The role of the 1280–1250 Ma Mutherbukin Tectonic Event in shaping the crustal architecture and mineralization history of the Capricorn Orogen

by

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The Capricorn Orogen in central Western Australia records the juxtaposition of the Archean Pilbara and Yilgarn Cratons to form the West Australian Craton over a time period of two hundred million years, followed by one billion years of episodic continental reworking and reactivation. The orogen includes the deformed margins of the Pilbara and Yilgarn Cratons, granitic and medium- to high-grade metamorphic rocks of the Gascoyne Province, and numerous variably deformed Proterozoic sedimentary basins, including the Mesoproterozoic Edmund and Collier Basins that sit unconformably on the province. Much of the orogen is a greenfields region. It is host to a variety of intrusion- or shear zone-related and sedimentary-hosted mineral deposits. However, owing to the long and episodic nature of intracontinental reworking, the controls on mineralization and the structural evolution of these deposits are poorly understood. Elucidating the architecture and timing of reworking events in the orogen with respect to mineralization is a critical step in greatly improving exploration targeting.

Since 2005, a systematic program of SHRIMP U–Pb dating of monazite and xenotime from low- to medium-grade metasedimentary rocks of the Gascoyne Province and sedimentary rocks from the overlying Edmund Basin, has begun to unravel the complex history of reworking in the region. These data, when combined with 1:100 000-scale mapping and the crystallization ages of magmatic zircons from the igneous rocks of the province, demonstrate the distinct, punctuated nature of these tectonomagmatic events as briefly explained below.

Following final suturing of the West Australian Craton during the 2005–1950 Ma Glenburgh Orogeny, the Gascoyne Province was subject to reworking during the 1820–1770 Ma Capricorn Orogeny, the 1680–1620 Ma Mangaroon Orogeny, the 1280–1250 Ma Mutherbukin Tectonic Event, the 1030–955 Ma Edmundian Orogeny, and the c. 570 Ma Mulka Tectonic Event. The overlying Edmund Basin was faulted and/or folded during the Mutherbukin Tectonic Event, the Edmundian Orogeny, and the Mulka Tectonic Event. In this contribution we focus on the Mutherbukin Tectonic Event because of its potential to form hydrothermal mineral systems.

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Mutherbukin Tectonic Event

Gascoyne Province

Mineral assemblages and tectonic fabrics related to the Mutherbukin Tectonic Event occur within a 50 km-wide corridor bounded by the Ti Tree and Chalba shear zones directly south of the Minnie Creek batholith. However, discrete narrow shear zones of this age are also present within, and to the north of, the Minnie Creek batholith.

The primary expression of this event is a strong, steeply dipping schistosity in metasedimentary rocks, and a widely developed foliation or gneissic banding within metamorphosed granites. The fabrics trend east-southeast and parallel the main structural elements of the province. Garnet and staurolite-bearing semi-pelitic schists are on the south side of the Minnie Creek batholith. The schists pass into upper amphibolite facies granitic gneisses that locally preserve evidence for in situ melting. Both the metasedimentary rocks and gneissic granites contain a strong, shallow east-plunging mineral lineation that is parallel to the hinges of variable-scale, shear-related folds. Abundant shear-sense indicators in both the schists and granitic gneisses reveal sinistral transtensional shear regimes.

Dating of metamorphic monazite mainly from garnet–staurolite schists at widely spaced localities provides a range of ages between c. 1280 and c. 1210 Ma, interpreted as the age of deformation and metamorphism.

Edmund Basin

Field evidence for Mutherbukin-age deformation in the Edmund Group sedimentary rocks and underlying Mount Augustus Sandstone is more cryptic, because it is of very low metamorphic grade and restricted to narrow shear zones

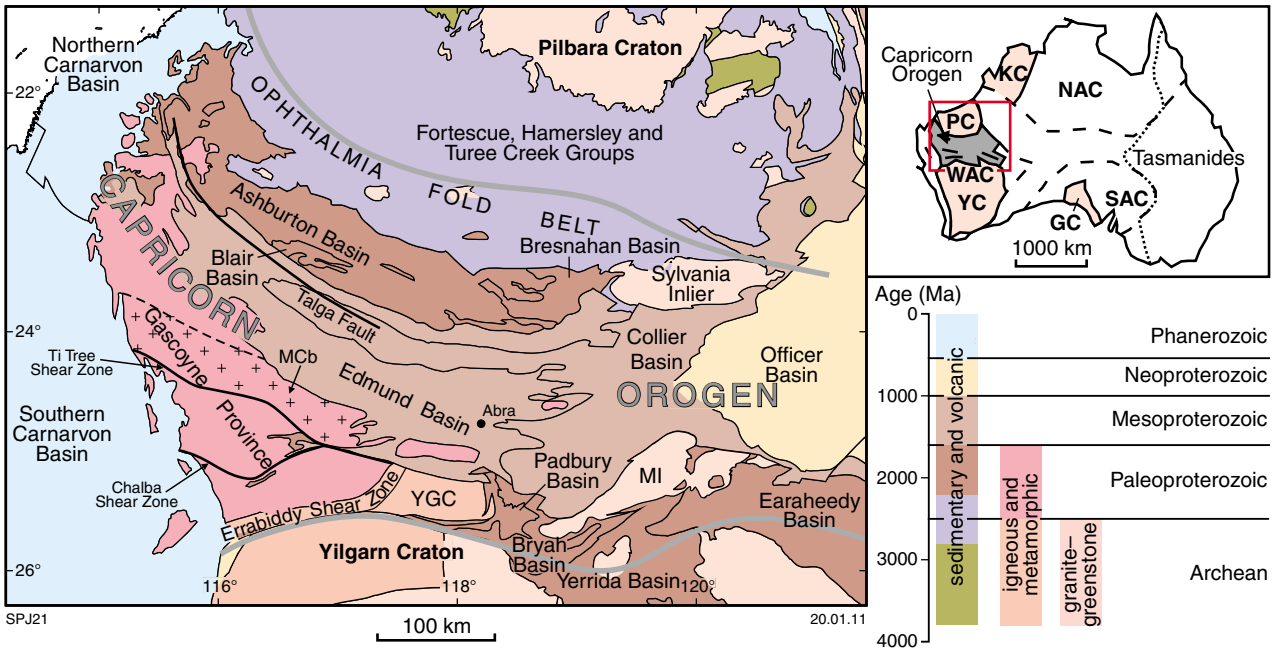

Figure 1. Elements of the Capricorn Orogen and surrounding cratons and basins; modified from Sheppard et al. (2010) and Martin and Thorne (2004). Abbreviations: YGC — Yarlarweelor Gneiss Complex; MCb — Minnie Creek batholith; MI — Marymia Inlier; modified from Myers et al. (1996)

and faults that were reactivated during the Edmundian Orogeny and Mulka Tectonic Event. However, abundant Mutherbukin-aged hydrothermal monazite and xenotime within these sedimentary rocks indicates that they were subject to low-grade metamorphism and hydrothermal alteration during this event.

Abra is a major polymetallic Pb–Ag–Cu–Au deposit within the lower Edmund Group. The deposit has been interpreted as part of a hydrothermal breccia-pipe system related to localized magmatism possibly associated with the nearby Tangadee Rhyolite (Pirajno et al., 2009). The geochronology of the deposit and surrounding sedimentary host rocks is complex. Hydrothermal monazite and xenotime suggest that mineralization occurred at c. 1385 Ma (Rasmussen et al., 2010) but this date is about 150 Ma older than the Re–Os date of c. 1280 Ma obtained on pyrite from the deposit itself (Pirajno et al., 2010). The age of the pyrite is similar to that (at c. 1235 Ma) of concentrically zoned, possibly magmatic, xenotime extracted from the Tangadee Rhyolite (Rasmussen et al., 2010). Irrespective of these geochronological complexities, these ages all demonstrate that this part of the Edmund Basin underwent a prolonged period of low-grade metamorphism, hydrothermal activity, and faulting, at a time when low- to medium-grade metamorphism and deformation was also affecting the underlying Gascoyne Province basement.

Architecture and mineralization

The Mutherbukin Tectonic Event may have been a relatively protracted intracontinental oblique strike-slip event, or series of events (c. 1385–1210 Ma), the driver of which is currently unknown. During the event, episodic magmatism and near-continuous shearing and faulting were accompanied by regional-scale hydrothermal fluid flow. The geological, geochronological, and geophysical data demonstrate that the major Mutherbukin-aged structures in the Gascoyne Province basement extend into the overlying Edmund Basin, albeit at much lower metamorphic and structural grade. Although the structures themselves may not be mineralized, they are essential for ore formation because they provided pathways for mineralizing fluids from the middle (and possibly lower) to upper crust. Magmatism, faulting, and the transport of hydrothermal fluids, appear to have played a critical role in the formation of the Abra polymetallic deposit. The regional-scale distribution of Mutherbukin-age structures and associated hydrothermal fluid flow, potentially makes this one of the most important primary mineralization events in the Capricorn Orogen, and targeted exploration in this region may lead to significant discoveries.

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