ROYALTIES FOR REGIONS

EXPLORATION INCENTIVE SCHEME

Structural development and mineralization of the western Edmund and Collier Basins

by

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Low-grade metasedimentary rocks of the Paleoproterozoic to Mesoproterozoic Edmund and Collier Basins form the youngest depositional elements within the Capricorn Orogen (Fig. 1). The succession comprises ~4 to 10 km of mainly fine-grained siliciclastic and carbonate sedimentary rocks that were deposited in a variety of shelf to basinal environments (Martin and Thorne, 2004). Sediments in the Edmund Basin were deposited unconformably on Paleoproterozoic basement rocks, including the Gascoyne Province, sometime between c. 1620 and c. 1465 Ma, based on the ages of the underlying Gascoyne Province and intrusive Narimbunna Dolerite. Sediments in the unconformably overlying Collier Basin were deposited across both the Paleoproterozoic basement and locally deformed sedimentary rocks of the Edmund Basin, after the Mutherbukin Tectonic Event at c. 1200 and before intrusion of the c. 1070 Ma Kulkatharra Dolerite.

Edmund Basin

The Edmund Basin corresponds to the present day outcrop of the Edmund Group. It contains four sedimentary packages whose depositional character was ultimately controlled by the primary orientation and repeated reactivation of major crustal structures in the Paleoproterozoic basement. These include the Talga, Godfrey, and Lyons River Faults in the west, and the Quartzite Well, Bujundunna, and Mount Vernon Faults in the east. Recently acquired deep seismic reflection data (Johnson et al., 2011a; Korsch et al., 2011) has highlighted the importance of the Talga, Godfrey, and Lyons River Faults, which are imaged as mantle-linked structures that dip steeply at the surface but become gently southward-dipping in mid- to lower-crustal levels. The Lyons River Fault has further significance in that it marks the early Paleoproterozoic crustal suture between the Glenburgh Terrane of the Gascoyne Province, and the Bandee Seismic Province of the Pilbara Craton.

Following the termination of the Mangaroon Orogeny at c. 1620 Ma, extensional reactivation took place on the Talga, Godfrey, Lyons River, Quartzite Well, Bunjindunna, and Mount Vernon Faults. Siliciclastic and carbonate sediments were deposited in the resulting half grabens, which show significant sediment thickness variations across the main structures. On the Pingandy Shelf to the north of the Talga Fault, the maximum thickness of Depostional Packages 1 and 2, in the lower part of the Edmund Group (Fig. 1), is ~1.5 km, whereas to the south they increase to ~3.75 km thick. Across the Godfrey Fault, Depositional Packages 1 and 2 increase in thickness from ~6 km to ~8.25 km. Depositional Packages 1 and 2 are also consistently thicker in the hangingwall of the basin-bounding extensional faults, suggesting that extensional downthrow on these major faults was toward the southwest. Depositional Package 2 is not present south of a line joining the Geegin Syncline with the Mount Vernon Fault, presumably having been incised and eroded away prior to the deposition of Depositional Package 3, which is up to 3 km thick in this area.

Collier Basin

Deposition in the Collier Basin (Depositional Packages 5 and 6 of the Collier Group) appears to have been less influenced by synsedimentary fault movements (Martin and Thorne, 2004), although the principal basin architecture parallels the main northwest–southeast to east–west structural trends seen within the underlying Edmund Basin and Gascoyne Province.

Mutherbukin Tectonic Event (1385–1200 Ma)

A major period of basin inversion took place during the 1385–1200 Ma Mutherbukin Tectonic Event (Johnson et al., 2011b), prior to deposition in the Collier Basin. In the underlying Gascoyne Province, this event was responsible for localized medium-grade metamorphism and deformation; however, evidence from the Edmund Basin has been more difficult to interpret, due to the very low grade nature of the metamorphism and difficulty in separating Mutherbukin-aged structures from similar, often coaxial, features formed during the later 1030–955 Ma Edmundian Orogeny.

Faults such as the Deverell Fault, in the eastern part of the Edmund Basin, have large, sinistral, strike-slip offsets, but show only small offsets in the overlying Collier Basin, suggesting pre-Edmundian Orogeny movements. These

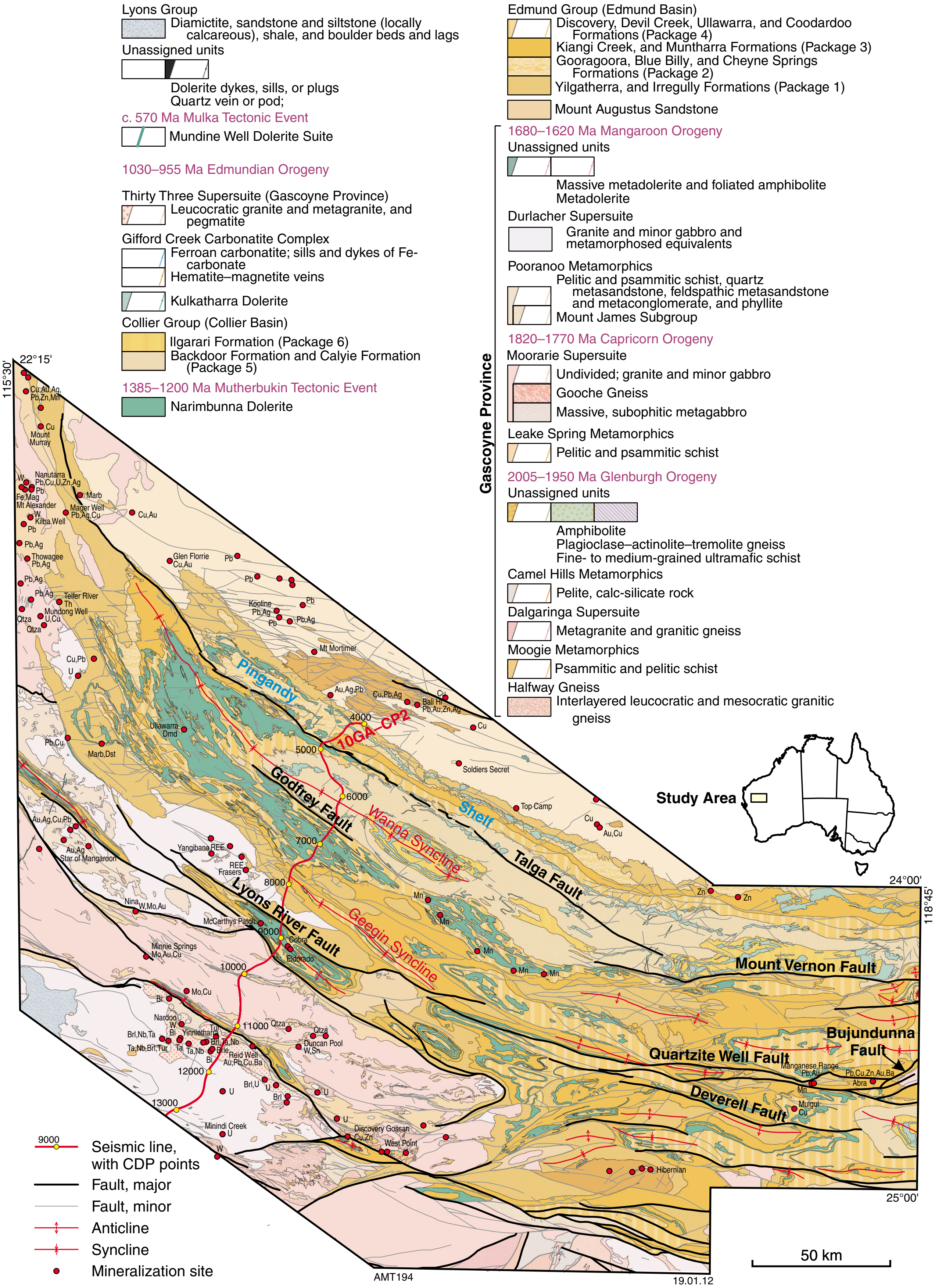

Figure 1. ***Geological map of the western Capricorn Orogen, showing the location of the principal structural elements within the Edmund and Collier Basins. The location of the deep seismic transect 10GA–CP2 is also shown.***

features are replicated in the Wanna Syncline, where the intensity of faulting is significantly greater in the Edmund Basin than in the Collier Basin. Although Mutherbukin and Edmundian structures are generally coaxial, an exception occurs in the western Wanna Syncline, where rocks of the Edmund Group's Depositional Package 1 record localized, north-northwesterly vergent reverse faulting and associated folding of the Mutherbukin Tectonic Event, which has been refolded during later, northeasterly directed compression during the Edmundian Orogeny.

Due to the brittle nature of faulting in the Edmund Group, direct age constraints on fault movements are rare. However, authigenic illite from a fault gouge that displaces sandstone and siltstone beds of the Kiangi Creek Formation (Fig. 2) has been dated at 1171 ± 25 Ma using the $^{40}K/^{40}Ar$ method (GSWA, unpublished data), which is close to the younger age limit of the Mutherbukin Tectonic Event.

Edmundian Orogeny (1030–955 Ma)

The 1030–955 Ma Edmundian Orogeny was responsible for low to very low grade metamorphism and transpressional folding in the Edmund and Collier Basins. Martin et al. (2005) identified three distinct deformation events ($D1_{ed}$, $D2_{ed}$, and $D3_{ed}$), although $D3_{ed}$ is now considered to be related to the c. 570 Mulka Tectonic Event. The main $D1_{ed}$ event resulted from northeast–southwest transpression, whereas the later $D2_{ed}$ event was caused by weak east-southeast to west-northwest compression. It is currently unclear how the $D1_{ed}$ and $D2_{ed}$ folding and faulting events in the Edmund and Collier Basins relate to localized amphibolite-grade metamorphism, deformation, and granite intrusion in basement rocks of the Gascoyne Province (Sheppard et al., 2007).

In the western and central Edmund and Collier Basins, the fold and fault structures trend west–east to northwest–southeast, and are concordant with both the general basin architecture and the regional-scale structures in the underlying Gascoyne Province basement. Faults are steep, and often occur as zones of quartz veining or brecciated quartz in an ironstone matrix. Folds are generally upright and open, but are tightened adjacent to faults, and generally plunge gently to the northwest or southeast.

Figure 2. ***A small-scale reverse fault (~50 cm displacement) and associated folding in siltstone and thin-bedded sandstone of the Kiangi Creek Formation. $^{40}K/^{40}Ar$ geochronology on the fault gouge indicates that the structure formed during the latter stages of the Mutherbukin Tectonic Event.***

Mulka Tectonic Event (c. 570 Ma)

The c. 570 Ma Mulka Tectonic Event is responsible for late-stage, dextral, brittle–ductile faults and shears, with associated quartz veins, in rocks of the Edmund and Collier Basins and Gascoyne Province. The faults also cut and offset dolerite dykes belonging to the c. 755 Ma Mundine Well Dolerite Suite (Sheppard et al., 2010).

Mineralization

The Edmund and Collier Basins have a history of minor gold, base metal, and phosphate production; however, a major orebody, the Abra polymetallic deposit, has also been discovered in these rocks. This deposit occurs in a fault-bounded structural corridor that links up with the mantle-tapping Lyons River Fault system, together with other prospective deposits, including vein-hosted gold mineralization at Cobra, and vein-hosted copper mineralization in Collier Group rocks at Ilgarari and Kumarina.

The formation of giant orebodies is often linked to the presence of crustal-scale plumbing systems that concentrate fluids, energy, and metals into specific sites in the crust. Many of these plumbing systems are intimately related to fossil subduction zones or old cratonic margins. The depositional and deformational history of the Edmund and Collier Basins was controlled by pre-existing crustal-scale structures in the underlying basement. These structures have also exercised a strong control on mineralization, with the multiply reactivated Paleoproterozoic fossil suture zone along the Lyons River Fault, in particular, appearing to have played a key role in orebody development (Tyler et al., 2011).

References

Johnson, SP, Cutten, HN, Tyler, IM, Korsch, RJ, Thorne, AM, Blay, O, Kennett, BLN, Blewett, RS, Joly, A, Dentith, MC, Aitken, ARA, Goodwin, J, Salmon, M, Reading, A, Boren, G, Ross, J, Costelloe, RD and Fomin, T 2011a, Preliminary interpretation of deep seismic reflection lines 10GA–CP2 and 10GA–CP3: crustal architecture of the Gascoyne Province, and Edmund and Collier Basins, *in* Capricorn Orogen seismic and magnetotelluric (MT) workshop 2011: extended abstracts (preliminary edition) *edited by* SP Johnson, AM Thorne, and IM Tyler: Geological Survey of Western Australia, Record 2011/25, p. 49–60.

Johnson, SP, Sheppard, S, Thorne, AM, Rasmussen, B, Fletcher, IR, Wingate, MTD and Cutten, HN 2011b, The role of the 1280–1250 Ma Mutherbukin Tectonic Event in shaping the crustal architecture and mineralization history of the Capricorn Orogen, *in* GSWA 2011 extended abstracts: promoting the prospectivity of Western Australia: Geological Survey of Western Australia, Record 2011/2, p. 1–3.

Korsch, RJ, Johnson, SP, Tyler, IM, Thorne, AM, Blewett, RS, Cutten, HN, Joly, A, Dentith, MC, Aitken, ARA, Goodwin, J and Kennett, BLN 2011, Geodynamic implications of the Capricorn deep seismic survey: from the Pilbara Craton to the Yilgarn Craton, *in* Capricorn Orogen seismic and magnetotelluric (MT) workshop 2011: extended abstracts (preliminary edition) *edited by* SP Johnson, AM Thorne, and IM Tyler: Geological Survey of Western Australia, Record 2011/25, p. 101–108.

Martin, DM and Thorne, AM 2004, Tectonic setting and basin evolution of the Bangemall Supergroup in the northwestern Capricorn Orogen: Precambrian Research, v. 128, p. 385–409.

Martin, DM, Sheppard, S and Thorne, AM 2005, Geology of the Maroonah, Ullawarra, Capricorn, Mangaroon, Edmund, and Elliott Creek 1:100 000 sheets: Geological Survey of Western Australia, 1:100 000 Geological Series Explanatory Notes, 65p.

Sheppard, S, Johnson, SP, Wingate, MTD, Kirkland, CL and Pirajno, F 2010, Explanatory Notes for the Gascoyne Province: Geological Survey of Western Australia, Perth, Western Australia, 336p.

Sheppard, S, Rasmussen, B, Muhling, JR, Farrell, TR and Fletcher, IR 2007, Grenvillian-aged orogenesis in the Palaeoproterozoic Gascoyne Complex, Western Australia: 1030–950 Ma reworking of the Proterozoic Capricorn Orogen: Journal of Metamorphic Geology, v. 25, p. 477–494.

Tyler, IM, Johnson, SP, Thorne, AM and Cutten, HN 2011, Implications of the Capricorn deep seismic survey for mineral systems, *in* Capricorn Orogen seismic and magnetotelluric (MT) workshop 2011: extended abstracts (preliminary edition) *edited by* SP Johnson, AM Thorne, and IM Tyler: Geological Survey of Western Australia, Record 2011/25, p. 109–114.