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Broken Hills District Epithermal Au-Ag Mineralisation

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Caption for cover page:

Gustav Nortje, MSc student, working underground, Broken Hills.

CONTEXT

The Broken Hills district is located on the southern portion of the Coromandel Peninsula (Figure 1), on the east of the North Island of New Zealand. The district is bounded to the north by the Hikuai township, to the east and south by the Kopu-Hikuai highway (State Highway 25A) and to the west by the Coromandel Ranges. The district is loosely defined by an area of low aeromagnetic signal, understood to be caused by the destruction of magnetite in volcanic rocks by hydrothermal fluids, and which therefore delineates the likely hydrothermal footprint of a paleo-hydrothermal system. The peninsula itself comprises the remnants of the extinct Coromandel Volcanic Zone, active between 18 and 2 Ma, producing steep, mountainous morphology, and numerous other epithermal deposits and prospects (Figure 1).

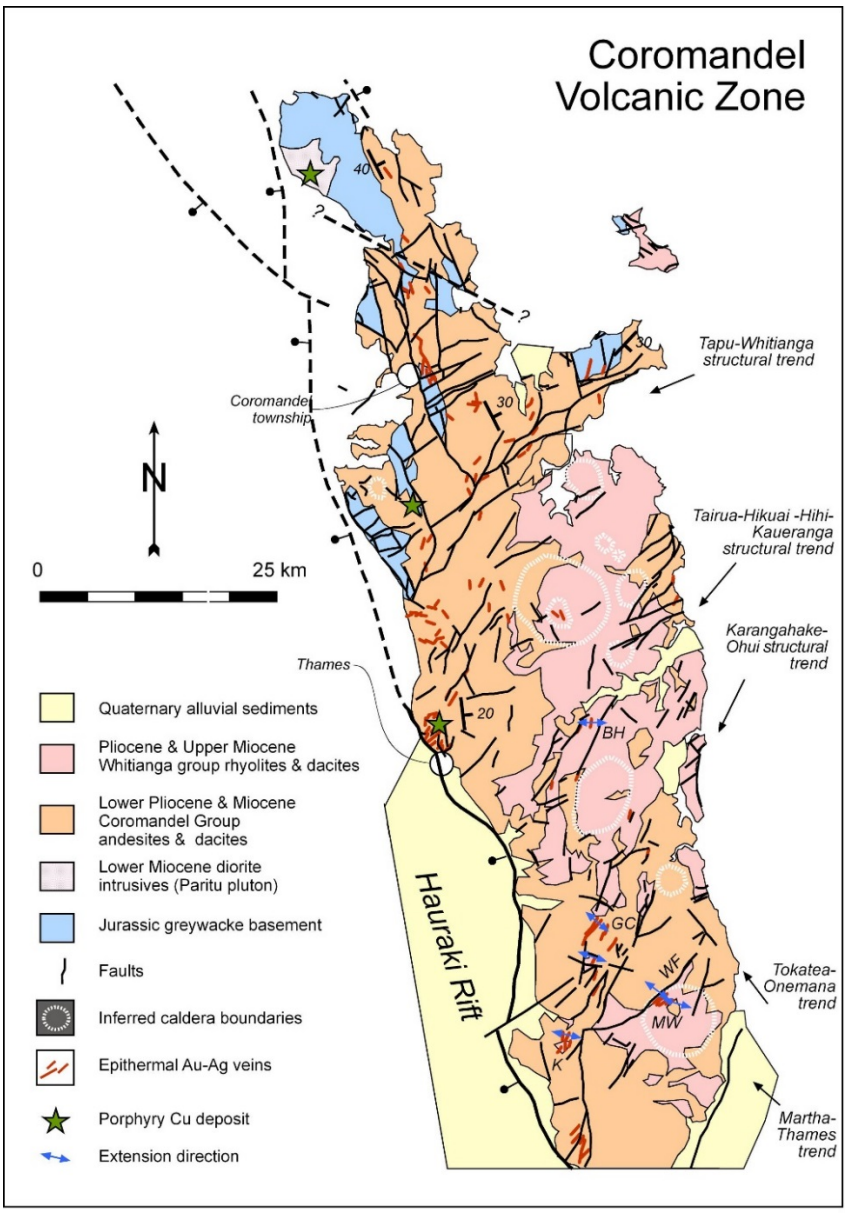

FIG 1 – Stratigraphic and structural map of the Coromandel Volcanic Zone (from Spörli *et al*, 2006 and Edbrooke, 2005) annotated with extension directions inferred for several deposits (from Mauk *et al*, 2011). Structural trends are annotated (after Christie *et al*, 2007). Thick lines show the trace of the Hauraki Rift border faults, dashed offshore, and are annotated with dip direction (balled line). Regional dip directions shown by strike and dip symbol annotated with approximate dip (from Edbrooke, 2005). Inferred caldera boundaries are shown by thick white dashed line (after Booden et al, 2012). BH = Broken Hills, GC = Golden Cross, K = Karangahake, MW = Martha-Waihi, WF = Waihi fault.

FIG 2 – Regional context and geography of Broken Hills district

GEOLOGY OF THE BROKEN HILLS DISTRICT

Exert from Nortje et al., 2006

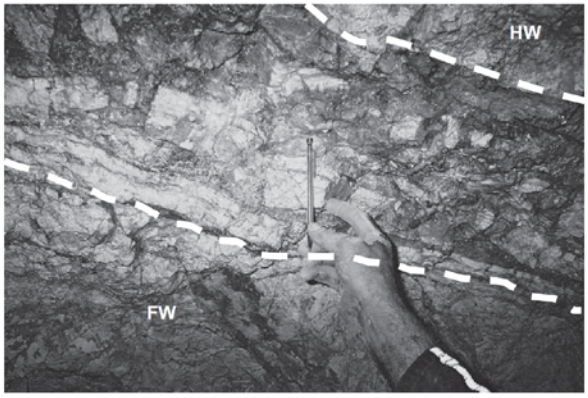

Fig. 2. Banded quartz along vein margins of the Blucher Reef (see Fig. 1a for location) with angular pieces of quartz that have been re-brecciated back into the vein. Hangingwall (HW) and footwall (FW) margins are shown by white dashed lines (Nortje, 2004).

2. Geological framework

From 15 Ma to 6 Ma, the Coromandel Peninsula, New Zealand was the site of arc volcanism associated with a subduction system trending northwesterly and lying to the east of Coromandel Peninsula (Fig. 1a) (Ballance, 1976). Volcanic products ranged from andesitic in the older centres to rhyolitic in the younger ones. Gold mineralisation occurred in the late stages of volcanism approximately 7 to 6 million years ago (Brathwaite et al., 1989). The Hauraki Goldfield has produced 1.37 million kg of gold-silver bullion (Brathwaite et al., 1989; Christie and Brathwaite, 1986). The major producer at present is Martha Mine in Waihi (Brathwaite et al., 1989), and Fig. 1a).

2.1. Broken Hills geology

Broken Hills is hosted in 5 Ma flow-banded rhyolites that are overlain by associated pyroclastic rocks. Surface sinter remnants located to the east of the deposit indicate that the paleo-thermal watertable was at approximately 150 m a.s.l. Given that the lowest mined level is at sea-level, gold deposition at Broken Hills most likely occurred over at least the uppermost 150 m of a fossil geothermal system.

Three major veins (Fig. 1a) hosted 1700 tons of gold-silver bullion mined out from 1899−1912 (Bell and Fraser, 1912). Although generally striking north-south, these structures are characterised by abrupt changes in vein orientation and thickness at the scale of observation (Nortje, 2004). The Blucher Reef has a general NNW strike, generally dips ∼75° WSW, with vein widths ranging from 10−90 cm, and mined grades of 15−20 g/t Au and 30 g/t Ag. The reef commonly exhibits banded quartz along its margins with a central zone comprising variable amounts and ratios of vein breccia, vein mixture, fine-grained hydrothermal quartz and clay gouge (Fig. 2). Vein mixture is microcrystalline brecciated vein material, most likely analogous to fault gouge.

The Pounon Reef, the second major structure along the main crosscut drive, is a splay branching north off the footwall of the Blucher Reef (Fig. 1a). It extends for ∼85 m along a northerly strike and dips steeply to the west. A zone of intense brecciation occurs at the Pounon-Blucher Reef intersection. Vein thickness ranges from 10−50 cm with an average mined grade of 5 to 40 g/t Au. At its northernmost extent, the vein thins into a clay gouge-bearing shear zone.

The Night Reef was only mined in the Battery Level (Fig. 1a). Where exposed, it occurs as banded quartz veneer on footwall and hanging wall surfaces. The vein formation is about 30−90 cm wide, with a NNE strike and steep dip to the WSW. However, at its northernmost extent it bends sharply to the east to intersect the hanging wall of the Blucher Reef. In this vicinity, the vein and host rock are extensively brecciated.

The No. 1 Reef is the third major reef intersected along the main crosscut drive and has an orientation similar to the other major reefs (Fig. 1a). Its northern half is currently inaccessible because of unstable ground. Mined grades of the stopped section were approximately 15 g/t Au but unmined sections have an average grade of <3 g/t Au. The No. 1 Reef is brecciated and puggy. Vein thicknesses range from 10−30 cm.

Breccia veins are typically 1−5 cm in size, comprising brecciated host rock and quartz vein fragments. Dominant orientations for breccia veins are WSW-ENE and WNW-ESE (Fig. 1b). There is no documented evidence to suggest that these structures carry gold.

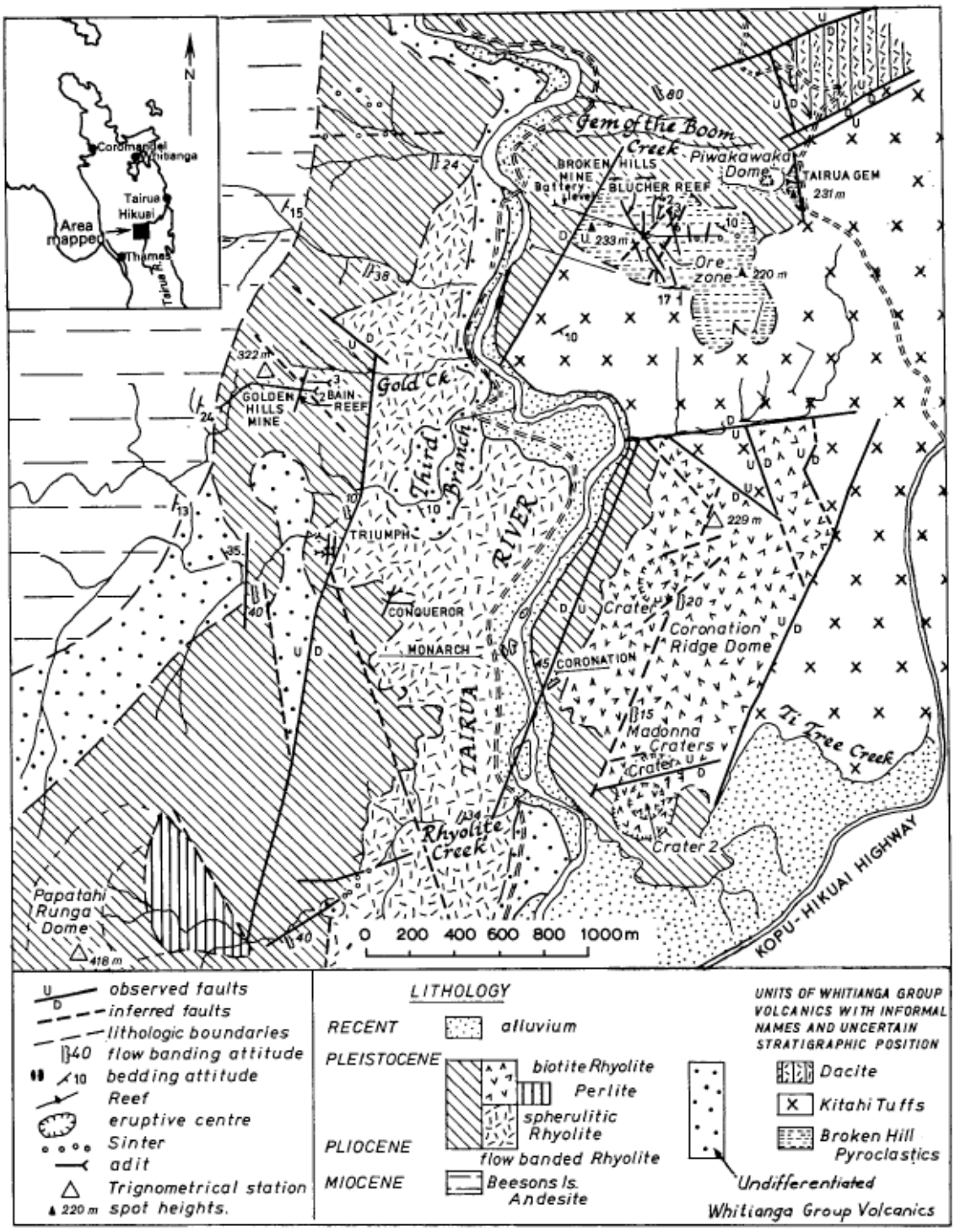

FIG 3 – Geology of the Broken Hills district mapped by Moore (1979)

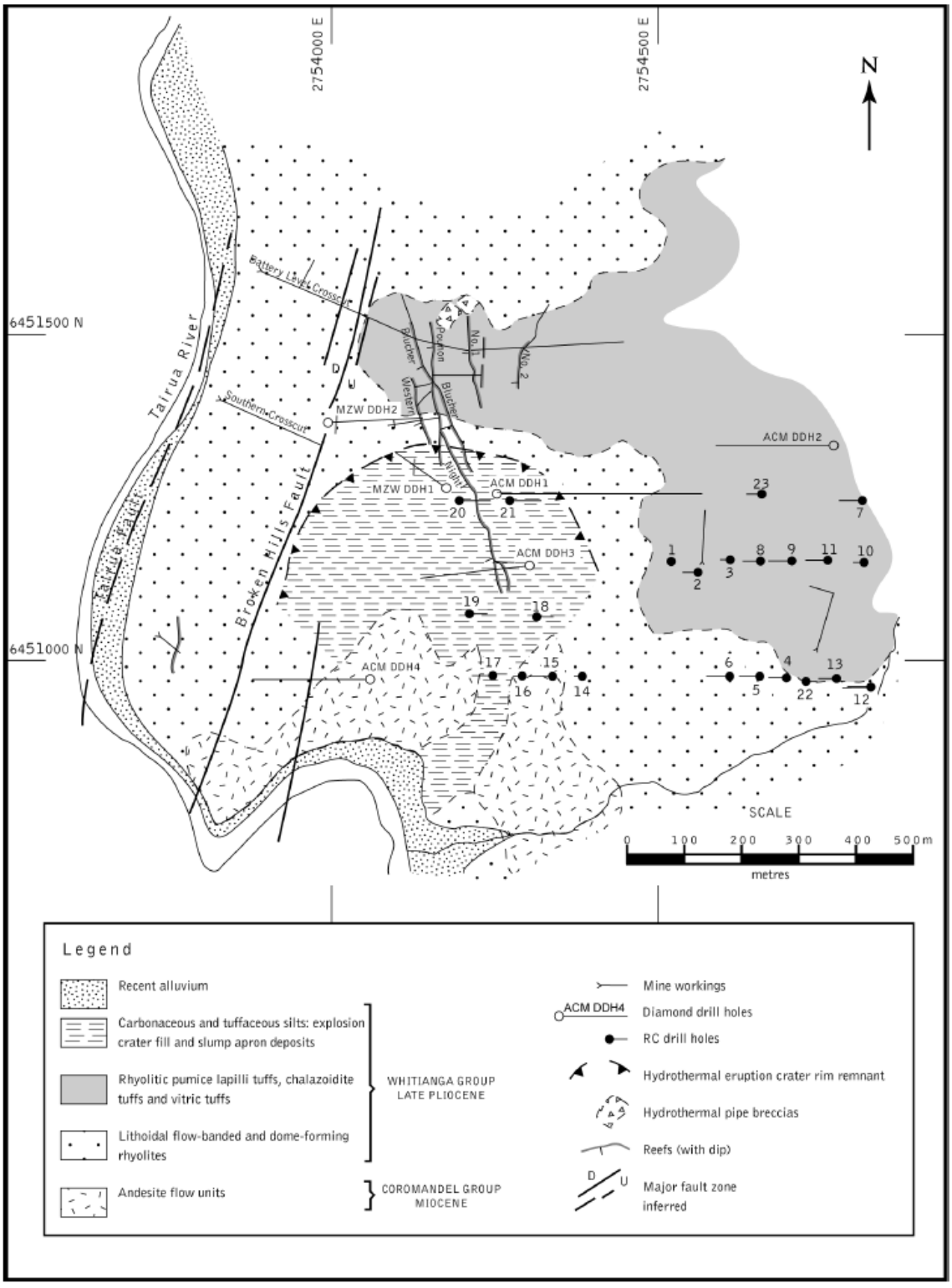

FIG 4 - Detailed map of the geology of Broken Hills (Rabone, 2006).

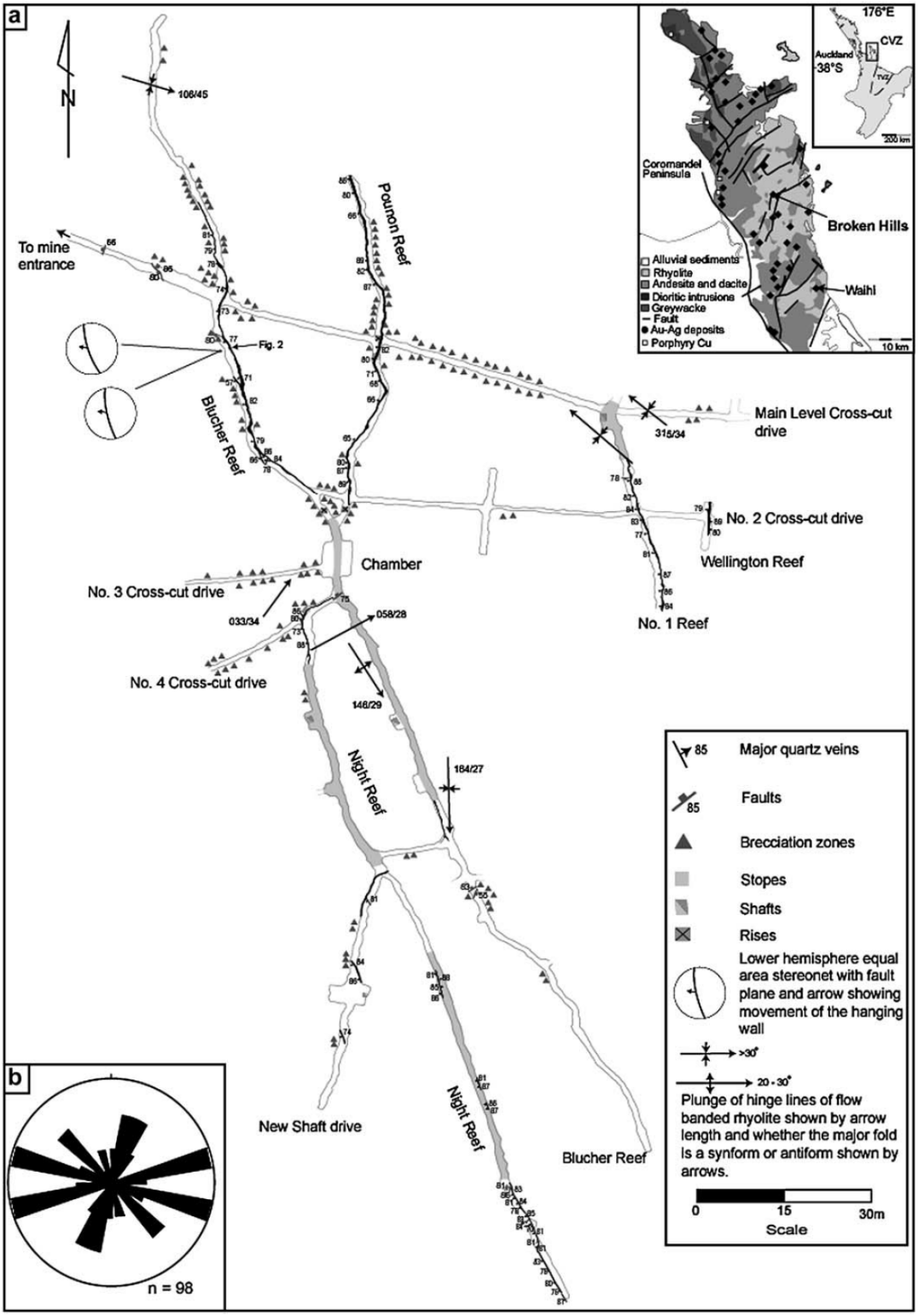

FIG 5 – a) Simplified map of the Broken Hills Au-Ag deposit (Nortje et al., 2006). B) Rose diagram of breccia veins.

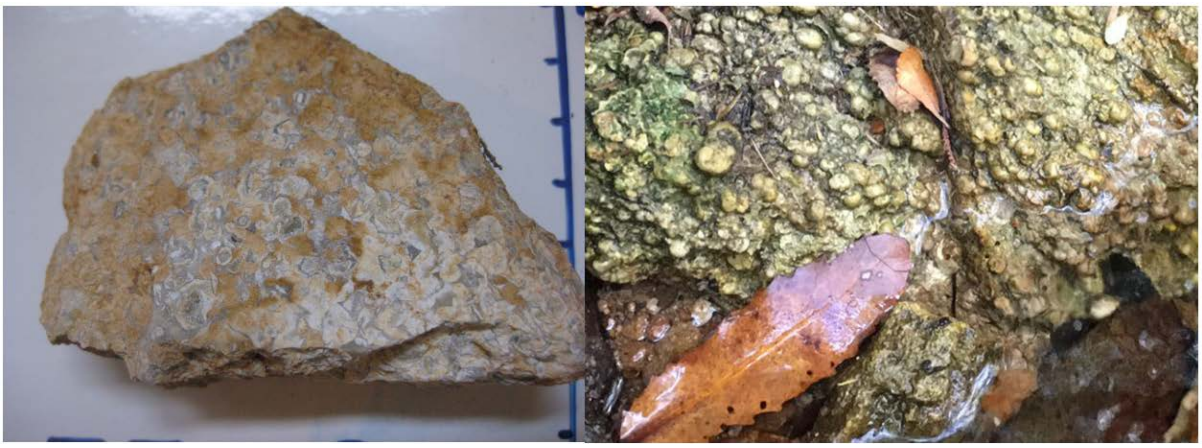

FIG 6 – silicified spherulitic rhyolite. This texture manifests sporadically in the flow-banded Minden Rhyolite, one of the dominant lithologies.

FIG 7 – left – flow-banded rhyolite, part of the Minden Rhyolite subgroup. Very common in Broken Hills – hosts a number of the major gold veins in BH; in locations distal from veining, zeolites such as mordenite are common in vugs and fractures. Right – highly altered and silicified rhyolitic ignimbrite: this caps the underlying flow-banded rhyolites.

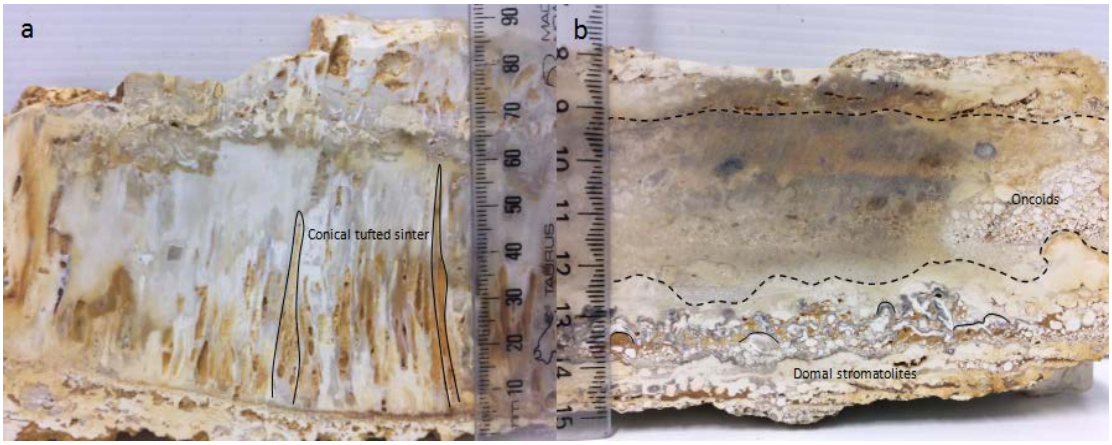

FIG 8 – siliceous sinter float collected approximately 1km to the southeast of Broken Hills mine

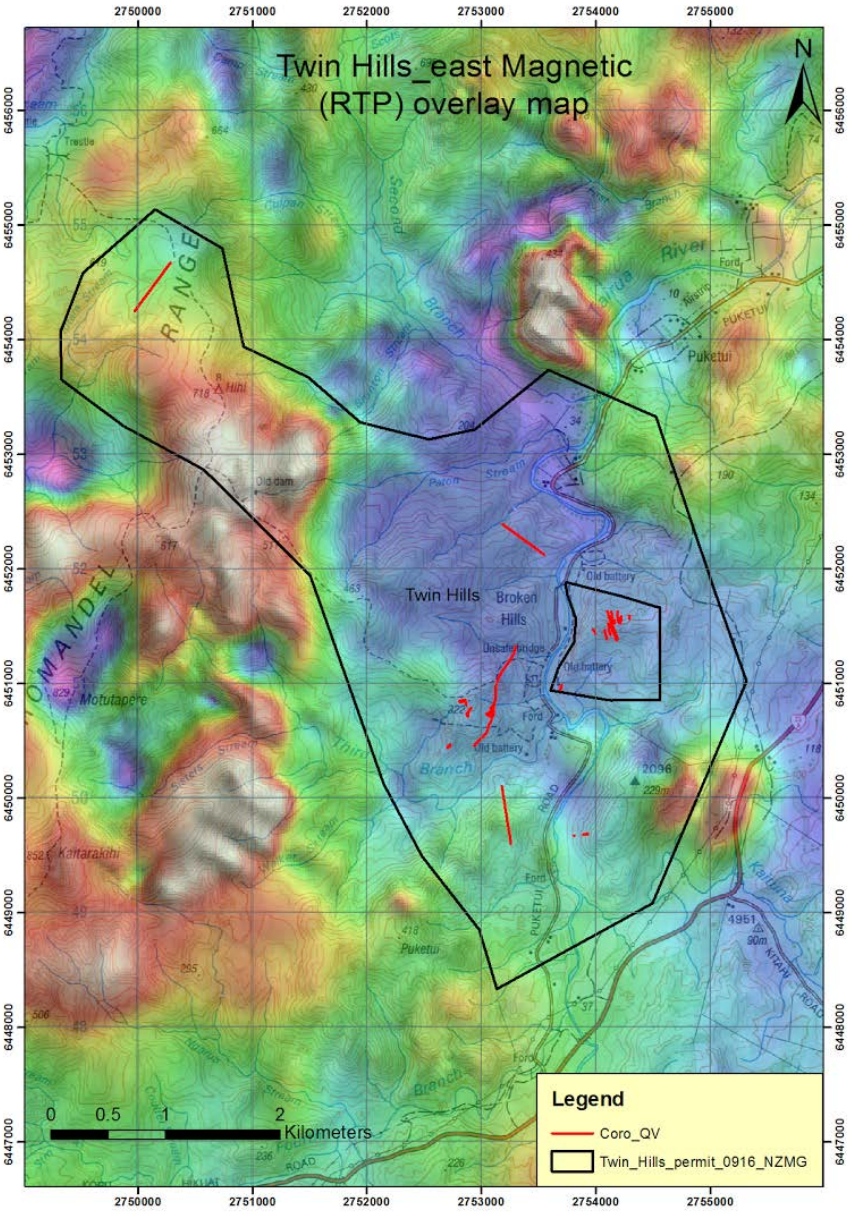

Figure 9. An aeromagnetic image of the Broken Hills district showing the location of tenements and veins. The Broken Hills mine is the smaller tenement. Red = magnetic high.

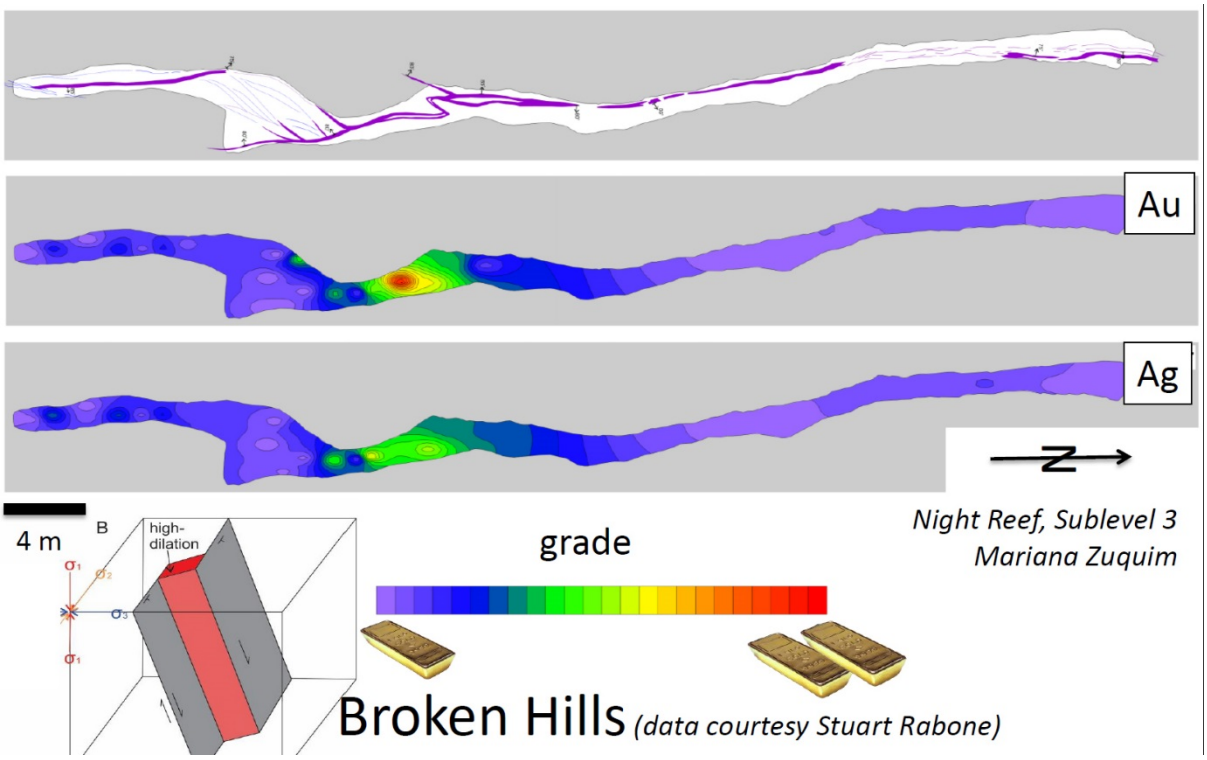

FIG 10 – Detail of structure in the Night Reef, colour-coded with grade (red = high).

Recommended reading

Downey, J. F. (1935). Gold mines of the Hauraki district: Wellington, New Zealand, New Zealand Govt.

Moore, C. R. (1979). Geology and mineralisation of the former Broken Hills gold mine, Hikuai, Coromandel, New Zealand. *New Zealand Journal of Geology and Geophysics*, *22*(3), 339-351.

Rabone, S. D. C. (2006). Broken Hills rhyolite-hosted high level epithermal vein system, Hauraki goldfield—100 years on. *Geology and exploration of New Zealand mineral deposits. Australas Inst Min Metall Monogr*, *25*, 117-122.

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