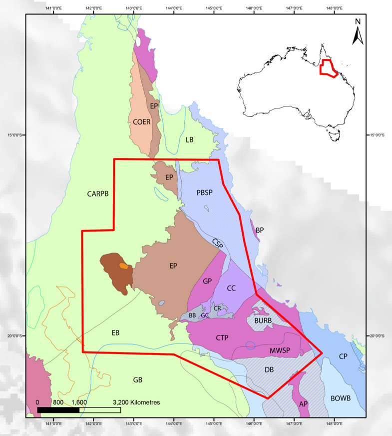
Palaeozoic ribbons and rollback in north Queensland



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Introduction

Palaeozoic continental growth and accretionary tectonism along the eastern margin of Gondwana is characterised by the inversion of back-arc basins and accretion of the magmatic arc terranes and micro-continental ribbons. In north Queensland the Gondwana margin is characterised by an extensive NNW-SSE trending belt of Ordovician calc-alkaline complexes that rest unconformably on Neoproterozoic to Cambrian aged basement (Fig 1).

Palaeozoic evolution - ribbon tectonics

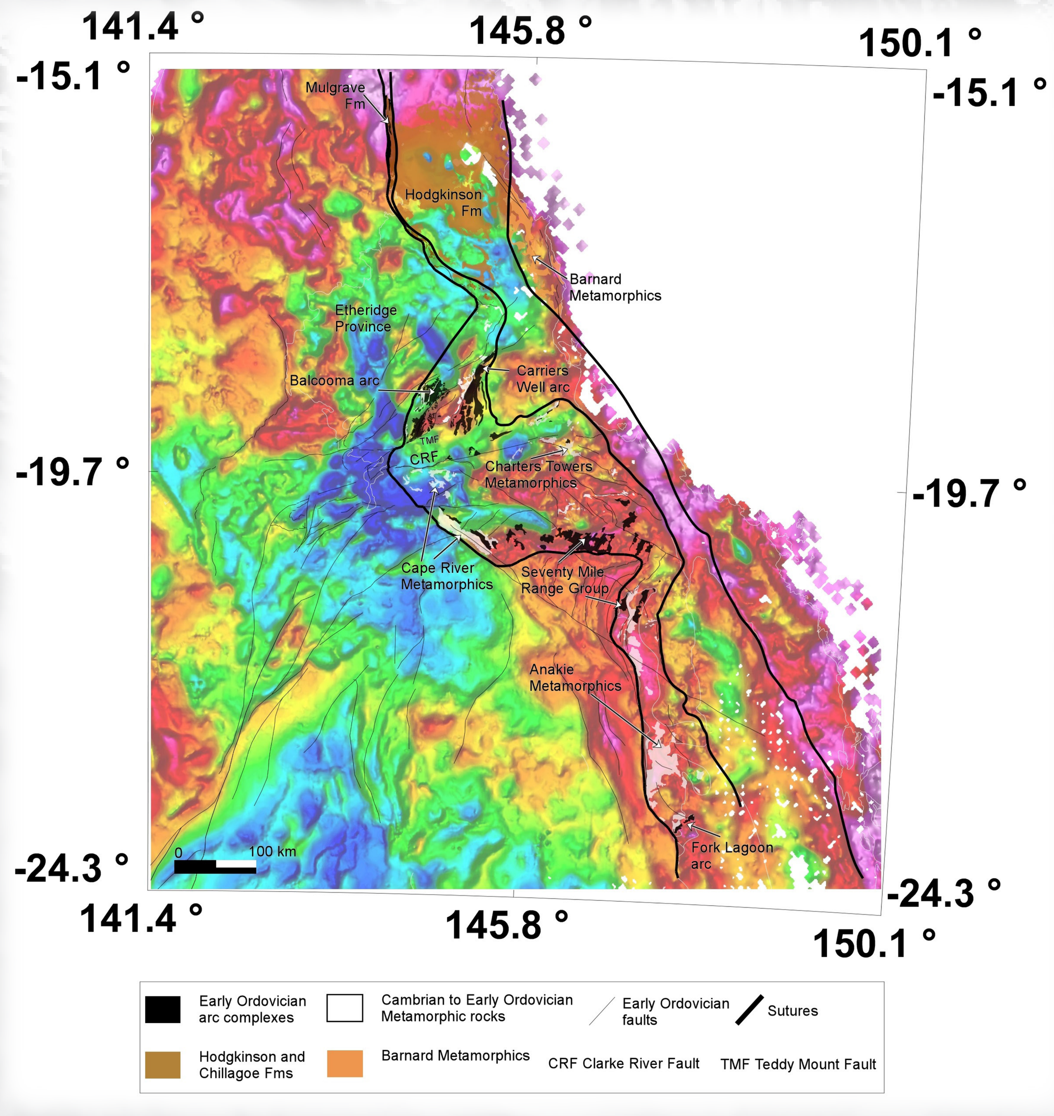
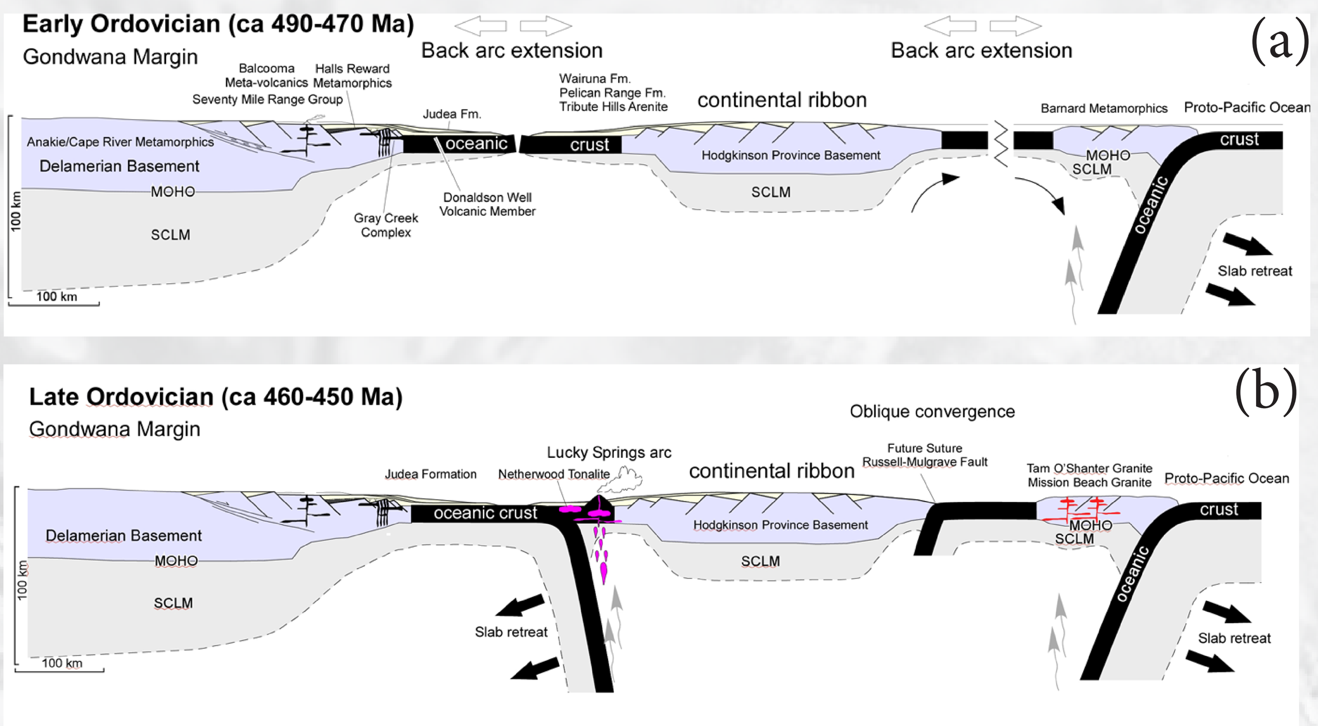


Figure 1: Extensive Ordovician arc complexes and Cambrian basement rocks that chararcterise the early Palaeozoic Gondwana margin in north Queensland.

In north Queensland we consider the extensive Ordovician arc complexes collectively as the Lucky Springs arc. This arc system developed at ca. 455 Ma above a retreating east-dipping subduction zone along the western edge of a continental ribbon (basement to Hodgkinson Province) which consumed the oceanic back-arc region separating the eastern margin of Gondwana from the Hodgkinson Province (Figs. 2 & 3). The east dipping polarity of the arc system is supported by east dipping crustal scale reflectors in deep crustal seismic profiles (Korsch et al. 2012).



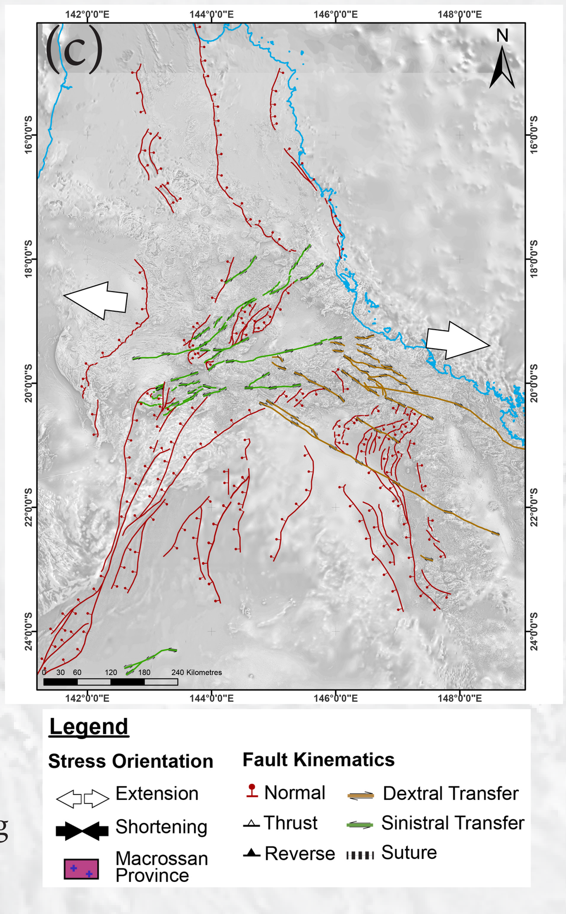


Figure 2: Ordovician tectonic evolution of the north Queensland. (a) Early Ordovician extension leading to several continental ribbons rifting from the Gondwana margin; (b) Late Ordovician development of the Lucky Springs arc above a retreating east dipping subduction zone; (c) Interpreted faults active during Early Ordovician east directed extension.

The remnants of the Lucky Springs arc and associated back-arc region are preserved as the Everetts Creek Volcanics and Carriers Well Formation in the Broken River Province (Figs. 1 & 2). We discrimiate these rocks on the basis of their trace element geochemistry as calc-alkaline with oceanic island arc affinities (low Th and Nb to Yb ratios) which suggests these rocks did not undergo deep crustal reworking expected in continental arcs such as the andean margin but instead are more similar to true oceanic arc systems e.g. Izu-Bonin-Mariana arc (Fig. 4a). We also use smoothness and shape analysis (O'Neill 2016) of the REE patterns for the Lucky Springs arc (Fig. 4b) to demonstrate that the parental magmas likely evolved at shallow crustal levels above the garnet stability field, but are influenced by a degree of crustal reworking which we intepret as interaction between an oceanic island arc and continental ribbon (basement to the Hodgkinson Province (Figs 2 & 3).

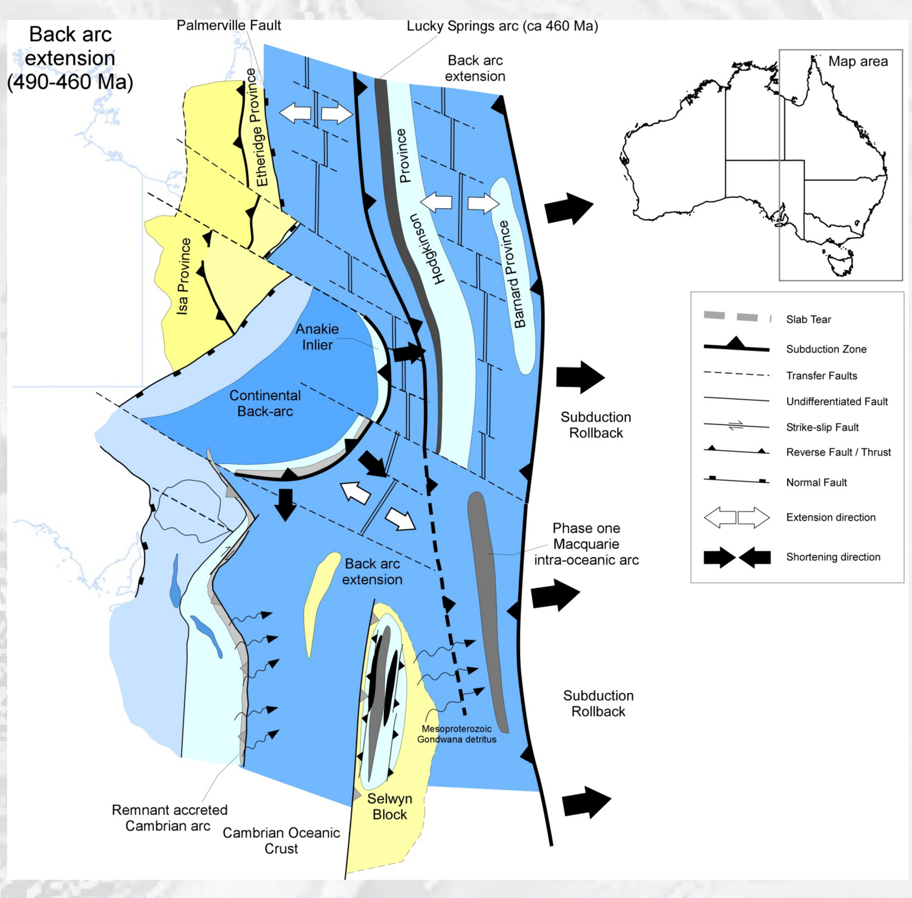


Figure 3: Tectonic evolution map of eastern Australia during the Early Ordovician showing the Lucky Springs arc forming above an east dipping subduction system and the continental ribbons rifted off the margin of Gondwana.

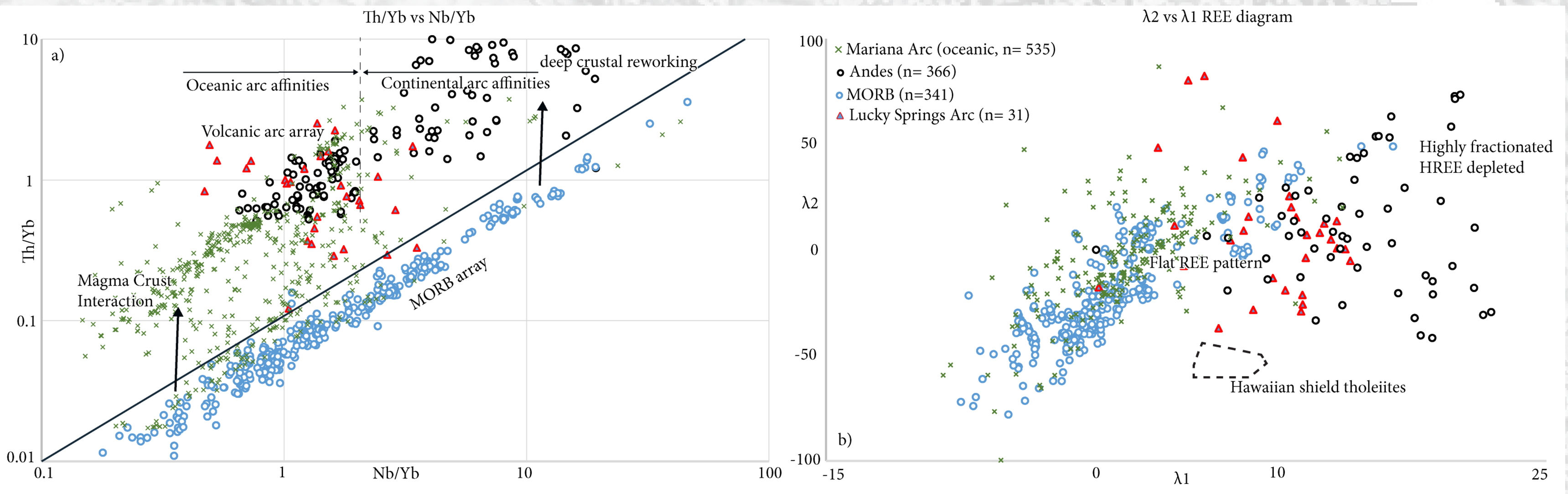


Figure 4: Trace and CI normalised REE element chemistry comparisons between the Lucky Springs arc with the Andean continental margin, Mariana oceanic arc and MORB arrays. (a) Th/Yb versus Nb/Yb diagram after Pearce 2008 highlighting oceanic arc affinities for the Lucky Springs arc; (b) Analysis of REE pattern shapes (λ2 vs λ1 diagram) after O'Neill 2016.

The Lucky Springs arc rocks were entrained between the Gondwana and the re-accretion of the Hodgkinson Province basement ribbon at ca. 450-440 Ma. Tectonic melange, imbricated turbidites (Judea Formation) and oceanic substrate (Donaldsons Well Volcanics), and the Wairuna Formation represent the remnants of a suture zone. Collision between the Barnard Province and the Hodgkinson Province was accommodated along the Russell Mulgrave Fault Zone, which we interpret as a suture zone between these two micro-continental ribbons (Fig. 5). To the south, arc-related rocks of the Fork Lagoon Beds are also likely to record the accretion of an Ordovician arc onto the margin of the Anakie Inlier at ca. 450 Ma. To the north, the suture zone between the Hodgkinson and the Etheridge provinces is preserved in Ordovician Mulgrave Formation which characterised by a series of fault bounded slivers against the Palmerville Fault Zone.

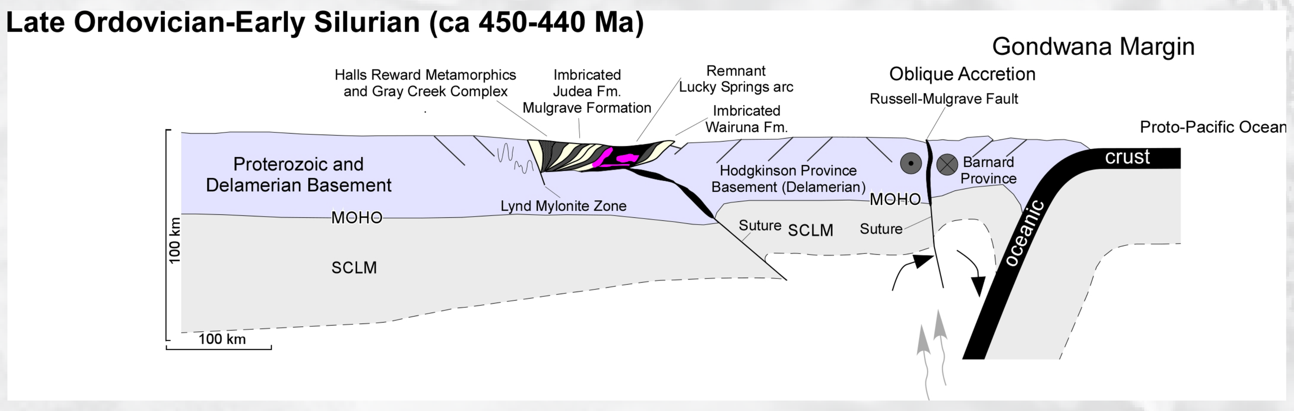


Figure 5: Accrection of the Lucky Springs island arc and collision of the Barnard and Hodgkinson continental ribbons in the Late Ordovician to Early Silurian.

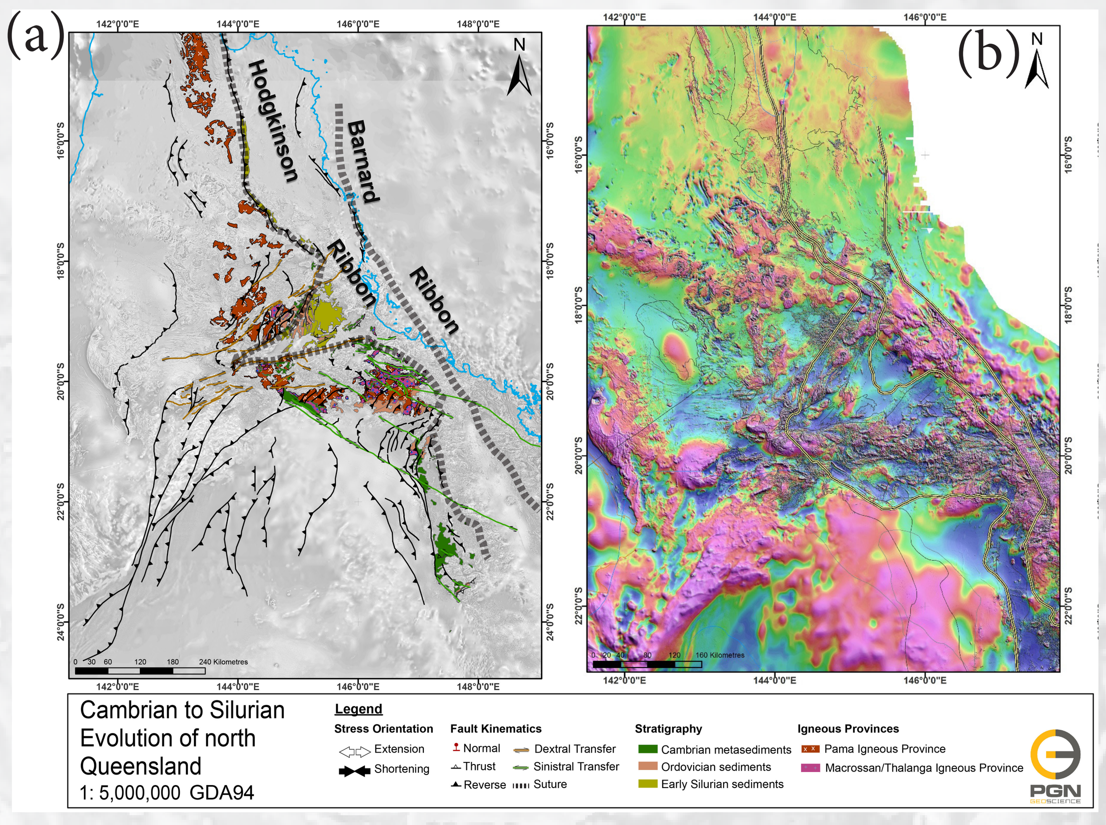


Figure 6: Late Silurian to early Devonian oroclinal structure highlighting the position of sutures between accreted continental ribbons. (a) Litho-structural map of north Queensland in the early Devonian; (b) RTP Aeromagnetic map of north Queensland highlighting the location of sutures and magnetic lineaments.

Curvilinear positive magnetic and gravity anomalies can be interpreted to correspond with these suture zones and suggests that the region forms a Late Silurian to early Devonian oroclinal structure (Fig. 6). This is supported in the geological record where Cambrian and Ordovician sedimentary and volcanic successions within the Charters Towers Province trend E-W, at a high angle to the NNE-SSW trends of correlative successions in the Broken River and Greenvale Provinces to the north, and the Anakie Inlier to the south. Palaeomagnetic constraints from the Charters Towers Province (McElhinny et al., 2003) suggests a polar shift of 120° for the Charters Towers Province with respect to the Gondwana margin at ca. 400 Ma.

Conclusion

We support the interpretation by Musgrave et al. (2015) that this shift is related to the formation of the Late Silurian to early Devonian Charters Towers orocline which we suggest resulted from initiation and subsequent rollback of a west-dipping subduction zone to the east of the accreted Hodgkinson Province in the early Devonian (Fig. 7).

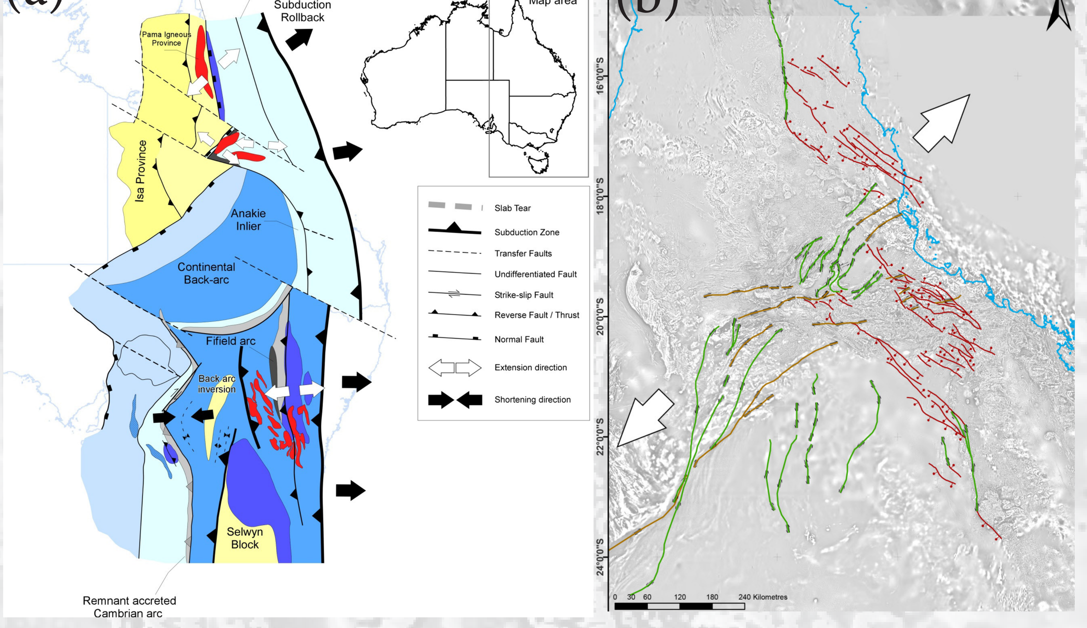


Figure 7: (a) initiation and subsequent rollback of a west-dipping subduction zone to the east of the accreted Hodgkinson Province in the early Devonian; (b) Extensional and strike-slip faults interpreted to be active during the early Devonian in north Queensland producing the Charters Towes orocline.