High to low temperature geo- and thermochronology and the reactivation and stability of continental lithosphere, western Canadian shield

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Understanding the processes responsible for the preservation or destruction of continents is a first-order problem. The increasing consensus that Earth's surviving continents are remnants of much larger volumes of past crust raises important questions regarding the mechanisms that disrupt and recycle continental lithosphere, and the lithospheric characteristics conducive to its long-term survival. Despite unusually thick lithospheric mantle roots that help protect cratons from later tectonism and deeper mantle convection, many of these regions were repeatedly reactivated from severe to mild degrees by younger events. Extensive exposures of HP granulites in the East Lake Athabasca region of the western Canadian shield record a severe tectonic event inferred to have de-stabilized cratonic lithosphere. U-Pb zircon geochronology on mafic granulites, combined with metamorphic constraints, document two HP-HT metamorphic episodes separated by 650 m.y. U-Pb (titan,ap,rt), $^{40}Ar/^{39}Ar$ (hbl,msc,bt) and (U-Th)/He (zrc) thermochronology constrain the subsequent 200 m.y. multistage exhumation and juxtaposition history of disparate lower crustal domains in the region. Together these data are interpreted to indicate 1) lithospheric stabilization at 2.55 Ga, 2) a subsequent interval of lithospheric stability, 3) disruption of the Archean craton at 1.9 Ga during asthenospheric upwelling, 4) multistage exhumation, and 5) reattainment of a stable lithospheric configuration by ca. 1.7 Ga.

Apatite (U-Th)/He thermochronometry provides a tool with which to constrain more subtle perturbations to "stable" cratons. Exploiting the recent recognition of radiation damage control on apatite (U-Th)/He dates can be used to gain additional insights into cratonic thermal histories and decipher lower amplitude burial and unroofing events that reflect vertical epeirogenic motions and eustatic sea level change. Although the East Lake Athabasca region is currently devoid of Phanerozoic strata, apatite (U-Th)/He data appear to require burial of the basement by >1 km of Phanerozoic units that were later eroded. These data point toward significant Phanerozoic deposition hundreds of kilometers east of where previously documented in this cratonic interior.

Thermal histories in sedimentary basins from integrated low-temperature thermochronometry: An example from the High Plains of New Mexico and western Texas

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The thermal histories of sedimentary basins hold important information regarding the evolution of orogenic systems. Low-temperature thermochronometry studies not only can constrain provenance, deposition and burial histories, but also geotherm evolution and later basinal unroofing. The Great Plains of the U.S. cratonic interior contains thick sedimentary sequences that represent ca. 500 m.y. of discontinuous Phanerozoic deposition. The western portion of this region, the High Plains just east of the Rocky Mountains and Rio Grande Rift, remains structurally intact, but underwent uplift and unroofing after Cretaceous time. Although elevation gain is surely related to the tectonism that generated the rugged topography of the western U.S., the timing and causes of uplift and unroofing are controversial. Integrated apatite fission-track (AFT) and (U-Th)/He thermochronometry across the High Plains of New Mexico and the Texas panhandle constrain the relative roles of geotherm evolution and unroofing in this region. A comprehensive AFT dataset for drillholes and surface samples define the base of an eastward tilted middle Cenozoic partial annealing zone (110°C isotherm) on the High Plains. AFT dates for Triassic surface samples range from late Oligocene (ca. 28 Ma) near Santa Fe, to Triassic (>200 Ma) in the Texas panhandle. Complementary apatite (U-Th)/He data for the Triassic sandstones yield Miocene (12 to 21 Ma) dates across eastern New Mexico, and indicate partial post-depositional resetting of apatites in western Texas. Together these data indicate 1) elevated geotherms (35-45°C/km) on the western High Plains at ca. 30-28 Ma, and 2) 1.5-3 km of unroofing from ca. 15 to 12 Ma prior to unconformable deposition of the Ogallala Formation. The results document a dynamic history of geotherm evolution and unroofing hundreds of kilometers east of the dramatic topographic expression of the Cordilleran front. Our data may reflect the development of the buoyant, low-velocity mantle anomaly beneath the southern Rockies, Rio Grande Rift and western High Plains that may provide partial support for the high elevations of these regions.