MOUNT CLEMENT
SYNGENETIC Au-Ag DEPOSIT

Introduction

- The Proterozoic Ashburton Basin is relatively underexplored, but hosts a number of small vein-hosted gold and base metal deposits (Fig. 1).
- Mount Clement is one of the larger gold deposits (~64,000 Oz Au at 1.77g/t, ~620,000 Oz Ag at 17 g/t; Border, 2012), and has been interpreted as either epigenetic or syngenetic-exhalative.
- Field mapping, visual and hyperspectral logging of two drill cores, and thin section petrography support a syngenetic exhalative origin, which has implications for regional mineral prospectivity and geodynamic evolution of the Ashburton Basin.

Geological Setting

- The Ashburton Basin forms the northern part of the Proterozoic Capricorn Orogen. It is dominated by fine- to coarse-grained clastic sediment, felsic to mafic volcanic rock, banded iron-formation, and dolostone of the Ashburton Formation (Thorne, 2016). Tuffaceous layers in the upper Ashburton Formation have ages of 1829 ± 5 Ma (Sircombe, 2003) and 1806 ± 9 Ma (Nelson, 2004).

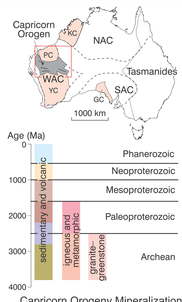
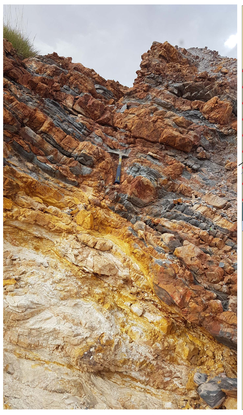


Figure 1. Map of the Capricorn Orogen showing the location of Mount Clement and other deposits of the Ashburton Basin that formed in response to the Capricorn Orogeny. GC: Gawler Craton; KC: Kimberley Craton; MI: Marymia Inlier; NAC: North Australian Craton; PC: Pilbara Craton; SAC: South Australian Craton; WAC: West Australian Craton; YC: Yilgarn Craton; YGC: Yarlarweelor Gneiss Complex.

- The Ashburton Formation mostly lies conformably on the Duck Creek Dolomite, but is unconformable on the Fortescue Group at the western closure of the Wyloo Dome, and disconformable on the 1799 ± 8 Ma June Hill Volcanics, north of the Wyloo Dome (Evans et al., 2003). The Ashburton Formation is unconformably overlain by rocks of the Capricorn, Mount Minnie, Bresnahan, and Edmund Groups, and by Mesozoic rocks of the Carnarvon Basin.
- The northern Capricorn Orogen experienced low-grade metamorphism and tight to isoclinal, non-cylindrical folds and associated strike-slip faults during two regional deformation events of the 1820 to 1770 Ma Capricorn Orogeny (Johnson et al., 2016). Granites of the Moorarie Supersuite intruded the Ashburton Formation at c.1817 – 1773 Ma (Nelson, 1999; Wingate et al., 2014; Fig. 4).
- Mount Clement is hosted by fine-grained sediments of the Ashburton Formation. Chlorite-, sericite-, and iron-altered clastic sediments are interlayered with sporadic intervals of stratabound (intraformational?) breccia and cherty chemical sediments. The base of the deposit is composed of massive carbonate which shows some talc alteration.
- Gold is fine-grained and dispersed throughout all local rock units, but highest grades are associated with gossans and secondary Cu-arsenate minerals chenevixite and conichalcite in talc and breccia layers (Fig. 2).



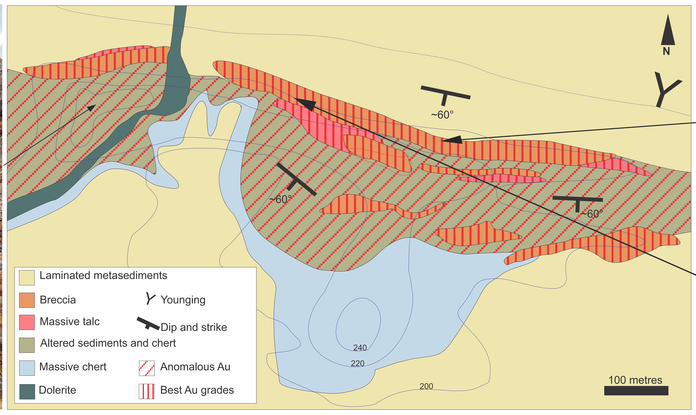


Figure 2. Deposit-scale map of the Mount Clement deposit. Contours are elevation in metres ASL (above sea level). Locations of photos indicated by arrows: Left - alternating stratabound layers of chert and siltstone and sandstone. Top-right - breccia with angular chert clasts in a quartz and goethite matrix; the clasts are up to boulder size. Bottom right - secondary Cu-arsenate mineral conichalcite (green) in a gossan outcrop. Some boxwork textures can been seen at small scale.

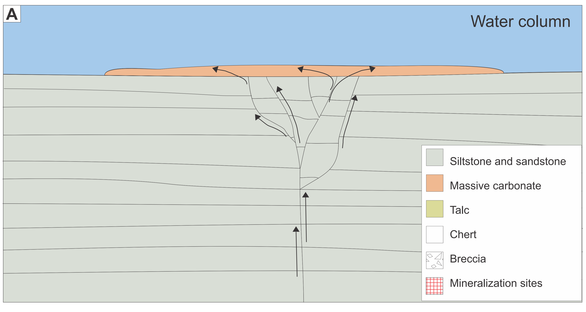
Metallogenesis

The geological setting of gold mineralization at Mount Clement suggests a hydrothermal vent-type depositional environment. The proposed metallogenic model invokes:

- Disruption of siliciclastic sediments by syndepositional faulting.
- Venting of early, carbonate-rich hydrothermal fluids at the ocean floor to deposit massive carbonate proximal to the hydrothermal vent, and mixed siliciclastic and carbonate deposits more distally (Fig 3A).
- Waning of hydrothermal fluid activity and return of dominantly siliciclastic sedimentation, but with intermittent venting of higher-temperature, silica-rich hydrothermal fluids, which deposited chemical chert layers at surface, and in the subsurface altered underlying massive dolomite to talc and formed breccia layers as vents became sealed by impermeable chert layers and eventually failed due to over pressurization and hydraulic fracturing (Fig. 3B).
- Gold and base metal sulfides were transported in the silica-rich fluids, and deposited in talc, chert, breccia, and altered clastic sediments. The last hydrothermal pulse produced massive chert at the top of the deposit, following which regional clastic sedimentation continued (Fig. 3B).
- Supergene processes weathered sulfides, remobilizing gold and base metals and depositing them as secondary minerals along cracks and voids.

Age of Gold Mineralization

- No minerals suitable for dating were found at Mount Clement, hence an age for the syngenetic gold mineralization is estimated from that of the Ashburton Formation.
- The age of the Ashburton Formation is poorly constrained to lie between c. 2008 Ma (the minimum age of the underlying Wyloo Group; Müller et al., 2005) and 1796 ± 9 Ma (the age of the Boolaloo Granodiorite that intrudes the Ashburton Formation; Wingate et al., 2014).
- A crystal-vitric tuff stratigraphically equivalent to Mount Clement has an age of 1806 ± 9 Ma (Nelson, 2004), and further indicates a magmatic event that perhaps provided a driver for hydrothermal processes at Mount Clement.
- Mount Clement is therefore interpreted to have formed between c.1806 Ma and c. 1796 Ma, or during the Capricorn Orogeny.



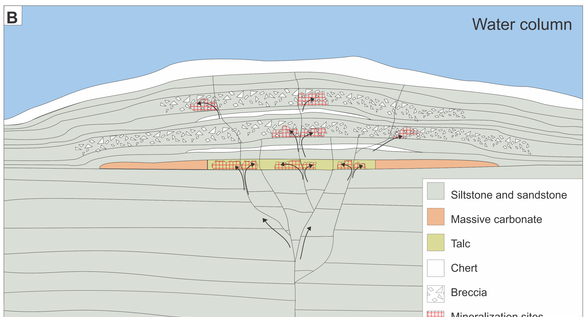


Figure 3. Stylized schematic of the formation of the Mount Clement deposit. Arrows indicate fluid flow. (A)Early venting of carbonate-rich fluids and deposition of massive carbonate; (B) Later venting of silica-rich, gold-mineralizing fluids.

A Capricorn Orogen Mineral System?

- There are other mineral deposits in the Ashburton Basin that also appear to have formed during the Capricorn Orogeny (Fig. 1):
  - Several small, quartz vein-hosted gold and base metal deposits formed during regional D2 deformation of the Ashburton Fold Belt (dated between 1786 ± 5 and 1784 ± 5 Ma; Thorne and Seymour, 1991; Krapez and McNaughton, 1999; Nelson, 2004).
  - Emplacement of the Moorarie Supersuite into the Ashburton Formation between c.1817 and 1773 Ma produced tungsten-skarn mineralization at Mount Alexander and Kilba Well (Davies, 1998, Nelson, 1999, and Wingate et al., 2014).
  - VMS deposits occur in the Ashburton Formation at Mount Stuart and Yarraloola (Doust, 1984).
  - The first mineralizing hydrothermal event at Mount Olympus occurred at c.1770 Ma (Fielding et al., 2017).

Conclusions

- Mount Clement is an exhalative-style gold deposit formed during deposition of the Ashburton Formation.
- The ages of the Mount Clement gold deposit and the host Ashburton Formation are poorly constrained to be between c.1806 Ma and c.1796 Ma.
- Mount Clement and the Ashburton Formation formed in an intracratonic foreland basin associated with the onset of crustal reworking during the Capricorn Orogeny (e.g. Tyler and Thorne, 1990; Thorne and Seymour, 1991; and Evans et al., 2003).
- The Capricorn Orogeny represents a potentially unrecognised mineralizing system that produced gold and base metal deposits throughout the Ashburton Basin.

References

Border, A 2012, Annual report for the period ending 31 December 2011 on E08/1606, E08/1841, M08/191, M08/192, M08/193: Artemis Resources Limited: Geological Survey of Western Australia, Statutory mineral exploration report, A92995 (Public).

Davies, BM 1998, Proterozoic zoned tungsten-bearing skarns and associated intrusives of the northwest Gascoyne Complex, Western Australia: unpublished Geological Survey of Western Australia Report 63.

Doust, G 1984, Stratiform polymetallic sulphide mineralization: An exploration perspective for the Ashburton basin, W.A.: James Cook University, Masters thesis (unpublished), 185p.

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 1805–1755 Ma: Diachroneity of the Pilbara–Yilgarn collision: Australian Journal of Earth Sciences, v. 50, no. 6, p. 853–864.

Fielding, IOH, Johnson, SP, Zi, J-W, Sheppard, S and Rasmussen, B, 2017, Linking multiple gold mineralization events to reactivation of crustal-scale faults: Geological Survey of Western Australia annual lectures

Johnson, SP, Thorne, AM, Sheppard, S and Korhonen, FJ 2016, Capricorn Orogeny (CC): Geological Survey of Western Australia, WA Geology Online, Explanatory Notes extract, viewed 05 February 2018, www.dmp.wa.gov.au/ens.

Krapez, B and McNaughton, NJ 1999, SHRIMP zircon U–Pb age and tectonic significance of the Paleoproterozoic Boolaloo Granodiorite in the Ashburton Province, Western Australia: Australian Journal of Earth Sciences, v. 46, p. 673–682.

Müller, SG, Krapez, B, Barley, ME and Fletcher, IR 2005, Giant iron-ore deposits of the Hamersley province related to the breakup of Paleoproterozoic Australia: New insights from in situ SHRIMP dating of baddeleyite from mafic intrusions: Geology, v. 33, no. 7, p. 577–580.

Nelson, DR 1999, 142931: biotite-muscovite-oligoclase granodiorite dyke, Two Wells: Geochronology Record 318: Geological Survey of Western Australia, 4p.

Nelson, DR 2004, 148922: crystal-vitric tuff, Koonong Pool: Geochronology Record 249: Geological Survey of Western Australia, 4p.

Thorne, AM 2016, Wyloo Group (P_WY-s): Geological Survey of Western Australia, WA Geology Online, Explanatory Notes extract, viewed 05 February 2018, www.dmp.wa.gov.au/ens.

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

Tyler, IM and Thorne, AM 1990, The northern margin of the Capricorn Orogen, Western Australia — an example of an early Proterozoic collision zone: Journal of Structural Geology, v. 12, p. 685–701.

Wingate, MTD, Kirkland, CL, Thorne, AM and Johnson, SP 2014, 169865: biotite granodiorite, Stuarts Well: Geochronology Record 1208: Geological Survey of Western Australia, 4p.

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