Slow start of plate tectonics despite a hot early Earth

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Writing in *PNAS*, scientists from Cologne university present important new constraints showing that plate tectonics started relatively slow, although the early Earth's interior was much hotter than today.

In an international collaboration, earth scientists at the University of Cologne discovered that during Earth's early history mantle convection, i.e. the internal mixing of our planet, was surprisingly slow and spatially restricted. This finding is unexpected because our planet was much hotter during the first hundreds of million years after its formation. Therefore, it has been assumed that mantle convection on Earth was much faster in its infancy. According to their study "Convective isolation of Hadean mantle reservoirs through Archean time," however, the Earth did not experience full speed mantle convection until 3 billion years ago, when modern plate tectonics is believed to have fully operated.

For their study, the geologists investigated up to 3.5 billion years old igneous rocks from NW Australia that cover 800 million years of Earth's early history. The analysis of these rock successions revealed that the oldest samples exhibit small anomalies in the isotope abundances of the element tungsten (W) that progressively diminish with time. The origin of these anomalies, namely the relative abundance of ^{182}W, relates to ancient heterogeneities in the terrestrial mantle that must have formed immediately after formation of the Earth more than 4.5 billion years ago. The preservation of these ^{182}W anomalies in the igneous rocks from NW Australia demonstrate that pristine mantle reservoirs from the beginning of our planet were conserved over timescales exceeding more than one billion years.

This finding is very surprising, because higher mantle temperatures in the early Earth suggest that mantle convection was more extensive and much faster than today. Interestingly, the observed ^{182}W anomalies start to diminish at around 3 billion years ago, within a geological era that is assumed to mark the beginning of modern plate tectonics. The onset of modern plate tectonics, involving subduction processes and mountain uplift, has been shown to be a key event triggering the emergence of large continental masses and an oxygen-rich atmosphere, all of which set the stage for the origin of more complex life.

More information: Jonas Tusch et al. Convective isolation of Hadean mantle reservoirs through Archean time. *PNAS* January 12, 2021 118 (2) e2012626118; doi.org/10.1073/pnas.2012626118

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