RECORD 2022/4

FORTESCUE–HAMERSLEY, 2022
EXTENDED ABSTRACTS

Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

Geological Survey of Western Australia

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Cover image: Journey to the centre of the Kimberley (© 2010 PL Schubert)

Contents

Mafic sills in the Fortescue Group, southern Pilbara

HM Howard and DMcB Martin

The volcano-sedimentary succession of the Fortescue Group in the South Pilbara Sub-basin is dominated by the presence of mafic sills that form a concentric map pattern around the inliers within the Wyloo, Jeerinah, Rocklea, Bellary and Milli Milli Anticlines (Fig. 1).

Whole-rock geochemistry of these mafic sills (Appendix) has revealed several distinct geochemical groups and clarified their association with parts of the Fortescue Group stratigraphy, which have been mapped in the Fortescue–Hamersley, 2022 Geological Information Series (GIS) package update.

The most abundant and well-exposed mafic sills of the region occur within the Hardey, Boongal and Jeerinah Formations. The mafic sills within the Hardey and Boongal Formation (Fig. 1) are well exposed in the Rocklea Anticline (Thorne et al., 1995) and Milli Milli Anticline (Thorne et al., 1996). They are commonly layered and mostly range from 30 to 100 m in thickness. A number of sills were sampled primarily for geochemistry near Rocklea Homestead on the southeastern side of the Rocklea Anticline and at Coppins Pool in the Milli Milli Anticline. At both of these localities, there are two main geochemical groups of mafic sills. The most abundant geochemical group has a composition similar to that of the Pyradie Formation. Major elements variations include 5.3 – 13.8 wt% MgO, 50.7 – 55.8 wt% SiO_2 and 0.7 – 1.4 wt% TiO, and the rocks have trace element characteristics that include LREE-enrichments and negative Nb anomalies (mean La/Nb = 2.2), with trace element concentrations similar to those of mafic lavas in the lower part of the Pyradie Formation (Fig. 2a).

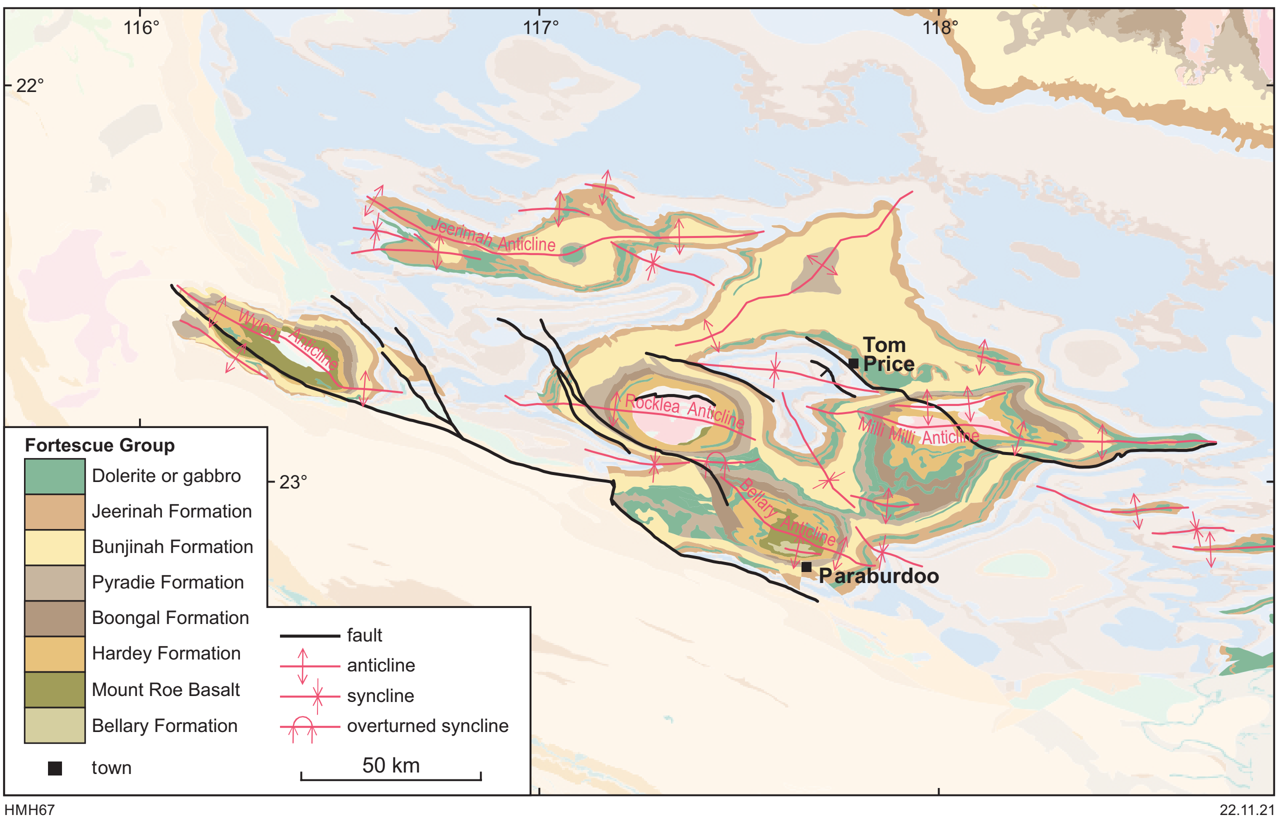

Figure 1. Map showing the Fortescue Group in the South Pilbara Sub-basin

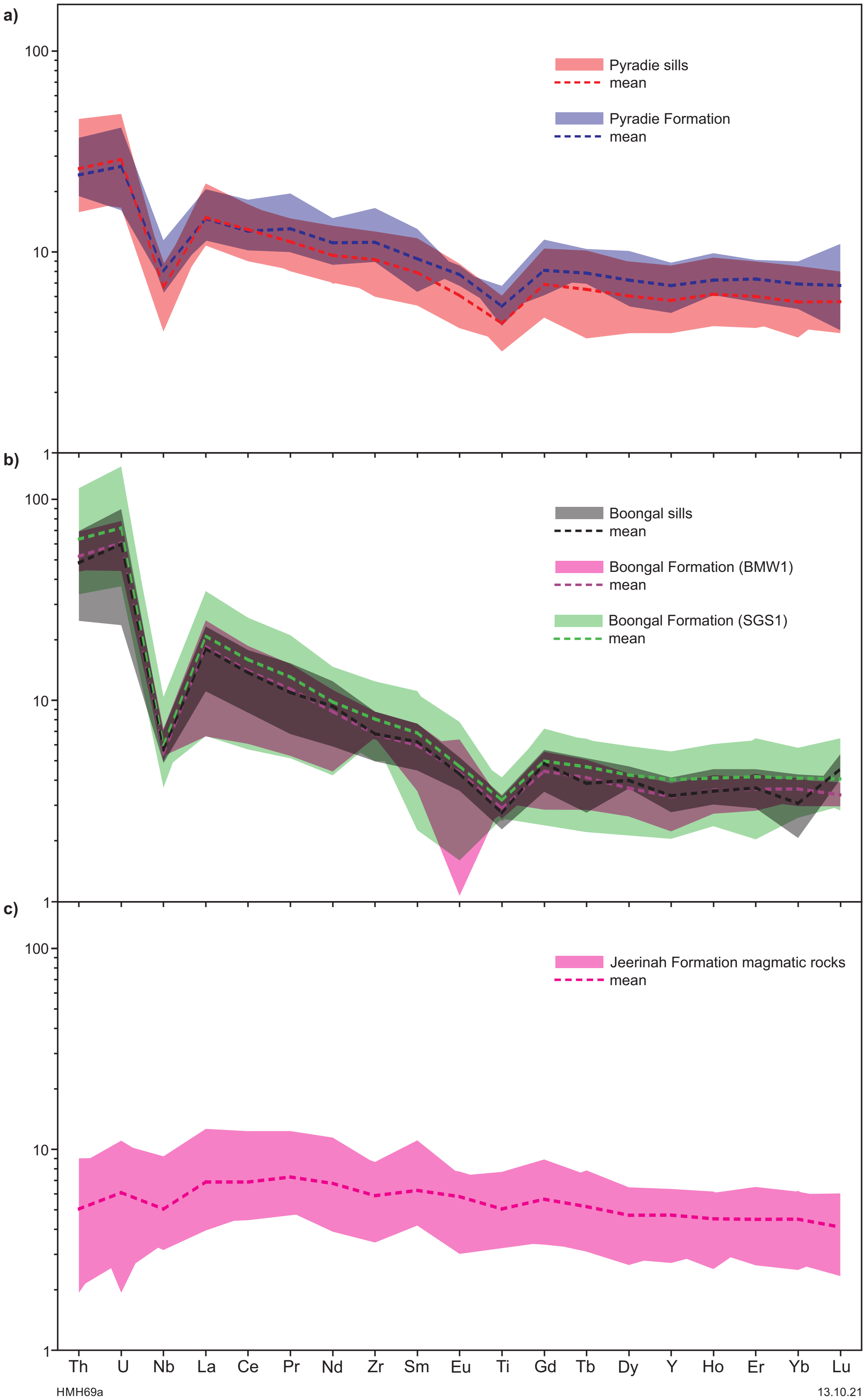

Figure 2. Primitive mantle normalized multi-element trace element plots showing mafic sills from within the Hardey and Boongal Formations. Mean values are shown by the thicker lines: a) sills and lavas of the Pyradie Formation; b) sills and lavas of the Boongal Formation; c) magmatic rocks of the Jeerinah Formation

A sample of a sill from Coppins Pool (Fig. 3a) gave a U–Pb date of 2716 ± 5 Ma (Wingate et al., 2021) that is similar to the currently accepted age of the Pyradie Formation. The age of the Pyradie Formation is constrained by the age of its lateral equivalent in the northern Pilbara, namely the Tumbiana Formation. A U–Pb date of 2715 ± 6 Ma (Arndt et al., 1991) was obtained from the youngest zircon population in a tuffaceous sandstone of the Tumbiana Formation. The geochemistry and geochronology of these sills both support them being related to the lower part of the Pyradie Formation.

At the top of the Hardey Formation, at both localities in the Rocklea and Milli Milli Anticlines, is a number of sills that are slightly more LREE-enriched than the Pyradie sills, have a greater negative Nb anomaly (mean La/Nb = 3.2) and lower concentrations of HREE than the Pyradie sills. Their major element concentrations include 5.4 – 8.5 wt% MgO, 53.2 – 58.7 wt% SiO_2 and 0.5 – 0.7 wt % TiO. These sills are most likely related to the Boongal Formation as they have very similar geochemical characteristics as shown by their trace element profiles (Fig. 2b). Their overall appearance, even texture, pale red-brown weathered surface colour, blocky fracturing and position in the stratigraphy is similar to the informally named Tin Hut basalt in the Wyloo Anticline and the Cooya Pooya Dolerite in the northwest Pilbara; however, this association has yet to be confirmed by geochemistry or geochronology.

The 2715–2629 Ma Jeerinah Formation is dominated by a deep-marine sedimentary succession but also includes abundant pillow lavas, thick massive flows, sills and subvolcanic intrusions. In the South Pilbara Sub-basin, the thickness of the Jeerinah Formation increases to the south because of the abundance of magmatic rocks that form 50% of the thickness (Thorne and Tyler, 1993; Thorne and Trendall, 2001). Many of the thicker subvolcanic units show glomeroporphyritic texture (Fig. 3b) and coarsening in the central parts of the flow, away from the margins. Thorne and Trendall (2001) observed that many flows can be traced laterally into pillow basalt and this is shown by the pillowed flow margin in Figure 3c. The geochemistry of these flows and subvolcanic intrusions is consistent with that of the pillow basalts in the Jeerinah Formation. Their major element concentrations include 5.4 – 9.4 wt% MgO, 48–52 wt% SiO_2 and 0.8 – 1.7 wt % TiO_2. The majority of the magmatic rocks have relatively unfractionated, MORB-like, geochemistry (Fig. 2c) that differs from the rest of the Fortescue Group.

In addition to the volcanic rocks of the Jeerinah Formation, there is a minor group of sills that has clear intrusive contacts with the sedimentary rocks. These sills show LREE-enrichment and are most likely associated with the younger magmatic rocks of the Hamersley Group and are therefore given a code for Archean or Proterozoic dolerite of unknown age (AP_-o-WAC).

Previous maps of the Fortescue and Hamersley Basins have shown the mafic sills as undivided units within the Fortescue Group, but the new geochemical data has allowed further classification to reflect their association with magmatism in specific formations of the Fortescue Group, namely the Pyradie, Boongal and Jeerinah Formations. The sills have thus been given the appropriate map codes A-FOp-og, A-FOo-od and A-FOj-od.

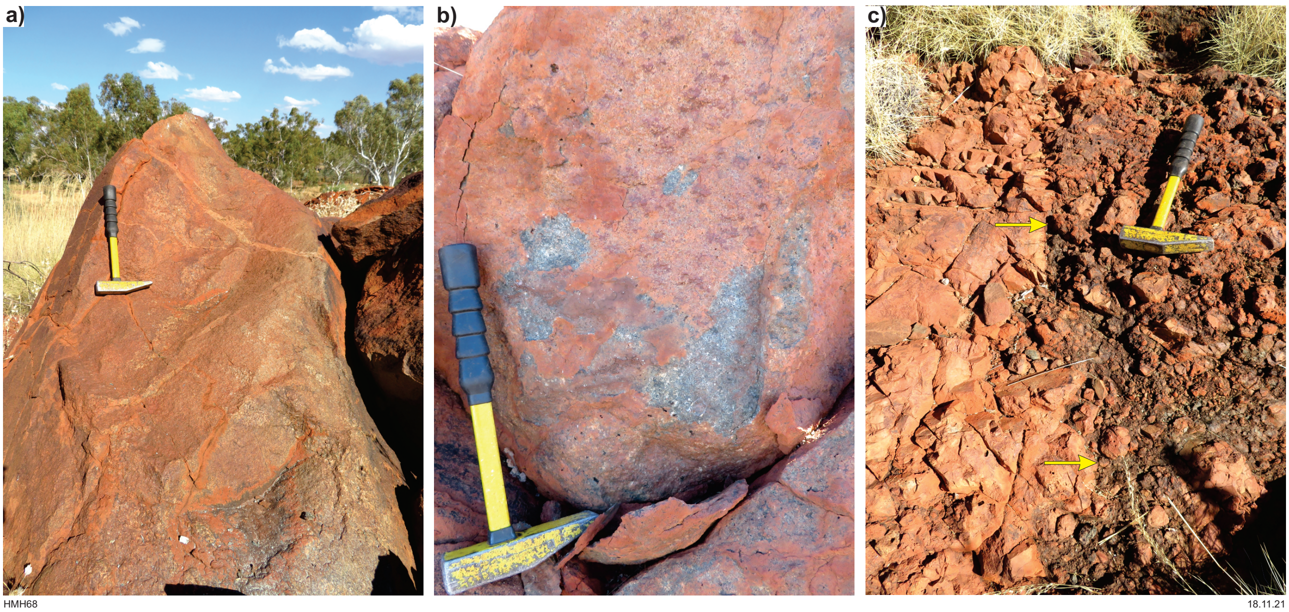

Figure 3. a) Outcrop photo of Pyradie sill at Coppins Pool (617281E 7468473N); b) coarse-grained glomeroporphyritic texture in leucogabbro sill of the Jeerinah Formation (581066E 7431405N); c) irregular basalt flow top with vesicular margin (shown by arrows), overlain by pillow breccia to the right (581088E 7432349N) in the Jeerinah Formation. Hammer used for scale (35 cm)

References

Arndt, NT, Nelson, DR, Compston, W, Trendall, AF and Thorne, AM 1991, The age of the Fortescue Group, Hamersley Basin, Western Australia, from ion microprobe zircon U–Pb results: Australian Journal of Earth Sciences, v. 38, p. 261–281.

Thorne, AM and Trendall, AF 2001, Geology of the Fortescue Group, Pilbara Craton, Western Australia: Geological Survey of Western Australia, Bulletin 144, 249p.

Thorne, AM and Tyler, IM 1993, Paraburdoo, WA Sheet 2451: Geological Survey of Western Australia, 1:100 000 Geological Series.

Thorne, AM, Tyler, IM and Blight, DF 1995, Rocklea, WA Sheet 2352: Geological Survey of Western Australia, 1:100 000 Geological Series.

Thorne, AM, Tyler, IM, Blockley, JG and Blight, DF 1996, Mount Bruce, WA Sheet SF 50-11 (2nd edition): Geological Survey of Western Australia, 1:250 000 Geological Series.

Wingate, MTD, Lu, Y, Howard, HM and Martin, DMcB 2021, 228400: leucogabbro, Coppin Gap; Geochronology Record 1729: Geological Survey of Western Australia, 5p., <www.dmirs.wa.gov.au/geochronology>.

Stratigraphic and structural revisions on the Wyloo and Yarraloola 1:250 000 map sheets

DMcB Martin, HJ Allen and OA Blay

Introduction

The Wyloo and Yarraloola 1:250 000 map sheets straddle the western margin of the Fortescue–Hamersley Geological Information Series (GIS) package, and the Yarraloola sheet (Williams et al., 1968) is one of the oldest published maps still in its first edition. The second edition Wyloo map (Blight et al., 1986) is also overdue an update. The Yarraloola sheet in particular was mapped before much of the modern stratigraphy of the region had been established. This abstract highlights some of the stratigraphic revisions and latest structural interpretations that have come about as a result of remapping a large proportion of these two sheets between 2017 and 2019, specifically focusing on units younger than the Hamersley Group. This mapping program involved field validation of the desktop interpretation presented in the 2018 edition of the Fortescue–Hamersley GIS. Specifically, this note summarizes the results of mapping on the Pannawonica, Elvire, Mount Stuart, Farquhar, Wyloo and Hardey 1:100 000 map sheets, particularly the stratigraphic subdivision of previously undivided units and new geochronology on these sheets.

Stratigraphy and geochronology

The most significant updates to the stratigraphy of this area are reflected in the detailed subdivision of the Fortescue Group in the Wyloo Anticline and corrections to incorrectly mapped units to the north on Wyloo; and detailed subdivision of previously undivided units between the Hamersley Group and Ashburton Formation on Yarraloola. Further stratigraphic revisions on the eastern part of Wyloo have previously been described by Martin (2020b).

Detailed structural and stratigraphic mapping of the Wyloo Anticline, that has extended the formal subdivisions of the Fortescue Group into the western parts and recognized new economically significant subdivisions of the Hardey Formation, has been included with the permission of Northern Star Pty Ltd. New geochronological results from this area have established an age of 2733 ± 5 Ma for the Boongal Formation (Wingate et al., 2017b), as well as constraining the age of gold mineralization at Paulsen Gold Mine which is hosted by a 2701 ± 11 Ma gabbro sill in the Hardey Formation (Fielding et al., 2017). An age of 2734 ± 14 Ma (Wingate et al., 2017a) was obtained for a dolerite sill within the Hardey Formation, suggesting it is an intrusive equivalent of the Boongal Formation. Although this note focuses on post-Hamersley Group strata, mapping has also identified the absence of characteristic dolerite sills from the Weeli Wolli Formation in the upper Hamersley Group over large parts of the western Hamersley province, thereby establishing that the locus of intrusion of these sills is in the central and eastern parts of the province.

A contentious area of the Wyloo map sheet is a fault-bound dolomite ridge that extends northwestwards for about 15 km from Cave Hill on Hardey. This ridge was incorrectly mapped as Beasley River Quartzite on the second edition map, and has since been included in the Turee Creek Group by many authors and proposed as an important record of the rise of atmospheric oxygen associated with the Great Oxidation Event (e.g. Martin et al., 2000; Barlow et al., 2016; Fadel et al., 2017; Krapež et al., 2017; Barlow and van Kranendonk, 2018; Soares et al., 2019). Recent mapping has established features within this ridge that confirm previous unpublished suggestions that it correlates with the Duck Creek Dolomite, as exposed in the type section 20 km to the west. Further work to confirm this, including dating of a tuff bed, is ongoing.

Another intriguing feature of the Wyloo second edition map is a fault-bound block 15 km northwest of Duck Creek Homestead that comprises basalt, basaltic agglomerate and a gabbro dyke within the Hamersley Group on Mount Stuart and Farquhar that was interpreted as a feeder conduit to the Cheela Springs Basalt by Thorne and Seymour (1991; Fig. 1). Subsequent baddeleyite U–Pb dating of the gabbro produced an age of 1832 ± 9 Ma (Müller, 2005), indicating that it is more likely a feeder to volcanic rocks within the Ashburton Formation that are best exposed about 190 km to the southeast near Mount Boggola (Sircombe, 2003; Wingate et al., 2019c). However, the field relationships between the gabbro and the host basaltic succession on Wyloo were not documented. Resampling of the original sample site of Martin et al. (1998) has produced an age of 2203 ± 4 Ma for the Cheela Springs Basalt (Wingate et al., 2019d,e) that is within analytical uncertainty of the original result. Thin units of vesicular basalt have also been identified within the Mount McGrath Formation on the Red Hill Creek section of Thorne and Seymour (1991) which is now recognized as containing an unconformable contact with the underlying Wooly Formation (Martin, 2020a), which also contains vesicular basalt in the Red Hill area. A new age of 1793 ± 5 Ma has been obtained from a felsic volcanic rock within the June Hill Volcanics (Wingate et al., 2019b) from the same sample site as reported by Evans et al. (2003).

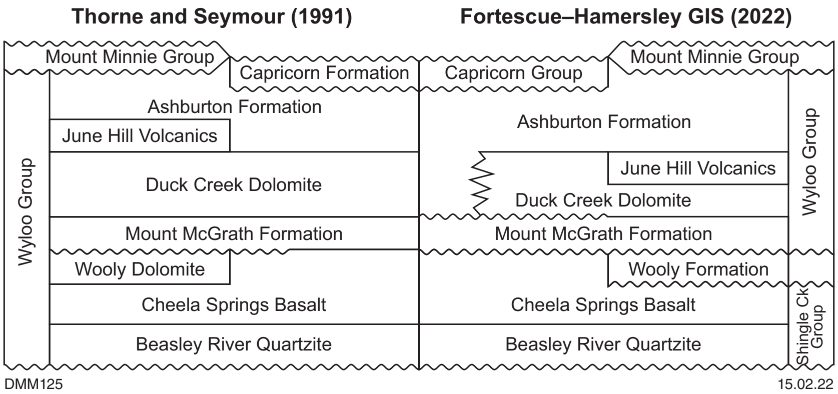

Figure 1. Stratigraphic revisions to the former Wyloo Group as originally proposed by Thorne and Seymour (1991) on Wyloo and Yarraloola map sheets. Note the revised stratigraphic assignments and newly recognized unconformities (wavy lines)

This result is within uncertainty of a number of other new ages from the region, including a 1787 ± 7 Ma porphyritic dacite near Mount Amy (Wingate et al., 2019a), an 1801 ± 6 Ma felsic tuff near the base of the Ashburton Formation (Wingate et al., 2021c), and two porphyritic microgranite intrusions dated at 1781 ± 8 Ma (Wingate et al., 2021a) and 1798 ± 9 Ma (Wingate et al., 2021b). This felsic magmatism is broadly coeval with the Moorarie Supersuite, with which the intrusive units have been correlated, suggesting a much wider geographic extent for this event than previously known.

On Yarraloola, previously undifferentiated units that were equated to the Turee Creek 'Formation', Beasley River Quartzite or Mount McGrath Formation by Williams et al. (1968) have now been subdivided and more precisely mapped, based on stratigraphic and structural relationships with lithologically distinctive units such as the Cheela Springs Basalt, Wooly Formation, Duck Creek Dolomite and June Hill Volcanics (Fig. 1). Also, many units that were previously mapped as Duck Creek Dolomite can now be confidently assigned to the Wooly Formation, based mainly on better recognition of the Mount McGrath Formation and its unconformable relationship with the latter (Fig. 1). This redefined Wooly Formation (Krapež et al., 2015; Martin, 2020b) is much more extensive than previously thought (cf. Thorne and Seymour, 199) and hosts copper occurences at Red Hill (Martin, 2020a). In addition to identifying extensions to the Moorarie Supersuite on Yarraloola, the revised mapping has also determined an age of 2453 ± 3 Ma for the uppermost Weeli Wolli Formation in the Hamersley Group on Pannawonica (Wingate et al., 2020).

Structure

The structural grain of most of the Fortescue–Hamersley project area is dominated by east-westerly trending folds formed during the Ophthalmia Orogeny (Martin, 2020b) although there appears to be little evidence for this event north of the Wyloo Anticline and west of the Lawloit Range Fault. This is likely due to a number of factors including poor exposure of Turee Creek Basin strata and the thickness and competency of the main strain marker, the Beasley River Quartzite. However, minor west-northwesterly trending folds are locally known from this unit, for example 7 km west of Mount Berry. To the west of the Lawloit Range Fault, most of the mapped folds trend northwesterly and are interpreted to be predominantly related to the Capricorn Orogeny because they affect all strata up to and including the Capricorn Group. However, there are two recently identified key areas, which preserve folding that may be related to the earlier Glenburgh Orogeny. The first is about 16 km north-northeast of Cardo Outcamp, on the Red Hill Creek section of Thorne and Seymour's (1991) area of work, where the Wooly Formation is folded about northwesterly trending axes, and overlain by the Mount McGrath Formation on an angular unconformity. The second area is at the southeastern closure of the Wandiona Syncline, 8 km southeast of Urandy Creek Outcamp, where an east–west trending fold that affects the Wooly and Mount McGrath Formations is refolded into a northwesterly trend in the hangingwall of an un-named normal fault.

The western margin of the Hamersley province is truncated by an extensive network of northwesterly trending faults that have previously been interpreted to constitute a predominantly dextral strike-slip system (Thorne and Seymour, 1991). However, detailed mapping in the southwest corner of Farquhar by Dalstra (2014) established that many of these faults have significant dip-slip displacements of thousands of metres that pre-date strike-slip reactivation. This fault network has now been extrapolated throughout the western Hamersley province, with particular attention paid to identifying major normal faults. Most of the strike-slip movement on faults to the east of the Lawloit Range Fault pre-dates the northwesterly trending c. 2008 Ma Panhandle Dolerite dyke which show little to no offset, and in some cases may intrude these faults. To the west of this fault, stratigraphic evidence suggests that most normal displacement post-dates the Ashburton Formation and pre-dates c. 755 Ma Mundine Well Dolerite dykes. However, the fault-bound inlier of Ashburton Formation mafic volcanic rocks within the Hamersley Group on Mount Stuart and Farquhar is clearly associated with a much younger period of extension that appears to post-date these dykes.

Remapping of the Wyloo Anticline and environs has shown that the westwards extension of the Nanjilgardy Fault from its type area at Mount Olympus, consists of two distinct splays. The first separates the anticline from the remainder of the exposed Ophthalmian foreland and consists mainly of late-stage brittle normal faults such as the Lawloit Range, Pinarra, Kungarra Gorge and Metawandy Faults that were reactivated as dextral strike-slip faults. This splay is commonly referred to in earlier work as the Nanjilgardy Fault (Johnson et al., 2012), or Menindee Fault Zone (Trendall, 1979). The second splay is a ductile shear zone that extends westwards through the southern half of the anticline, and is here named the Mindle Shear Zone.

References

Barlow, E, Van Kranendonk, MJ, Yamaguchi, KE, Ikehara, M and Lepland, A 2016, Lithostratigraphic analysis of a new stromatolite-thrombolite reef from across the rise of atmospheric oxygen in the Paleoproterozoic Turee Creek Group, Western Australia: Geobiology, v. 14, no. 4, p. 317–343, published online 29/02/2016, doi:10.1111/gbi.12175.

Barlow, EV and van Kranendonk, MJ 2018, Snapshot of an early Paleoproterozoic ecosystem: Two diverse microfossil communities from the Turee Creek Group, Western Australia: Geobiology, v. 16, no. 5, p. 449–475, doi:10.1111/gbi.12304.

Blight, DF, Seymour, DB and Thorne, AM 1986, Wyloo, WA Sheet SF50-10 (2nd edition): Geological Survey of Western Australia, 1:250 000 Geological Series.

Dalstra, HJ 2014, Structural evolution of the Mount Wall region in the Hamersley province, Western Australia and its control on hydrothermal alteration and formation of high-grade iron deposits: Journal of Structural Geology, v. 67, p. 268–292, doi:10.1016/j.jsg.2014.03.005.

Evans, DAD, Sircombe, KN, Wingate, MTD, Doyle, M, McCarthy, M, Pidgeon, RT and van Niekerk, HS 2003, Revised geochronology of magmatism in the western Capricorn Orogen at 1805-1785 Ma: Diachroneity of the Pilbara-Yilgarn collision: Australian Journal of Earth Sciences, v. 50, no. 6, p. 853–864.

Fadel, A, Lepot, K, Busigny, V, Addad, A and Troadec, D 2017, Iron mineralization and taphonomy of microfossils of the 2.45–2.21 Ga Turee Creek Group, Western Australia: Precambrian Research, v. 298, p. 530–551, doi:10.1016/j.precamres.2017.07.003.

Fielding, IOH, Johnson, SP, Zi, J-W, Rasmussen, B, Muhling, JR, Dunkley, DJ, Sheppard, S, Wingate, MTD and Rogers, JR 2017, Using in situ SHRIMP U-Pb monazite and xenotime geochronology to determine the age of orogenic gold mineralization: An example from the Paulsens Mine, southern Pilbara Craton: Economic Geology, v. 112, p. 1205–1230.

Johnson, SP, Thorne, AM and Tyler, IM 2012, Capricorn Orogen seismic and magnetotelluric (MT) workshop 2011: Extended abstracts: Geological Survey of Western Australia, Record 2011/25, 120p.

Krapež, B, Müller, SG and Bekker, A 2015, Stratigraphy of the Late Palaeoproterozoic (~2.03 Ga) Wooly Dolomite, Ashburton Province, Western Australia: A carbonate platform developed in a failed rift basin: Precambrian Research, v. 271, p. 1–19,doi:10.1016/j.precamres.2015.09.022.

Krapež, B, Müller, SG, Fletcher, IR and Rasmussen, B 2017, A tale of two basins? Stratigraphy and detrital zircon provenance of the Paleoproterozoic Turee Creek and Horseshoe Basins of Western Australia: Precambrian Research, v. 294, p. 67–90.

Martin, DMcB 2020a, Tectonic setting and exploration potential of the Wooly Formation (poster) *in* GSWA Open Day, Fremantle, 13 February 2020, Geological Survey of Western Australia.

Martin, DMcB 2020b, Geology of the Hardey Syncline — The key to understanding the northern margin of the Capricorn Orogen: Geological Survey of Western Australia, Report 203, 62p.

Martin, DMcB, Li, ZX, Nemchin, AA and Powell, CMcA 1998, A pre-2.2 Ga age for giant hematite ores of the Hamersley Province, Australia? Economic Geology, v. 93, p. 1084–1090.

Martin, DMcB, Powell, CMcA and George, AD 2000, Stratigraphic architecture and evolution of the early Paleoproterozoic McGrath Trough, Western Australia: Precambrian Research, v. 99, p. 33–64.

Müller, SG 2005, The tectonic evolution and volcanism of the Lower Wyloo Group, Ashburton Province, with timing implications for giant iron-ore deposits of the Hamersley Province, Western Australia: The University of Western Australia, Perth, Doctor of Philosophy thesis (unpublished).

Sircombe, KN 2003, Age of the Mt Boggola volcanic succession and further geochronological constraint on the Ashburton Basin, Western Australia: Australian Journal of Earth Sciences, v. 50, p. 967–974.

Soares, GG, Van Kranendonk, MJ, Belousova, E and Thomson, S 2019, Phosphogenesis in the immediate aftermath of the Great Oxidation Event: Evidence from the Turee Creek Group, Western Australia: Precambrian Research, v. 320, p. 193–212, doi:10.1016/j.precamres.2018.10.017.

Thorne, AM and Seymour, DB 1991, Geology of the Ashburton Basin, Western Australia: Geological Survey of Western Australia, Bulletin 139, 141p.

Trendall, AF 1979, A revision of the Mount Bruce Supergroup, in Annual report for the year 1978: Geological Survey of Western Australia, p. 63–71.

Williams, IR, Ryan, GR and Halligan, R 1968, Yarraloola, WA Sheet SF50-6: Geological Survey of Western Australia, 1:250 000 Geological Series.

Wingate, MTD, Fielding, IOH, Lu, Y and Martin, DMcB 2021a, 225797: porphyritic microgranite, Three Peak Hill; Geochronology Record 1814: Geological Survey of Western Australia, 4p.,<www.dmirs.wa.gov.au/geochron>.

Wingate, MTD, Fielding, IOH, Lu, Y and Martin, DMcB 2021b, 239798: porphyritic dyke, Pannawonica Road; Geochronology Record 1818: Geological Survey of Western Australia, 4p.,<www.dmirs.wa.gov.au/geochron>.

Wingate, MTD, Fielding, IOH, Lu, Y and Martin, DMcB 2021c, 242908: tuffaceous volcanic rock, Red Hill mine; Geochronology Record 1819: Geological Survey of Western Australia, 5p.,<www.dmirs.wa.gov.au/geochron>.

Wingate, MTD, Lu, Y, Blay, O and Johnson, SP 2017a, 206953: dolerite sill, Tin Hut Bore; Geochronology Record 1433: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y, Fielding, IO and Johnson, SP 2019a, 219588: porphyritic dacite, One Tree Well; Geochronology Record 1570: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y, Fielding, IOH and Johnson, SP 2019b, 219580: felsic volcanic rock, Catho Well; Geochronology Record 1630: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y, Fielding, IOH and Johnson, SP 2019c, 219592: felsic volcanic rock, Mount Boggola; Geochronology Record 1632: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y, Fielding, IOH, Martin, DMcB and Johnson, SP 2019d, 219585: volcaniclastic sandstone, Urandy Creek; Geochronology Record 1613: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y, Fielding, IOH, Martin, DMcB and Johnson, SP 2019e, 219586: volcaniclastic sandstone, Urandy Creek; Geochronology Record 1614: Geological Survey of Western Australia, 7p.

Wingate, MTD, Lu, Y and Johnson, SP 2017b, 209948: felsic volcanic rock, Beaghy Bore; Geochronology Record 1379: Geological Survey of Western Australia, 4p.

Wingate, MTD, Lu, Y and Martin, DMcB 2020, 225735: tuffaceous siltstone, Yallangi Bore; Geochronology Record 1683: Geological Survey of Western Australia, 5p.

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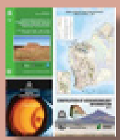

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