Ore fluid chemistry and genetic significance of hydrothermal processes: examples from Australian and Myanmar gold and base metal deposits

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Laporan (Report)

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Abstrak (Abstract)

Myanmar, formerly known as Burma has a long history of mining for base metals, tin-tungsten, gold-silver, and gemstones. Myanmar has world class deposits such as the Bawdwin Mine (the largest polymetallic base metal deposit in the world before World War II), and the famous gemstone tract of the Mogok-Momeik area in northern Myanmar. Australia is one of the most productive mineral-rich countries in the developed world and consists of base metal mineralisation such as volcanic- and sediment-hosted massive sulphide deposits and a diverse style of gold mineralisation from Archean lode gold deposits, ironstone-hosted Tennant Creek gold deposits to epithermal gold deposits.

Myanmar consists of tectonostratigraphic terranes which now form continental mainland SE Asia. Myanmar can be sub-divided into six N-S trending tectonic domains, from west to east (1) the Arakan (Rakhine) Coastal Strip as an ensimatic foredeep, (2) the Indo-Burman Ranges as an outer arc or fore arc, (3) the Western Inner-Burman Tertiary Basin as an inter-arc basin, (4) the Central Volcanic Belt (Central Volcanic Line) as an inner magmatic-volcanic arc, (5) the Eastern Inner-Burman Tertiary basin as back-arc basin and (6) the Sino-Burman Ranges or Shan-Tenasserim Massif as an ensialic continental region. The Sagaing Transform

Fault occurs as a tectonically significant boundary between the Eastern-Burman Basin and the continental, ensialic Sino-Burman Ranges.

The Indo-Burman Ranges contains Triassic to Eocene flysch sediments and obducted ophiolites which contains chromite, nickel, PGE and precious metals, and has potential for the discovery of Cyprus type Cu (Au) deposits. The Central Volcanic Belt forms as a magmatic-volcanic arc of Late Cretaceous-Tertiary age and hosts the Monywa porphyry Cu (Au) deposits and a variety of gold-silver deposits (e.g. Kyaukpahto deposit). The Sino-Burman Ranges, which is also termed the Shan-Thai terrane contains Late Pre-Cambrian to Paleozoic sedimentary rocks and local Mesozoic clastics. The Sino-Burman Ranges is the most important region in terms of Myanmar's mineral potential and include at least three different styles of base metal mineralisation, the finest, world class ruby, sapphire, jade deposits and the potential for the discovery of sizeable alluvial diamond deposits. In addition, tin-tungsten veins and structurally controlled, turbidite-hosted, gold deposits are associated with Early Cretaceous-Late Eocene granites at the western margin of the Indo-Burman Ranges in a narrow zone along the Sagaing Transform Fault. The enrichment of base metal mineralisation is exemplified by the Bawdwin Mine (volcanic-hosted base metal deposit), the Theingon Mine (Mississippi-Valley type) and the Yadatheingi Mine (cavity-filled, epigenetic deposit).

Ore fluid research has been currently undertaken at Centre of Ore Deposit and Exploration Studies (CODES), University of Tasmania in collaboration with CSIRO (Commonwealth Scientific and Industrial Organisation) and AGSO (Australian Geological Survey Organisation) using advanced analytical techniques such as fluid inclusion heating/freezing stage, electron microprobe, SEM/WDS, PIXE (Proton-induced X-ray Emission) and LRS (Laser Raman Spectroscopy), FTIR (Fourier Transform Infra-Red) and mass spectrometry. The research has shed light on the understanding of the evolution of hydrothermal processes for the Australian and Myanmar gold and base metal deposits. The research results also provide guidelines for the selection of targets for mineral exploration.

The Hellyer and Mt. Chalmers deposits are mound-style volcanic-hosted massive sulphide (VHMS) deposits in Australia. At Mt. Chalmers, Type I inclusions up to 20 μm are found in quartz from the mineralised zone, and these inclusions yielded homogenisation temperatures of 160–268°C and salinities of 5–8 NaCl equiv. wt %. Laser Raman spectroscopic (LRS) analysis indicates the presence of CO_2 (< 1 mole %) in the Mt. Chalmers VHMS systems. Semi-quantitative SEM/WEDS microprobe analyses of fluid inclusion decrepitates indicate that the Mt. Chalmers ore fluids were enriched in potassium and calcium but depleted in magnesium relative to seawater. PIXE microanalysis of fluid inclusions in quartz also indicates a significant base metal concentration in these fluids. Cation composition and higher salinities relative to seawater suggest that recycled seawater alone cannot be the sole source of the ore fluids. High base metal content and the presence of CO_2 in the fluid inclusions imply that magmatic input of ore metals during seawater leaching of the footwall volcanic pile is a distinct possibility.

KHIN ZAW receiving momento from E.B. Yeap.

Gold-copper-bismuth mineralisation in the Tennant Creek goldfield of the Northern Territory occurs in pipe-like, ellipsoidal, or lensoidal lodes of magnetite ± hematite ironstones which are hosted in turbiditic sedimentary rocks of Proterozoic age. Fluid inclusion studies have revealed four major inclusion types in quartz associated with mineralised and barren ironstones at Tennant Creek; (1) liquid-vapour inclusions with low liquid/vapour ratios (Type I), (2) liquid-vapour inclusions with high liquid/vapour ratios or high vapour/liquid ratios and characteristic dark bubbles (Type II), (3) liquid-vapour-halite inclusions (Type III), and (4) liquid-vapour inclusions with variable liquid/vapour ratios (Type V). Type I inclusions are present in the barren ironstones and the unmineralised portions of fertile ironstones, whereas Types II and III inclusions are recognised in fertile ironstones. Type I fluid inclusions have homogenization temperatures of 100° to 350°C with a mode at 200° to 250°C. Type II inclusions in mineralised ironstones (e.g. Juno, White Devil, Eldorado, TC8 and Gecko K-44 deposits) have homogenisation temperatures of 250°C to 600°C with a mode of 350°C. Type I fluid inclusions have a salinity range of 10 to 30 NaCl equiv. wt %. Salinity measurements on fluid inclusions in the mineralised zones gave a range of 10 to 50 NaCl equiv. wt % with a mode of 35 NaCl equiv. wt %.

Fluid inclusion studies indicate that the Tennant Creek ironstones were formed from a relatively low temperature and moderately saline fluid, whereas gold and copper mineralisation was deposited from later hydrothermal fluids of higher temperature and salinity. Gas analysis indicates the presence of N_2 and CO_2, with very minor CH_4 in Types II inclusions but no N_2 or CH_4 gases in Type I inclusions. Microprobe analysis of the fluid inclusion decrepitates indicates that the inclusions from Tennant Creek contain sodium and calcium as dominant cations and potassium in a subordinate amount.

The high temperatures (≥ 350°C), high salinities (≥ 35 NaCl equiv. wt %) and cation composition of the Tennant Creek ore fluids suggest that the ore fluids were derived from upward migrating heated basinal brines, although contribution from a magmatic source cannot be ruled out. Close association of vapour-rich Type IIb and salt-rich Type III inclusions in the mineralised ironstones (e.g. Juno, White Devil, Eldorado, TC8 and Gecko K-44) indicates heterogeneous trapping of ore fluids. This heterogeneous trapping is interpreted to be due to unmixing (exsolution) of a gas-rich (e.g. N_2) fluid during the upward migration of the metal bearing brines and/or due to degassing caused by reaction of oxidised ore fluids and host ironstones. Fluid inclusion data have important implications regarding the deposition of gold in the ironstones, and can be used in discriminating fertile from barren ironstones in conjunction with other exploration techniques.

The Kyaukpahto gold deposit in Myanmar is located at Latitude 23° 47' 55" N and Longitude 95° 56' 35" E in the Kawlin-Wuntho district, Sagaing Division. Gold mineralisation is hosted in turbiditic sandstone of Male Formation (Lower to Middle Eocene) and occurs as stockwork and dissemination. Gold mineralisation is also associated with intense silicification, sericitisation and argillic alteration. Major sulphide minerals are pyrite and arsenopyrite with minor galena, chalcopyrite, and sphalerite. Gold occurs predominantly as free gold grain (electrum) in stringery quartz veins, and native gold as electrum is also a dominant mineral in the oxidised and supergene zones. The gold grains vary in size from 1 µm to 250 µm and electron microprobe analysis of the grains yields a range of fineness from 844 to 866. Preliminary fluid inclusion study at Kyaukpahto gold deposit reveals three major fluid inclusion types in quartz in the ore zone: (1) Type I, two-phase, H_2O liquid, vapour and CO_2 liquid inclusions and (3) Type III, two-phase, liquid-rich inclusions with variable liquid and vapour ratios. Primary Type I fluid inclusions are 5–15 µm across and yielded homogenisation temperatures of 239°–310°C and salinities of 1.2–10.9 NaCl wt %. Present geological, mineralogical and fluid inclusion characteristics demonstrate that the Kyaukpahto gold deposit is comparable to the Carlin type sediment-hosted gold deposits.