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Using Earliest Outcrops of Earth's Crust to Monitor Early Earth Conditions: Triple Oxygen Isotope Perspective Coupled with Detailed Geological Investigation

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With the increased ease of analyzing zircons for their $\delta^{18}O$ vs U-Pb age and a variety of other parameters, data deriving from zircons are over-represented in early Earth studies. Many rocks, however, do not have zircons, creating preservation bias, and when present, zircons are third cousins of surface conditions especially when it deals with the reconstruction of past hydrosphere and temperature on Earth. Comprehensive oxygen stable isotopic investigations of the rare surviving outcrops of oceanic and continental crust, now commonly crystalline and metamorphic, provide a more comprehensive approach towards understanding surface conditions. Coupled with detailed field and chemical characterization, the oxygen and hydrogen isotope compositions of their protoliths represent a snap-shot view of past water-rock interaction and temperature of the process. Nevertheless, metamorphism into crystalline assemblies preserves these signatures in the geologic record and allows reconstruction of details of the original, syn-emplacement conditions recording isotopic values of the hydrosphere, while accounting for the effects of a long post-formation history of these metamorphic outcrops. Newly emerged triple oxygen isotope geochemistry allows disentangling of the effects of $\delta^{18}O$ parental or altering water and temperature of interaction, creating a new tool and interpretive framework for recognition of past environments. We here report new results and summarize the results of recent studies of triple oxygen isotope investigation of Acasta gneiss (4.03 Ga), Nuvvuagittuq metabasalts (4.3-3.8 Ga), Saglek-Hebron (3.8 Ga) and Isua (3.8 Ga) metabasalts and metasediments. Most of these represent examples of submarine hydrothermal processes in the Hadean-Eoarchean of sediment-covered oceanic crust, and our studies yield significant $\delta^{18}O$ (12 ‰) and $\Delta'^{17}O$ ranges (-0.1 to 0 ‰) that we interpret as resulting from low and high-temperature hydrothermal alteration during igneous formation. We also recognize the effects of isotopic shifts due to hydrothermal silicification by seawater. Acasta gneiss is an example of continental crust and preserves $\Delta'^{17}O$ values ranging from -0.02 to -0.09‰ suggesting involvement of meteoric and seawater at relatively low temperatures. In this talk, we will address questions regarding our ability to recognize $\delta^{18}O$ of surface waters and temperature of interaction in ancient rocks, and their implications for the early Earth surface conditions.