FORTESCUE–HAMERSLEY PROJECT

Igneous geochemistry of the Fortescue and Hamersley Basins

The 2775–2630 Ma volcano-sedimentary Fortescue Group and the conformably overlying 2630–2445 Ma Hamersley Group together with the 2445–2208 Ma Turee Creek Group constitute the Mount Bruce Supergroup, which unconformably overlies the granite–greenstones of the Pilbara Craton in Western Australia. Not only does this supergroup incorporate the world's best preserved sequence of Archean ultramafic to felsic volcanic deposits, arguably the world's most continuous transect across the Archean–Proterozoic boundary, and the Great Oxidation Event, it remains the most economically important stratigraphic unit on the Australian continent.

Fortescue and Hamersley Groups

The stratigraphy of the Fortescue Group has been previously described in detail by GSWA. It has an estimated thickness of 6.5 km. In most areas it is subdivided into seven formations, including several basaltic units with volumes and aerial extents similar to Phanerozoic flood basalt provinces. At the base is the Bellary Formation and Mount Roe Basalt, which consist of subaerial basaltic lavas, subaqueous basaltic (pillow) lavas and water-lain volcaniclastic and siliciclastic rocks. This is overlain by sedimentary, mafic and felsic volcanic rocks of the Hardey Formation, subaerial basaltic flows (Kylena and Maddina Formations), sedimentary and volcaniclastic rocks (Tumbiana Formation) in the north Pilbara, and subaqueous basaltic to komatiitic lavas and volcaniclastic rocks in the south (Boongal, Pyradie, Bunjinah Formations). The uppermost unit (Jeerinah Formation) is mostly argillaceous in the north but contains abundant basaltic lava and volcaniclastic rocks in the south. The formations of the Fortescue Group are grouped into five major tectono-stratigraphic units.

The Hamersley Group is a dominantly low-grade metasedimentary succession that includes chert, BIF, jaspilite, dolomite, mudstone, siltstone, basalt (Fig. 1), felsic volcanic rocks and numerous dolerite sills. It is subdivided (in ascending order) into the Marra Mamba Iron Formation, Wittenoom Formation, Mount Sylvia Formation, Mount McRae Shale, Brockman Iron Formation, Weeli Wolli Formation, Woongarra Rhyolite (Fig. 2) and Boolgeeda Iron Formation.

Project objectives

Using spatially and stratigraphically controlled, detailed, high-precision geochemical, isotopic and geochronological data, obtained from outcrop and diamond drillhole sampling, the main objectives are:

- a detailed, systematic, regional synthesis of the geochemical variation of magmatic units throughout the entire Mount Bruce Supergroup
  - to establish which of the mafic intrusive rocks of the region are related to the Fortescue and Hamersley Groups
  - to investigate the geochemical relationship between felsic igneous rocks of the Fortescue and Hamersley Groups and the associated mafic and ultramafic rocks
- re-evaluate the definition of the Mount Bruce Supergroup and revise where necessary
- characterise associated sedimentary rocks (using lithogeochemistry) and determine the relative contribution of terrigenous vs volcanic sources
- review the stratigraphy and structural evolution for compilation of a regional interpreted bedrock geology map
- understanding the relationships between the volcanic and sedimentary units and integrate this with petrogenetic constraints on magmatism to better constrain the tectonic setting and evolution of the Mount Bruce Supergroup

Stratigraphic revisions

Preliminary fieldwork and compilation of the regional bedrock geological interpretation has identified a number of important observations that will require revisions to the stratigraphy of the Mount Bruce Supergroup and overlying Wyloo Group (Fig. 4). These observations include:

- recognition of a genetic link between the Turee Creek and lower Wyloo Groups has resulted in the renaming of the latter to Shingle Creek Group (Fig. 4)
- the identification of a paraconformity at the base of the Turee Creek Group, which may necessitate a re-evaluation of the status of the Mount Bruce Supergroup
- the presence of a thin glacigenic diamictite horizon at the top of the Boolgeeda Iron Formation (the Cave Hill Member, Fig. 5a, b) that is clearly older than the Meteorite Bore Member (Fig. 4). The Cave Hill Member has been eroded beneath the Turee Creek Group paraconformity in many places and is commonly concealed beneath recent colluvium
- localised basalt flows in the Joffre Member and Weeli Woli Formation (Figure 1), and dolerite sills intruded into the basal Marra Mamba Iron Formation in addition to those in the Joffre Member and Weeli Wolli Formation, attest to widespread igneous activity during deposition of the Hamersley Group
- stratigraphic relationships on June Hill (Fig. 5c) which suggest that part of the Ashburton Formation, as currently mapped, probably belongs to the unconformably overlying Capricorn Group
- significantly wider distribution of the Wooly Dolomite, between the Cheela Springs Basalt and the Mount McGrath Formation, beyond the type area southeast of Mount De Courcy.

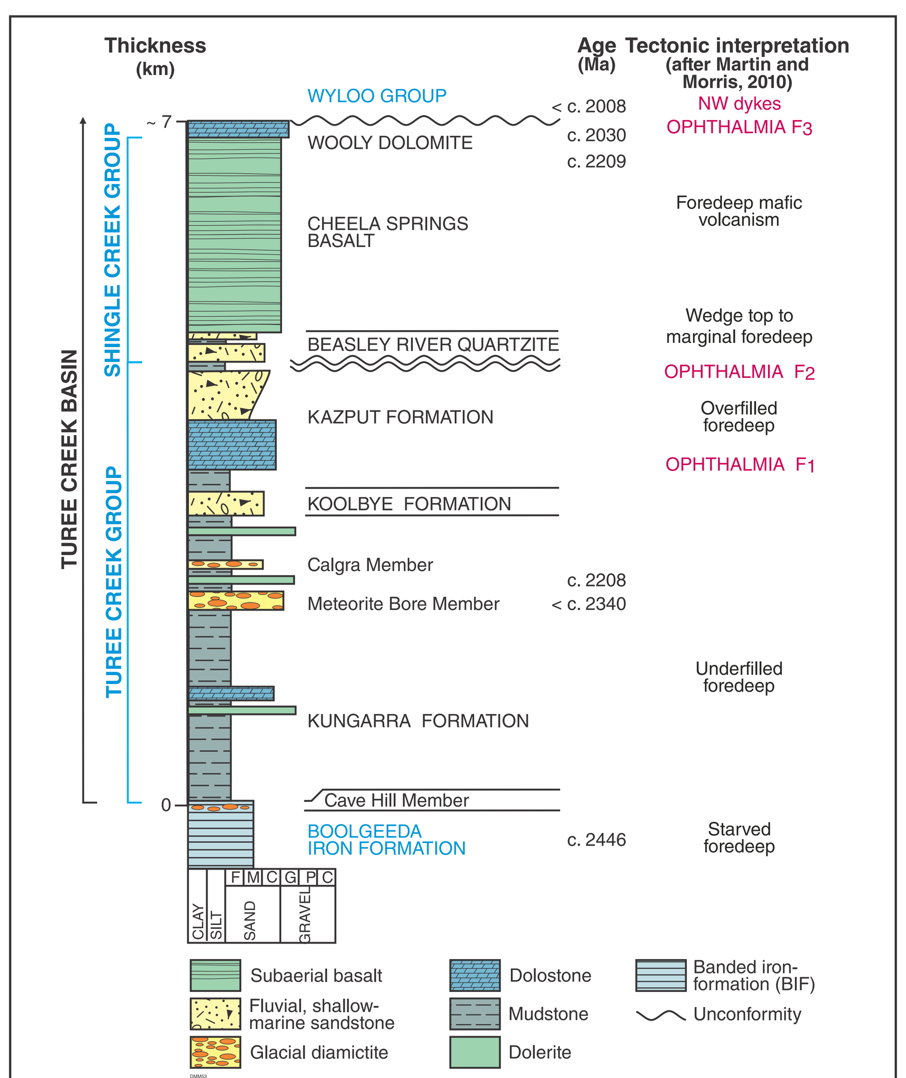


Figure 4: Revised stratigraphic nomenclature of the Turee Creek and Shingle Creek (lower Wyloo) Groups

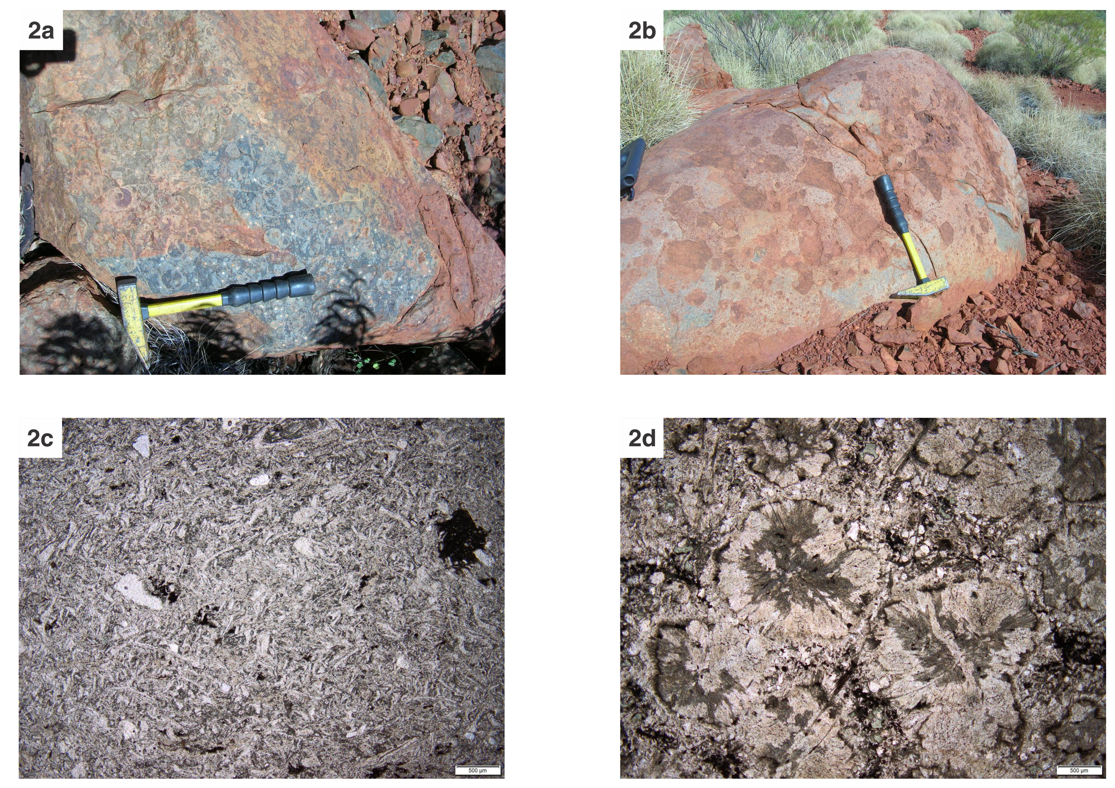


Figure 2 Volcanic textures in the Woongarra Rhyolite (a) Macro-perlite (b) Volcaniclastic breccia (c) vitriclastic tuff with relict shards (plane-polarized light) (d) spherulitic rhyolite (plane polarized light)

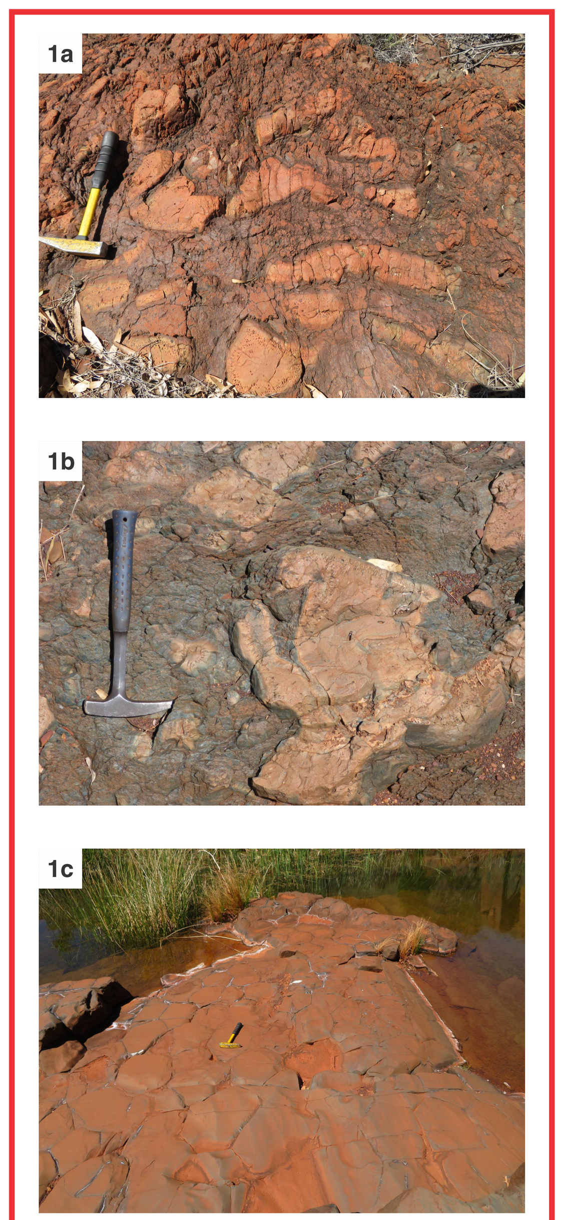
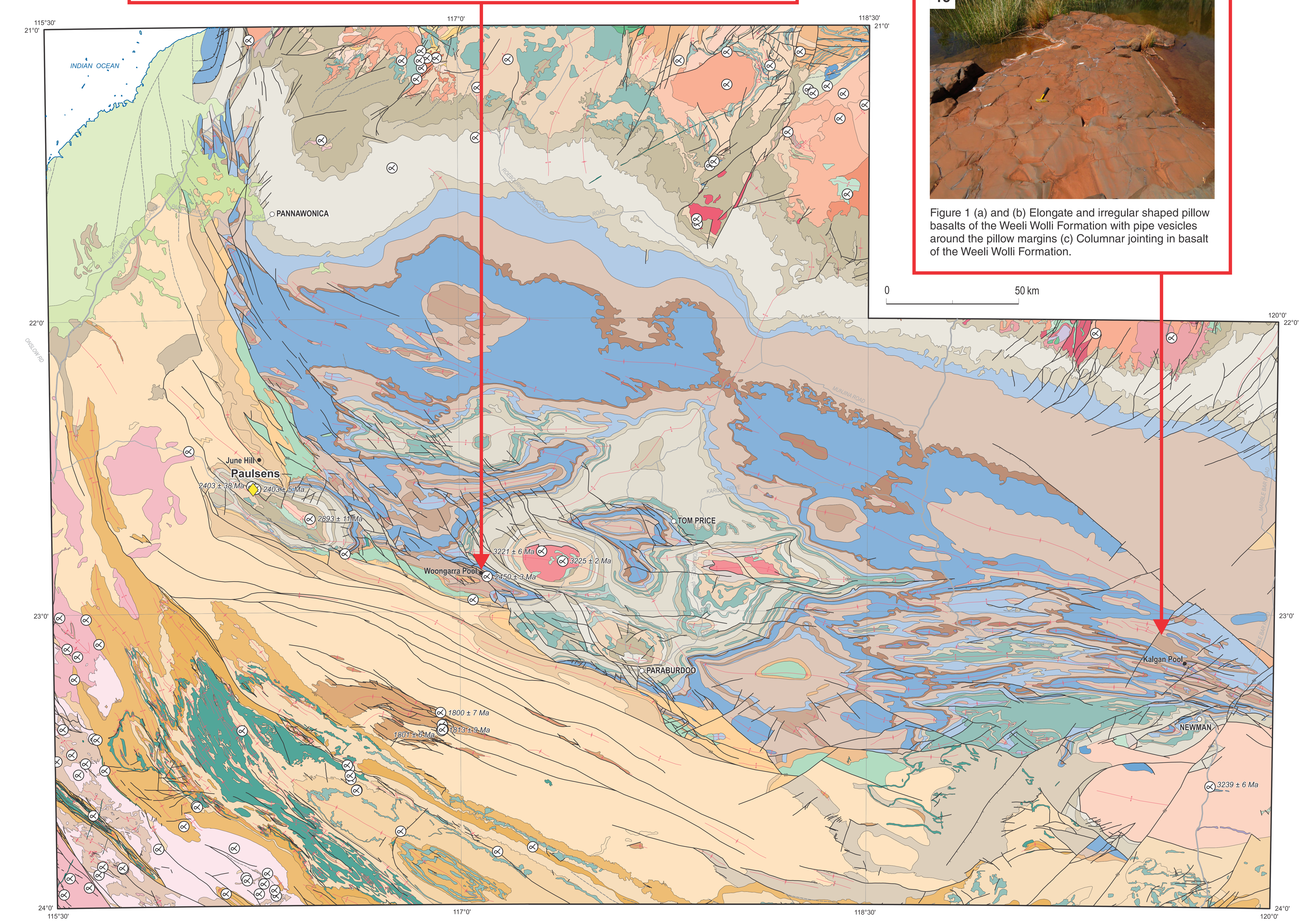


Figure 1 (a) and (b) Elongate and irregular shaped pillow basalts of the Weeli Wolli Formation with pipe vesicles around the pillow margins (c) Columnar jointing in basalt of the Weeli Wolli Formation.



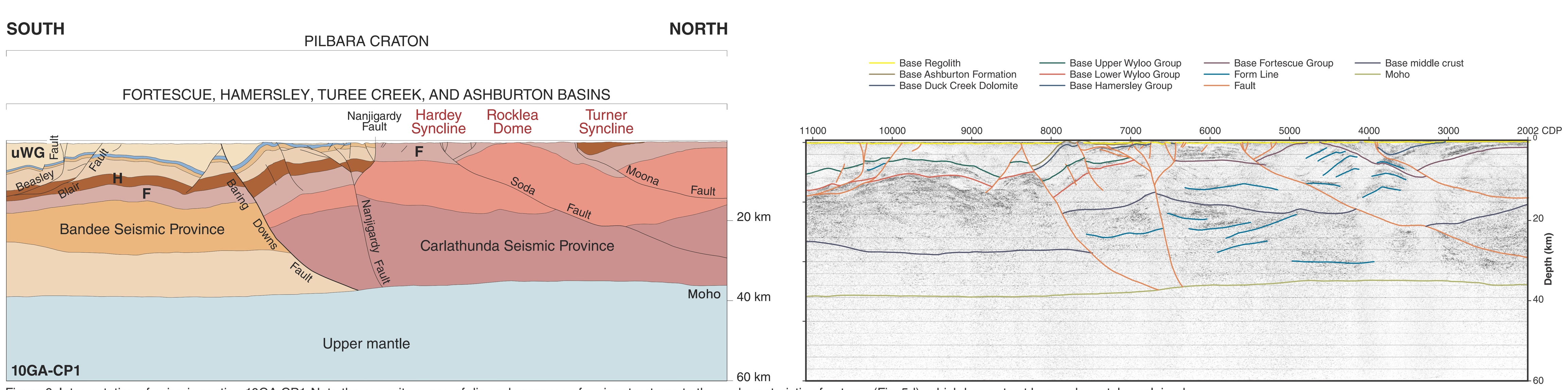


Figure 6: Interpretation of seismic section 10GA-CP1. Note the opposite sense of dip and vergence of major structures to those characteristic of outcrop (Fig. 5d), which has not yet been adequately explained.

Tectonic Evolution of the Mount Bruce Supergroup

Mantle plumes have been proposed to explain the evolution of many Phanerozoic flood basalt provinces in general; however, the three main basaltic units of the Fortescue Group were interrupted by sedimentary deposition (Hardey and Tumbiana Formations) and therefore, a single plume model is inadequate. The lower part of the Fortescue Group has been interpreted in terms of a two-phase continental breakup model, but an alternative explanation argued that discrete periods of lithospheric extension alone, related to continental breakup, could account for this flood basalt volcanism.

GSWA suggested the Fortescue Group is part of a rift sequence where west-northwesterly trending faults controlled the margins of the rift and were buried beneath a breakup unconformity. This was overlain by a passive margin sequence, comprising the uppermost unit of the Fortescue Group and the overlying Hamersley Group. A collisional setting for the BIF and mafic and felsic rocks in the upper part of the Hamersley Group has been proposed. According to this interpretation, the Turee Creek Group was deposited in a foreland basin related to the collision.

Preliminary geochemistry results

Systematic geochemical sampling through part of the Fortescue Group in the Paraburdoo area, reveals some differences in major and trace element concentrations upwards through the volcanic succession. In particular, incompatible trace element ratios such as the La/Nb ratio show a progressive increase within both the Mount Roe Basalt and the Boongal Formation (Fig. 3). The Bunjinah Formation can be subdivided into geochemical groups with low or high La/Nb ratios. The increase in La/Nb ratio within each of these formations is most likely a reflection of a crustal influence in the mafic magma.

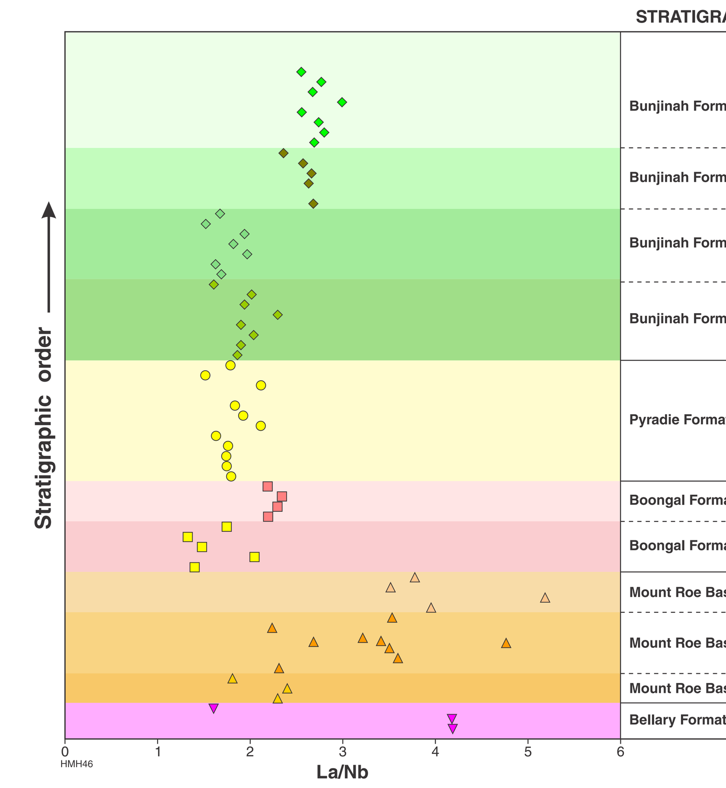


Figure 3 Geochemical plot showing the La/Nb ratio of 67 sampled basalt flows from a traverse that started near the base of the Fortescue Group (Bellary Formation) to the Bunjinah Formation. Each point represents a single basalt flow.

Ophthalmia Orogeny

One of the principal aims of recompiling the interpreted bedrock geology of the Hamersley region, supported by targeted fieldwork, is to gain a better understanding of the geological evolution of the Ophthalmia Orogeny and to resolve controversies regarding its structural history. In particular, there is currently disagreement regarding the chronology of structural events, and how they relate to known orogenic events within the Capricorn Orogen. There are even suggestions of hitherto unrecognised orogenic events. Also, there is a discrepancy between the orientation and vergence of structures as determined from outcrop observation (Fig. 5d) and seismic interpretation (Fig. 6). The mapping component of this project aims to resolve many of these issues, and to gain a better understanding of the geological evolution of the northern margin of the Capricorn Orogen during the Ophthalmia Orogeny and related events.

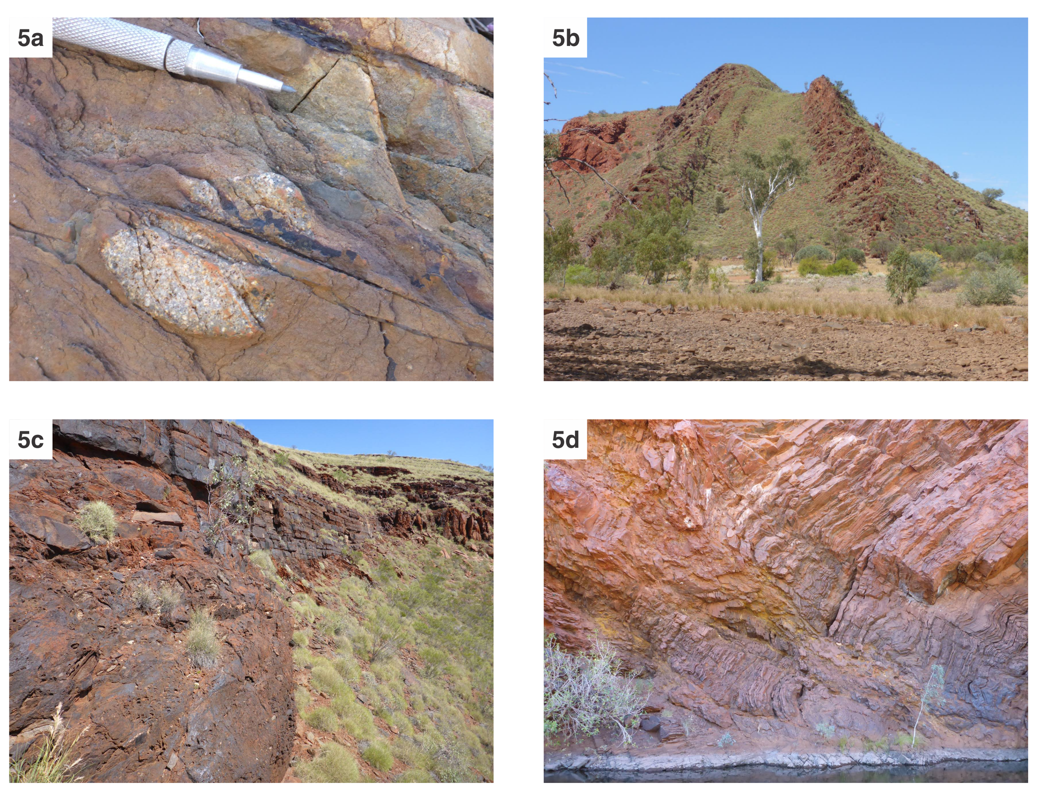
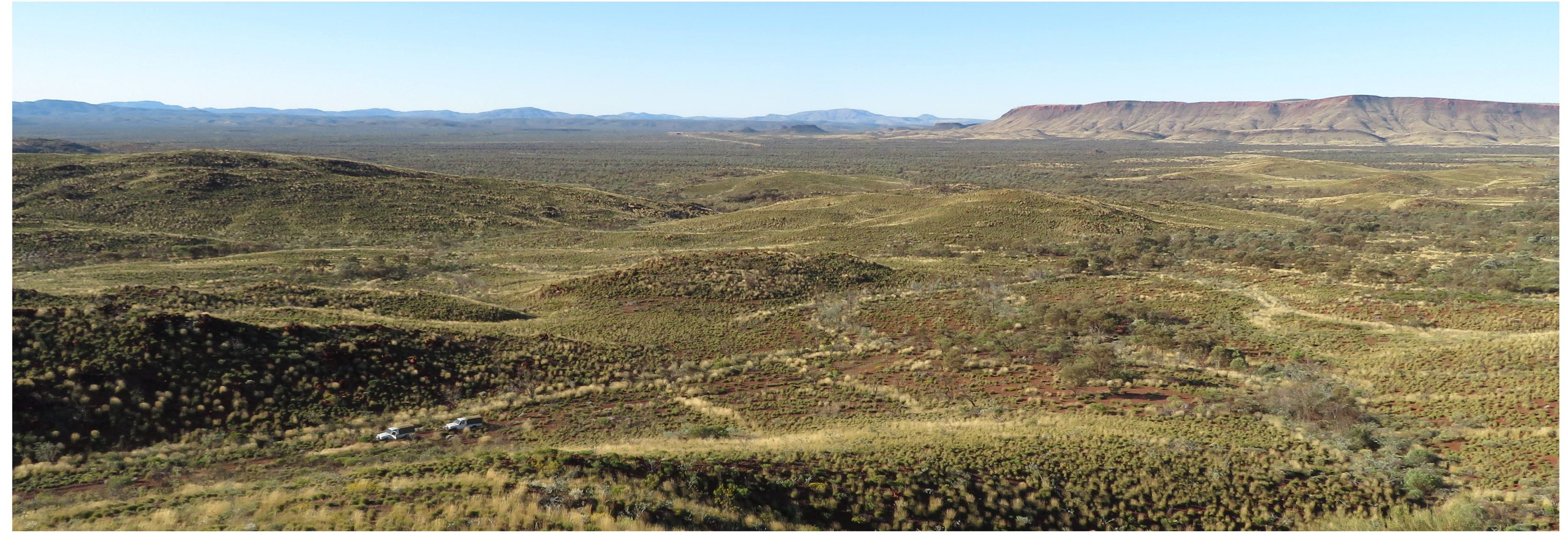


Figure 5a: Glacigenic clast of Woongarra Rhyolite within the Cave Hill Member of the Boolgeeda Iron Formation at Woongarra Pool.

Figure 5b: View east of the Boolgeeda Iron Formation and underlying Woongarra Rhyolite at Woongarra Pool. The Cave Hill Member consists of a recessive unit and thin overlying BIF at the far right of the Boolgeeda outcrop.

Figure 5c: Unconformable contact between interpreted Capricorn Group and underlying June Hill Volcanics of the Wyloo Group at June Hill.

Figure 5d: South-dipping thrust fault and associated north-verging anticline within Joffre Member of the Brockman Iron Formation at Kalgan Pool. This deformation style is typical of the Ophthalmia Orogeny throughout the Hamersley province (c.f. Fig. 6).



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