Mineralogy and petrography of primary copper mineralization from Moonta Mines

Thesis submitted in accordance with the requirements of the University of Adelaide for an Honours Degree in Geology

Dale Cameron

October 2014

THE UNIVERSITY of ADELAIDE

MINERALOGY AND PETROGRAPHY OF PRIMARY COPPER MINERALIZATION FROM MOONTA MINES: A RE-INVESTIGATION OF MCBRIAR’S 1962 THESIS SAMPLE SUITE

MINERALOGY AND PETROGRAPHY: MOONTA-WALLAROO

ABSTRACT

Samples of massive bornite- and chalcopyrite ore from the Moonta and Wallaroo Mines, originally collected by Erica Maud McBriar for her M.Sc. thesis in 1962, have been investigated to determine mineralogical and petrographic relationships between co-existing minerals. Much is known about the mining history of Moonta-Wallaroo but few previous studies have attempted to characterise the mineralization itself and compare it with that present elsewhere. Results show that massive copper ores from the Moonta and Wallaroo Mines share a number of mineralogical and textural similarities with other IOCG systems in the Olympic Cu-Au Province. Other mineralogical features, such as the abundant pyrrhotite, appear to be a reflection of unusually reduced conditions, although late, superposed hematite infers a shift towards oxidized conditions in the final stages of mineralization.

The replacement of bornite by chalcopyrite and of chalcopyrite by bornite, even in the same sample is suggestive of multiple episodes of ore crystallization, possibly during a single protracted event. The observations do not contradict established models of ore genesis in which the Moonta orebodies are the products of structurally-controlled IOCG-style mineralization. Ore-forming fluids were likely derived from ~1.6 Ga Hiltaba Suite intrusives and driven along shear zones. The study, based around polished sections prepared from precious sample material collected more than 50 years ago contribute to a genetic model that takes account of the diversity of mineralization styles, which can assist with ongoing exploration in the Moonta-Wallaroo area.

KEYWORDS

IOCG, Moonta-Wallaroo, Petrology, Sulphide Mineralization, Alteration.

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

Figure 13: *Sample 162/11 – Chalcopyrite (Bell Metal): (a) Image shows the general distribution of the chalcopyrite with gangue grains and tiny pyrite inclusions, (b) Bell Metal chalcopyrite is effected by anhedral pyrite inhabitants, (c) Bell Metal chalcopyrite contains rare inclusions of apatite and what is interpreted as Malayaite (An Sn bearing Hydrothermal alteration of cassiterite-quartz assemblage and Sn-bearing skarns. Structurally related to titanite.),(d) Tiny rare inclusion of apatite within a 30um pyrite grain within the bell-metal chalcopyrite*

Figure 14: *Sample 162/53 – Sphalerite Sulphide: (a) Sphalerite grains are massive and euhedral, grains extend up to 3mm in size, (b) The matrix is made up of some sort of aluminosilicate, darker areas are presumed to be calcite as they are high in calcium, where they grey gangue mineral is calcium depleted. The matrix is host to small phenocrysts of pyrite and Sphalerite grains, (c) Chalcopyrite is common throughout the sample as anhedral grains that plays host to pyrite inclusions, (d) Where the Sphalerite grains meet the matrix there is a defined border of calcium enriched aluminosilicate that also hosts to small chalcopyrite and pyrite grains.*

Figure 15: *Sample 162/10: (a-d) Reflected light photomicrographs showing exsolution of tiny bornite granules within chalcopyrite. The excreted bornite tends to have a linear distribution, following crystallographic planes in the host mineral. (e and f) Relationship between hematite and chalcopyrite suggestive of later overgrowth.*

Figure 16: Sample 162/53 (sphalerite): Two distinct pyrite morphologies co-exist. There are smaller Euhedral grains (Eu) that often occur as inclusions within chalcopyrite, and anhedral grains (An) that are observed outside of the chalcopyrite within gangue quartz.

Figure 17: (a) *Sample 162/104 – Pyrrhotite: Fractured Pyrrhotite hosts many inclusions, majorly being hornblende and apatite, (b) Sample 162/104 – Pyrrhotite: Elongate stringer grains containing Ma.*

Figure 18: *Sample 162/49 – Cobaltite Sulphide: (a) Sample is dominated by abundant Pyrite with a rare native Bismuth granule no bigger than 50µm, gangue matrix is composed of Calcite and other aluminosilicates (b) Fractured areas within the Pyrite can sometimes contain chalcopyrite mineralization along with the Calcite gangue, (c) Cobaltite grains are scarce but large in size (1-2mm), the grains are euhedral and heavily fractured. Pyrite grains are also euhedral and similar in size, however can range from 20µm-1.5mm, (d) Within the fractures of the Cobaltite, quartz mineral growth has occurred along with the odd chalcopyrite granule.*

Figure 19: *Sample 162/66 – Covellite Sulphide: (a) The overall trend of the sample, covellite needles growing off the quartz gangue, (b) Deformed quartz is surrounded by covellite needle boundary with grain inclusions of Pyrite, (c) scarce amounts of tiny grains of rutile are present within the quartz, (d) Pyrite grains range up to 150µm in diameter within the covellite, (e) Rare orthoclase granules surrounded by covellite, (f) Titanite (or sphene), a calcium titanium nesosilicate is a rare inclusion within the deformed quartz groundmass.*

Figure 20*: Schematic diagram illustrating the main ingredients for IOCG-style mineralization in the Moonta area (sourced from Conor et al. 2010)*

Figure 21: *Sample 162/53 – Sphalerite Sulfide: A grain of Iron rich sulfides, Cu Zonation within the grain. The red line designates cu rich areas, those areas being determined as Chalcopyrite. The Cu Poor areas are pure Fe and S, with ratio of 1:2 favouring Sulfur, hence Pyrite. There are also small grains of Galena in the Sphalerite dominated sample.*

Figure 22: *Sample 162/59 – Bornite Sulfide: Uranium rich grains are within the voids of the bornite dominated groundmass. Hematite grains include inclusions of bornite and magnetite inclusions.*

Figure 23: Sample 162/106 – Moonta Hematite: (a) Iron Oxide Hematite needles are spontaneous and are *not in a lamellae form in amongst the aluminosilicate gangue, (b) Some Hematite needles contain inclusions from the aluminosilicate groundmass, (c) Some Hematite needles look like they have been eaten away from the inside, (d) Elongate quartz grains are spread amongst the hematite needles almost separating the gangue*

Figure 24: (a) *Sample 162/106 – Moonta Hematite: Big Parallel Fractures run throughout the whole sample, giving distinct growth restrains to the hematite needles, (b) Sample 162/106 – Moonta Hematite: Rare inclusion that is high in Y,Si and O, demonstrates a conchoidal grain distribution.*

Figure 25: *Sample 162/109 – Moonta Hematite: (a) Chalcopyrite and Hematite border is very sharp, showing no sharing of elements what so ever, (b) Euhedral Pyrite accessory grains within Chalcopyrite, quartz mineral growth through fracture zones, (c) Within the gangue, the majority is made of Albite Plagioclase with grains of apatite (>400um in size) with the odd inclusion of chalcopyrite, (d) Image shows the relationship between hematite and chalcopyrite*

Figure 26: (a) *Sample 162/110 – Ferberite: Ferberite grains are somewhat in a needle-type form. Ferberite consists roughly 75% of the sample. Some quartz inclusions are common throughout the voids, long elongate grains of chalcopyrite sulphides are common, (b) Sample 162/110 – Ferberite: The chalcopyrite inhabited elongate grains tend to grow in the fracture plains. Mineralization in the fracture plains also consists of a FeSiO.*