



## The Lachlan and Buchan orogens

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The southeastern Lachlan Fold Belt (SE LFB) is characterised by a predominantly N-S trending tectonic grain defined by the alignment of adjacent, but parallel granite batholiths, extensional basins and multiple sets of upright folds. Multiple basin fill cycles are separated by upright folding events, as evidenced by the unconformable contact and less complex deformation histories between the progressively younger, overlying units. This evidence suggests that the eastern LFB has undergone multiple extension and compression cycles, i.e. accordion-style orogenesis.

The SE LFB is also characterised by a gentle ( $\sim 10^\circ$ ), albeit segmented, tilt to the north so that upper crustal sections (i.e. basins) are exposed in the north while deeper crustal sections containing granite plutons and HTLP metamorphic complexes are exposed to the south. Basin bounding structures continue south where they also envelope the HTLP metamorphic rocks.

Structural, metamorphic and magmatic analysis of HTLP complexes and surrounding rocks of the LFB have revealed that the HTLP complexes formed at 3-4 kbars at the base of the extensional basins. HTLP metamorphism was concomitant with extension and sedimentation in the upper crust. Furthermore, granite batholiths also formed at the base of these basins and in close association with the HTLP metamorphic complexes.

Multiple cycles of compression and extension are inferred for formation and crustal growth in the eastern LFB. Multiple cycles of HTLP metamorphism occurred during long-lived (~8 Ma) cycles of extension, but these high-temperature events were terminated during short-lived (~2 Ma) periods of compression. HTLP metamorphism is interpreted to have formed in response to the emplacement of magmas as well as conductive heating of the crust during extension.

The 480-400 Ma Caledonides of Scotland have also undergone multiple periods of compression and extension and many features of the HTLP Buchan terrain are comparable to those observed for the SE LFB described above. The 40 x 40 km<sup>2</sup> Buchan terrain is surrounded on three sides (west, south and east) by complexly deformed and metamorphosed, high temperature/moderate pressure rocks of the Barrovian terrain, but the two exhibit contrasting thermal and structural histories. The transition between Buchan and Barrovian is everywhere marked by the presence of large-scale shear zones. Sedimentary facies boundaries parallel these structures and layered mafic magmas intrude them. The HTLP metamorphic isograds are spatially associated with the mafic intrusives but also geometrically aligned with major structures separating the Buchan and underlying Barrovian metamorphics.

Asymmetric extension is proposed as the primary mechanism leading to the positively perturbed geotherm exhibited by the Buchan. Movement and strain partitioning along the Portsoy-Duchray Hill Shear Zone (P-DHL) controlled east-directed continental and lithospheric extension. Incremental emplacement and progressive inflation of the ca. 470 Ma Newer Gabbros at the boundary between the Buchan and underlying Barrovian terrain during this period of extension is envisaged. Emplacement of the gabbros was focused along this major extensional detachment, and its geometry is reflected in their regular outcrop pattern. Their emplacement is interpreted to have resulted in HTLP metamorphism in the Buchan terrain prior to the onset of compressive deformation. Their emplacement is also recorded as a HTLP metamorphic overprint (sillimanite) on the underlying Barrovian rocks. Oblique, compressive deformation following extension, which was again focused along the P-DHL, resulted in asymmetric thrusting of the Buchan over Barrovian metamorphic rocks to the west, terminating the HTLP metamorphism.

Features characteristic of both regions includes: (1) HTLP mineral assemblages dominated by porphyroblast growth between periods of upright folding and fabric development, sometimes coeval with the formation of a sub-horizontal fabric; (2) regions of HTLP metamorphism often enveloped by steeply, inward-dipping margin faults that may also continue northwards where they envelope associated granite plutons. In the LFB, the same faults are also semi-continuous with basin margin faults; (3) mafic, silicic and/or intermediate magmas emplaced during HTLP metamorphism; (4) mafic

magma emplaced early during the HTLP metamorphic history, typically confined to shallow-dipping structures that form along the base of these HTLP complexes; (5) HTLP metamorphism coeval with deposition of basin sediments and (6) the timing of compressive deformation is coincidental with the termination of HTLP metamorphism.