Volcanogenic massive sulfide deposits in New Zealand

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Abstract

In New Zealand, volcanogenic massive sulfide (VMS) deposits are found in three main geological environments associated with (1) ophiolitic basalts of Oligocene age in Northland and East Cape (e.g. Pupuke, Pakotai, Parakao and Lottin Point), (2) with chert and pillow lava in greywacke sequences of Permian-Jurassic age (Torlesse and Waipapa terranes; e.g. Kawau Island, Te Kumi and Maharahara), and their metamorphic equivalents (Haast Schist; e.g. Moke Creek and Waitahuna), and (3) with greenschists (metabasalts) and metaserpentinite of Permian-Triassic age (Ponamu Ultramafics) in Westland (e.g. Bowen and Wilberg ranges). The deposits consist of small lenses of disseminated to massive sulfide minerals, mainly pyrite and chalcopyrite. Small quantities of copper ore were mined from some deposits in the 1800s (e.g. Kawau Island from 1846), with the last mining at Parakao from 1961 to 1966. Several deposits have been recently examined for their gold potential with assays on sulfide rock samples as high as 75 g/t Au (Lottin Point).

Keywords: *Volcanogenic massive sulfide, copper, gold, zinc, barite, basalt*

Introduction

GNS Science has commenced a project on onshore volcanogenic massive sulfide (VMS) deposits to compliment its project on offshore VMS deposits in the Kermadec Arc. The onshore VMS project commenced with a literature review and compilation of a summary report as well as data sheets for the main deposits. This has been followed with a GIS data compilation of exploration data for the East Cape area (e.g. Lottin Point) and some field work. This paper is the first output of the project and provides a brief summary of VMS deposits in New Zealand.

VMS deposits are formed by sea floor hydrothermal systems generated by submarine volcanic activity. The first metalliferous mining in New Zealand was production of copper ore from a VMS deposit on Kawau Island from 1846 to 1860 (Fig. 1). The known VMS deposits in New Zealand consist of small lenses composed mainly of pyrite and chalcopyrite that are associated with (1) marine basalts of Cretaceous age in Northland and near East Cape, (2) with chert and pillow lava in greywacke sequences of Permian-Jurassic age, and their metamorphic equivalents, and (3) with greenschists (metabasalts) and metaserpentinite of Permian-Triassic age in Westland (Fig. 1). Exploration from the 1970s has focussed mainly on prospects at Lottin Point and Te Kumi near East Cape, and the Maharahara deposit in the Ruahine Ranges.

VMS deposits associated with ophiolitic basalts

Previously mined VMS copper deposits at Pupuke, Pakotai and Parakao in Northland, and some VMS shows at Lottin Point near East Cape are associated with allochthonous ophiolitic

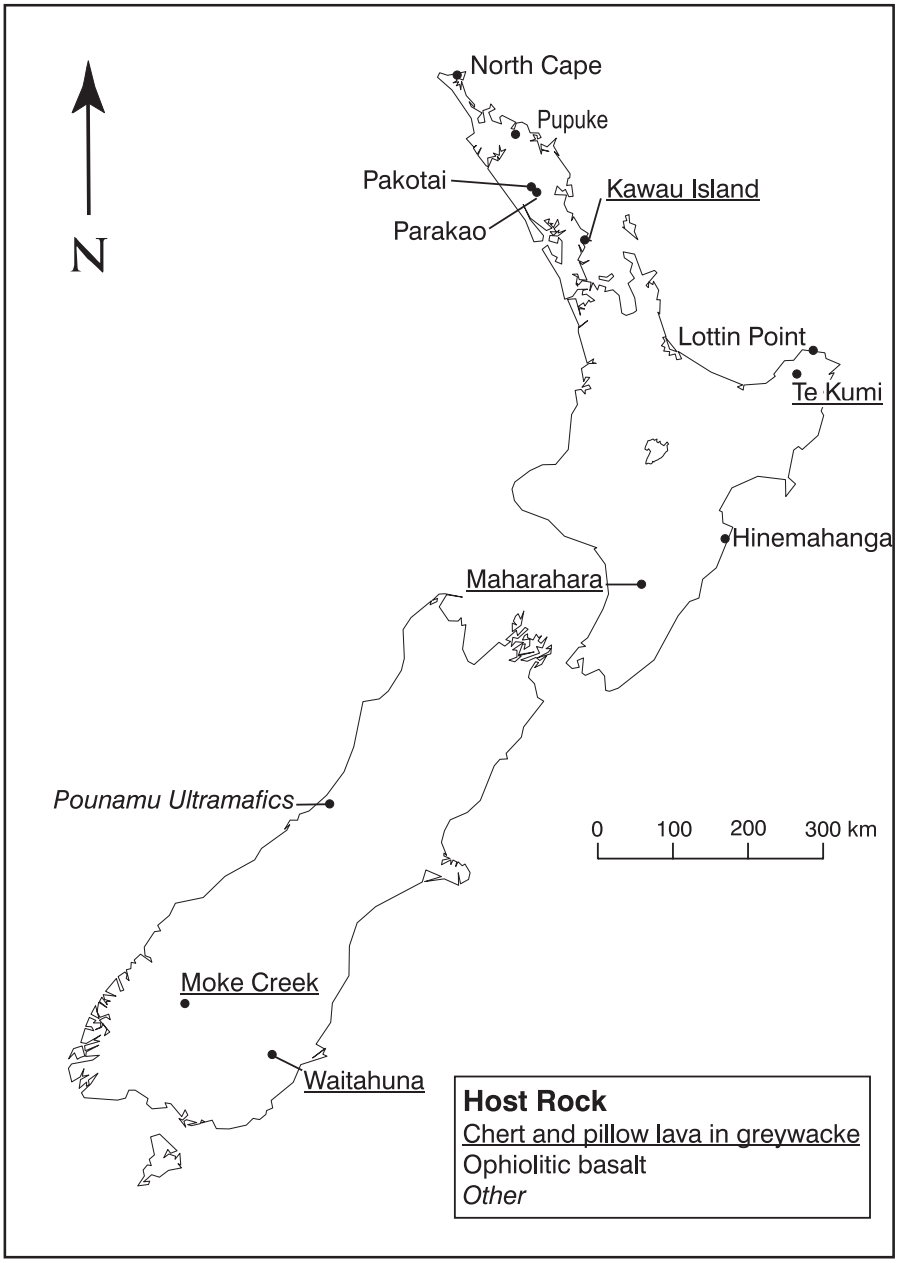

Figure 1. Location of VMS deposits in New Zealand.

basalts of the Tangihua Complex of Northland and the Matakaoa Volcanics of East Cape. Shrimp U-Pb zircon and Ar-Ar geochronology indicates that the Tangihua ophiolites are of Oligocene (29-26 Ma) age (Whattam et al., 2005). Recent geochemical trace and rare earth element studies have indicated that they contain island arc tholeiites, in addition to mid-ocean ridge basalts, and were formed in a suprasubduction zone setting close to their Late Oligocene obduction site (e.g. Nicholson and Black, 2004; Whattam et al., 2004, 2005).

Brathwaite and Pirajno (1993) suggested that the VMS copper deposits were similar to Cyprus type VMS deposits, and were formed in the black smoker environment of mid-oceanic ridges, where hydrothermal systems are generated by basaltic volcanism and intrusion associated with construction of the seafloor. Additional copper occurrences are found in dolerite and volcanic conglomerate near North Cape (Bowen, 1969a, 1969b) and in pillow basalts at Hinemahanga Rocks (Kairakau Rocks) on the southern Hawkes Bay Coast (Black et al., 1984).

Pupuke

Small, irregular, tectonically disturbed sulphide lenses are enclosed in claystone and sandstone, in close proximity to dolerite and basalt. The sulfide lenses are up to 7.3 m thick (Bell & Clarke, 1909) and consist of pyrite, marcasite and chalcopyrite, with minor sphalerite and galena (Mason & Kobe, 1989). Secondary copper minerals include covellite, malachite, bornite, native copper and chalcocite. Copper was first discovered in the area in 1892 and prospecting continued until 1910. The deposit was mined in the early 1900s and one 12 t shipment of ore contained 5.9% Cu, 15 g/t Ag and 0.5 g/t Au (Bell & Clarke, 1909). Some prospecting and mining of small quantities of ore were carried out by Hazelbrook Mines from 1964 1968. Licence (1989) reported that 8 grab samples of massive sulfide assayed 0.08-3.8% Cu, <1.0-5.3 g/t Ag and <0.01-0.9 g/t Au.

Pakotai

Discontinuous sulfide lenses, hosted in mudstone in fault contact with volcanic rocks, contain pyrite, chalcopyrite, sphalerite and marcasite (Roser, 1983). The deposit was discovered in 1944 and produced about 1400 t of copper ore between 1947 and 1951. Assays of shipped ore averaged 12.7% Cu, 57 g/t Ag, and 5.8 g/t Au (Hay, 1960). Licence (1989) reported that 7 grab samples of massive sulfide assayed 0.5-35% Cu, 15-155 g/t Ag and 0.9-21.5 g/t Au.

Parakao

A small lens of sulfides in sheared volcanic rocks and shales in the Pekapekarau Range was worked as the Copper Queen mine. A limonite gossan passes down into an oxidised zone with azurite, malachite and minor native copper and cuprite. Below this at a depth of about 5 m, pyritic lode material contains secondary sulfides. The primary ore consists of pyrite and chalcopyrite with minor sphalerite (Mason & Kobe, 1989). The oxidised and secondary enriched ores were mined between 1961 and 1966, and produced about 1040 t of copper ore. Licence (1989) reported that 3 grab samples of massive sulfide assayed 11-19% Cu, 20-24 g/t Ag and 5.1-19.5 g/t Au.

Lottin Point

In the Lottin Point area, the Matakaoa Volcanics (Cretaceous to Oligocene) consist of pillowed and massive basalt, and volcanic breccias, intruded by doleritic to gabbroic dikes and sills (Pirajno, 1980). The volcanic pile also contains discontinuous lenses of arenaceous sedimentary units, limestones, tuffs and cherts ranging in size from a few centimetres to several hundred metres in length (Pirajno, 1980). Stream sediment, soil and rock chip geochemical surveys have outlined zones of anomalous Ba, Zn and Pb geochemistry, including Creek B-13, where sulfide-mineralised float was discovered as well as at another locality approximately 1.5 km along strike (Pirajno, 1978a, 1980; Murfitt et al., 1998; Grieve and Bryner, 1999). The massive sulfide in these boulders consists of barite+pyrite+marcasite+sphalerite±Au±Ag±galena, and assays 20-46% Ba, 1-11% Zn, 5-75 g/t Ag and 1.5-22.3 g/t Au (Pirajno, 1980; Merchant in Murfitt et al., 1998). Another mineral association, massive pyrite+chalcopyrite+magnetite, is found in a sulfide lens in a wave cut platform at Sulfide Bay (Upokongaruru). Samples of this association contain up to 0.65% Cu. Other exploration on the prospects has included ground magnetometer and EM surveys, and an aeromagnetic survey (McConnochie & Hartley, 1989; Hartley, 1990). A single diamond drill hole, collared drilled to test the B-13 polymetallic sulfide zone, failed to intersect significant mineralisation, and appears not to have reached the target (Grieve and Bryner, 1999).

Elsewhere in the Matakaoa Volcanics, Cody and Grammer (1981) reported that boulders of massive sulfide composed of pyrite and chalcopyrite with minor marcasite, pyrrhotite and rare sphalerite were found in Mangatutu Stream on the northern flank of Pukeamaru Range, southwest

of Hicks Bay. One sample contained 8.5% Cu, but a stream sediment geochemical survey of the Mangatutu and adjoining catchments failed to locate the source of the copper mineralisation (Cody & Grammer, 1981).

VMS deposits associated with chert and pillow lava in greywacke

Several small copper deposits occur in Torlesse Supergroup and Waipapa Group greywacke, and are associated with cherts and/or spilitic pillow lavas. Brathwaite and Pirajno (1993) suggested that these deposits were similar to Besshi type VMS deposits. The Besshi-type is similar to Cyprus-type, but they are formed along with thick sequences of continentally derived clastic sediment in epicontinental rifting environments (e.g. Guaymas ridge in Gulf of California).

Kawau Island

En echelon lodes of massive sulfide mineralisation are associated with chert and metabasite in a mélange zone within Waipapa Group argillite and greywacke (Williams, 1959; Roser, 1983). The lodes are 2 m to 6 m thick and concordant with the bedding of the enclosing country rock. The primary ore contains 1-2% Cu and consists of massive pyrite with stringers of chalcopyrite and minor sphalerite, marcasite, pyrrhotite, bornite, tetrahedrite and hematite (Roser, 1983). Oxidation and secondary enrichment have resulted in oxidised material with up to 12% Cu overlying the primary sulfides. The deposit was discovered in 1846, and was mined between 1846 and 1860 to produce about 2500 t of ore, principally from the oxidised zone.

Te Kumi

Massive sulfide lenses are associated with red tuff in greywacke at Te Kumi, located in Copper Creek, a tributary of Donovan Creek (Pirajno, 1979). The sulfide lenses range up to 6.7 x 2.1 x 1.5 m in size and consist of pyrite (~80%) and chalcopyrite (~20%), with traces of sphalerite, magnetite, quartz and carbonate (Pirajno, 1979). Three prospecting drives totalling 55 m were excavated between 1917 and 1920. Analyses of dump and outcrop samples range from 0.24-7.3% Cu (Rishworth, 1969; Pirajno, 1979). Geochemical surveys of the area defined copper anomalies at the Te Kumi prospect and in the Tapuaeroa Valley to the south (Pirajno, 1978a, 1978b). The source of the copper anomaly in the Tapuaeroa Valley appears to be malachite staining in red tuffs (Pirajno, 1979) associated with volcanic rocks in the turbidite-dominated Ruatoria Group of Cretaceous age.

Maharahara

At Maharahara, sulfide lenses are hosted by red hematitic chert within greywacke (Roser, 1983). The deposit has a strike length of up to 46 m and a variable thickness of up to 1.3 m. Primary minerals include pyrite and chalcopyrite, with minor sphalerite, pyrrhotite, and barite. Underground mining during 1881-1891 and 1930 produced 50 t at around 2% Cu. Exploration in 1983-85 included soil and rock chip geochemical sampling and a self potential geophysical survey (Bell, 1983, 1986). The soil survey outlined a copper geochemical anomaly associated with red chert. Maximum values in rock chip samples were 7.8% Cu and 22 ppm Ag, with Au below detection limit. Copper mineralisation has also been reported from several other localities in the Ruahine Ranges in addition to Maharahara (NZGS, 1980).

Moke Creek

At Moke Creek, copper-rich sulfide layers, 1-20 cm thick, occur in greyschist with interbedded greenschist (metabasalt) (Wood, 1967; Henley, 1975; Barber & Craw, 2002). The sulfides consist of chalcopyrite, with pyrrhotite, pyrite and minor sphalerite, and occur as bands, a few centimetres

thick, sub-parallel to foliation in the schist. Similar, but much smaller copper-bearing bands occur in Dead Horse Creek, in Home Creek near Lake Luna, in the Ox Burn, and in several other places in the Richardson Mountains (Batt, 1974). The Moke Creek deposit has been prospected intermittently for at least 80 years, with some underground workings as recently as 1966-1968. However, the only recorded production was a parcel of 3 t of ore, assaying up to 24% Cu, shipped to Australia for treatment in 1917 (Wood, 1967).

Waitahuna

At Waitahuna, copper mineralisation occurs in a sulfide band within the host greenschists (Lowery, 1979). The band is up to 0.6 m thick and contains pyrite, marcasite, chalcopyrite, pyrrhotite and minor sphalerite. The deposit was mined in the late 1800s. Parcels of ore shipped for trial smelting assayed 6-11% Cu (NZGS, 1980), and hand picked material assayed 22% Cu, 19 g/t Ag and 0.6 g/t Au (Williams, 1974). An electrical conductivity survey by Modriniak and Marsden (1938) identified a conductive zone striking NW, over a length of at least 1250 m, and a width of about 100 m. A soil geochemical survey defined a geochemically anomalous zone approximately coincident with the geophysical anomaly. MacDonell and Associates (1997) reported assays of four samples collected near the 1882 shaft, with a best assay of 6.0% Cu, 30 g/t Ag and 0.23 g/t Au.

Massive sulfide lenses in the Pounamu Ultramafics

Small massive sulfide lenses are present in greenschist metavolcanics and metaserpentinite of the Pounamu Ultramafics on the western side of the Southern Alps in Westland. The Pounamau Ultramafics are interpreted as ophiolite (ocean crust) basement to the Torlesse terrane (Cooper & Reay, 1983). Copper-bearing sulfide lenses have been found in the Newton Range (Beck, 1965), Diedrich, Meta and Bowen ranges (Mackenzie, 1984), Whitcombe River area (Cooper & Reay, 1983), and in the Wilberg Range (Coleman, 1980). Those in the Wilberg Range appear to be the largest, with a mineralised zone 3 m to 9 m wide and 1500 m long containing numerous pyrite-chalcopyrite lenses (30 cm to 90 cm wide) (McPherson, 1970). Later exploration in the same area identified a more extensive zone of mineralisation comprising small pods of massive sulfide within greenschist, with grades of 0.5-2.0% Cu (Coleman, 1980). A sample from the Diedrich Range returned 5.1% Cu and 3.9 ppm Ag.

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