The stabilization of continental crust to form cratons plays a fundamental role in the evolution of our planet. These coherent domains of crust are the end product of intense magmatic, tectonic, and metamorphic episodes that progressively organize the crust and underlying lithosphere into a stable compositional and thermal profile. However, few terranes preserve a detailed record of the processes leading to cratonization. In this contribution we synthesize the results of detailed studies in the Capricorn Orogen, Western Australia, to document the cumulative events that lead to stabilization of the crust. Our understanding of these events provides new insights into the processes related to protracted cratonization.

The Proterozoic Capricorn Orogen is a complex region that records the punctuated assembly of the Archean Pilbara and Yilgarn Cratons with the Glenburgh Terrane to form the West Australian Craton (Cawood and Tyler, 2004). Following the final assembly of the West Australian Craton, the orogen was structurally and thermally reworked during at least five intraplate orogenic events (Fig. 1), with metamorphism and deformation partitioned into discrete tectonic corridors (Sheppard et al., 2010) that progressively narrow with time. Many of the events, particularly the older ones, were accompanied by the intrusion of voluminous felsic magmatic rocks. The overall crustal evolution has been well characterized using Sm–Nd whole rock data, and Lu–Hf and δ^{18}O isotopic data from magmatic and inherited zircon from the four main magmatic suites (Johnson et al., 2017). These data reveal a near-complete record of crustal differentiation, with a significant period of crustal growth along a subduction margin just prior to continental collision (Cycle 2; Fig. 1). Subsequent magmatic cycles become increasingly dominated by reworking of older crustal sources, with the final magmatic cycle (Cycle 4) formed exclusively by crustal reworking.
Fig. 1. Time–space event summary of the Capricorn Orogen (after Korhonen and Johnson, 2015).

Magmatic cycles shown in red; * denotes minor, localized intrusions. Abbreviations: CHM, Camel Hills Metamorphics; GCCS, Gifford Creek Carbonatite Suite; KD, Kulkatharra Dolerite; LSM, Leake Spring Metamorphics; MD, Muggamurra Dolerite; MM, Moogie Metamorphics; ND, Narimbunna Dolerite; PM, Pooranoo Metamorphics; WD, Waldburg Dolerite.
Following Cycle 4 magmatism, the orogenic crust displays a broad secular change to more rigid behavior (Fig. 1), allowing the emplacement of abundant mafic dykes and sills into the shallow crust and the formation of thick intracontinental sedimentary basins. However, the granitic rocks generated during the reworking events show an increasing enrichment in heat-producing elements (HPEs; Korhonen and Johnson, 2015), demonstrating that differentiation of the orogenic crust culminated in an enriched, radiogenic upper crust. The present-day heat production values exceed values for typical granitic rocks and those for the bounding Pilbara and Yilgarn Cratons. A radiogenic mid- to upper crust will elevate the thermal gradient, potentially making the crust more susceptible to deformation and reworking (McLaren et al., 2005), despite the overall refractory nature of the crustal profile. Following Cycle 4 magmatism and the deposition of up to 10 km of siliciclastic sedimentary rocks into the Edmund Basin (Cutten et al., 2016), those areas dominated by a highly radiogenic batholith emplaced during Cycle 4 were reworked during the Mesoproterozoic Mutherbukin Tectonic Event (Fig. 1). Numerical models show that slight thickening of this HPE-rich crust during transpressional deformation formed a thermal lid, which elevated the regional thermal gradient and sustained metamorphism over prolonged timescales (>110 Ma; Korhonen and Johnson, 2015; Korhonen et al., 2017). The timing of this event was coincident with numerous mid-Mesoproterozoic events around the West Australian Craton, suggesting that thick cratonic roots may play a significant role in propagating stresses generated at distant plate boundaries.

In contrast to the reworking events that are partitioned into progressively narrower corridors, orogen-scale reactivation of faults and shear zones occurred immediately after the final reworking event (Fig. 1; Piechocka et al., submitted). Field observations are consistent with lateral extrusion of the crust during N–S compression between the bounding Pilbara and Yilgarn Cratons. The reactivation of these structures at this time is interpreted as the transition from reworking to cratonized behavior (Piechocka et al., submitted; Holdsworth et al., 2001).
References


Piechocka, AM, Sheppard, S, Johnson, SP, Rasmussen, B and Jourdan, F submitted, Death of an orogen, birth of a craton: Geology.