On the emergence of plate tectonics

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Plate tectonics (PT) likely operated similar to the present-day back through the Phanerozoic. However, whether Earth had PT back through the Precambrian or, if not, when and how a globally-linked network of narrow plate boundaries emerged are matters of debate. The widespread appearance of low T/P metamorphism in the Neoproterozoic reflects the modern style of cold collision and deep continental subduction, but whether rare occurrences of low T/P metamorphism in the Paleoproterozoic reflect localized regions of cold collision or a global signature requires additional data. Low T/P metamorphism is unknown from the Archean geological record, suggesting that cold collision and deep continental subduction were absent. Earth's mantle was warmer in the Precambrian compared to the Phanerozoic, although by how much is unclear. A hotter mantle could have precluded stable subduction and sporadic evidence of intermittent subduction is insufficient to identify PT. Thus, Earth could have required an alternative mode of heat loss before PT. The widespread appearance of two thermobaric types of metamorphism (intermediate and high T/P) at the beginning of the Neoarchean likely records the dual thermal regimes that are the hallmark of subduction and collision at convergent plate margins. Prior to this, the Archean lithosphere likely comprised a more-or-less continous 'squishy' lid, and any subduction was probably intermittent. This lithosphere would have been strongly affected by plumes, which potentially could have triggered subduction in which retreating slabs surrounded expanding cells of plate-like behavior. Influx of asthenosphere beneath the 'plates' could have generated plateau-like crust, partial melting of which would have generated TTGs, forming protocontinents. Collision between cells and protocontinents due to retreat of the slabs could have amalgamated the protocontinents to form the first continents. Stabilization of subduction and the emergence of PT were likely linked to the rise of these continents above sea level, increased erosion, accumulation of sediments at the continental edges, and GPE-driven spreading of continental over oceanic crust, depressing it into eclogite facies. This process could have initiated and then stabilized subduction due to the ongoing availability of lubricating sediments, ultimately enabling the emergence of a globally-linked network of plate boundaries during a Neoarchean transition to PT.