Sagduction and the onset of plate tectonics

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The origin of granitic magma is a key element in the debate about the onset of plate tectonics. Granitoids with petrology and geochemistry essentially the same as modern granitoids are known in sequences as old as 4 Ga, and granitoids are the main component of continental crust from this age to the present. In today's geodynamic regime, granitic magma is produced in large volumes only in subduction settings, and if it is assumed that plate tectonics started only towards the end of the Archean, an alternative mechanism must be invoked for the formation of felsic magmas that built the archean continental crust.

One commonly cited mechanism is "sagduction", the process whereby the lower part of a thick basaltic pile (ocean crust or an oceanic plateau) converts to dense eclogite, founders and then partially melts to produce granitic magma. Here we use a numerical thermo-mechanical model to investigate this process assuming a realistic configuration of thick mafic crust. Such crust is differentiated with upper layers composed of evolved basalt and lowermost layers composed of olivine cumulates. Hydrated rock is confined to the uppermost portion of the crust and the lower portions are dry. Our modeling shows that such a configuration is stable and that lower layers do not founder. If an unstable layer is imposed at the the base of the oceanic plateau, downwellings may entrain upper portions of the crust. However, felsic magma is produced only minor amounts. Abundant hydrated basalt at the top of the pile will not be dragged down to depths where melting is possible. In addition, melting under these conditions cannot produce the "subduction signature" – negative Nb-Ta anomalies and positive Pb anomalies - that characterizes all rocks of the continental crust, both modern and Paleoarchean.

In the absence of an alternative credible mechanism for producing large volumes of granitoid magma, we conclude that subduction, and therefore plate tectonics, started in the Paleoarchean.