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A Transition from Stagnant to Mobile Lid Tectonics Between 4.0 and 2.55 Ga Is Recorded in Continental Crust of the Wyoming Craton, USA

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The Archean Wyoming craton (WC) can be subdivided into three terranes that preserve distinct stages of crust-mantle evolution from ~4.0 to 2.55 Ga: the Montana Metasedimentary Terrane (MMT), Beartooth-Bighorn Magmatic Zone (BBMZ), and Wyoming Greenstone Terrane (WGT). The main stages of crustal evolution are recorded in: 1) 3.5-4.0 Ga detrital zircons from quartzites from across the northern WC record the oldest evidence of sialic continental crust. 2) ~3.5-3.1 Ga tonalite-trondjhemite-granodiorite (TTG) gneisses (e.g., Spanish Peaks, Tobacco Root, Beartooth, and Granite Mountains). These rocks are interpreted as the source for the major peak in detrital zircon age-spectra in Archean quartzites throughout the northern WC. Semi-continuous generation of silicic magmas over this interval of ~400 Ma (3.5-3.1 Ga) primarily reflect melting of a thick, mafic crust, in some cases leaving a garnet-bearing residuum. The arc-signature evident in trace element abundances of mafic and TTG rocks (e.g., elevated LILs, relative depletion of HFSE, and <10x HREE) suggest short episodes of sag- or subduction. Older Sm-Nd model ages for these rocks (to 4.2 Ga) suggest this mafic crust formed several hundred million years prior to the oldest part of the rock record, i.e., comparable to the ages of the oldest detrital zircons. Along with intercalated supracrustal rocks, this crust underwent a cycle of tectonic thickening with peak metamorphic conditions of ~10 Kb and up to 800^oC (Tobacco Root Mtns. and Spanish Peaks). 3) A second, subduction-driven magmatic event produced voluminous calc-alkaline and TTG rocks at ~2.8 Ga in the Beartooth and Bighorn Mountains (BBMZ). These rocks range in composition from diorite to granite, with elemental signatures (e.g., REE, HFSE depletion, etc.) typical of modern continental volcanic arcs; Pb-Pb and Sm-Nd systematics indicate interaction with older crust (ave. εNd (t) of -3). The ~2.8 Ga magmas intruded both the older high-grade gneisses and a thick sequence of anomalously low-grade, gold-bearing, metasedimentary rocks (Jardine metasedimentary sequence) in the Beartooth Mtns. 4) Neoarchean assembly of the northern WC concluded with tectonic juxtaposition (including Alpine-style nappes) in the North Snowy Block of the Beartooth Mountains, intrusion of the post-deformational Pt-Pd-bearing Stillwater mafic complex (2.7 Ga), and emplacement of 2.55 Ga leucogranites along ductile shear zones. This unique record of crustal evolution likely began over a zone of mantle upwelling and included one or more episodes of “sagduction” from 3.5-4.0 Ga (i.e. stagnant lid model). The development of a deep (>200 km) keel of sub-continental lithosphere began at this time. The craton-keel system evolved through episodic, largely vertical accretion of sialic magmas from both depleted and enriched sources, lateral accretion through displacement and juxtaposition of discrete tectonic blocks, intracrustal differentiation and recycling from tectonic thickening and deep burial of supracrustal rocks, and subduction (i.e., mobile lid model). Stabilization of the craton occurred at ~2.8 Ga, immediately after the cessation of subduction. This crust-keel system was strong enough to prohibit penetration of the craton during numerous collisional events that produced the bounding Paleoproterozoic mobile belts (Cheyenne Belt, Great Falls Tectonic Zone, Trans-Hudson Orogen, Farmington Zone). At present, the craton-keel system may be under duress as a consequence of disruption by thick-skinned Mesozoic Laramide faulting and penetration by fluids derived from dehydration of the subducting Farallon plate.