Characterization of Lower Crustal Xenoliths From the Wyoming Craton, Montana (USA), Using Accessory Mineral Chemistry and Geochronology with Implications For Lower Crustal Evolution

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The Bearpaw Mountains in north-western Montana comprise Eocene intrusive and volcanic rocks that contain entrained middle to lower crustal xenolith bodies spatially associated with the Wyoming Craton. Xenoliths include mafic granulites and amphibolites along with meta-basic cumulate rocks. Mineral geothermobarometry provides P-T estimates between 524-796°C and 3.5-8.48 kbar. Detailed cathodoluminescence (CL) imaging of zircon reveal complex internal structures within both metamorphic and magmatic grains resulting from recrystallization of original domains. U-Pb geochronology on zircon and apatite produce a spectrum of dispersed Late Archean to Proterozoic Ages (2.0-2.53 Ga) together with a dominant younger Paleoproterozoic age population (1.70-1.85 Ga). Zircon oxygen ($\delta^{18}O$ = 4.4-8.2 ‰) and hafnium (ε_{hf} = -20.6 to +3.7) isotope data record both mantle and crustal signatures, and together with trace element information show a complex multi-stage crystallization history. At least one metamorphic event is inferred between 1.70-1.85 Ga resulting from tectonic activity associated with the Great Falls Tectonic Zone (GFTZ). The xenoliths represent metamorphosed Late Archean crustal rocks together with juvenile Paleoproterozoic protolith magmas that crystallized at lower crustal levels.