Microtextural and geochemical evolution of zircon during long-lived metamorphism

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Zircon plays a pivotal role in our understanding of deep crustal rocks, as they are often the only remaining 'witnesses' to ancient events. Variation in zircon microtextures in conjunction with trace and isotopic analyses has the potential to reveal information about the age, environment and processes related to sub-solidus recrystallization and/or growth from an anatectic melt.

We present zircon U-Pb, Lu-Hf and REE trace element data from a suite of quartzo-feldspathic gneisses dredged from the Chukchi Borderland, a bathymetric high in the Arctic Ocean north of Alaska. U-Pb results exhibit a wide distribution, with metamorphic ages between 560-475 Ma with a main peak ~500-520 Ma. Within this age bracket, REE patterns and microtextures systematically transform with decreasing age: from slightly modified grains with steep (igneous) HREE patterns to newly formed metamorphic zircons with flat to negative HREE patterns. Ti-in-zircon thermometry suggests minimum metamorphic temperatures of 750-850 °C for zircon recrystallization and growth. $^{176}Hf/^{177}Hf$ results show an evolution of zircon geochemistry with time. Zircons >530 Ma exhibit a narrow range of ratios between 0.282066-0.282341 and younger zircons (530-475 Ma) have highly scattered ratios between 0.281698-0.282531.

REE and Lu-Hf analyses together with microtextural observations suggest that early increasing temperatures and partial melting caused zircon modification and radiometric resetting by sub-solidus recrystallization and dissolution/reprecipitation of existing zircons with garnet forming later on. Textures and geochemical signatures of younger zircons advocate that they grew during peak to post-peak metamorphism. REE and Lu-Hf results suggest that new zircons crystallized from an externally derived, Zr-bearing melt in the presence of garnet. As the rocks continued to cool, residual melts crystallized late homogenous rims on pre-existing metamorphic zircons.