Delamination assisted plate convergence explains secular changes in Archean rock record

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The Earth witnessed major, irreversible changes in its continental rock record during ~3.2-2.5 Ga that include: evidence for lateral movement of crustal blocks, the appearance of paired metamorphic belts, compositional changes in the igneous rocks, and the first eclogitic inclusions in diamonds [cf.1]. These changes have been associated with the transition from an early stagnant-lid regime to a more mobile, plate tectonics type regime by ~3.2-3 Ga [cf.1]. However, the metamorphic, magmatic and deformation record argue for the involvement of weaker lithospheric blocks during late Archean, suggesting the prevalent plate interactions to be different than today [2-4]. Thus, the geodynamic style that can reconcile the late Archean secular geologic changes, remains elusive.

Using numerical modelling, here we show that delamination (not dripping) driven convergence of proto-continental plates – peeling-off tectonics [5] – can explain the enigmatic geologic transitions of the late Archean. Our models predict a distinct dichotomy in the peak metamorphic P-T conditions that match the signature of late Archean paired metamorphism [2]. Models also show partial melting of metabasic rocks at variable depths, thus corroborating the late Archean record of TTGs which shows their coeval formation at three different pressure domains [3]. Thus, peeling-off tectonics can cause spatially juxtaposed contrasting thermal regimes of metamorphism and magmatism, reflecting the presence of asymmetric thermal regimes observed at modern convergent boundaries. Our study suggests that the early phases of plate convergence were dominated by delamination, unlike the modern subduction-collision system.

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