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How and when did the continental crust form?

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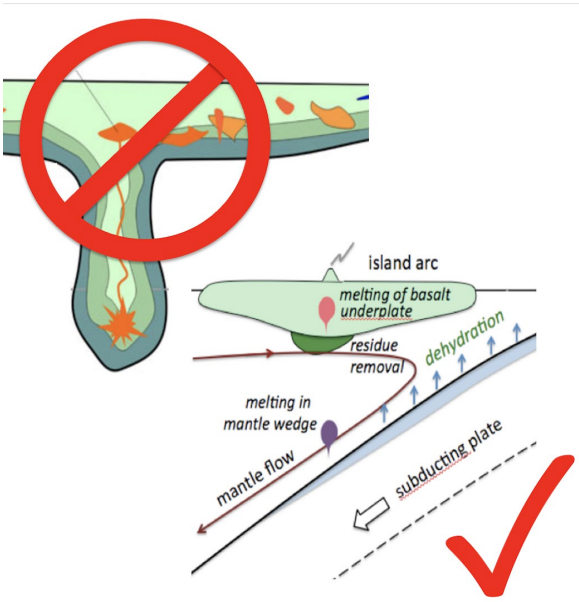

When plate tectonics started on Earth is a subject of animated debate. Many authors argue for an onset in the early Archean or even the Hadean. Others advocate a later onset, around 3 Ga or later.

A key element in the debate is the process that generated the felsic rocks of the continental crust. One school argues that through most of geological time, these rocks formed at convergent margins like modern granitoids. The other school promotes the idea that from the Hadean to at least 2.5-3.0 Ga, the continental crust was generated within an immobile or sporadically mobile lid. In one version of this model, the lower part of thick mafic crust partially melts to produce felsic magma. In another, a process called sagduction operates: the lower part of a thick pile of mafic rocks converts to eclogite, sinks into the mantle, and partially melts to form the felsic magmas that build the continental crust.

I argue that the latter processes are implausible. The lower part of thick oceanic crust consists of mafic-ultramafic cumulates, not basalt, and these rocks are dry. Missing is the fertile basaltic material and water which are needed for melting, or which can convert to eclogite to drive sagduction. Hydrated volcanics are not deeply buried and any water released during dehydration migrates upwards into cooler rocks. Within-crust melting cannot produce the characteristic trace-element signature of granitoids.

All the changes that are said to signal a change in geodynamic regime around 3 Ga are better explained as the nexus of several ongoing processes: progressive growth of felsic crust, which provided material for reworking into later granitoids; a gradual drop in sea-level, which allowed erosion and generation of detrital sediments; a persistent decline of temperatures in mantle and crust, which changed the style of intracrustal deformation.

The subduction needed to generate continental crust probably started at the end of the Hadean. This subduction was sporadic and shallow, but it transported basalt and water to the depths needed to generate felsic magma. Early subduction does not imply an early onset of global plate tectonics, which happened sometime later.