STRUCTURAL AND METAMORPHIC GEOLOGY OF A CRITICAL AREA ADJACENT TO THE BROKEN HILL OREBODY, WILLYAMA COMPLEX, AUSTRALIA

by

William Peter Laing, B.Sc (Hons) (Sydney)

VOLUME 1

of 2 volumes plus attached appendices

Department of Geology and Mineralogy

University of Adelaide

April, 1977

VOLUME 1

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

SUMMARY

The Willyama Complex in the area of North Mine and the adjacent Northern Leases comprises a sequence of pelitic metasediments and lesser acid and basic gneisses which have been strongly deformed and metamorphosed to upper amphibolite/lower granulite facies. Conformably within the sequence lies a horizon carrying sulphide mineralization (the Lode Horizon) and in North Mine this horizon contains a high-grade lead-zinc-silver orebody.

Prominent layering in the pelitic metasediments represents bedding, on the basis of composition, well-developed compositional grading in many layers,continuity, and parallelism with gross lithological boundaries. The pelitic metasediments were derived from a mature granitic or metamorphic terrain and deposited, partly as turbidites, in a distal basinal environment.

The metamorphic and structural history is characterized by three main events, with close similarities and progressive changes from one event to the next. These are categorized as the Olarian Orogeny. In all rock-types a layer-parallel schistosity S_1 containing a strong mineral lineation L_1 is the earliest recognizable structure, formed during the M_1 high-grade metamorphism. Mesoscopic F_1 folds are extremely rare, but one macroscopic example is described from the Parnell Track area northwest of Broken Hill. D_1 is inferred to have involved regional nappe formation and/or large-scale thrusting. There is some evidence that a phase of folding followed D_1 and preceded D_2, without development of any penetrative fabric. D_2 also took place during high-grade metamorphism, and formed tight, inclined to upright F_2 folds on all scales. F_2 folds appear to be almost invariably developed parallel to L_1. In the pelitic metasediments a strong schistosity S_2 and a strong mineral lineation L_2 are commonly formed in the axial plane of F_2 folds, by crenulation and recrystallization of the S_1/L_1 microfabric. The L_2 lineation plunges uniformly to the southwest, generally parallel to F_2 fold axes and the L_1 lineation, but in some areas is oblique to these structures where the latter show anomalous northeast plunges. The southwest-plunging lineation direction is inferred to represent the principal maximum axis of strain during D_2 and possibly D_1. The third deformation overlapped with D_2 but generally refolded D_2 structures; D_2 and/or D_3 and their associated metamorphisms M_2 and M_3 were probably diachronous. F_3 folds are open to tight, upright, and show variable plunge. The microfabric of the weak to strong S_3 axial-plane schistosity in the pelitic metasediments is defined by various medium and low-grade assemblages which successively replace each other in a down-grade sequence,

indicating that D_3 took place during waning metamorphism. D_3 structures are transitional to the structures within retrograde shear zones, the initiation of which marked the cessation of regionally pervasive ductile deformation. This represents the close of the Olarian Orogeny.

Within the retrograde zones evidence from displacement of marker units and from the geometry of mesoscopic structures substantiates deformation by simple shear. Vertical displacement on the major Globe-Vauxhall Shear varies systematically along the Shear suggesting rotational movement, and is between 300 m and 1000 m, southeast-block-up. The horizontal displacement is small.

The major folds southeast of the Globe-Vauxhall Shear, including the North Mine area, are F_2 structures, named the Hangingwall Synform and the Broken Hill Antiform. The Hangingwall Synform has also been recognized in the subsurface northwest of the Shear. The linear North Mine orebody occupies the hinge of a parasitic fold on the common limb of these folds, which in the North Mine area show anomalous northeast plunge. The orebody is parallel to F_2 and L_1 and oblique to the southwest-plunging L_2 lineation. The Lode Horizon and the orebody are concordant with bedding.

Transposition of bedding into parallelism with the axial-plane schistosity of tight folds was previously thought to have created a new layering and to have destroyed stratigraphic sequence in the North Mine area. However the tight but generally not isoclinal nature of F_2 and F_3 folds, and consistent stratigraphic younging from graded beds over large areas show that any transposition which occurred must have been during D_1 and on a macroscopic scale only. A consistent stratigraphic sequence is observed throughout most of the area; in the Mine area this sequence is inverted around the large F_2 folds, which are therefore downward-facing.

Within the inverted sequence the Lode Horizon occurs stratigraphically at the top of a metasedimentary sequence which contains probable volcanogenic units (the acid and basic gneisses), and is overlain by a metasedimentary sequence lacking such units. This probably reflects a link between volcanic activity and sulphide deposition. The inverted sequence also places the lead lodes stratigraphically above the zinc lodes, thus removing an inconsistency in previous volcanogenic models.

The study confirms the unparallelled usefulness of the pelitic metasedimentary rocks in structural analysis, metamorphic investigations, and stratigraphic reconstruction. Methods of analysis of structures in drillcore are described which complement surface and underground mapping.