Myths and mylonites — some new perspectives on the Proterozoic evolution of the west Musgrave Complex

by

RH Smithies, P Evins*, and HM Howard

The Musgrave Complex, in central Australia, lies at the triple junction between the North, South, and West Australian Cratons (Fig. 1). Despite occupying such a crucial position in the architecture of ancient Australian plates, this east-trending and strongly deformed and metamorphosed Proterozoic terrane remains one of the least-understood pieces of Proterozoic Australia. However, detailed regional mapping and extensive geochronological and geochemical studies over the last few years are beginning to provide some new geological perspectives, and to dispel some widely held myths about this region.

It has generally been held that felsic gneisses in the central western Musgrave Complex are from mixed igneous and sedimentary protoliths and form a 1600 to 1500 Ma basement. New isotopic and geochronological data still require a 1900 to 1330 Ma basement, but this is nowhere exposed. The exposed basement gneisses belong to two metasediment-dominated packages deposited between c. 1370 Ma and c. 1330 Ma.

Most of the granites that dominate the Musgrave Complex have been attributed to the 1225 to 1160 Ma Musgravian Orogeny. However, Gray (1978) and White et al. (1999) obtained ages between c. 1330 and c. 1300 Ma for granitic and gneissic rocks at Mount West, a small area in the south of the west Musgrave Complex, but the regional significance of these could not be assessed. It is now clear that, in the west Musgrave Complex, such rocks are the dominant felsic component to the south of the east-trending Mann Fault, a late, major structure that bisects the complex. In the west Musgrave Complex, rocks from 1330 to 1300 Ma may be as volumetrically significant as Musgravian-aged rocks.

The granitic framework of the west Musgrave Complex was intruded by a series of layered mafic–ultramafic igneous bodies (Giles intrusions) that locally carry significant Ni–Cu mineralization. This c. 1070 Ma magmatism is generally regarded as a passive response to a mantle plume that formed the Warakurna large igneous province covering much of central, western, and northern Western Australia (Wingate et al., 2004). The emplacement level of the Giles intrusions is thought to be very deep, but shallowing to the west. In the west Musgrave Complex, the Giles Event now appears to be an incredibly dynamic period, possibly of the order of ~10 m.y., during which at least four separate mafic magmas and four felsic magmas were emplaced or extruded. The tectonic environment was neither passive, nor simply extensional, based on our recognition of compressional syn-magmatic mylonites and large-scale folds. Nor were the Giles intrusions deep-seated. Structural, textural, and field evidence indicate that most intrusions in the west Musgrave Complex were shallow, and perhaps sub-volcanic. The Blackstone and Cavanagh intrusions were emplaced into the more or less contemporaneous Mummawarrawarra Basalt, and are cut by felsic dykes geochemically related to the overlying Smoke Hill Volcanics and Hogarth Formation. This indicates a significant disconformity within the previously defined Tollu Group (Mummawarrawarra Basalt to Hogarth Formation). Well-developed and asymmetric layering suggests the intrusions are sills, and so the likely strike continuity between the Blackstone intrusion and the Jameson and Bell Rock intrusions indicate that they too are high-level bodies.

Dominated by poly-metamorphosed granulite-facies rocks, the Musgrave Complex is typically regarded as an extremely ‘dry’ terrain. However, extensive vein-controlled and pervasive hydrothermal alteration is associated with areas that were at or close to the surface during the c. 1070 Ma Giles Event. Alteration assemblages include quartz, sericite, adularia, epidote, and chlorite. Late pegmatite dykes also represent volatile-rich magmatism, and are locally common in northwest-trending structural corridors to the north of the Mann Fault. Preliminary dating of zircons from one tourmaline-bearing pegmatite has yielded ages around 620 Ma. There is a pronounced geophysical (aeromagnetic and gravity) link between the Musgrave Complex and the northwest Paterson Orogen in northern Western Australia, and it now appears that they share a c. 600 to 620 Ma felsic magmatic event, one that is unique (in the region) to these two areas.

The main shear zone network that transects the Musgrave Complex is typically attributed to the c. 550 Ma Petermann

* Presenter

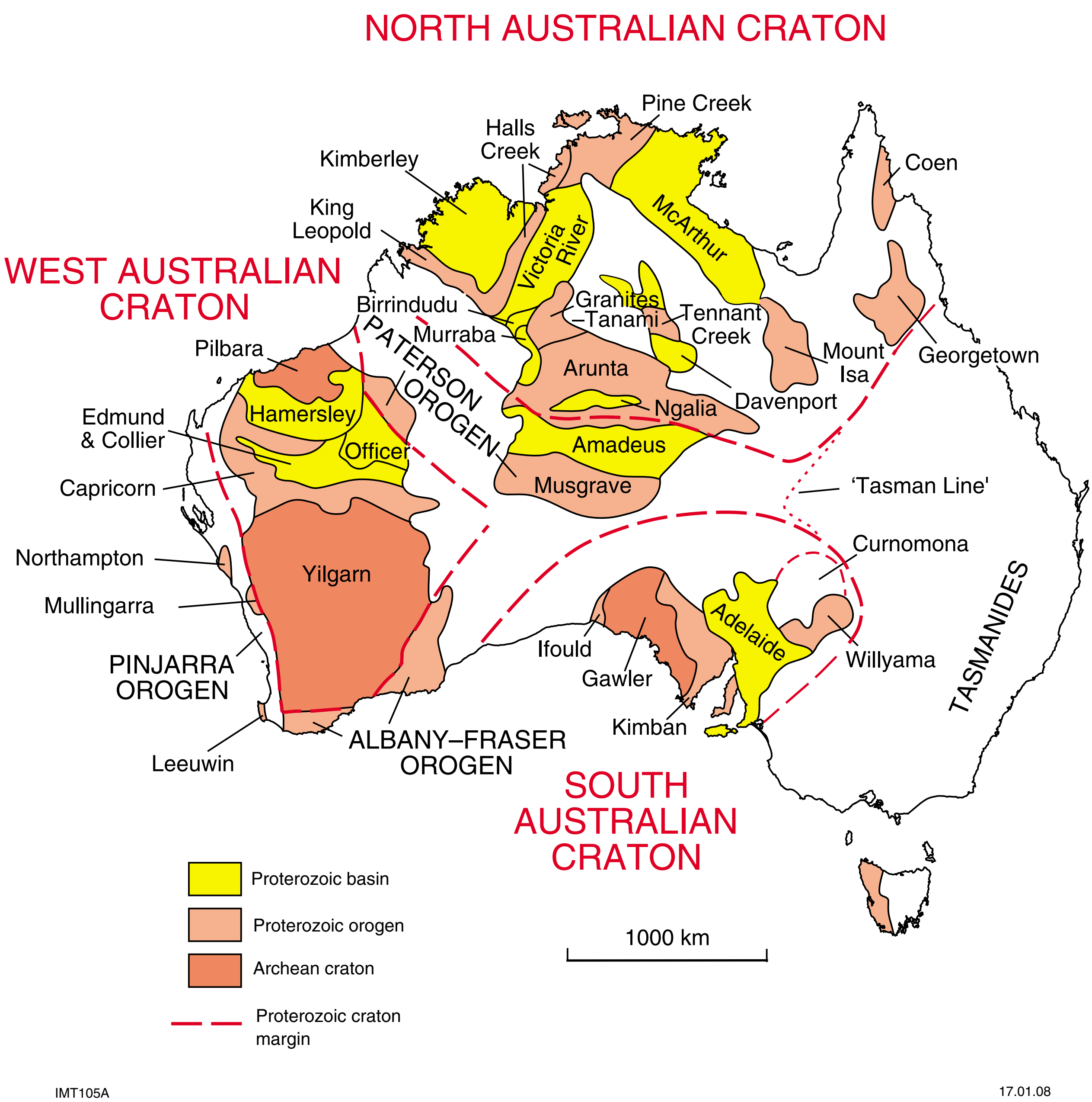

Figure 1. Main tectonic elements of central and western Australia, from Tyler (2005)

Ranges Orogeny. During this period, large vertical movements along east-trending shears were accompanied by extensive dextral displacements, concentrated on the Mann Fault. The area to the north of the Mann Fault was thrust to the north, over younger rocks of the Amadeus Basin (Edgoose et al., 2004). However, in the west Musgrave, nearly all young mylonite zones show 'top to the southwest' movement, adding a degree of complexity to the northwards-thrusting model. Also, field relationships with dated igneous rocks make it clear that many of the major structural elements and, in particular, the northwest- and west-northwesterly trending structures, pre-date the Petermann Ranges Orogeny, and are at least as old as the Giles Event. In addition, the Mann Fault becomes a less discrete structure westwards in the Musgrave Complex, forming a series of splays in the western part of the complex. Here, there is little clear evidence that the main horizontal movement was dextral. Several lithological markers in the west Musgrave Complex are equally consistent with a ~25 km sinistral displacement.

References

Edgoose, CJ, Scrimgeour, IR, and Close, DF, 2004, Geology of the Musgrave Block, Northern Territory: Northern Territory Geological Survey, Report 15, 4p.

Gray, CM, 1978, Geochronology of granulite facies gneisses in the Western Musgrave Block, central Australia: Journal of the Geological Society of Australia, v. 25, p. 403–414.

Tyler, IM, 2005, Australia: Proterozoic, *in* Encyclopedia of Geology *edited by* RC Selley, LRM Cocks, and IR Plimer: Elsevier, Oxford, Vol. 1, p. 208–221.

White, RW, Clarke, GL, and Nelson, DR, 1999, SHRIMP U–Pb zircon dating of Grenville-age events in the western part of the Musgrave Block, central Australia: Journal of Metamorphic Geology, v. 17, p. 465–481.

Wingate, MTD, Pirajno, F, and Morris, PA, 2004, The Warakurna large igneous province: a new Mesoproterozoic large igneous province in west-central Australia: Geology, v. 32: p. 105–108.