Exploration at Te Puke, Hauraki Goldfield — The Last 30 Years

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ABSTRACT

Epithermal Au-Ag mineralisation occurs in the Te Puke area in the Western Bay of Plenty region on the front of the Papamoa horst block, hosted in a Late Pliocene andesitic sequence with minor associated rhyolitic units. The vein-bearing rocks are generally covered by 30 - 50 m of late Pleistocene (0.22 Ma) Mamaku Ignimbrite units in the area. The epithermal system comprises a broad NNE-trending belt of quartz vein development, including several well defined reefs (notably Muir's reef and Massey's reef), which have been extensively investigated and worked historically. Muir's reef was the ninth largest producer in the Hauraki Goldfield on a tonnage basis, yielding 43 000 oz Au equivalent from 64 000 t mined between 1920 and 1924. Exploration drilling in the 1980s and 1990s investigated the area north and NNE of the previously mined reefs under the late Pleistocene to Recent ash cover, and established the presence of an extensive broad quartz vein stockwork zone with widespread low grade gold mineralisation, north of Muir's reef. The overall extent of the vein system is more than 2 km along strike, and over 1 km wide. However, exploration has been hampered by the thick ash cover and the dimensions and configuration of the system are not defined.

The system is an adularia-sericite type, with the mineralisation being dominated by electrum without significant associated silver minerals or other sulfides. Alteration is predominantly propylitic-argillic, with relatively narrow envelopes of higher temperature quartz-adularia alteration adjacent to the known reefs, although silicification appears more extensive in the quartz vein stockwork zone to the north of Muir's reef. Structural aspects of the vein zones suggest the system formed in a frontal wedge of the Papamoa horst block in dilational jogs within a belt of dextral transcurrent and normal faulting. Significantly mineralised vein/reef zones appear to be preferentially hosted in a competent fine-grained andesite lava flow unit, and veins are weakly developed in associated epiclastic tuff formations, indicating significant lithological control on vein system development.

Keywords: adularia, drilling, electrum, epithermal, andesite, Mamaku Ignimbrite, Massey's reef, Muir's reef, Papamoa horst, Te Puke, Au, Ag.

INTRODUCTION

Epithermal Au-Ag mineralisation is located at the southern extremity of the Hauraki Goldfield in the Te Puke area, 12 km west of the town of Te Puke in the western Bay of Plenty (Figure 1). As such it is transitional geographically, and possibly also geologically and temporally, with the younger geothermal activity and deposits of the Taupo Volcanic Zone.

Several reefs were discovered in this area at the turn of the 20th century, hosted in andesitic volcanic rocks largely covered by thick late Pleistocene to Recent rhyolitic volcanic ash cover. The only productive reef was Muir's reef, which was worked until the late 1920s.

From the late 1960s to early 1990s the area was reinvestigated with a number of geophysical and drilling programs, which established that the vein system is significantly more extensive under the ash cover. However, no new economic mineralisation was discovered.

HISTORY

Prospecting was carried out in the area as early as 1895, in two areas known as Clarke's Freehold (north of the Wairapukao Stream) and Fleming's Freehold to the south. Several adits were driven in the former area, but nothing of value was found. In Fleming's Freehold, a large reef, initially called Fleming's, but subsequently known as Massey's reef, located north of Raparapahoe Stream, was investigated by several adits up to 1901. This reef was found to be low grade, and no further work was done until 1914 when G Muir acquired the ground and reassessed it (Downey, 1935). After initial investigation of Massey's reef, he turned his attention (following the advice of an experienced prospector) to a prominent spur about 300 m to the NE of Massey's. A cross-cut put into this spur discovered a reef zone subsequently known as Muir's reef, which was found to carry significant values, and was developed vigorously over the next five years. This reef was mined systematically through to 1924, producing some 64 000 tonnes for 43 000 oz Au equivalent (Downey, 1935). Subsequently a shaft was put down from surface to a depth of about 150 m, from which cross-cuts were put out at 7 level to test both Massey's and Muir's reefs, but no significant veining was encountered in either, and all work ceased in 1928.

Little work was done in the area until the early 1960s, and in 1969 the area was taken up by Mineral Resources (NZ) Ltd. Over the following 25 years a number of exploration programs were carried out, most notably by BP Oil NZ Ltd in the 1980s under joint venture with Mineral Resources, and subsequently in the early 1990s by Mineral Resources themselves (Slater, 1987; Rabone, 1995). The BP Oil NZ Ltd program included the drilling of eight diamond drill holes, mainly testing at depth and immediately along strike of Massey's and Muir's reefs, and RC drilling along strike to the north of Muir's reef. Their drilling was

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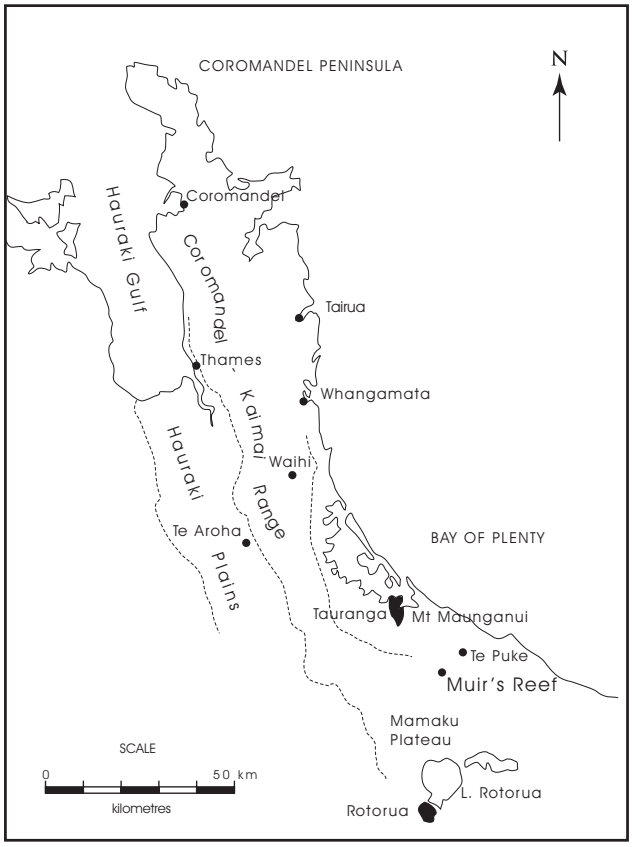

FIG 1 - Location map, Muir's Reefs, Te Puke, Western Bay of Plenty, North Island, New Zealand.

somewhat restricted in scope by the position of the then prospecting licence eastern boundary, and when this was revised under a new tenement in 1993, Mineral Resources subsequently carried out further rotary and RC drilling programs testing the area NE of Muir's reef beneath the Mamaku Ignimbrite cover. These RC programs demonstrated that a broad zone of complex quartz stockwork veining continues NNE from Muir's reef for over 800 m, but increasing thickness of ash cover made continued investigation difficult, and results problematic to interpret, and Mineral Resources withdrew from further exploration in 1998.

LOCAL STRATIGRAPHY

Mineralisation at Te Puke is hosted in an andesitic sequence of probable late Pliocene age on the eastern frontal flank of the Papamoa horst block. Drilling data indicate that the host rock sequence in the vicinity of Massey's – Muir's reefs comprises an upper pyroclastic unit that contains some rhyolitic component, underlain by a massive andesitic lava flow unit about 100 m thick that hosts the upper part of Massey's reef and the intermediate part of Muir's. This flow is underlain by bedded epiclastic tuffs that are approximately 50 m thick, and include some carbonaceous siltstone horizons. Underlying this tuff unit is a xenolithic andesitic lava flow. Stipp (1968) obtained K -Ar ages of 2.95 and 2.54 Ma from andesite units in the Papamoa Range in the general vicinity of Muir's reef that may be broadly correlative with the vein-hosting andesitic sequence.

This andesitic sequence is unconformably overlain by Mamaku Ignimbrite ash and pumice lapilli tuff units (0.22 ma; Houghton *et al*, 1995), which range in thickness from 10 to 50 m, being thinnest on the buried topographic spurs of the Massey's and Muir's reef zones. The Mamaku Ignimbrite units are subhorizontal, although close to the contact with the underlying andesites they drape the palaeotopography. On the basis of drill hole data and information from the original shaft workings, the andesitic sequence appears to dip gently to the east, in contrast to the apparent westerly back-tilt of the Papamoa horst. This suggests the veining may be located in a subsidiary downfaulted wedge in front of (ie east of) the main horst block itself.

VEIN STRUCTURE AND MINERALISATION

The two main vein zones in the area, Massey's and Muir's reefs (Figure 2), both have overall NNE strike, and dip west at high angles, or are subvertical. Massey's reef, as exposed at surface in an open cut and in shallow adits, is a broad zone of massive to complexly banded quartz in total up to 25 m wide, but more typically about 10 m wide. However, the zone is generally low grade, with only narrow bands of the reef zone containing gold values exceeding 5 g/t. At the surface, it shows some broad zones of significant mineralisation, averaging 3.5 g/t Au over a 20 m width across the open cut and in adjacent shallow adits. However, diamond drill testing to about 50 m below surface by BP Oil NZ Ltd in their drill holes TP3-5, showed only narrow widths of significant grade, with the highest gold value of 5.6 g/t Au over 1.4 m in TP4 (Slater, 1987). Gold:silver ratios in significantly mineralised bands are in the range 3:1 to 1.5:1.

Massey's reef is known over a strike length of approximately 350 m, from No 3 level North, in the north, to BP's DDH TP5 to the south; 200 m further to the south of TP5, near the Raparapahoe Stream, several adits have been driven on a zone of chalcedonic quartz veining known as the Blue reef. This lies more or less along strike southward from Massey's reef and may be part of the same reef zone, or an en-echelon fissure. The veining in the Blue reef area is low grade (<0.3 g/t Au), although some high values have been obtained from selective sampling, (up to 130 g/t Au). Its structure is complex, with several cross-cutting zones of WNW faulting. Although the overall trend of Massey's reef is NNE, individual vein structures commonly have strike directions that are more NE, suggesting the reef zone is a series of en echelon tension gashes within a belt of NNE dextral transcurrent faulting.

Muir's reef, as defined by mine level development, has a strike length of over 450 m, but is much narrower than Massey's, generally in the range 0.5 to 2 m wide, with some minor branch veins. It appears to be cross-cut by several WNW fault zones in its northern part, and ENE faults in the south (Figure 2). Although developed vertically over seven levels, the vertical range of the ore shoot was between 1 and 4 levels, ie less than 100 m, within the horizon where the reef is hosted by the andesitic lava flow unit.

BP Oil NZ Ltd's diamond drilling tested the historically worked extent of Muir's reef in four drill holes, TP1, TP2, TP6 and TP7 (Figure 2). TP1 intersected the reef zone about at 1 level, encountering a stope and an adjacent reef remnant assaying 23 g/t Au. TP 2, 130 m to the south of TP1, showed that there was a zone of stockwork veining about 20 m wide adjacent to the main reef, but that this was not significantly gold-anomalous. TP6 tested 90 m below surface and 20 m below 3 level (the lowest level where the reef carried payable values historically), near the south end of the workings, where it showed the reef to be 2 m wide, but low grade (0.4 g/t Au: 50 per cent core recovery). DDH TP7 was intended as a deep test of the reef below 7 level (220 m below 3 level). A CSAMT anomaly was also outlined here and that had been interpreted to represent a zone of quartz veining. However, no veining was found and the drill hole traversed a 50 m zone of sheared andesite at about the inferred position of Muir's reef.

Muir's reef has not been investigated southward of the workings except by geophysical surveys (CSAMT and Gradient

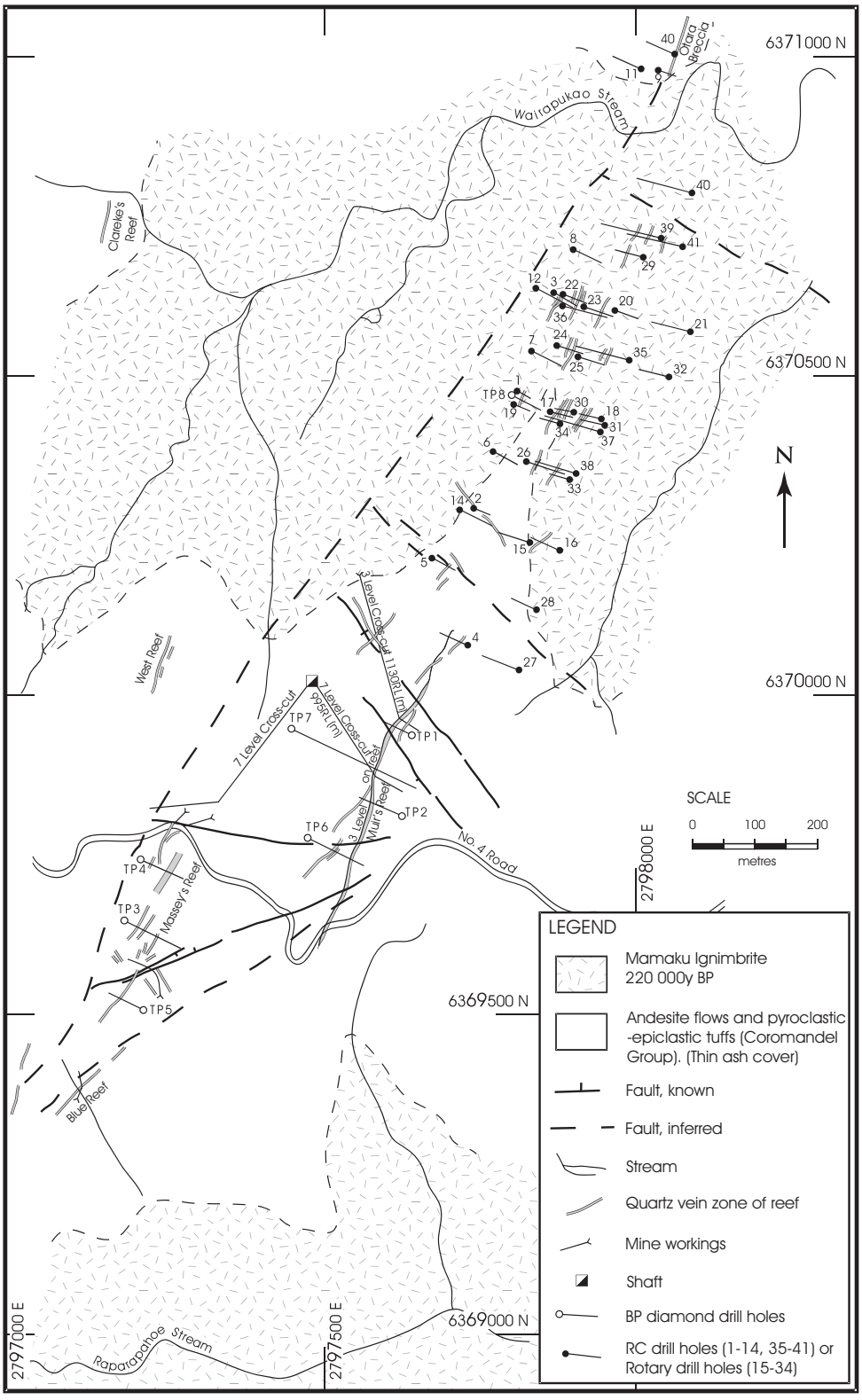

FIG 2 - Generalised geology of the Muir's Reefs area, No 4 Road, Te Puke, showing historically worked reefs, stockwork zones and locations of diamond, rotary and reverse circulation drill holes.

Array), which indicate it may continue southward along strike for some 500 m to Raparapahoe Stream. To the north of the mine workings, its inferred strike projection has been tested by shallow RC and diamond drilling by BP Oil NZ Ltd (RC1-14, DDH TP8; Slater, 1987), and by shallow rotary and RC drilling by Mineral Resources (R15-34, RC35-41; Rabone, 1995).

These drilling programs covered a strike extent of 800 m and tested a belt of country some 150 - 200 m wide. The drilling showed that a broad zone of stockwork or sheeted style quartz veins extends NNE of Muir's reef under cover of some 30 - 50 m of Mamaku Ignimbrite units for a distance of over 700 m. The full width of the zone is not defined, but locally exceeds 100 m.

This stockwork zone carries widespread low-grade gold mineralisation, typically ranging between 0.5 and 1.5 g/t Au; in RC36 a section of the zone averaged 1.4 g/t Au over an 18 m interval, while in RC39 an 8 m interval averaged 3.4 g/t Au. The vein zones generally comprise oxidised silicified andesite and banded white chalcedonic quartz and platy quartz after calcite.

Drill testing of this zone has (with the limited exception of TP8) been by rotary and RC methods, which has hampered accurate sampling and has limited geological interpretation. The zone has only been tested to approximately 120 m below surface, equivalent to a depth of 50 - 80 m below the base of the ash-ignimbrite cover.

North of this stockwork zone, towards Wairapukao Stream, there appears to be a pronounced structural break along an east-west trend, but thick cover hampers interpretation. To the north, veining and alteration appear to be much less extensive. To the north of Wairapukao Stream a distinctively different zone of mineralisation is exposed in the Otara area (Clarke's Freehold), and known as the Otara breccia (Slater, 1988). This comprises a narrow N-striking, moderately E-dipping (45 - 60^{o}) zone of polymict milled breccia on the contact between the andesite and a younger rhyolitic unit. The breccia zone is relatively narrow (<0.5 m), but has significant strike extent, being mapped for over 1100 m from north of Wairapukao Stream. It contains quartz-adularia altered clasts in a siliceous matrix, with arsenopyrite-pyrite mineralisation accompanied by antimony and minor Au-Ag. However, the highest gold value from rock sampling or drilling of the breccia by BP Oil NZ Ltd was 6.7 g/t Au. While the breccia shows a high temperature alteration assemblage (quartz-adularia-illite), alteration of the adjacent host rock is much lower-temperature (chlorite-illite/smectite) (Slater, 1988). The relationship between the Otara breccia and the Muir's and Massey's reef zones is not established.

A N-striking zone of quartz stockwork veining (known as Clarke's reef) is exposed in a small adit in Wairapukao Stream 800 m west of the stockwork zone outlined by drilling north of Muir's reef (Figure 2). This zone assayed 3 g/t Au, but investigation has been limited, in part due to poor exposure. Nevertheless, it shows that the development of veining in the overall area has considerable extent 'across strike'.

West reef, to the north of Massey's reef (Figure 2), is only exposed as surface floaters of banded chalcedonic quartz, and no drilling has been carried out to investigate it; its extent is not known.

HYDROTHERMAL ALTERATION

Interpretation of the hydrothermal alteration pattern is hampered by poor exposure, although there appears to be a central higher temperature zone associated with Muir's reef and its northerly stockwork continuation. This central zone is characterised by narrow envelopes of higher-rank alteration and a rapid transition to pervasive propylitic assemblages. Peripheral areas to the north and south (eg in the area of the Blue reef) show lower temperature argillic assemblages.

From limited investigations higher rank alteration is phyllic-potassic (quartz-adularia-illite), and indicates possible maximum temperatures of ~300°C; a phlogopite-magnetite assemblage was found in alteration envelopes in TP3 (Maxwell, in Slater, 1987). Limited fluid inclusion data indicate temperatures in the range 150 - 220°C, and interlayered smectite-illite clays in the Blue reef area indicate temperatures of ~150°C (Hedenquist, in Slater, 1987).

The veining in Muir's and Massey's reefs contains a significant amount of adularia, and the gold mineralisation occurs as electrum grains on quartz-adularia laminations within the veining (Simmons, in Slater, 1987). The electrum Au:Ag ratio is similar to the overall Au:Ag ratio from historical production, and from BP Oil NZ Ltd's sampling, indicating the absence of significant amounts of associated silver sulfides (or their supergene alteration products).

The limited collective alteration and mineralisation data suggest the Massey's – Muir's zone has been deposited in an adularia sericite epithermal system. The age of the mineralisation is not known and will only be definitively established by dating of alteration minerals from the deposit itself, but if it is inferred that the Papamoa andesite units dated by Stipp (1968) are stratigraphically correlative with the vein-hosting andesitic sequence, then a Late Pliocene or Lower Pleistocene age can be inferred for the vein system.

CONCLUSIONS

The epithermal system at Te Puke is an adularia-sericite type. The system is dominated by two reef zones, Massey's and Muir's. These appear to lie en echelon to each other, possibly in tension gash-type fissures developed in dilational jogs along a NNE belt of normal-transcurrent faulting fronting the Papamoa horst block.

The known strike length of the vein zone is nearly 2 km, not including the further northward continuation of the Otara breccia, and the vein zone has an extent normal to strike of over 1 km. It accordingly represents a system of significant extent, but which is not fully defined because of the thick late Pleistocene to Recent covering ash units.

Data from historical mining and recent drilling programs suggest that host rock lithologies have played an important role in the development of the system, with the significantly mineralised and physically more strongly developed veins hosted in a massive andesite lava flow unit, and weaker veining in underlying epiclastic tuffs.

Both Massey's and Muir's reefs are zones of resistant silicification and quartz veining, and formed palaeotopographic highs, which cropped out above the onlapping Mamaku Ignimbrite cover, a fortunate combination of circumstances that contributed to their discovery. However, the general extent and thickness of the cover precludes the evaluation of the true extent and potential of the system.

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