Micron-scale oxygen isotope zoning in metabasalt zircon: A robust history of crustal fluid flow during crustal growth

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The Borden Lake belt is a slab of metabasalt and metasedimentary rock that was thrust to lower crustal depths during Neoarchean craton formation prior to Proterozoic exhumation as part of the Kapuskasing crustal cross-section (Superior Province, Canada). Here we report on U, Pb, O isotope zoning in metamorphic zircons using CL imaging and coordinated ion microprobe (SHRIMP and CAMECA 1280) analysis. These zircons were separated from six sites along a 10 m transect in granulite-facies mafic gneiss (metabasalt) away from a contact with paragneiss ($\delta^{18}O$=+10‰). These zircons record growth over ~100 Ma time span [$^{207}Pb/^{206}Pb$ ages (<6% discordance) of 2660 to 2550 Ma; $\pm$15 to 60 Ma, 2sd]. Beyond 8.5 m from the paragneiss contact, $\delta^{18}O$ values of early zircon cores range from 7.8 to 9.1‰ ($\pm$ 0.2 to 0.4, 2 sd) averaging 8.4‰, similar to high-grade mafic gneiss regionally, and record early (low T?) alteration of the basalt protolith by $^{18}O/^{16}O$-enriched (non-mantle) fluid sources. Within 8 m of the paragneiss, zircon cores have significantly higher $\delta^{18}O$ values of 9.6 to 11.5 (ave. 10.8‰), indicating infiltration of the contact zone with $^{18}O/^{16}O$-enriched fluid/melt from paragneiss early in burial. Episodic growth of zircon continued throughout the metabasalt for another ~80 Ma at lower crustal depths, with new zircon rims between 5 and 8 m from the paragneiss recording variable $\delta^{18}O$ values ranging from 11.1 down to 7.6‰. The lower $\delta^{18}O$ rim values indicate subsequent channelized infiltration of lower $\delta^{18}O$ low $a(H_2O)$ fluid/melt into the lower crust, and increased contribution of mantle sources to these fluids. This fluid history is not resolvable with main phase minerals, however correlated micron-scale trace element, U-Pb age, and oxygen isotopic zoning in zircons document upper and lower crustal fluid/melt infiltration events involved in the geochemical maturation of early crust.