Epithermal gold-silver deposits in New Zealand: a new wall poster

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Abstract

The epithermal gold-silver deposits wall poster is one in a series of posters on different mineral deposit types being produced by GNS Science to raise awareness of the characteristics of New Zealand mineral deposits and their prospectivity.

Epithermal deposits consist of quartz veins, quartz vein stockworks and hydrothermal breccias that are mainly hosted in subaerial andesitic or rhyolitic rocks of Tertiary age. The deposits were formed at depths of typically less than 1 km and at temperatures between 180° and 320°C, although ore-grade mineralisation was generally deposited at less than 270°C.

In New Zealand, epithermal deposits occur in association with late Cenozoic volcanic rocks in the Northland, Coromandel and Taupo volcanic regions. All of the past and present gold production, estimated at greater than 380 t (along with 1300 t Ag) comes from the Miocene-Pliocene Coromandel Volcanic Zone, where about 50 epithermal gold-silver deposits occur over a 200 km long belt. In Northland, silver and mercury have been produced from hot spring type epithermal deposits, and several gold-silver prospects have been identified. Ore-grade gold-silver mineralisation is currently being deposited in several active geothermal fields of the Taupo Volcanic Zone, and extinct geothermal systems occur on the western side of the zone. The active systems have provided natural laboratories to help understand the processes of epithermal mineralisation.

Keywords: *Epithermal, gold, silver, Tertiary, Quaternary, andesite, rhyolite, Northland, Coromandel Volcanic Zone, Taupo Volcanic Zone*

Introduction

The epithermal gold-silver deposits wall poster is one in a series of posters on different mineral deposit types being produced by GNS Science to raise awareness of the characteristics of New Zealand mineral deposits and their prospectivity. The main target audience is the minerals industry (mainly exploration geologists) and tertiary-level geology students. Each poster in the series contains summary information on the characteristics of the specific mineral deposit type and descriptions of occurrences in New Zealand. The information for the epithermal poster and this paper draws mainly from Christie and Brathwaite (1997, 2003).

Characteristics

World-wide, epithermal gold deposits comprise quartz vein, breccia and stockwork mineralisation formed at depths from near surface down to about 1500 m, at temperatures between 180-300°C, and from fluids with salinities generally less than 3 equivalent wt.% NaCl (Cooke & Simmons, 2000). Epithermal deposits occur predominantly in subaerial, felsic to silicic volcanic terrains

in volcano-plutonic arcs associated with subduction zones. Most deposits in the world are of Tertiary age, because older ones have generally been eroded away. Two main types are recognised: adularia-sericite and acid-sulfate (Heald et al., 1987).

Adularia-sericite deposits

Adularia-sericite deposits are characterised by the presence of sulfide minerals with a low sulfur/metal ratio, such as pyrite, sphalerite, galena and chalcopyrite. They are associated with calc-alkalic to alkalic, andesite, dacite and rhyolite. Hydrothermal alteration typically consists of quartz-adularia±sericite "silicification" adjacent to veins, grading outward to chlorite-calcite-epidote "propylitic" and/or illite-smectite mixed-layer clay "argillic" alteration. The veins exhibit open-space filling textures, crustification, comb structure, colloform banding and multiple brecciation. Rarely preserved sinter terraces and hydrothermal eruption breccias represent the surface expressions of the deposits. Gold occurs mainly as electrum, with rare gold-silver sulfosalt and telluride minerals. The electrum is accompanied by acanthite (argentite), pyrite, sphalerite, galena, chalcopyrite and tetrahedrite, with marcasite or arsenopyrite present in some deposits. Quartz, calcite and adularia are the gangue minerals. International examples found in andesitic rocks include Comstock in Nevada; Hishikari in Japan; Colqui in Peru; Baguio in the Philippines and Pajingo in Queensland, whereas Round Mountain and Sleeper in Nevada are examples hosted in rhyolitic rocks. Deposits associated with alkalic rocks include the gold telluride-bearing deposits at Cripple Creek in Colorado and Vatakoula in Fiji.

Acid-sulfate deposits

Acid-sulfate deposits are characterised by the presence of sulfide minerals with a high sulfur/metal ratio, such as enargite/luzonite and tetrahedrite. They are associated with calc-alkalic andesite, dacite and rhyodacite, and were probably formed within or below stratovolcanoes and above porphyry copper systems. Advanced argillic alteration with alunite and pyrophyllite, and acid-leached rock represented by vuggy, residual silica are characteristic. International examples include: Goldfield in Nevada; Summitville in Colorado; Nansatsu in Japan; Yanacocha in Peru; El Indio in Chile; Temora in New South Wales; and Lepanto and Nalesbitan in the Philippines.

Epithermal gold-silver deposits in New Zealand

Introduction

Epithermal gold-silver deposits occur in New Zealand associated with Tertiary-Recent volcanic rocks mainly in the Northland, Coromandel and Taupo volcanic zones (Fig. 1A; Brathwaite & Pirajno, 1993). Gold and silver production has nearly all been from the Coromandel Volcanic Zone, but there are also known Au-Ag prospects in Northland and the Taupo Volcanic Zone. Furthermore, many of the active geothermal systems in the Taupo Volcanic Zone are known to be forming gold-silver mineralisation and are considered modern analogues of epithermal gold-silver deposits. Research on these modern geothermal systems has helped establish genetic models for epithermal gold deposits worldwide.

Coromandel Volcanic Zone and Hauraki Goldfield

Some 50 separate epithermal Au-Ag deposits are associated with Miocene-Pliocene calc-alkaline volcanic rocks of the Coromandel Volcanic Zone in a 200-km long by 40-km wide metallogenic belt that constitutes the Hauraki Goldfield (Brathwaite & Piranjo, 1993; Brathwaite et al., 1989; Fig. 1B). The Hauraki Goldfield has a recorded (1862-present) production of more than 380 t of gold and 1300 t of silver, mostly from deposits hosted by andesite and dacite, although a few veins in rhyolite and basement greywacke were also worked. The Waihi (Martha Hill) deposit is by far the largest, with total gold production to date of about 202 t (6.5 M oz), ranking it as a

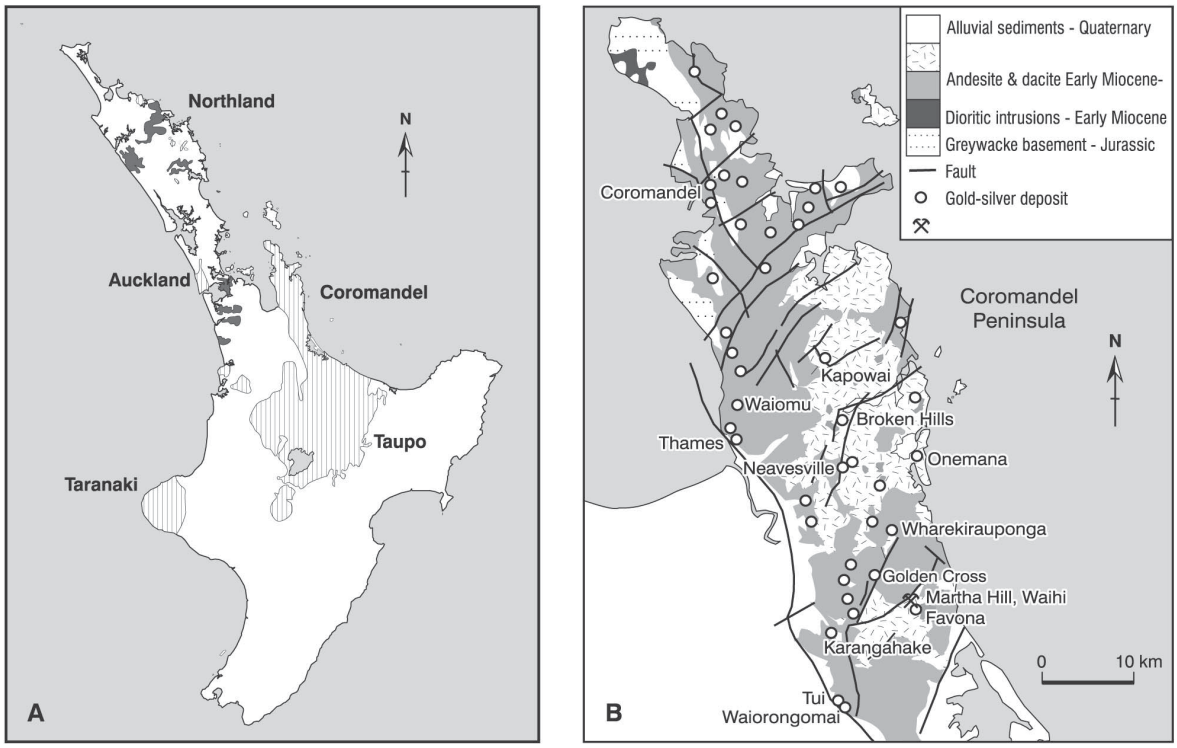

Figure I. A. Location of Cenozoic volcanic rocks in the North Island (vertical pattern denotes andesite, dacite and rhyolite, whereas black fill denotes basalt), and B. Coromandel Volcanic Zone geology and mineral deposits.

world class deposit. Major production also came from Golden Cross (37.1 t Au), Karangahake (29.4 t Au) and the Thames field (21.8 t Au).

The Au-Ag mineralisation occurs predominantly in quartz veins along tectonically-controlled fault-fracture systems, which are parallel with the main regional fault trends. The quartz veins dip at steep to moderate angles and are typically 0.3-5.0 m wide, 200-1600 m long, and have depth extents of 170-300 m. A few larger veins display a greater depth range (400-700 m) as at Waihi and Karangahake. Stockwork quartz veins are present in some deposits (e.g. Golden Cross). The quartz veins are surrounded by extensive zones of propylitic and clay alteration characterised by chlorite, calcite, illite, smectite and pyrite as hydrothermal minerals. Higher rank alteration with strong silicification plus adularia and/or illite borders the quartz veins.

The main ore minerals are electrum and acanthite. They are associated with pyrite and variable, though usually minor, amounts of sphalerite, galena and chalcopyrite. Pyrargyrite, gold and silver tellurides and selenides, arsenopyrite, tetrahedrite, stibnite, and cinnabar are found in some deposits. The main gangue minerals are quartz and calcite (commonly with lattice texture). Vein textures comprise crustiform and rhythmic banding made up of chalcedonic and mesocrystalline quartz with sulfides. Hydrothermal breccias are also common.

Northland Region

Several hot spring type epithermal deposits are known in Northland related to Pliocene rhyolitic volcanism that is accompanied and succeeded by Pliocene-Pleistocene basaltic volcanism (Brown, 1989; Brathwaite & Pirajno, 1993; Fig. 2A). Small quantities of silver and mercury have been produced at Puhipuhi and mercury at Ngawha, and several Au-Ag prospects are known, but there has been no gold production to date. The best known prospect is at Puhipuhi (Fig. 2A), partly because of classic exposures of Hg-Sb-bearing sinter (Mt Mitchell and Plum Duff) and hydrothermal eruption breccias (Plum Duff). Limited exploration drilling has intersected some gold-rich zones (e.g. 10 m averaging 5.3 g/t Au and 18.5 g/t Ag).

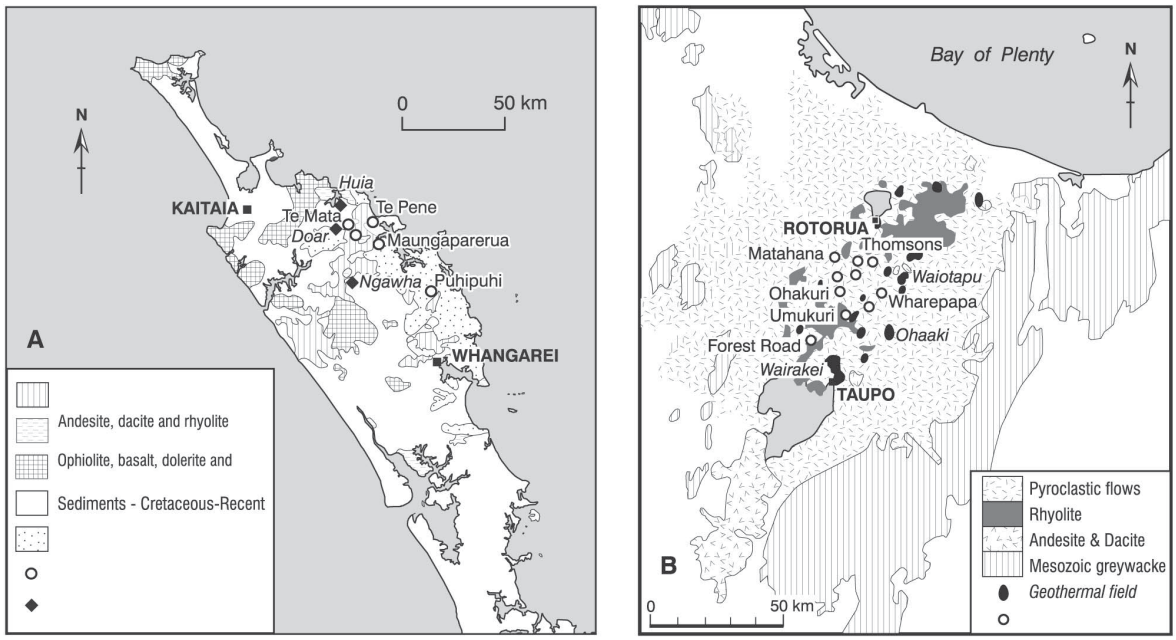

Figure 2. Geology and epithermal deposits in A. Northland and B. Taupo Volcanic Zone.

Taupo Volcanic Zone (TVZ)

The Taupo Volcanic Zone contains young volcanic rocks (<2 Ma) of calc-alkaline composition, mainly rhyolitic tephras, ignimbrites and lavas, with minor dacite and andesite lavas. The region has elevated heat flow resulting from thin crust (15 km) intruded by magma. The convective heat flow is manifested by 17 high-temperature geothermal fields, each about 10-20 km^2 in area, which are mainly confined to the currently active eastern side of the Taupo Volcanic Zone (Fig. 2B). A number of extinct geothermal systems have been recognised in the western side of the zone.

Ore-grade gold-silver mineralisation is currently being deposited in several active geothermal fields, including Ohaaki and Waiotapu. The mineralisation is found in surface siliceous sinters, subsurface quartz veinlets, quartz infilling cavities and silicified hydrothermal breccias, and disseminated in wallrock. Highly mineralised precipitates, with up to 6% Au, have also been found in drillhole discharges and pipes during development of the geothermal fields for electricity generation (Brown, 1986). The metals are present in the geothermal waters at low concentrations (e.g. around 1 ppb Au) and therefore deposition of high grade mineralisation represents considerable concentration by depositional mechanisms such as boiling. Some of the active geothermal systems such as Ohaaki, Waiotapu and Rotokawa have been identified as models for epithermal gold-silver deposition (Cooke and Simmons, 2000).

Several epithermal Au-Ag prospects have been identified (Fig. 2B), but to date, only the Ohakuri prospect has been tested with a major exploration drilling programme. At Ohakuri, rhyolitic pyroclastic rocks of the Ohakuri Ignimbrite Group are hydrothermally altered over an area of at least 15 km^2. Drilling to the north of the Waikato River outlined a large, low grade gold deposit (126 million tonnes at 0.38 g/t Au and 8.5 g/t Ag) within a flat-lying zone between 50 and 300 m depth (Grieve 2000).

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Bob Brathwaite has BSc and MSc degrees from Victoria University of Wellington, and a PhD from the University of Tasmania. He spent 15 years in mine and exploration geology in Australia with several major mining companies. In 1979 he joined the New Zealand Geological Survey (now GNS Science), where he has been a Senior Minerals Geologist for the past 25 years.