V52E-12 1630h

An Application of Open-System $^{18}O/^{16}O$ Exchange Kinetics to the Valhalla Metamorphic Core Complex, British Columbia, Canada

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Whole-rock, quartz, and feldspar oxygen isotope analyses of samples collected from the Valhalla metamorphic complex in SE British Columbia show evidence for large-scale fluid-rock interaction related to detachment faulting. Near the Slocan Lake low-angle normal fault (SLF), the upper plate Nelson granodiorite has $\delta^{18}O_Q$ = +11.3 to +12.1 and $\delta^{18}O_F$ = -5.0 to +9.0. On a $\delta-\delta$ plot, these values define a steep array (slope = 18) with $\delta^{18}O_F$ as the y-axis. Application of an open-system kinetic exchange model (see Gregory et. al., Chem. Geol., v. 75, p. 1-42) with the parameters T = 300°C, $k_Q = 10^{-14}$, and initial $\delta^{18}O_W$ = -15, suggests that water-rock interaction was intense and short-lived ($\approx 10^5$ yr) during the extensional faulting. Rocks within the brittle portion of the SLF have $\delta^{18}O$ = +0.3 to +0.9, giving open system water-rock ratios of 0.34 (wt. units). Assuming a length scale of 15 km along the SLF with upward and westward fluid flow, the time-integrated fluid flux is 1350 kg/cm^2. This corresponds to a plausible average permeability of 100 μD, assuming constant flow rates over the lifetime of the system. Lower plate greenschist-grade mylonites show less water-rock interaction ($\delta^{18}O_Q$ = +11.0 to +11.4; $\delta^{18}O_F$ +6.6 to +9.5). A systematic $\delta^{18}O_F$ decrease occurs within 1-2 km of the SLF in both the upper and lower plates, suggesting that fluid-flow was channelized by the fault and that exchange occurred at the time the fault was active. This model-derived, short-lived hydrothermal system along the SLF contrasts with geochronologic data that suggest 100°C cooling over 6.5 Ma (Parrish et. al., Tectonics, v. 7, p. 181). An intermittent flow system with transient changes in permeability (e.g. seismic pumping) may account for this difference. Along the west-bounding Valkyr shear zone (VSZ) $\delta^{18}O_Q$ = +7.8 to +11.2 and $\delta^{18}O_F$ +0.2 to +8.8. These systematics define a shallower array on a $\delta-\delta$ plot (slope = 2.3), suggesting longer-lived and/or higher temperature hydrothermal activity at the VSZ, possibly associated with deformation and/or emplacement of younger Coryell series plutons that outcrop nearby. Oxygen isotope data on coexisting quartz and feldspar from gneisses in the lower plate at 1-4 km depth beneath the detachment faults show no evidence of meteoric-hydrothermal exchange.