-640; Th 1.5-50; U 7-150; Nb 0.1-1.4), but are highly coherent. REE Kds fit lattice strain model parabolas very well, and all Kds show very strong negative correlations with T indicators (Zr_{glass}, T_{Zr}, Ti_{zircon}). Useful Kds for zircon can be estimated from Ti_{zirc}-$Kd_{element}$ correlations.

Most of our elemental concentrations were determined on polished grain interiors, where the rim analysis incorporates the final ≥ 20 microns of crystal growth. For the four Mount St. Helens samples, we also measured concentrations and high-precision U-Th ages of zircon surfaces (outer 1-2 microns), in some cases with adhering glass (melt-crystal contact). Kds based on those analyses that yielded eruption U-Th ages were broadly consistent with those using conventional rim analyses from the same samples, generally differing by a factor of ~50% or less.

[1] Colombini et al. 2011; [2] Boehnke et al. 2013