Constraining the Birth of Plate Tectonics

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Plate tectonics, involving a globally linked system of lateral motion of rigid surface plates, is a characteristic feature of our planet, but estimates of how long it has been the modus operandi of lithospheric formation and interaction range from the Hadean to the Neoproterozoic. We review sedimentary, igneous and metamorphic proxies along with paleomagnetic data to infer both the development of rigid lithospheric plates and their independent relative motion, and conclude that significant changes in Earth behaviour occurred in the mid- to late Archean, between 3.2 Ga to 2.5 Ga. These data include: sedimentary rock associations inferred to have accumulated in passive continental margin settings, marking the onset of sea-floor spreading; the oldest foreland basin deposits associated with lithospheric convergence; a change from thin new continental crust of mafic composition to thicker crust of intermediate composition, along with increased crustal reworking and the emplacement of potassic and peraluminous granites indicating stabilization of the lithosphere; replacement of dome and keel structures in granite-greenstone terranes, which relate to vertical tectonics, by linear thrust imbricated belts; the commencement of a temporally paired system of intermediate and high dT/dP gradients with the former interpreted to represent subduction to collisional settings and the latter representing possible hinterland back-arc settings or ocean plateau environments. Paleomagnetic data from the Kaapvaal and Pilbara cratons for the interval 2780-2710 Ma and from the Superior, Kaapvaal and Kola-Karelia cratons for 2700-2440 Ma suggest significant relative movements. We consider these changes in the behaviour and character of the lithosphere to be consistent with a gestational transition from stagnant lid tectonics, arguably with localized subduction, to the birth of sustained plate tectonics.