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Destabilization of long-lived Hadean protocrust and onset of pervasive hydrous melting at 3.8 Ga recorded in detrital zircons of the Green Sandstone Bed, South Africa

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The timing of the onset of plate tectonics remains one of the fundamental questions in Precambrian geology. While some hypotheses suggest that plate tectonics was already active in the Hadean, others propose that the Hadean was characterized by long-lived protocrust. This ambiguity is in large part due to the scarcity of Archean rocks and the total absence of known Hadean rocks. We conducted εHf, $\delta^{18}O$ and trace element geochemical analyses on 4.2 to 3.3 Ga detrital zircons from the newly-discovered Green Sandstone Bed (GSB) in the Barberton Greenstone Belt, South Africa. The GSB experienced early silicification and only lower greenschist-grade metamorphism, resulting in the excellent preservation of primary mineral grains. GSB zircons record a transition in the nature of the crust and crustal processes in the Eoarchean. Prior to 3.8 Ga, these zircons show subchondritic εHf values with decreasing εHf through time while their TE signatures indicate an affinity to the undepleted mantle. After 3.8 Ga, εHf values are predominantly chondritic to slightly subchondritic and an increase in the U/Nb values of the zircons indicates the onset of pervasive hydrous melting as seen in modern continental arcs. Throughout this time, zircon $\delta^{18}O$ values are variable, indicating derivation from mantle melts or from melts that involved high- and low-temperature altered crust. In general, $\delta^{18}O$ values are below 7‰. These results are consistent with a transition at 3.8 Ga from the dominance of isolated, long-lived protocrust to the onset of crustal reworking and juvenile crustal genesis. This shift coincides with a shift in εHf that has been recognized in other Archean terranes in the ~3.8 to 3.6 Ga time period[1]. The concomitant shift to juvenile additions and wet melting supports the notion that the onset of pervasive crustal instability and recycling – possibly a sign of early plate tectonics – occurred between ~3.8 and 3.6 Ga.

[1]Bauer et al (2020) GPL. 14, 1-6.