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EXPLORATION, GEOLOGY AND MINERALISATION OF THE MONYWA COPPER DEPOSITS, CENTRAL MYANMAR

U Kyaw Win and Douglas Kirwin

Indochina Goldfields

Abstract - The Monywa copper district in central Myanmar is presently being evaluated and developed jointly by the Myanmar Government and Ivanhoe Myanmar Holdings Ltd.

The copper mineralisation is of high sulphidation style and occurs predominantly within chalcocite-bearing breccia bodies. The mineralisation is hosted in late Tertiary dacite intrusions and acid pyroclastics located along a northerly-trending volcanic arc which bisects the Inner Burrnan Tertiary Basin. The breccia bodies appear to have been initiated in the uppermost portions of subvolcanic dacite intrusions that were highly enriched in volatiles, copper and sulphur. Chalcocite is the dominant ore mineral and occurs as fracture coatings, disseminations and breccia matrix. The gold content of the copper ore is negligible. Low sulphidation epithermal quartz veins to the north and east of the breccia bodies contain sub-economic levels of silver and gold.

Introduction

The Monywa copper district is located 110 kilometres west of the city of Mandalay on the western side of the Chindwin River. Four recognised copper deposits occur within an area of 20 square kilometres: Letpadaung, Kyisintaung, Sabetaung and Sabetaung South (Figure 1). This paper presents the exploration history, regional geology and mineralisation of these deposits.

Exploration History

Copper mineralisation in the Monywa district has been known for many centuries. Prior to 1900, copper was extracted, for the Burmese kings, from shallow oxide zones at the southern end of the present Letpadaung deposit. Early this century a British company registered gold and copper claims in the Letpadaung area and several small adits were excavated. The first exploration after World War II was a two-week evaluation in 1955 by Yugoslavian geologists. This was followed-up by detailed mapping and self potential surveys conducted in 1957 as part of a joint cooperation agreement between the Yugoslav and Myanmar governments. Between 1958 and 1983 the Myanmar government and various aid agencies drilled an accumulated total of approximately 56 000 meters of diamond core. These included the Myanmar government (1972-1976), Metal Mining Agency of Japan (1972-1976) and RTB-Bor of Yugoslavia (1972-1984). The British Government, as part of a technical assistance program sponsored under the Colombo Plan, conducted airborne and ground geophysical surveys between 1969-1971. A 125 diamond drill hole program was undertaken at Letpadaung during the period 1974 to 1978 by Myanmar

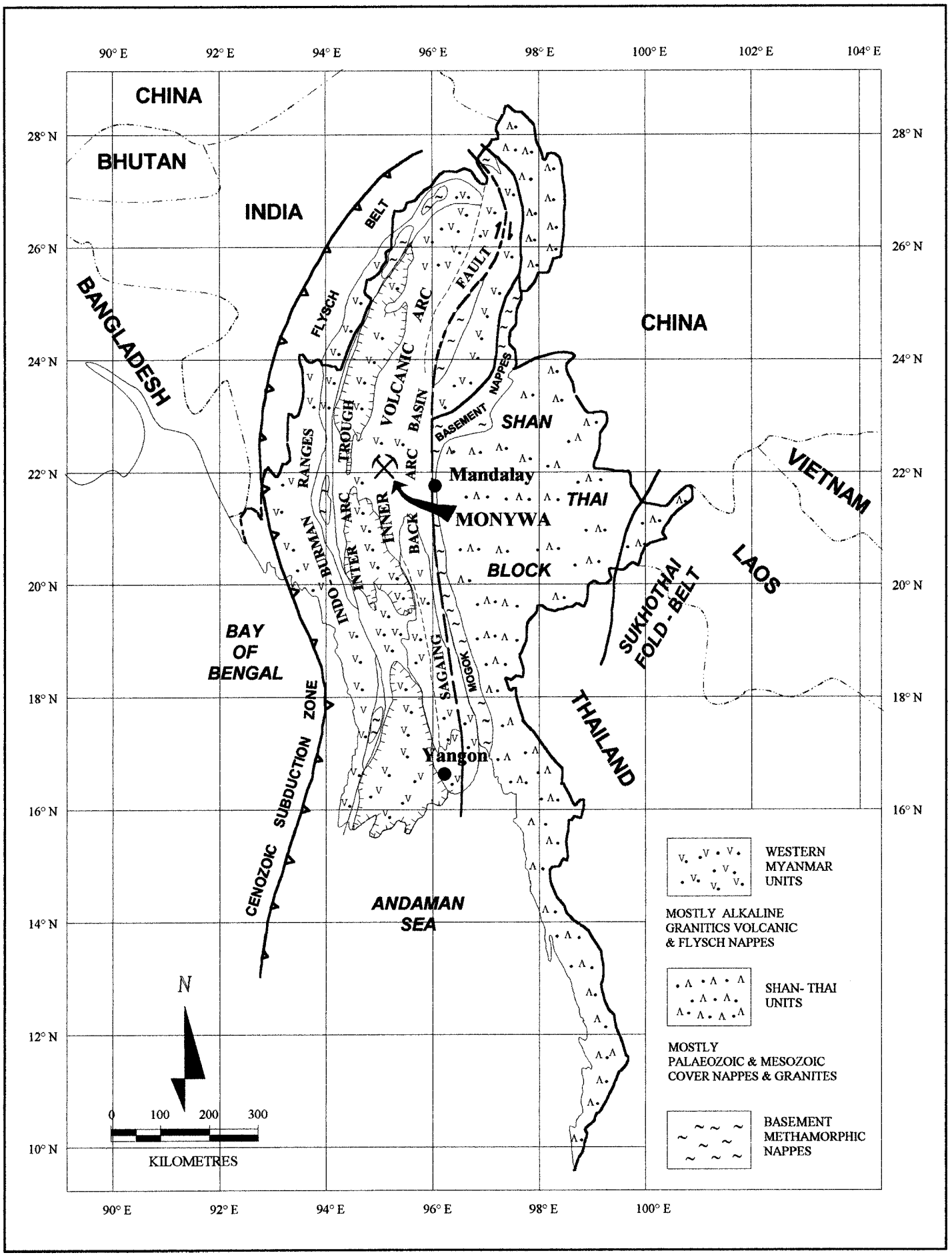

Figure 1. Location and tectonic setting of the Monywa copper district.

agencies in conjunction with the United Nations. In 1975 and early 1976 the Metal Mining Agency of Japan drove a small adit into the southwestern part of the Sabetaung deposit and erected a small pilot plant. Since 1986, the Myanmar Government has operated a small scale open pit mine at the Sabetaung deposit with a mill and floatation plant for recovery of copper concentrate.

Detailed exploration and evaluation of the Monywa copper deposits by a joint venture between the Myanmar Government and Ivanhoe Myanmar Holdings Ltd (IMHL) commenced in 1994. By the end of 1995, 143 exploration, development and metallurgical drill holes (mostly angled, large diameter diamond holes) totaling 21,300 meters were completed at the Sabetaung and Kyisintaung deposits. Successful heap leach tests and copper recovery from a pilot plant, utilising acid leach and the solvent extraction-electrowinning process (SX-EW), were part of a final feasibility study in March 1996. At the Letpadaung deposit, 305 diamond drill holes (91,800 meters), combined with extensive Government drilling, formed the basis of a separate feasibility study which was completed in March 1997. The low sulphidation epithermal vein systems, peripheral to the copper deposits, were also evaluated (4,500 meters of diamond drilling) but with negative results.

A high resolution aeromagnetic survey was flown in 1996 to search for targets under the flat alluvial terrain surrounding the known copper deposits. Four magnetic high anomalies in the vicinity of the Letpadaung deposit were drilled and found to be related to post-mineralisation andesite prophyry bodies.

Commercial production commenced at the Sabetaung-Kyisintaung deposits in September, 1998 at a phase I capacity of 25,000 tonnes of cathode copper per annum.

Regional and local geology

The Monywa copper deposits occur within an uplifted section of the Burma Volcanic Arc which comprises a northerly trending geanticline between the western and eastern sections of the Inner Burman Tertiary Basin. Basement to the volcanic arc includes upper Cretaceous mica schist, greenstone and amphibolite. The western part of Myanmar can be divided into distinct structural elements which from west to east include the Indo-Burman Ranges (northern extension of the Outer Volcanic Arc), Inter Arc Trough, Inner Volcanic Arc and the Back Arc Basin which are related to the eastward subduction of the Indian oceanic plate beneath Myanmar. These structural elements are part of the Burma plate which is bounded on the eastern side by the dextral Sagaing (or Shan) fault. The Asian plate lies to the east of this fault (Figure 1).

The Inner Volcanic Arc consists of terrestrial acid to intermediate volcanics and the Monywa copper district is situated within a local sedimentary basin which was the site of Oligocene volcanic and intrusive activity. The copper mineralisation at the Letpadaung deposit is associated with high level dacitic intrusive rocks dated at 19 Ma based on K-Ar ages of sericite and alunite whilst the intrusive at the Kyisintaung deposit is dated at 13 Ma. Post-mineralisation hornblende-biotite porphyry dykes have a single age date of 5.8 Ma. The volcanic rocks are overlain by Quaternary clastic sediments and younger olivine basalt flows (Figure 2).

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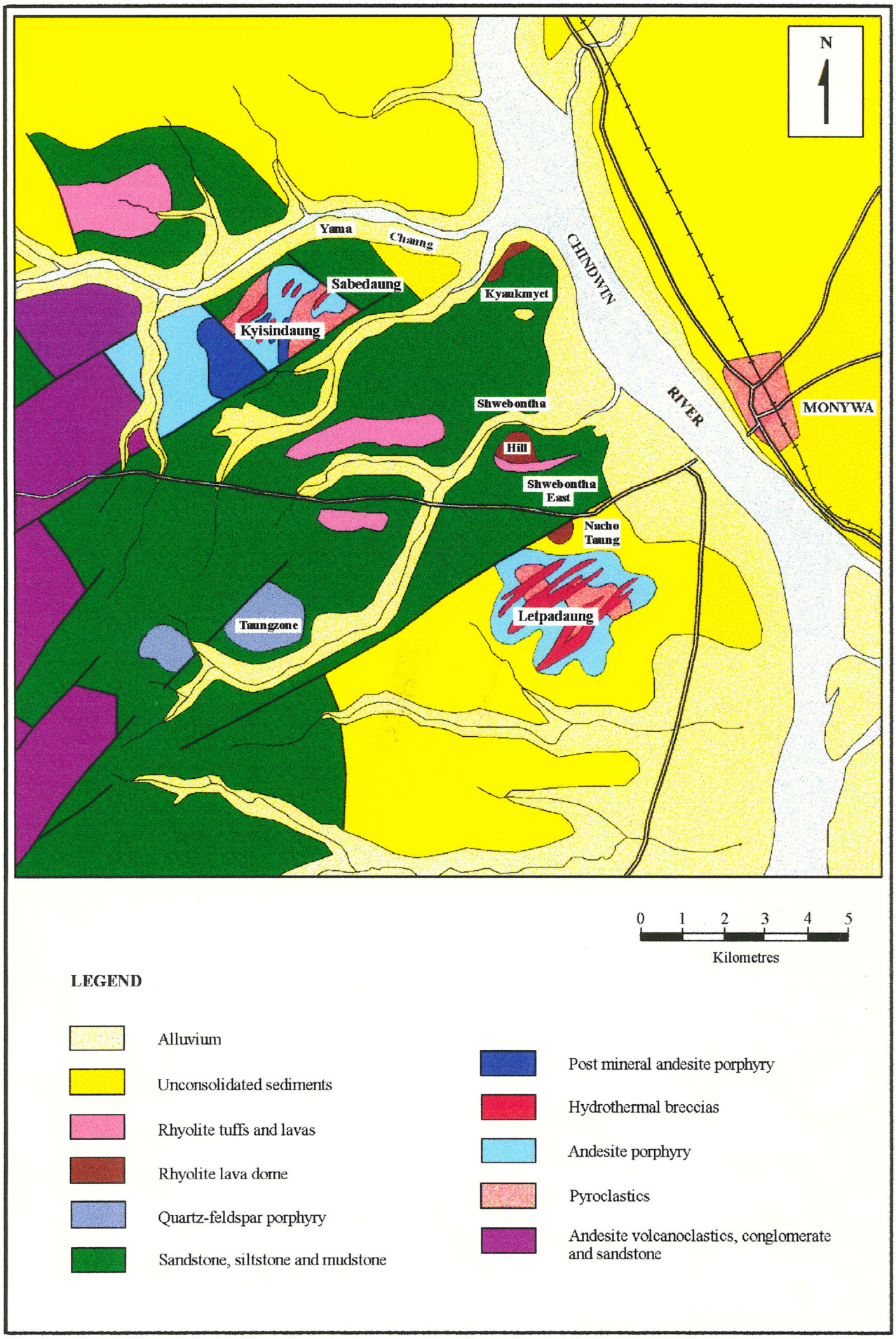

Figure 2 : Local geological map, Monywa district

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Mineralisation and alteration

Pyrite and primary/secondary copper sulphide minerals, principally chalcocite, occur in hydrothermal breccia, fracture fillings and as disseminations. The breccia hosted coppper mineralisation is best developed at the Letpadaung deposit where northeast trending, vertical to sub-vertical, dyke-like breccia bodies outcrop over an area of five square kilometres. The individual breccia dykes range in thickness from centimetres to greater than 70 metres and can be traced along strike in excess of one kilometre. The breccia clasts are mostly dacite porphyry and wall rock volcanoclastics. Clast angularity and clast to matrix ratios vary considerably. The matrix is composed of variable amounts of silicified rock flour and chalcocite. Whilst multi-phase brecciation is present, the bulk of the brecciation appears to have occurred in a single event. At the Letpadaung deposit copper mineralisation occurs mainly within the breccia matrix. The copper mineralisation at the Sabetaung, Sabetaung South and Kyisintaung deposits occurs within sheeted fractures and subordinate, narrow, sub-parallel, linear, breccia zones.

A vertical section through the deposits reveals a distinct mineralogical zonation. From top to bottom this consists of :

- Leached cap
- Supergene zone
- Mixed secondary and primary zone
- Primary (hypogene) zone

The leached cap consists of intensely acid-leached altered volcaniclastic rocks and dacite porphyry to a depth of 80 meters. The leached cap mineralogy is characterised by purple to black indigenous and exotic haematite indicative of multi-cycle leaching and oxidation of chalcocite. The lack of secondary copper minerals probably reflects the high pyrite to chalcopyrite ratio of the primary ore. The cap is essentially barren of copper and gold but may be anomalous in arsenic (typically 300 ppm) and lead (typically 200 ppm). Molybdenum and zinc values are not anomalous. The arid climate, brief monsoon season, positive topographic relief and pyritic fractured host rocks have provided ideal leaching conditions at all the Monywa copper deposits.

Supergene mineralisation comprises sooty chalcocite and digenite typically replacing pyrite and as coatings on crystalline chalcocite and covellite. The thickness of the supergene zone varies from 20 to 50 meters and to a large extent is controlled by the intensity of fracturing and proximity to sheeted veins and breccia bodies. It does not form a continuous blanket as most of the inter breccia zones are barren.

The mixed secondary and primary zone is characterised by pyrite coated with chalcocite occurring in breccia matrix and fractures. It is dominantly structurally controlled reflecting fluid permeability, and is tens of metres in thickness in places. Hypogene mineralisation consists of abundant pyrite, coarse grained chalcocite, digenite, covellite and minor enargite. Polished section studies show that early pyrite is overprinted by the copper minerals. In deeper levels of the Letpadaung deposit chalcocite and covellite occur occasionally as crystalline masses lining vughs and as disseminations in the dacite porphyry. Chalcopyrite and bornite occur as rare

inclusions in pyrite in the Letpadaung deposit and as minor fracture coating at the Sabetaung South deposit. Crystalline chalcocite veinlets display distinctive covellite-pyrite intergrowths. Hydrothermal alteration assemblages and paragenesis are similar at each of the deposits. At the Letpadaung deposit, which is the best known and largest of the deposits, the alteration zone is developed over an area of five square kilometres and is still present at drill depths of 500 meters. Petrological studies show a distinct alteration zonation characterised by specific mineral assemblages. A central zone is characterised by intense leaching which results in residual vughy quartz and destroys the original fabric of the volcanic host. This grades outwards into quartz + pink crystalline alunite + diaspore and continues into quartz + alunite + diaspore + pyrophyllite with sericite or illite. Propylitic alteration occurs peripheral to this zone. This zonation reflects the progressive neutralisation and cooling of initial hot acid fluids in response to reaction with host rocks and fluid mixing and is characteristic of high sulphidation alteration. A late stage alteration event, of probable supergene origin, overprints the above assemblages and is characterised by kaolinite ± cubic alunite ± rare dickite and/or carbonate.

During the initial stage of the evaluation by the joint venture partners, two low sulphidation vein systems were discovered at Kyaukmyet and Nachetaung-Shwebontha East . The Kyaukmyet prospect is located five kilometres east-northeast of the Kyisintaung copper deposit and the Nachetaung-Shwebontha East prospect occurs two kilometres north of the Letpadaung deposit. At Kyaukmyet the vein system extends over an area of 0.25 square kilometres and silver-gold mineralisation occurs in polyphasal quartz veins and breccias hosted by siliceous argillaceous sediment, rhyolite and intercalated arenaceous sediment. Quartz-sericite-pyrite alteration associated with the veins has been overprinted by quartz-alunite-dickite with minor enargite and covellite. Diamond drilling to a depth of 170 meters encountered sub-economic precious metal values.

The Nachetaung-Shwebontha East prospect occurs over an area of one square kilometre and consists of quartz veins and variably silicified zones within rhyolite, interbedded mudstone, arkose, tuffaceous sediments and volcanics. A rhyolite flow dome complex forms a prominent hill on the northern side of the prospect. Mineralisation is associated with a quartz-sericite-pyrite±adularia assemblage which is post-dated by quartz-barite-pyrophyllite-alunite and dickite. Diamond drilling to a vertical depth of 180 meters returned sub-economic gold values.

Discussion and conclusions

The widespread presence of zoned advanced argillic alteration assemblages and primary chalcocite imply that the copper mineralisation at the Monywa copper deposits may be classified as high sulphidation type. The lack of enargite and abundance of primary chalcocite and covellite are indicative of a deep level system (Figure 3).

The difference between the wide copper-bearing breccia zones at the Letpadaung deposit and the mineralised sheeted fractures with subordinate narrow breccia dykes at the other deposits appears to be related to their respective positions above the breccia pipe complex. This breccia system may have a diameter of up to two kilometres. The Letpadaung deposit is inferred to be proximal to the main breccia pipe whilst the Sabetaung, Sabetaung South and Kyisintaung deposits are inferred to be at a higher level. There is no evidence to suggest that the breccias explosively

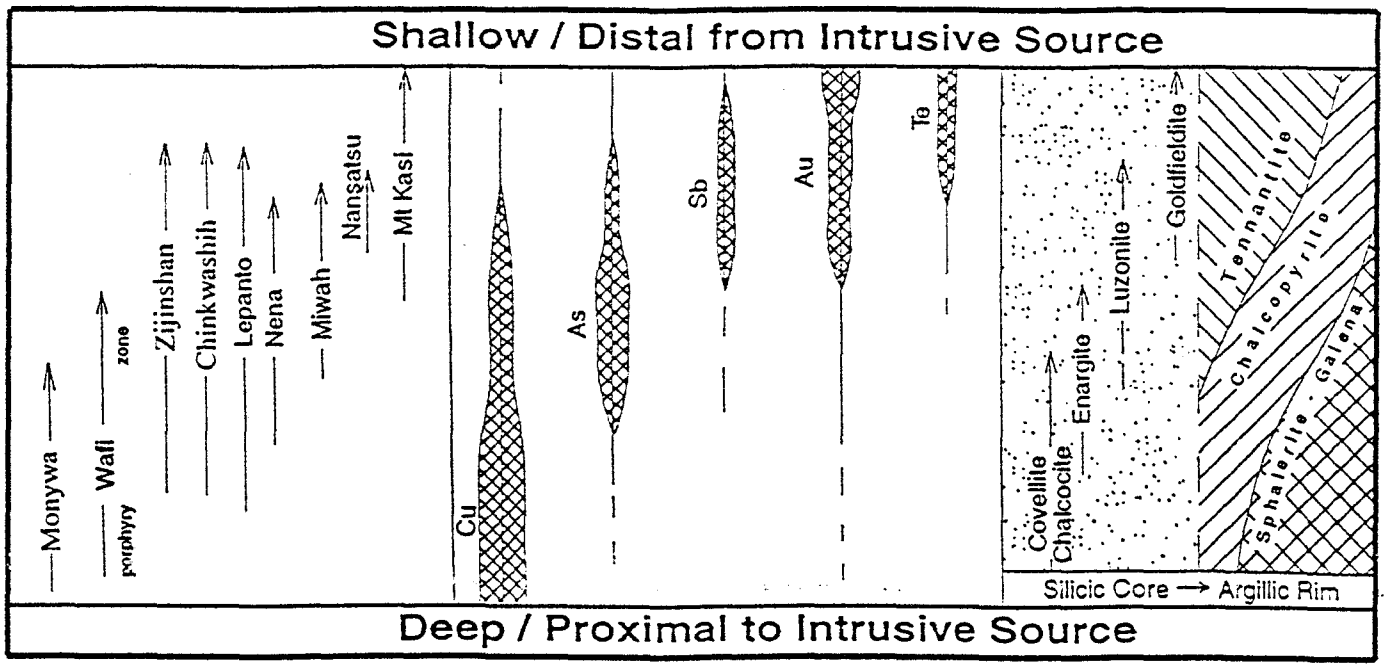

Figure 3 : Zonations in Metals and Copper Sulphides in High Sulphidation systems

vented at the surface. Deep drill holes in the Letpadaung deposit intersected vesicular carapaces of mineralised dacite which are locally brecciated. These rocks are considered to be the source of the mineralisation and volatiles which generated the breccia pipe and overlying linear breccia zones and sheeted fractures zones.

Porphyry style mineralisation or associated alteration has not been recognised at Monywa. The potential for gold in the Monywa copper deposits is low unless extensive high level enargite mineralisation is encountered. Preliminary mass balance copper calculations (based on selected drill hole data) show significant deficiency in the copper content of the supergene zone when compared with the calculated copper loss from the leached cap, assuming the leached zone originally had similar values to the primary zone. This is particularly apparent at the Kyisintaung deposit where leaching has been most thorough. The combination of intense leaching accentuated by the strong fracturing of the host rocks and the presence of a shallow aquifer may result in the potential for exotic secondary copper deposits within the flat terrain surrounding the Kyisintaung and Letpadaung primary deposits.

The late stage advanced argillic alteration overprint on the epithermal low sulphidation vein system in the Kyaukmyet and Nachetaung-Shwebontha East prospects is inferred to have occurred contemporaneously with the main alteration event evident in the Monywa copper deposits. Therefore, the low sulphidation deposits predate the copper deposits.

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Photograph 1 : View of Sabedaung open pit, Monywa.

Photograph 2 : View of leached cap at Kyisindaung, Monywa.

Photograph 3 : View of Letpadaung deposit, Monywa.

Photograph 4 : Pyrite-chalcocite breccia matrix hosted mineralisation, Sabedaung open pit.

Photograph 5 : Mineralised hydrothermal breccia with matrix pyrite-chalcocite. DDHL149-539 m, Letpadaung deposit.

Photograph 6 : Dacite porphyry with feldspar phenocrysts replaced by crystalline pink alunite, dickite and chalcocite, Letpadaung deposit.

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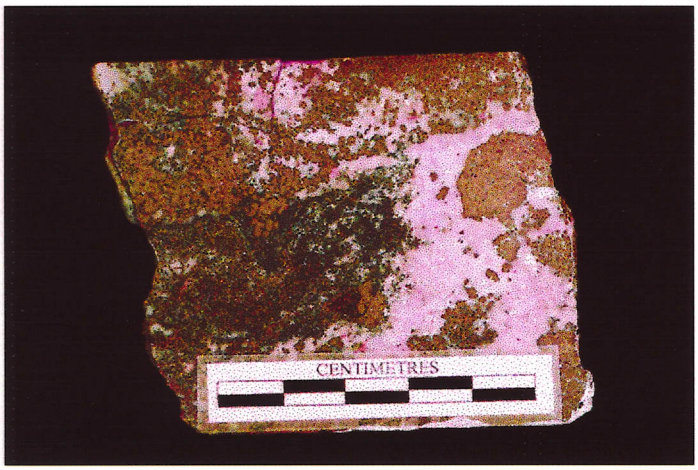
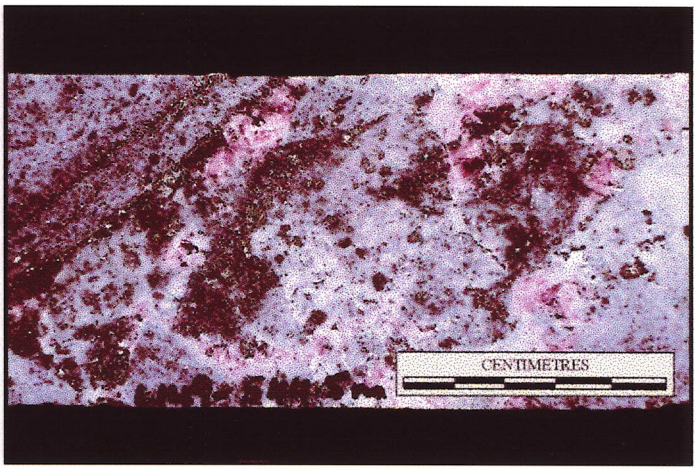
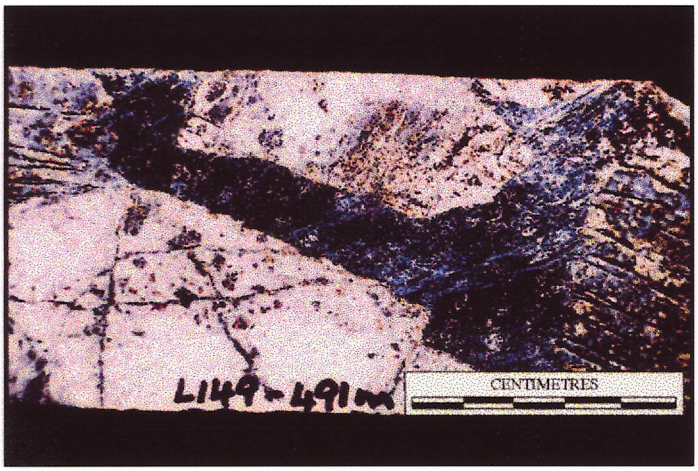


Photograph 7 : Massive crystalline pink alunite, pyrite and chalcocite breccia matrix, Letpadaung deposit.



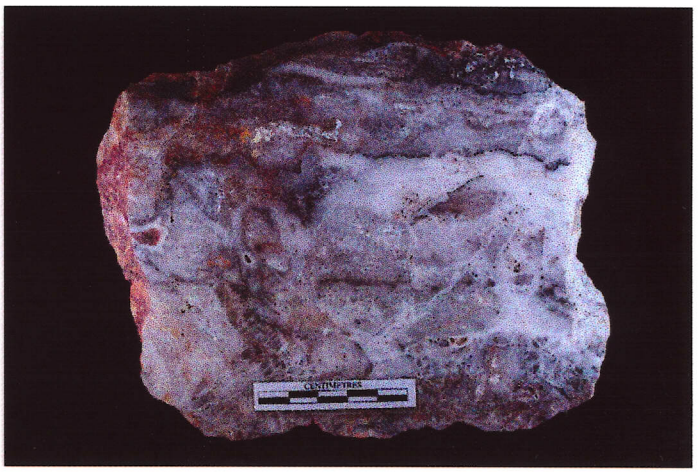
Photograph 8 : Silicified dacite porphyry breccia with matrix bladed pink alunite, Letpadaung deposit.



Photograph 9 : Silicified dacite porphyry breccia with matrix blue crystalline covellite, Letpadaung deposit.

Photograph 10 : Silicified brecciated dacite porphyry with matrix native sulphur and crystalline chalcocite, Letpadaung deposit.

Photograph 11 : Colloform banded epithermal vein quartz, Kyaukmyet.



Photograph 12 : Multiphase epithermal quartz vein breccia, Kyaukmyet.

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