MINERALISATION AT MOUNT LYELL
AND EXPLORATION OF THE
BUFFER ZONE, MINE LEASE AND
E.L. 9/66

prepared for

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A review of the Mount Lyell geological data coupled with field studies has shown that the mineralisation post-dates the Pioneer Beds of Ordovician age and that it results from upwelling hydrothermal fluids in the Great Lyell Fault. These fluids may originate from the east-west fractures with fluid damming against the wall of impermeable Owen Conglomerate. Segmentation of the Great Lyell Fault by cross fractures caused fluid channelling with subsequent boiling and self-sealing or a meeting of hydrothermal fluids with cold ground water in permeable Pioneer Beds. These processes resulted in ore deposition as in closed-cell convection systems or stacked-cell convection systems similar to the Berger and Eimon models.

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To date most of the Lyell production has been derived from replacement bodies impinging on the Great Lyell Fault. However there is considerable evidence of ore and mineralisation occurring in cross fractures and a drilling programme has been proposed to test these mineralised structures in the Linda Valley within the Mine Lease. This drilling is now in progress.

An analogue of the North Lyell structure and stratigraphy occurs in the Gormanston Corridor and a drilling programme is proposed to test for potential North Lyell-type mineralisation in this structure which occurs in the Buffer Zone adjacent to the Mine Lease.

The above two areas are of considerable significance as any discovery of high grade ore could be developed quite rapidly from the Prince Mine workings.

The possibility that ore deposition may develop where Pioneer Beds or possibly Tyndall Group overly fluid-carrying structures creates significant exploration targets along the bounding faults of the Linda and Comstock Valleys and at the western end of the latter on the concealed Great Lyell Fault.

In the Buffer Zone south of Gormanston Gap the Great Lyell Fault is strongly imbricated by the major fractures crossing

Mount Owen. Mineralisation is known in this area (Duke Lyell, Great Lyell and Lyell Estates)and the area should be explored for high grade ore in the schist embayments.

The potential for further ore deposits within the Mine Lease, Buffer Zone or EL 9/66 is considered to be favourable. After the necessary review work and data compilation in all three areas it is recommended that drilling budgets be considerably expanded even at the expense of other projects. From the point of view of future mine planning it would appear that the potential viable reserves of Mount Lyell should be clarified as soon as practical.

The recognition of post-Ordovician ore in structural - stratigraphic replacement traps is of considerable significance in Tasmania and the overall implications of this concept should be considered with regard to exploration in the rest of the State and in particular to exploration in E.L. 9/66.

A programme of immediate exploration is suggested in order to test for possible higher grade ore which would be accessible from the Prince Mine workings. These targets are:-

i] the Blocks Lode
ii] the King Lyell Lode
iii] the Gormanston Corridor
iv] the Pioneer Lode
v] the Comstock Mine area
vi] the North Lyell-Tharsis Corridors.

Secondary targets within the Mine Lease include the Great Lyell Fault interface with the Pioneer Beds and/or the limey beds of the Tyndall Group at the western end of the Comstock Valley. The Comstock Fault interface with the Pioneer Beds to the east of the Comstock Mine constitutes a valid exploration target.

Within the Buffer Zone (excluding the Gormanston Corridor) a minimum budget of $500,000 per annum for the next three years should be considered in order to evaluate the following targets:

i] the North Lyell fault and its interface with the Pioneer Beds especially McDouals Prospect

ii] the Owen Spur Fault and its interface with the Pioneer Beds

iii] the embayments developed in the Great Lyell Fault south of Gormanston Gap including the Duke Lyell, Great Lyell and Lyell Estates Prospects

iv] the auriferous potential of the faults traversing Mount Owen

v] the southwest corner of Mount Sedgwick where the Sedgwick Fault intersects the Great Lyell Fault

vi] the Comstock fault to the east of the Mine Lease

vii] extensions of the Linda Lodes from the Mine Lease into the Buffer Zone.

INTRODUCTION

The writer was briefed verbally and by Memorandum (see Appendix I) from L.A. Newnham dated 17th October 1983 to evaluate the exploration potential of the 'Buffer Zone' at Mt. Lyell. The Buffer Zone being that area ($50km^2$) contained within the periphery of EL 9/66 abutting Mining Lease 30M/80 held by The Mount Lyell Mining and Railway Co. Ltd. As its name implies the area was intended as a buffer between the Mount Lyell Mine Lease and the joint ventured E.L. Virtually no exploration has been undertaken in the Buffer Zone during the currency of EL 9/66 which must be reduced from 450 km^2 to 125 km^2 in August 1984. It is clear that retention of the 50 km^2 of the Buffer Zone would severely limit retention options of the remaining EL in that 400 km^2 would have to be reduced to 75 km^2. Incorporation of the Buffer Zone within ML 30M/80 would resolve this problem and Mt. Lyell has submitted such an application to the Mines Department.

The writer reviewed and collated data at Mt. Lyell and the Burnie office of Gold Fields over a period of 60 days from 18th October to 10th November 1983 and from 6th January to 18th February 1984. In this period collation and integration of the valid Buffer Zone and Mine Lease geological data was achieved; however as realistic exploration targets could not be generated in the Buffer Zone without an understanding of the ore controls at Mt. Lyell much time was devoted to this subject in conjunction with Mr M. Bird (Senior Mine Geologist). It rapidly became clear that much of the mineralisation was related to post-Owen and/or post-Pioneer structures, as had been claimed by M. Bird. In fact more time was directed towards the Mine Lease geology than to a study of the Buffer Zone. In view of the understanding gained in ore controls and its resultant generation of geological concepts in regard to the Buffer Zone this study was most worthwhile.

Dr. R.H. Sillitoe arrived on 9th January to review the Mt. Lyell mineralisation and during the one month he spent at Lyell considerable time was devoted to group field observations and discussions. Outcrops of reputed fossil gossans and reworked gossans in Owen Conglomerate were examined and conclusively shown to be replacement deposits. Sillitoe in the course of mapping the North Lyell area proved that the overwall alteration of the North Lyell ore body occurred in Pioneer Beds thus clearly debunking the Cambrian volcanogenic model. This observation coupled with the close spatial relationship of all mineralisation (except the Linda Lodes) with the Great Lyell Fault resulted in a complete re-assessment of the ore controls at Mt. Lyell (see Appendix II, "A reappraisal of the Mt. Lyell copper deposits, Tasmania: implications for exploration", by R.H. Sillitoe, 9/2/84). The writer is in accord with this study which should be read as a pre-cursor to this report.

It is indeed somewhat ironical that in the centenary year of Mt. Lyell a return should be made to the structural/replacement ideas of ore genesis espoused by Gregory and Loftus Hills as early as 1905.

This report has been kept as brief as possible in order to avoid losing the important issues in a plethora of data and conjecture. Some repetition of concepts is unavoidable in order to provide logical structuration of various sections of this report. The geology of Lyell is so complex that the length of a geological report on Lyell can be as long as there is time available to write.

METHODOLOGY

This sub-heading is a misnomer to some extent as there is little methodology to apply apart from rumaging through old records and transferring relevant data to 1:5000 plans and/or file. Some 3-4 months was allowed for this compilation and after some 60 days work (much of it on Mine Lease geology) it is not entirely complete but it is an appropriate time to report on the findings.

Various geological plans relevant to the Buffer Zone were photographically brought to 1:5000 scale and transferred to 1:5000 base maps. Geological data by Corbett was preferred in areas of geological conflict. The Cambrian geology of the Mine Lease has been annotated from a compilation by P. Hills and the Ordovician sequence is largely from Solomon. Mapping by Sillitoe has also been incorporated.

A compilation of geochemical and geophysical data has yet to be undertaken as an understanding of the geological concepts was considered of prime importance.

The geological data is presented as 1:5000 dyeline worksheets of the geological compilation of the following sheets, Lake Margaret (southern half), Mine, Township, Beatrice (southern half), Lyell and Princess. This data and the topographic bases have been photographically reduced to 1:10000 and the geological data transferred to a composite of the above sheets. This 1:10000 compilation accompanies this report and the 1:5000 geological work sheets have been submitted to Mr L. Newnham.

SCOPE OF THIS REPORT

The prime function of this report is to assess the potential of the Buffer Zone and to provide a basis and a programme for further exploration in this area (see Appendix I). However in order to lucidly present these concepts it is necessary to review the relevant regional geological parameters together with the local ore control parameters as known from the Mine Lease. Furthermore as aspects of the Buffer Zone and Mine

Lease relate to the remainder of EL 9/66 some comments regarding the E.L. are incorporated.

ACKNOWLEDGEMENTS

This report owes much to M. Bird whose total and untiring commitment to the project and his unreserved sharing of ideas and knowledge resulted in a meaningful and co-ordinated approach to the geology of Mt. Lyell.

The contribution of R.H. Sillitoe is acknowledged with acclaim, particularly his critical field observations and his ability to weld our various concepts and ideas into a cogent exposition.

The enthusiastic help and critical comments from Peter Hills and Garth Stewart are recorded together with John Carswell's self-appointed, necessary and well-argued role of devil's advocate.

The encouragement and faith given by Messers Shakesby and Newnham is acknowledged together with their constructive comments during many discussions. The cordial assistance of the General Manager of Mt. Lyell Mr M.W.D. Ayre is also acknowledged with gratitude.

The writer also wishes to express much appreciation for the opportunity to be involved in this study of Mt. Lyell.

G E O L O G Y

It is not intended that this section should be a mere re-hash of the voluminous descriptions of the geology of Mt. Lyell and the West Coast Range; instead its purpose is to draw attention to alternative view points which are not in accord with the accepted doctrinaire of Tasmanian geology. These ideas reflect some of the results of discussions with M. Bird.

REGIONAL CONCEPTS

The presence of stable-shelf-type Proterozoic sediments indicates that Tasmania largely or wholly rests on a block of crust which was stablilised during the Archaean; therefore accepted plate-tectonic theory is considered to be irrelevant to the formation ? of the Cambrian volcanics.

The major control of the structural and igneous history of Tasmania, at least from Cambrian to Devonian, appears to be the Tyennan Geanticline or rather the history of the granitic rocks which, from gravity data clearly underly it at shallow depth.

Reference to the structural map of Tasmania in Williams clearly shows the various major components of Tasmanian geology to be peripheral to the margin of the Tyennan Block. The Cambrian volcanics discontinuously encircle the Block and the Owen Conglomerate occurs on its western and northern margin as does the Gordon Limestone. Much of the Owen Conglomerate is thought to be the debris derived from the uplifted Tyennan Block and dumped into collapsing volcano-tectonic depressions. The Devonian granites tend to occur in a partial ring some 70 km from the Tyennan Block on its northern half. These fringing features are viewed as developing in response to megatectonics resulting from the plutonic history subjacent to the Tyennan Block. The Cambrian volcanism possibly developed from a ring fracture around the Tyennan Block.

The Ordovician to Silurian sediments are contained in elongate graben-like structures and mapping together with Landsat Imagery shows Western Tasmania to be transected by numerous major fractures. It is considered that some of these fractures are possible hydrothermal fluid channels and/or ore-bearing structures.

Over the past fifteen years it has been generally accepted that two phases of mineralisation occurred in Tasmania, a Cambrian volcanogenic phase and a Devonian "granitic phase". The deposits of Lyell, Rosebery and Que River have been considered to be a product of Cambrian volcanism; however our (i.e. Bird, Sillitoe and Brook) recent work at Lyell has shown the Lyell mineralisation to be post-Pioneer and hence probably Devonian. A brief visit by the writer to Rosebery showed that there are considerable problems associated with fitting Rosebery to a simplistic volcanogenic model. Further discussion of this topic is beyond the scope of this report; however the subject should be pursued.

Corbett 1979 has erected the concept of three sequences in the Cambrian volcanics. This appears to be fundamentally correct with the central and eastern sequences being predominantly acid intrusives and/or lava domes controlled by the bounding structures of the Owen Conglomerate basins.

It is generally accepted that the Cambrian volcanics have been isoclinally folded yet no fold closures have been identified in the Mine Lease. The rocks appear to have been transposed to an essentially vertical orientation by massive vertical tectonics induced by granitic intrusions in a manner and style reminiscent of the Archaean rocks of the Western Australia Shield. This is presumably a pre-Owen development. Movement on the Great Lyell Fault and its eastern equivalent during Owen formation resulted in major structural deformation of the adjacent Owen Conglomerate. Pioneer Beds and subsequent sediments lapped over these structures and were themselves folded and faulted during the east-west graben and cross-structure development and possible re-activation of the Great Lyell Fault. Subsequent folding developed during emplacement of granitic bodies during the Devonian. Thus the writer views the post-

Proterozoic structural development of Tasmania as being one of the interplay of mega-fractures and massive deep-seated igneous activity related to long-lived hot-spot activity.

It is considered that current or accepted geological thought in Tasmania over-emphasises the concept of stratigraphic superimposition of rock units into strict time slots. However it is thought by us (Bird and Brook) that the geology should be viewed more as the product of processes and that these processes span the time slots imposed by the superimposition dogma. For example some of the Owen Conglomerate appears to be tuffaceous (hand lens observation only) and the Tyndall Group seems to conformably underlie Pioneer Beds and may be related to the Crown Hill Andesite volcanism dated at 473 my. Thus volcanism may have continued or occurred during Gordon Limestone deposition (450-490 my). It is understood that recent dating (not published) by the Mines Department of "Cambrian" volcanic rocks has given ages as young as 390 my.

THE WEST COAST RANGE

This mountain belt formed from Owen Conglomerate runs from Mount Farrel to South Darwin Peak a distance of 70 km. Its northern boundary is marked by the truncating Henty Fault and north of the Mount Owen its eastern and western margins are characterised by sharp upturns. To the south of Mount Owen the writer is not familiar with the geology and can only speculate from the 1:250,000 Queenstown Sheet. However it would appear that the graben-like structure continues south from Mount Darwin to Moores Valley (45 degrees 45 minutes South). The eastern edge of this graben more or less trends south near Mount Ficham, Cracroft Hills and the Princess Range.

The southern extension of the West Coast Range may be truncated by a fault parallel to the Henty Fault near the Kelly Basin Road; however the 1:250,000 map shows conformable relations.

The mineralisation associated with the West Coast Range almost invariably occurs in close proximity to the Owen Conglomerate-volcanic contact and this interface is considered to be of vital importance in controlling mineralising fluids.

OWEN CONGLOMERATE - MT. READ VOLCANIC INTERFACE

As mentioned in the previous section this interface has played a critical role in controlling mineralising fluids. At Lyell drilling has shown the western contact to generally dip west at 60-80 degrees and the down-dip extension of the contact is a minimum of 1500m. This contact is known as the Great Lyell Fault and continues northwards to the Henty Fault zone. Its southern extension from Mt. Owen is not known to the writer. The eastern margin of the West Coast Range shows sharp upturns in the Owen Conglomerate but there is very little subsurface data on the geometry of this contact. The Owen Conglomerate from Mount Owen to the Henty Fault can be viewed as a fault-bounded elongate prism set in Cambrian volcanics and extending to a depth of up to 1500m or more.

Fold structures within the Owen Conglomerate of the West Coast Range tend to be gentle away from each margin. Locally Cambrian volcanics occur within the West Coast Range (e.g. southern flank of Mount Sedgwick, Lake Julia and Red Hills). These contacts are probably mainly fault-bounded cross structures but in places they may have been eroded back sufficiently to expose the depositional contact of the Owen Conglomerate.

The nature of the Owen-Cambrian contact can only be explained satisfactorily by accumulated Owen Conglomerate collapsing en masse into the volcanics along the bounding fractures of its basin of deposition. The infilling of a developing rift valley would tend to produce the relationships observed but the very rapid infilling of a volcano-tectonic depression such as Lake Taupo or Taba with the weight of fill material possibly associated with magma withdrawal causing further collapse would more adequately explain the field relationships. In view of the nature of volcanism in the Cambrian the latter explanation is favoured. The development of acid domes along the Owen boundaries may reflect igneous activity along the collapse structures.

The Great Lyell Fault is cut in numerous places by cross-structures and oblique structures repeat the Great Lyell Fault and this structural interplay creates favourable fluid-dammed-channels.

The west-dipping Great Lyell Fault (generally viewed as a reverse fault) is the logical dip for a collapsing structure as inward dips on collapsing structures would hinder collapse (e.g. the geometry of a bath-plug, pers. comm. Bird & Atkinson).

CROSS STRUCTURES

The mineralisation at Mount Lyell is related to east-west-structures occurring within a large complex structure whose southern boundary extends for 57 km from Trial Harbour along Pearl Creek Fault to a little east of Bubs Hill. Its northern boundary is not well defined but to the east it probably trends through Eldon Peak, Walford Peak and Red Hills. Within this structure there are a series of horsts and grabens preserved in the West Coast Range as outlined below:

i] Mt. Owen horst where northwest faults transect the mountain

ii] Linda Valley graben bounded by the Owen Spur and North Lyell Faults with tightly folded Pioneer Beds plunging eastwards and westward from the west and east margins of the Owen Conglomerate to the centre of the Linda Valley

iii] Mt. Lyell horst

iv] Comstock Valley graben bounded by the Comstock and Sedgwick Faults producing a down-faulted block similar to the Linda Valley.

v] Red Hills - Selina where a structurally disturbed zone extending south to Mt. Tyndall on the western margin and to Lake Dora on the eastern margin is mineralised. It may be idle speculation but it is worth noting that the Hercules and Rosebery deposits lie 6-7 km to the northwest along the projected strike of this structure across the Henty fault.

vi] Cross cutting structures south of Mount Owen have not been studied.

The cross-structures are rather strange in that although they have a most marked effect on the Owen Conglomerate their effect on the adjacent Cambrian appears to be minimal. This may be a reflection of inadequate mapping or that the structural effects were taken up on the confining structures of the Owen Conglomerate.

MINERALISATION

Virtually all of the known mineralisation of the West Coast Range occurs in close proximity to the Owen Conglomerate on either one of the bounding faults or in a cross-structure.

Sillitoe (pp. 7-15 of Appendix II) discusses the mineralisation at Mt. Lyell and it is not needlessly repeated here; however it constitutes essential reading and is an integral part of this report.

The writer considers that the cross-structures associated with the structures of the Trial Harbour-Bubs Hill disturbance were the prime source of mineralising fluids and that the deep-sounding block of Owen Conglomerate acted as a barrier to these fluids which were then channeled along it particularly the western side i.e. the Great Lyell Fault. The indented nature of the Great Lyell Fault produced by cross structures, caused fluid flow restrictions and fluid entrapments. Continued upwelling of the hydrothermal fluids resulted in metal deposition in the stacked cell convection model or a closed cell convection model proposed by Berger and Eimon.

In the stacked-cell convection model the overlying sediment is generally Pioneer Beds or their equivalent Newton Creek Beds. The carbonate-bearing sediments and limestones of the Tyndall Group in proximity to fluid-bearing structures is also a potential ore-bearing horizon of this type. Silicification of the Pioneer Beds occurs and the resultant self-sealing creates conditions amenable for mineralisation in the plane of the Great Lyell Fault and as replacement of suitable rock units and more importantly for high grade ore bodies of North Lyell-type below the sealed Pioneer Beds.

The recognition by Sillitoe that the North Lyell orebody lies below Pioneer Beds is the most significant observation made at Lyell since Gregory in 1905 recognised the relationship of mineralisation to the Great Lyell Fault and cross fractures. Exploration can now be targetted to specific areas and problem of E.L. reduction can be viewed with a far stronger degree of confidence.

MINE LEASE - BUFFER ZONE CONCEPTS

It is beyond the scope of this report to describe in detail the complexities of Lyell geology: reader familiarity with these is assumed and in this section it is proposed to draw attention to salient economic features or ideas which are relevant to future exploration.

It is impractical to separate the concepts of Mine Lease - Buffer Zone geology and these are integrated in the following pages; however recommendations for further work on the Buffer Zone are treated separately.

From the view point of economic geology there are three important stratigraphic units, namely:-

i) the volcanic breccias which host the Prince Lyell-type ore. As RGC management does not consider these a valid exploration target in the short term because of adequate reserves of this type they will not be considered further.

ii] The Pioneer Beds/Gordon Limestone where they overly the Great Lyell Fault and cross structures thereby creating conditions suitable for development of North Lyell-type ore.

iii] The Tyndall Group of tuffs, (?) lavas, limestones, marls, silts greywackes etc. At Comstock this group appears to host the Comstock ore and also hosts a large amount of low grade replacement ore (Pb, Zn, Ag, Ba, F, Cu, and pyrite). The massive Pb-Zn Tasman Crown ore may occur in this horizon. Corbett recognised that the Comstock Tuff overlies the Central Sequence of volcanics. It also appears to be conformably overlain by the Pioneer Beds and a conglomerate unit similar to the Jukes Conglomerate. (The geological compilation does not distinguish between the Jukes Conglomerate underlying the Owen Conglomerate and its 'look-alike' above the Tyndall Group).

The conformable relationship between the Pioneer Beds and the Tyndall Group surely must indicate that the Tyndall Group is post-Owen or more importantly post-Great Lyell Fault. Thus where the Tyndall Group overlies the Great Lyell Fault and if sufficiently permeable and amenable to replacement then it can generate the stacked-cell convection system of Berger and Eimon. The relationships of the Tyndall Group with other rocks should be studied closely in the field before acceptance of the above supposition.

From the view point of structural controls the interplay of cross-structure with the Great Lyell Fault together with mineralisation in the cross-fractures themselves is the fundamental guide to ore. Within the Mine Lease - Buffer Zone the Great Lyell Fault trends more or less northerly although disrupted and repeated by numerous cross-structures and most of the known Lyell ore bodies are associated with the Linda Structure. Both the Linda and Comstock Structures are approximately two km wide and they are presumably similar in origin and should show similar geological structures and relationships. The Comstock Valley is bounded by the Sedgwick Fault to the north by the Comstock Fault to the south.

Exposure is poor in the Comstock Valley being masked by glacial debris and post-Owen rocks. Drilling on the Mine Lease and mapping of the EL have defined the mineralised Tyndall Group and several E/M anomalies remain un-tested at its junction with the Sedgwick Fault.

Exploration of this area will be difficult because of the cover rocks; however the western end of the Comstock Valley where traversed by the Great Lyell Fault must be viewed as being as potentially well mineralised as the Linda Structure - Great Lyell Fault combination.

The two-bounding faults and associated structures may be mineralised and some evidence to confirm this is given by Hole C49 which intersected cupriferous clays adjacent to the Comstock Fault in the Buffer Zone.

From Cape Horn to the Blow, which represents almost the entire width of the Linda Structure, the Great Lyell Fault and/or adjacent rocks are virtually continuously mineralised and largely constitute ore.

There is abundant evidence of mineralisation in the cross structures and these constitute immediate and important targets as a possible source of readily available +2% Cu and noble metals.

Southwards from Gormanston Gap to the limit of the Buffer Zone, a distance of 2.2 km, the Great Lyell Fault is cut by several major fractures and there is abundant evidence of mineralisation, e.g. Great Lyell, Duke Lyell, Lyell Estates, alluvial gold and lode gold in the Owen Fault. The structure interpretation shown on the plans in this area is somewhat different from previous workers in that the cross faults are shown here as forming the southern margins of the embayments generated by the interplay of these structures with the Great Lyell Fault. This enables a more simplistic and sensible interpretation and upgrades the potential of the area for fluid entrapment and ore generation. In the past 50 years this area has received scant attention. Its proximity to the western cliffs of Mount Owen would probably prevent any open cut mining.

EL 9/66

Various aspects of the preceeding section are relevant to EL 9/66 and will not be repeated here although several additional comments are considered relevant. Throughout the exploration history of EL 9/66 the target and model have been based on the volcanogenic concept. Whilst the presence of such an ore type is not discounted within the EL it must be emphasised that all or nearly all the known mineralisation is in close proximity to the Owen Conglomerate - volcanic interface. Exploration philosophy, direction and application has not given cognisance to this fact. Little structural mapping has been undertaken and the implication of structural controls on ore deposition have not been considered.

EXPLORATION POTENTIAL

On the basis of the previous sections, Sillitoe's report and consideration of ore requirements for Mt. Lyell it is clear that two main targets exist within the Mine Lease and Buffer Zone.

i] North Lyell-type ore in the following places

(a) at the Pioneer Beds and/or Tyndall Group Great Lyell Fault interface at Comstock

(b) at the Pioneer Beds/Great Lyell Fault interface at Gormanston

(c) at depth in the North Lyell system

ii] high grade hypogene ore in the cross fractures of the Linda and Comstock Valleys.

There are five main targets here:

(a) North Lyell Fault including McDoualls Prospect

(b) Blocks structure

(c) Comstock structure

(d) Pioneer gossan

(e) King Lyell gossan

Secondary targets within the Mine Lease - Buffer Zone are:-

(i) North Lyell-type ore in the embayments within the Great Lyell Fault generated by the cross fractures on Mt. Owen.

(ii) Replacement lead-zinc-silver bodies in the limey beds of the Tyndall Group.

(iii) Epithermal gold in the cross fractures of Mt. Owen.

(iv) The Lyell Estates, Duke Lyell and Great Lyell prospects; the emphasis being for gold-copper bodies rather than Prince Lyell types (as far as is known no gold determinations have been undertaken on these prospects).

(v) Additional bodies of Prince Lyell-type which could be expected at depth below Glen Lyell; however such an orebody is not required in the short term in view of Prince reserves and potential Western Tharsis reserves.

Within EL 9/66 it is considered that prospector activity has been sufficiently intense to have located all significant areas or camps of mineralisation. In the northern part of the EL the Red Hills - Newton Creek to Dora-Selina areas are prime areas for exploration based on structural and stratigraphic traps.

The southern part of the EL presumably contains similar traps; however the writer is not sufficiently familiar with the geology of this region to be specific.

The exploration potential of the EL is viewed with some optimism provided that exploration takes cognisance of the controls of the mineralisation at Mt. Lyell.

F U R T H E R   W O R K

This section of the report is specifically written to the problems of short term mine grade and continued low copper prices.
The writer considers that the present configuration of economic circumstances affecting Mt. Lyell for the next two years requires a major and rapid effort to demonstrate the existence of potential and significant high grade (+3% Cu) reserves. By rapid it is meant that by December 1984 the targets below should have been drilled. If no significant high grade ore is found the future of the mine can be predicated from known reserves and the prevailing economic climate.

The exploration programme should be designed so that any ore found can be developed as rapidly as possible for mill feed. Thus potential ore situations near the eastern extensions of Prince Lyell development or North Lyell tunnel should be tested first. Any significant intersection should be pattern drilled immediately with additional rigs.

Thus the first targets on the Mine Lease should be the

Blocks Lode
King Lyell Lode
Gormanston Corridor
Pioneer Gossan

Excluding the three holes presently scheduled for Blocks a total of 9 holes (approximately 3200m) is considered a bare minimum as a first pass evaluation. Two rigs could be advantageously used in this area. At $100/m this represents a budget of $320,000.

Comstock should also be tested as soon as data evaluation is completed. Testing of Comstock should not be delayed, because if the Linda Lodes and Gormanston fail then Comstock becomes the only hope with potential for underground development from the Prince Mine system. It is considered that a minimum of six holes (approximately 2400m) would be required to test the Comstock potential, i.e a budget allocation of $240,000.

Thus on this basis a budget of approximately $560,000 is required to probe the potential high grade areas on the Mine Lease by December 1984.

The writer has not addressed the problem of additional North Lyell ore in the North Lyell Corridor or the Lyell Tharsis Corridor. A complete geological assessment of this area is required before decisions are made regarding drill targets. However it is thought unlikely that bodies significantly larger than 12 West would exist and although such a body would resolve the short term problem its long term effect would not be great. However, it can also be argued that if it resolved the short term problem its long term effect could be great.

In order to achieve the above programme several procedures should be followed as detailed below to be completed by June 30th, 1984.

a] office and personnel organisation so that efficiency is increased with clear objective scheduling;

b] old core storage organised so that reference core from Comstock and Gormanston is usable (preferably in the Mine Office core shed or a new shed);

c] organisation of the old file data pertinent to the exploration targets and areas outlined in this report;

d] immediate evaluation and reconstruction of the following data;
i) Gormanston Corridor
ii) Comstock Mine and environs
iii) North Lyell - Tharsis Corridors
This reconstruction should be on Imperial scale with final transfer to metric scale by photographic techniques.

BUFFER ZONE

The Buffer Zone work is very dependent on results obtained from Mine Lease drilling. Success on the Linda Lodes and Gormanstn area will lead naturally into more testing to the east and in the Buffer Zone.

The Buffer Zone contains the following targets:

i] Comstock Fault
ii] North Lyell Fault
iii] Owen Faults
iv] West Owen mineralisation
v] Southwest Sedgwick
vi] Gormanston Corridor

Using the observation that fluids from cross structures travelling in the Great Lyell Fault produced North Lyell ore below the Pioneer Beds it is not inconceivable that similar deposition occurred in association with Pioneer Beds in juxtaposition with cross structures such as the Comstock fault, North Lyell Fault, Owen Spur Fault etc. There is of course one element missing and that is the absence of volcanics below the Pioneer Beds. Within the cross structures Owen Conglomerate lies below the Pioneer Beds. The Owen is not generally favourable to replacement although several instances of manto-type replacement (albeit vertical) of beds by haematite and minor barite have been noted. Hence one could conceive the presence of fissure-fill hypogene ore and manto type ore below the Pioneer Beds in the cross structures. With this thought in mind the type of replacement mineralisation in the Telluride Conglomerate described by Mayor and Fisher could be relevant.

There is considerable evidence of mineralisation in the cross structures and this is listed below:

1] 12 West bornite body lies on the 12 west fault
2] McDouall Prospect on the North Lyell Fault; according to old reports it was a gold deposit but Mr G.F. Hudspeth states that it also contained copper.
3] The known Linda Lodes.

4] Alluvial gold shedding from Mt. Owen, Mt. Lyell, the presumed source being cross structures.

5] DDH C49 intersected copper bearing clays at the end of the hole as it approached the Comstock Fault.

Assuming that the cross fracture/Pioneer Beds interface is a valid ore depositional site then the Comstock, North Lyell and Owen Spur Faults can be considered as major targets because they constitute the greatest linear distance of this particular interface. It is therefore recommended that three holes be targeted at McDouall Prospect and three holes to test the Comstock Fault. In the case of Comstock a review of the geophysics is warranted in light of the drilling results prior to targeting further holes. The possible use of seismic techniques at Comstock to define the Great Lyell Fault and the base of overlying beds should be investigated.

The southwest corner of Sedgwick is possibly a North Lyell type structure. It partially occurs within the Mine Lease, Buffer Zone and EL 9/66. A geophysical anomaly occurs in the area.

As lower priority exploration in the Buffer Zone the Owen faults should be assessed. This will involve field mapping, prospecting with particular emphasis on gold and epithermal alteration plus assembling old data and drill core, relogging and assaying for gold. The intersection of these faults with the Great Lyell Fault constitute a more immediate target for mapping and prospecting.

The following programme is proposed for the Buffer Zone over the next 3 years commencing June 1984.

Year I (a) Completion of 6 holes to probe the North Lyell Fault and Comstock Fault interface with the Pioneer Beds. Say 2500m at $200/m all up, i.e. $500,000.

(b) Mapping, prospecting, relogging etc, of the West Owen area. Work to be done in conjunction with above drilling at no significant additional cost.

(c) Investigation of the southwest Sedgwick area by initial assessment of old data.

Year II — A minimum allowance of $500,000 for drill-testing of structures other than North Lyell and Comstock. Any encouraging results from Year I should receive additional funding.

Year III — A minimum allowance of $500,000 to clean-up remaining untested targets. Any follow-up targets from Year II would require additional funding.

EL 9/66

The recognition of the fundamental ore controls at Mt. Lyell should be seriously considered in relation to exploration of EL 9/66. The mineralised areas of the EL should be carefully reviewed and mapped in terms of structural geology with particular attention being paid to the geometry of the Owen-volcanic contact. The presence of Pioneer Beds, correlates and carbonate-bearing Tyndall Group should be carefully studied particularly in relation to structures. Retention of selected portions of EL 9/66 at June 1984, should be based on the concepts embodied in this report and those of R.H. Sillitoe.

REGIONAL CONSIDERATIONS

The West Coast of Tasmania has for many years been considered one of the most productive mineral belts in the world. This can be rationalised when the relatively unique structural setting of Tasmania is recognised.

Leaving aside consideration of volcanogenic deposits it is clear that most deposits are structurally controlled and occur in structures or are replacement deposits of carbonate beds.

There is considerable scope for reviewing the geology and mineralisation of Tasmania in the above terms.

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APPENDIX I

MT. LYELL BUFFER ZONE PROJECT

MEMORANDUM FROM L.A. NEWNAHM

DATED 17 OCTOBER 1983

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GOLD FIELDS EXPLORATION PTY. LIMITED

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MEMORANDUM

To: Bill Brook. c.c. R.A.S., Mike Bird, Mike Ayre, G.Purvis.

From: L.A.Newnham

Subject: Mt.Lyell Buffer Zone project.

Date: 17th October, 1983.

Background:

In the late 1970's, the Mt.Lyell Company, in an effort to reduce costs, decided to reduce the size of their Consolidated Mining Lease. At this time, they also held an Exploration Licence E.L. 9/66 which completely surrounded their Consolidated Mining Lease and which they were Joint Venturing with Getty (40%). The Mining Lease was reduced by some 50sq. kms., which was incorporated into E.L. 9/66., but not subjected to the Getty J/V.

This 50sq.kms. is known as the Lyell Buffer Zone and is controlled 100% by our Company.

However, the State Mines Department regards it as part of E.L. 9/66 and thus subject to the conditions which apply to that licence. There are two such conditions which are now of concern to us viz:

(i) The 450 sq km. E.L. will have to be reduced to 125 sq kms. in August 1984.

(ii) The complete E.L. will have to be relinquished by August 1987.

The implications of these two conditions are obvious.

Firstly, we need to define any areas with minimum potential which could be relinquished before August 84.

Secondly, we need to conduct such exploration as required to thoroughly evaluate the Buffer Zone prior to August 1987.

Beyond August 1987, areas of high interest (drill defined resource stage) can probably be retained for further evaluation either as Mining Leases or special "Retention Areas".

Project:

The purpose of your work on the Buffer Zone in the next 3-4 months is to :

(a) Evaluate existing exploration data on the Buffer Zone.

(b) Further assess this data with respect to recent developments in exploration on the adjoining Mt.Lyell Mining Lease and Tyndall Joint Venture areas,

(c) Recommend a 3 year program of further exploration which would ensure a thorough evaluation of the Buffer Zone.

Previous Data:

Mt.Lyell has previously held four tenements which now cover the Buffer Zone.

(i) Original Mt.Lyell Mining Lease.

(ii) E.L. 9/66 (Tyndall) - North of Queenstown.

(iii) E.L. 41/71 (Henty-Yolande) - West of Queenstown.

(iv) E.L. 10/69 (Dora-Huxley - South of Queenstown.

These are now all amalgamated into E.L. 9/66.

Data on all these areas is to be found both at Mt.Lyell and Burnie offices.

Most of the original Mt.Lyell Mining Lease data is at Queenstown. Most of the E.L. data is at Burnie.

The original E.L. 9/66 covered such project area names as:

Red Hills
Selina
Rolleston
Howards Anomaly
White Spur
East and West Tyndall
Henty Fault Zone.

None of these areas has any immediate coverage in the Buffer Zone.

E.L. 41/71 (Henty-Yolande) covered such project areas as:

West Sedgwick
Basin Lake
Madam Howard

All these have some relevence to the B.Z.

E.L. 10/69 (Dora-Huxley) covered such project areas as:

Roaring Meg
Little Owen
Great Lyell

Beatrice
Huxley

Again, all these have some relevence to the B.Z.

Annual Reports, Interim Reports, and transparencies of all plans enclosed there-in are held in Burnie.

The B.Z. is covered by a series of Standard plans at 1:50,000, 1:10,000, and 1:5000. Some of the plans at the latter two scales, require final drafting but this is in hand.

Mt.Lyell Mine may well have coverage at larger scales (eg) 1:2,000 and 1:1,000. Further, I believe Mt.Lyell's standard sheet layout over this area maybe different to G.F.E.L.'s.

Most of the data which exists in old reports is on a variety of Imperial Scales.

The B.Z. of course has had a variety of geophysical, geochemical, geological and drilling progress already completed upon it.

Mt.Lyell -E.Z - G.F.E.L. recently completed a regional compilation of all existing data at 1:50,000 over the complete Queenstown - Rosebery belt. This data is in an overlay form and may be of some value.

A compilation of geophysical data has been taken further by our geophysical consultant Dr.J.Bishop in conjunction with Mike Bird and it would be productive to become familiar with this work.

Last summer, a small team of geologists led by Gerald Purvis reviewed all existing data on E.L. 9/66 (excluding the B.Z.) and their Review Report should also be useful to you.

I am uncertain as to the volume of data Mike has for you at Lyell, but I'm sure its substantial.

Timing and Liason:

We are hoping that this project can be completed by end of February, as its results can be considered and incorporated in our 1984-85 budget.

Mike Bird is currently undertaking a substantial exploration program on the Mt.Lyell lease, following some significant rethinking of Lyell geology.

APPENDIX II

A REAPPRAISAL OF THE MOUNT LYELL COPPER DEPOSITS, TASMANIA: IMPLICATIONS FOR EXPLORATION

BY R.H. SILLITOE

DATED 9 FEBRUARY 1984

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A REAPPRAISAL OF THE MT. LYELL COPPER DEPOSITS, TASMANIA: IMPLICATIONS FOR EXPLORATION

A report prepared for GOLD FIELDS EXPLORATION PTY. LIMITED.

By: Richard H. Sillitoe

February, 1984

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SYNOPSIS

A one-month reappraisal and partial remapping of the geology of the Mt. Lyell copper deposits, Tasmania, has resulted in a revised model for their emplacement. Currently accepted theory invokes ore deposition during Pre-Late Cambrian Mt. Read volcanism, with both epigenetic replacement and syngenetic volcanic-exhalative bodies being developed in volcanic host rocks. Post-Middle Cambrian sedimentary rocks of the Tyndall Group, Owen Conglomerate and Gordon Limestone are presently considered to post-date hypogene ore deposition.

During this study, it was recognized that sulphide mineralization, including massive chalcopyrite-bornite ore at North Lyell, did in fact affect the sedimentary succession. So did ore-related silicification and hematite-barite alteration. Ore deposition and hematite-barite alteration were also very closely controlled by a complex fault system, especially the pre-eminent Great Lyell fault, which juxtaposed volcanic rocks with the Owen Conglomerate. It is further concluded that native copper mineralization in the Gordon Limestone (the so-called Copper Clay deposits) was not derived by supergene oxidation of volcanic-hosted sulphide deposits to the west but is fracture-controlled hypogene mineralization later subjected to deep karstic weathering. Ore depositon in the volcanic and younger sedimentary rocks is attributed to channeling of hydrothermal fluids along the western boundary (the Great Lyell Fault) of a deep Owen Conglomerate-filled graben in an area where it is over printed by the second-order Linda Valley graben. If the hydrothermal system responsible was related to late stages of Mt. Read Volcanism, Owen and Gordon sedimentation must have taken place more rapidly than is currently assumed.

Recognition that Tyndall Group, Owen Conglomerate and Gordon Limestone at Mt. Lyell are mineralized modifies significantly the exploration approach in the district. In particular it focuses attention on the long-neglected sedimentary formations. On the basis of available data, potential for further discoveries

of high-grade, silver-rich copper ore of North Lyell type exists in the North Lyell-Lyell Blocks, Lyell Comstock and Gormanston areas. At North Lyell, Lyell Comstock and Gormanston, precise compilation of old mine data and detailed relogging of existing drill core should precede selection of specific targets. If hypogene copper-silver ore is shown to underlie the near-surface Lyell Blocks native copper workings, then deeper exploration of copper-bearing structures in the other Copper Clay deposits (e.g. King Lyell, Lyell Consols) will be justified. Gold mineralization associated with faults that bound and parallel the Linda Valley southeast of Mt. Lyell require reconnaissance sampling to determine their potential.

The ore potential of the Mt. Lyell district combined with its proximity to a mining operation are considered to justify a long-term commitment to a programme of geologically orientated exploration. It is felt that the programme should be assigned a high priority in the context of the Company's exploration efforts in Tasmania. Furthermore, the conclusions stemming from this study underscore the need to pay greater attention to Late Cambrian-Ordovician sedimentary formations elsewhere in Tasmania, especially in the vicinities of volcanic-hosted base- and precious-metal prospects currently interpreted to be strictly coeval with volcanism.

INTRODUCTION

At the request of Gold Fields Exploration Pty. Ltd., the writer spent one month (from 9th January - 9th February, 1984) at the Mt. Lyell copper mine in Tasmania with the object of assessing the exploration potential of the mine leases.

The writer's initial intention was to study the volcanic setting of the Mt. Lyell deposit in order to better understand its origin as a basis for formulation of exploration guidelines. During the first few days of office and field familiarization with Mt. Lyell geology it became apparent that the deposit is perhaps not as closely allied to volcanism as currently accepted. Evidence in support of this view is widely available in the North Lyell sector of the lease area. Since the North Lyell orebodies are higher in grade than other Mt. Lyell copper mineralization and therefore represent the most interesting exploration targets, a 1:2,500-scale geological map was prepared of the North Lyell area and environs, followed by additional mapping in the Gormanston and Lyell Comstock areas (Fig. 1). Orthophotos were used as a base, and particular attention was payed to understanding the complex and critical structural framework of the area.

This report briefly summarizes presently held views on the geological setting and genesis of the Mt. Lyell deposit as a prelude to presentation of evidence in support of a modified model for orebody emplacement. The model is then used as a basis for guiding future exploration in the North Lyell area, elsewhere at Mt. Lyell and, very briefly, in a more regional sense.

This report owes much to M. Bird, Senior Geologist of the Mt. Lyell Copper Division of Renison Goldfields Consolidated Ltd., and W.A. Brook, independent consultant, who shared their ideas on Mt. Lyell geology, and discussed

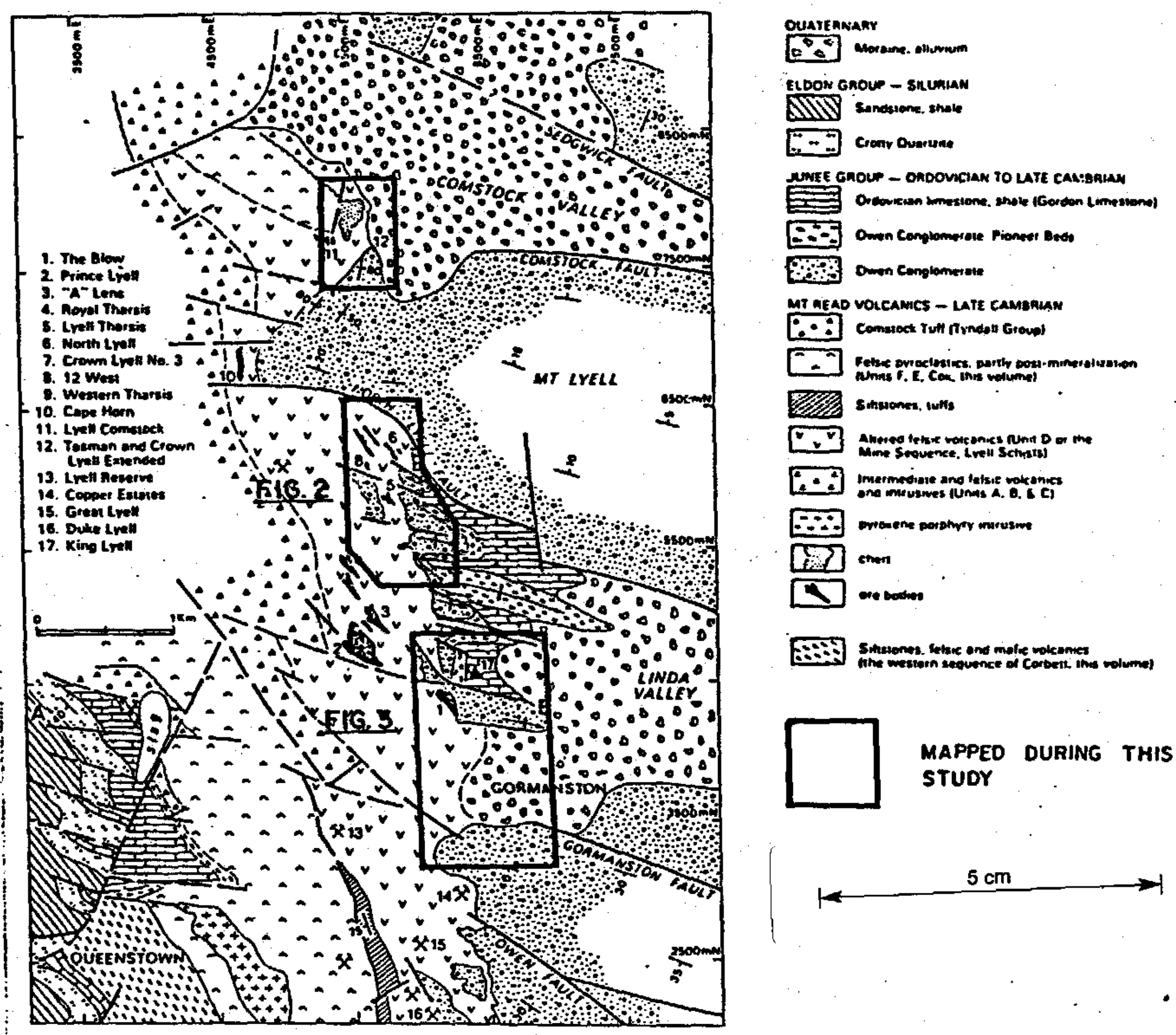

Figure 1: General location Map, Mt. Lyell area

them freely on numerous occasions. The study (and, in particular, Figures 4 and 5) depended heavily on M. Bird's encyclopaedic knowledge of the Mt. Lyell property, and specifically on his three-dimensional appreciation of the copper orebodies. This study is complimentary to W.A. Brook's appraisal of the Mt. Lyell Buffer Zone, a tract of country transitional between the mine lease and E.L.'s extending northward and southward from Mt. Lyell. Appreciation is also due to M.W.D. Ayre, General Manager of the Mt. Lyell Copper Division, for placing Company facilities at the writer's disposal; to L.A. Newnham, Assistant Exploration Manager (Tasmania & New Zealand) of Gold Fields Exploration Pty. Ltd., for his organization and support of the assignment; to G. Stewart and P.E. Hills of the mine geology department, for their enthusiastic collaboration during the field mapping; and to J. Carswell of the mine geology department for discussions. Nearing the conclusion of the assignment, R.A. Shakesby, Exploration Manager of Gold Fields Exploration Pty. Ltd., and G. Purvis, Gold Fields' geologist in charge of the contiguous E.L.'s, joined M. Bird, W.A. Brook, L.A.Newnham and the writer to discuss findings. G. Purvis is thanked for subsequently conducting field visits to Selina and Huxley prospects.

B. SUMMARY OF CURRENT GEOLOGICAL MODEL

1. Geological Setting

As affirmed by a number of descriptions of Mt. Lyell geology, and most completely and recently by Reid (1975) and Walshe and Solomon (1981), much of the mineralization is hosted by a sequence of felsic lavas and pyroclastics (the Mt. Read Volcanics).

In the Lyell Comstock area (Fig. 1), the mineralized volcanic sequence is disconformably overlain by the Tyndall Group, which is considered to be post-mineral and late Middle Cambrian to early Upper Cambrian in age (Jago et. al., 1972).

To the east of, and commonly abutting, much of the mineralized zone the Mt. Read Volcanics are juxtaposed with the Late Cambrian to Early Ordovician Owen Conglomerate (which is locally underlain by Jukes Conglomerate). The uppermost part of the Owen Conglomerate, the Pioneer Beds, is separated from the rest of the Owen succession by the high-angle Haulage Unconformity. The Pioneer Beds, in turn, are overlain, in apparent conformity, by the Gordon Limestone. In the Lyell Comstock area, the Tyndall Group is overlain directly by the Pioneer Beds, with no intervening Owen Conglomerate.

The structural setting of the Mt. Lyell area is dominated by the north-striking Great Lyell fault, and a series of northwest- to north-northwest striking cross faults associated with the western end of the Linda Valley (Fig. 1). Walshe and Solomon (1981) conclude that both sets of faults were active during Cambrian mineralization and again during Owen sedimentation, when the Great Lyell fault was probably a border fault along the west side of an Owen Conglomerate-filled graben.

Although early Paleozoic structures are recognized at Mt. Lyell, much of the observable rock deformation is attributed to the Middle Devonian (Tabberabberan) orogeny.

2. Mineralization types

In summary, four types of copper mineralization are generally recognized at Mt. Lyell:

(i) Large-tonnage, low-grade disseminated pyrite-chalcopyrite ores formed by replacement of more permeable volcanic horizons (Prince Lyell type).

(ii) High-grade massive to disseminated chalcopyrite-bornite ores replacing volcanic rocks high in the succession (North Lyell type).

(iii) Massive pyritic ores exhibiting well-developed sulphide banding and emplaced syngenetically at the top of the volcanic pile (Blow type).

(iv) Native copper and cuprite mineralization as flat, dispersed zones in Gordon Limestone to the east of the main volcanic-hosted mineralization (Copper Clay deposits, or Lyell Blocks type).

3. Ore genesis

It is generally accepted (Reid, 1975; Walshe and Solomon, 1981) that ore types (i), (ii) and (iii), above, are volcanogenic and emplaced as part of the Cambrian Mt. Read volcanism, prior to accoumulation of the Tyndall Group, Owen Conglomerate and Gordon Limestone. The Prince Lyell-type mineralization is considered to have been generated in subsurface conduits, which were feeders for sea-floor hot springs, at the sites of which Blow-type ores were precipitated. North Lyell-type mineralization is considered to have been generated in near-surface rocks immediately beneath sites of fluid debouchment, and in association with so-called "hematitic chert breccias". Hematitic chert breccias (Fig. 1) are interpreted as either sinters or near-surface replacements of volcanic rocks (Walshe and Solomon, 1981).

Solomon (1967) and Walshe and Solomon (1981) interpreted bodies of hematite, barite and subordinate chalcedonic silica as combinations of in situ fossil gossans and transported gossanous material accumulated near to weathering sulphides, depending on whether the bodies are present at the Mt. Read Volcanics/Owen Conglomerate contact (the Great Lyell fault) or within the Owen succession. On the basis of this interpretation, they concluded that sulphide ores were undergoing oxidation during the Late Cambrian-Early Ordovician, and were therfore clearly volcanogenic in origin.

Solomon (1969), Markham (1968) and Walshe and Solomon (1981) interpreted the Copper Clay deposits (iv, above) as the combined products of Ordovician and Tertiary weathering. Copper liberated during weathering of Cambrian sulphides is considered to have been incorporated in Gordon Limestone shales during their accumulation, and then to have undergone Tertiary oxidation together with further metal enrichment as a result of continued oxidation of the nearby volcanogenic ores.

Devonian orogeny caused elongation of sulphide bodies parallel to mineral lineation within the plane of cleavage (S_2), and widespread cataclasis of pyrite and streaking of chalcopyrite (Markham, 1968; Cox, 1981). Remobilization of sulphides is restricted to limited solution and redeposition of chalcopyrite (but not pyrite) in quartz-carbonate-chlorite-specularite-filled gash fractures.

C. CONTRADICTORY EVIDENCE

1. Structural control

Copper deposits at Mt. Lyell exhibit a remarkably close relationship to major faults (Figs. 2, 3, 4 and 5). All deposits, except for the Copper Clay deposits, are in contact with the Great Lyell fault. Deposits either grow upwards from it (North Lyell and Prince Lyell types) or lie against it (the Blow). Although Walshe and Solomon (1981) advocate the existence of the Great Lyell fault during Cambrian mineralization, the intimate association between ore bodies and the Fault is difficult to explain unless mineralization post-dated juxtaposition of the volcanic host rocks with the Owen Conglomerate. It is geometrically impossible to explain the physical contact of all ore bodies with the Great Lyell fault, within only centimetres of the footwall Owen Conglomerate but with no fault displacement or truncation of ore, if mineralization

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were volcanogenic and pre-Owen in age.

Furthermore, intersections of the Great Lyell fault with cross structures appear to localize most deposits. According to M. Bird, many Prince Lyell-type bodies (Prince Lyell, Royal Tharsis, Cape Horn) are centred on northwest-striking faults, and converge downward to points where the cross faults intersected the Great Lyell fault. North Lyell is closely controlled by the 12 West cross fault and an unnamed fault that appears to have displaced it (Figs. 2 and 4), and the 12 West ore body also occurs as a pod-like body on the 12 West fault along the northern boundary of Tharsis Ridge. The Blow lies against the Great Lyell fault along its eastern (structural footwall) side and against a cross fault along its southern side (Fig. 3). The concealed (and exploited) South Lyell orebody was emplaced upward from the subsurface point of intersection of the Great Lyell and Tharsis faults (Fig. 5).

This intimate structural control of the Mt. Lyell orebodies is a feature not seen in other volcanogenic ore fields, and is interpreted to demonstrate that the structural pattern of the Mt. Lyell district was extant at the time of mineralization (see also Gregory [1905] and Loftus Hills [1927]). Moreover, the fault pattern appears to owe little to Devonian orogeny.

2. Silicification

The use of the term "chert" for the bodies of massive chalcedonic silica at North Lyell (Figs. 2 and 4) and Lyell Comstock is a misnomer and should be discontinued. The bodies are products of silicification of pre-existing rocks, and are not sinters (subaerial or subaqueous hot-spring precipitates). The bodies are generally cut by veins and patches of barite, hematite and, at Lyell Comstock, fluorite, and have undergone widespread hydrothermal brecciation, with fragment interstices filled by hematite.

Much of the North Lyell silicified body developed at the expense of Pioneer Beds, and only a minor proportion of it from the Mt. Read Volcanics (Figs. 2 and 4). Interbedded sandstones and conglomerates can be seen to be transitional to massive chalcedonic silica at surface (Fig. 2) and in drill holes 1099 and 1100. Even where Pioneer Beds are totally silicified, cross-bedding and well-rounded pebbles inherited from pre-existing conglomerate are locally visible. Similarly at Lyell Comstock conglomerate beds can still be discerned within the silicified mass; they probably pertain to the Tyndall Group. At North Lyell, silicification took place immediately above the Haulage unconformity, which at the site of silicification separates Pioneer Beds from Mt. Read Volcanics. The disconformity between the Tyndall Group and the Mt. Read Volcanics or an horizon within the Tyndall Group may prove to be the base of silicification at Lyell Comstock.

Recognition of Early Ordovician Pioneer Beds as the precursors of the North Lyell silicified body is supported by numerous observations made during intensive exploitation of North Lyell ores (Batchelor, 1905; Loftus Hills, 1927; Wade and Solomon, 1958), when the silicified rock was termed "quartzite". Since silicification affected late Middle Cambrian-Early Ordovician rocks it cannot be volcanogenic in a strict sense.

3. Hematite-barite alteration

This prominent alteration type developed by impregnation and partial to near total replacement of Mt. Read Volcanics, Owen Conglomerate and Pioneer Beds, and is transitional to massive silicification. It is closely associated with the orebodies (Wade and Solomon, 1958), and appears to have developed as a discontinuous envelope to sulphide concentrations.

Figures 2 and 3 demonstrate that hematite-barite alteration is structurally controlled. It appears as irregular or lens-like bodies along parts of the Great Lyell fault, the Tharsis fault, several cross faults and, locally, on the Haulage unconformity. In places, it clearly borders or overlies the orebodies.

Solomon's (1967) proposal that several of these hematite-barite bodies represent in situ or transported gossans of Late Cambrian-Early Ordovician age is in error. His two principal examples of in situ fossil gossans occur at Lyell Tharsis and the Blow. That at Lyell Tharsis (Fig. 2) spans the Mt. Read/Pioneer contact, which there is the Great Lyell fault, and so cannot be a pre-Ordovician gossan. The Blow example was removed during the early part of the century and could not be examined by Solomon or myself. However, according to mapping by Loftus Hills (1927) and other early workers, it was not in contact with the massive pyrite body but extended southeastwards from its southeastern corner, in accord with emplacement as a replacement body along the major cross fault which bounds the southern side of the Blow orebody (Fig. 3). Solomon's (1967) principal transported gossans occur in Owen Conglomerate at the northern end of Tharsis Ridge (Fig. 2) and at Lyell Comstock. Both examples were clearly formed by replacement of coarse, immature conglomerate horizons in the Owen sequence as shown by the presence of veinlets and irregular patches of barite. Barite would be present as pebbles if it had been transported from an oxidizing Cambrian sulphide body. What appear on superficial examination to be pebbles of hematite are in reality pebbles replaced by hematite after their incorporation in the conglomerate, as shown by pebbles enveloped by replacement rims of hematite or partially replaced in less regular fashion. Replacement of the conglomerate beds at the north end of Tharsis Ridge took place on faults which connect in depth with the Tharsis and Great Lyell faults (Figs. 2 and 4), and at Lyell Comstock in beds in the immediate footwall of the Great Lyell fault.

Appreciation that Late Cambrian-Early Ordovician beds are replaced by ore-related hematite and barite, and that none of the hematite-barite bodies is a gossan precludes a pre-Late Cambrian age for mineralization.

4. Sulphide Mineralization

Although much of the Owen Conglomerate abutting the Great Lyell fault lacks obvious sulphides, and therefore gives the impression of being post-mineral in age, a number of examples of Owen-hosted sulphides may be cited. The most important is at North Lyell, where all early workers, until as recently as Wade and Solomon (1958), recognized that a small proportion of the massive chalcopyrite-bornite ore occurred in conglomerate, now assigned to the Pioneer Beds. The high-grade (40% Cu) 49 stope was largely in conglomerate. At least some of the chalcopyrite-bornite ore accompanied Pioneer Beds transformed to chalcedonic silica.

In the area of Lyell Blocks and Batchelor's (gravel) quarry (Fig. 2), pyrite, locally accompanied by barite, is present in the Pioneer Beds. On the access road to Batchelor's quarry, fine-grained, delicately banded pyrite (similar to that in the Blow orebody) partially replaced a Pioneer sandstone bed; banding is perpendicular to bedding! Disseminated pyrite cubes partially replaced by supergene chalcocite are present in Owen Conglomerate within a few metres of the Blow orebody.

Several faults cutting the Owen Conglomerate sequence are cupriferous. Chalcopyrite and bornite occur as blebs in a shallowly dipping fault, close to its intersection with the Great Lyell fault, in Batchelor's quarry, where a high-angle cross fault contains stringers and grains of native copper (Fig. 2). Pyrite and supergene copper minerals were encountered on the Tharsis fault immediately east of the Blow, and on the Gormanston fault, where is juxtaposes Pioneer Beds and Gordon Limestone near to the Gormanston road (Fig. 3).

At Lyell Comstock, the Tyndall Group was interpreted as post-mineral in age (Jago et al., 1972; Reid, 1975), and sulphides in it (e.g., in DDH C50) were considered to be clastic in origin. This is clearly not the case. Fine-grained pyrite,in C50 replaced the matrix of a clastic unit, and pyrite galena and sphalerite are widespread as dispersions in calcareous sedimentary members of the Tyndall Group.

It is concluded that although the major part of the sulphide at Mt. Lyell is present in the Mt. Read Volcanics, sulphides, locally of economic significance, are also present in the Owen Conglomerate.

5. Copper Clay deposits

The Lyell Blocks-type Copper Clay deposits are hosted by Gordon Limestone. Despite exploration at King Lyell, Lyell Consols (Figs. 2 and 3) and elsewhere, only Lyell Blocks (Fig. 2) produced any significant quantity of native copper ore. During at least the last two decades, the deposits have been accepted as blanket-like supergene copper concentrations (Solomon, 1969; Walshe and Solomon, 1981). It appears, however, that much of the mineralization is structurally controlled by faults bounding or within the tight synclines which preserved the Gordon Limestone at the western end of the Linda Valley (Figs. 2 and 3). The deposits appear to underlie outcropping linear gossans (Figs. 2 and 3), and much of the native copper and cuprite appears to be present in massive limonitic gossan. Furthermore, as recognized some time ago by M. Bird, the Lyell Blocks mine exploited a steep 10-15m wide structure, as revealed on old stope plans.

If the Lyell Blocks-type mineralization is structurally controlled, then copper concentration during Gordon Limestone sedimentation (Solomon, 1969) is an unlikely origin. Moreover, any supergene addition of copper during the Tertiary presupposes pre-existing sulphides, at least pyrite, since cuprite must possess a chalcocite precursor, which itself would have had to have been introduced as a replacement of another sulphide. At this stage it seems most likely that the Lyell Blocks structures were mineralized at the same time as the emplacement of the other Mt. Lyell orebodies and by the same mechanism. Old press cuttings reveal that the mineralogy of the Lyell Blocks orebody changed in depth to chalcocite, which is present as a common hypogene mineral in the adjoining North Lyell ores. Chalcopyrite, bornite, galena, sphalerite and pyrite are also present in small amounts in the Copper Clay deposits (Markham, 1968; Solomon, 1969), in support of a normal hypogene origin. Native copper and cuprite are also reported from the surficial parts of the North Lyell orebody, and it is suggested that their development to greater depths at Lyell Blocks (and in the other Copper Clay deposits) is due to deep Tertiary oxidation under karst conditions restricted to the Gordon Limestone terrain. The Copper Clay deposits do not therefore provide evidence for pre-Late Cambrian volcanogenic mineralization subjected to Ordovician weathering, but support sulphide mineralization at Mt. Lyell in post-Gordon Limestone times.

D. A MODIFIED GENETIC MODEL AND ITS IMPLICATIONS

1. Modified genetic model

It is clear from the evidence presented above that copper mineralization at Mt. Lyell took place later than Ordovician Gordon Limestone deposition but before Middle Devonian orogeny. The replacement ores restricted entirely to the Mt. Read Volcanics (Prince Lyell type) were probably

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also emplaced at the same tine in view of their close association with demonstrably post-Middle Cambrian massive chalcopyrite-bornite ores at North Lyell (Crown 3 orebody) and Lyell Tharsis. Although the presence of a large volume of mineralization in the Mt. Read Volcanics and its general characteristics suggest a pre-Owen Conglomerate age of emplacement, this timing cannot be sustained when all available evidence is taken into account.

The writer subscribes to the basic ore depositional model accepted by Gregory (1905) and Loftus Hills (1927), with faulting, especially fault intersections, exerting a fundamental control over localization of orebodies. Mineralizing fluids appear to have been introduced up the Great Lyell Fault, which is tentatively suggested to have been an open structure in the vicinity of its intersections with northwest-striking cross faults. The interplay of the Linda Valley fault system with the Great Lyell fault is therefore highlighted as the principal metallotect at Mt. Lyell. Copper-bearing fluids preferentially replaced Mt. Read Volcanics on or adjacent to the Great Lyell fault (Prince Lyell and Blow types), or were channeled upwards from the Great Lyell fault along the unconformity between the Pioneer Beds and the Mt. Read Volcanics (North Lyell type) or along minor structures into the Gordon Limestone (Lyell Blocks type). The silicified bodies at North Lyell and Lyell Comstock appear to have acted as impermeable caps beneath which ore was preferentially localized (Fig. 4). A composite sketch illustrating these structural locales is presented as Figure 6.

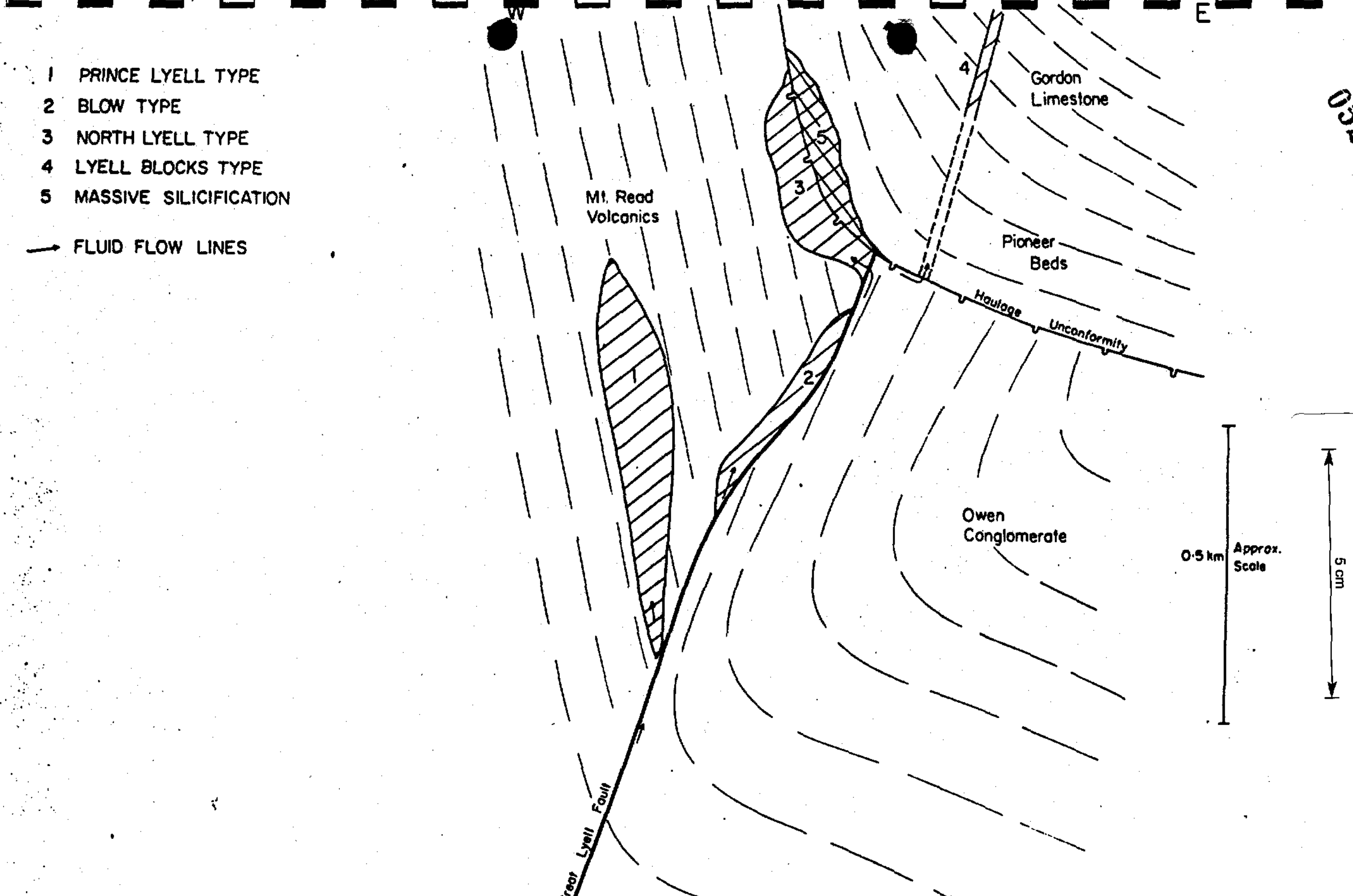
The ultimate source of ore fluids at Mt. Lyell remains enigmatic. Two possibilities present themselves: A volcanogenic origin, with ore fluids supplied by late-stages of Mt. Read volcanism. Since the Owen Conglomerate and the Gordon Limestone had to be emplaced and faulted and folded prior to metal introduction, it seems unlikely that a volcanogenic hydrothermal system could remain active for long enough unless the Owen-Gordon succession is very severely temporally compressed. Owen-Gordon deposition during a time interval of only 2 to 3 million years (the life of a hydrothermal system) might have been possible, given that the Great Lyell fault bounded the Owen sedimentary basin (as shown by abrupt thinning of Owen Conglomerate across it), and was active during Owen sedimentation (as evidenced by restriction of the Haulage unconformity to within about 0.5 km of it). If correct, then substantial modification of the timing of Mt. Read, Owen and Gordon events would be required. This model envisages copper introduction along the structurally complex western side of a major graben, perhaps a late-stage volcano-tectonic depression (but definitely not part of a caldera), in an area where it is intersected by the smaller, second-order Linda graben.

An alternative model, not favoured at this time by the writer, bears no relationship to Mt. Read volcanism, and embodies a fluid supply by either basin dewatering (perhaps of the Owen-filled graben) or as a result of unlocalized intrusive activity (possibly of Early Devonian age).

2. Implications

Irrespective of the ultimate origin of the Mt. Lyell ore fluids, recognition that Ordovician sedimentary rocks are mineralized significantly changes the focus of future exploration. A strictly volcanogenic model of ore deposition, involving search for volcanic-exhalative massive sulphides and subjacent mineralized stockwork feeder zones, can be replaced by search for either volcanic-or sediment-hosted replacement ores using a specific structural model.

Given the current world copper price and future projections, the only Mt. Lyell ore type that constitutes an attractive exploration target is the North Lyell type, both because of its high copper (4.5 million tonnes of 5.5% Cu) and silver (34 gm/tonne) contents. If the present mining



SCHEMATIZED STRUCTURAL SETTINGS OF THE Mt.LYELL ORE TYPES

FIG.

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operation continues, then even small North Lyell bodies are attractive targets if they are either located close to existing underground developments or are amenable to open-pit mining.

During the last two decades or so, the prevailing genetic model for Mt. Lyell mineralization has precluded any exploration for hypogene mineralization in the Tyndall Group, Owen Conglomerate and Gordon Limestone. These lithologies therefore become prime exploration targets if suitable structural situations can be encountered. This revised model for Mt. Lyell ore emplacement also possesses implications for further exploration of North Lyell-type ores in volcanic host rocks abutting the Great Lyell fault.

E. RECOMMENDATIONS FOR EXPLORATION

1. North Lyell - Lyell Blocks

This area, remapped at surface during this study (Fig. 2), is considered as the top priority exploration target at Mt. Lyell, given the present state of geological knowledge and its history as a high-grade copper-silver producer. Two possibilities deserve detailed attention:First, the presence of hypogene ore below the upper native copper-bearing part of the Lyell Blocks structure; and second, the presence of unmined ore in the North Lyell area, particularly in the deeper eastern parts adjoining the former Lyell Blocks lease boundary.

Deep exploration beneath the Lyell Blocks native copper workings has apparently been very limited. Metallurgical difficulties experienced due to downward increase in the chalcocite content of ore discouraged in-depth exploration during native copper exploitation, and during recent times the accepted supergene model for the Copper Clay deposits deterred any deep exploration as well as introducing a fatal flaw to a major shallow exploration programme: The assumed blanket-like geometry of the native copper mineralization dictated a programme of vertical drilling, whereas inclined holes are required if any chance exists of finding additional shallow ore in steep structures.

Drilling of several inclined exploration holes beneath the exploited part of the Lyell Blocks structure may be undertaken as soon as practicable. What evidence is available suggests that the structure is relatively simple (although perhaps branching), and that it may continue as a mineralized entity through to the North Lyell orebody. The target is a small tonnage (<0.5 million tonnes) of medium-grade copper ore, which if chalcocite-bearing could be silver-rich. (Minor pockets of native silver ore are reported from the native copper workings.)

The North Lyell orebody is structurally complex, and large parts of it have been mined out. Comprehension of ore controls is limited by the absence of any accessible underground openings and by the chaotic state of the old data. The cross section of the North Lyell area (Fig. 4) was constructed, with assistance from M. Bird and W.A. Brook, on the basis of the writer's surface mapping (Fig. 2) and underground data from old plans. It emphasizes emplacement of high-grade copper-silver ore immediately beneath (and partly within) massively silicified Pioneer Beds, which occupy the axial portions and intervening limb of a steeply southeastward plunging anticline-syncline pair. Fold limbs are partly faulted out, with faults (12 West and a cross fault in Fig. 4) acting as bounding surfaces during ore deposition. Silicification and/or hematitite-barite alteration constitute a halo to massive sulphide ore.

The deep parts of the North Lyell ore zone are difficult to interpret, but are thought to involve the Great Lyell fault, which is unconformably overlain by the Pioneer Beds. The North Lyell "Corridor", between the Tharsis Ridge and the North Lyell cross fault (Fig. 2) is believed to be underlain by a shallow portion of the Great Lyell fault, which southwards is duplicated at surface by east-side-down, high-angle displacement on the Tharsis fault (Figs. 2 and 4). The Great Lyell fault inferred in the deep part of the North Lyell orebody is shallowly westward dipping, and was offset eastward by the 12 West fault.

Any further drilling of the North Lyell zone should not be undertaken until all existing data is compiled on maps and sections. The geological interpretation noted above should guide the compilation but will require substantial refinement before drilling is contemplated. At this stage, however, the chances of finding small tonnages of high-grade copper-silver ore in the deeper eastern part of the North Lyell area seem fairly good.

2. Other Copper Clay areas

Exploration during the early years of the century revealed small tonnages of +2% Cu ore at King Lyell and Lyell Consols. Surface geology (Figs. 2 and 3) and old records suggest that the mineralization is confined to southeast-trending structures, and explain why more recent exploration has been unsuccessful. If interesting results are obtained beneath the Lyell Blocks native copper workings, similar drilling campaigns will be required beneath the other native copper-bearing structures.

The areas where mineralized Gordon Limestone-hosted structures approach the Great Lyell fault also deserve further consideration as exploration targets, given the Lyell Blocks structure could continue into the North Lyell area.

3. Lyell Comstock

During this study some preliminary surface mapping (available at the mine but not included in this report) was carried out by the writer at Lyell Comstock and environs. The volcanic-hosted Lyell Comstock orebodies are bounded to the southeast by the Great Lyell fault, and are partly overlain by a major body of hematite-barite-bearing chalcedonic silica. It is suspected that the silica body originally overlay all the mineralization, in a similar manner to at North Lyell, prior to glacial erosion. On the basis of results of drilling and on evidence for replaced conglomerate beds in the silica body, it is thought likely that much of the silicification affected Tyndall Group sedimentary rocks, although isolated silica bodies nearer to the Great Lyell fault developed at the expense of volcanics. Tight folding of North Lyell type prior to ore deposition is suggested by W.A. Brook and M. Bird on the basis of old records, although this cannot be convincingly documented at surface.

The similarities between Lyell Comstock and North Lyell underscore the potential of the former locality. Two exploration targets are envisaged: high-grade North Lyell-type copper-silver bodies beneath the silicified body or in areas previously overlain by it; and low-grade bulk-minable silver mineralization in calcareous units of the Tyndall Group. Both targets are rendered more elusive by a widespread cover of glacial moraine. The high-grade type of target will be underlain by (i.e., on the hanging-wall side of) the Great Lyell fault and could be found as far north as a poorly located major cross fault (the Comstock fault on Fig. 1). The Great Lyell fault and any associated mineralization is not likely to continue uninterruptedly across this fault, although the zone of intersection could be of some interest. The low-grade silver type of target is considered as a distal replacement of calcareous rocks outward from the copper orebodies. Although silver values recorded to date from dispersed sulphide mineralization are too low to be of interest, higher values could be present locally in more structurally confined situations.

The next exploration stage at Lyell Comstock involves detailed relogging of all available drill core and replotting of all old mining data, with a North Lyell model clearly in mind. Compilation of resulting observations, maps and plans, assisted by examinations of any accessible underground openings, should provide a basis for selection of drill sites.

4. Gormanston Area

The Gormanston area (Fig. 3) is geologically similar to the North Lyell "Corridor", but exploration is made more difficult by an extensive cover of glacial moraine and varved clays. A restricted campaign of drilling failed to reveal any ore-grade mineralization.

Remapping of the area, and its northward extension to the Blow orebody, revealed the structural setting, which was not appreciated previously. Two strands of the Great Lyell fault are present, but only the repeated eastern one crops out; the main western one is concealed but can be defined in subsurface using old data concerning the South Lyell orebody (Fig. 5). Further evidence for the subsurface presence of Owen Conglomerate (and therefore of the Great Lyell fault) is provided by a discontinuous trail of boudins of sandstone and conglomerate along the surface trace of the Tharsis fault (Fig. 5). These boudins, not appreciated previously, require the presence in depth of the Great Lyell fault. Southwards the Tharsis fault and the Great Lyell fault are inferred to diverge with the Great Lyell continuing westward through Gormanston gap and the Tharsis trending southeastward along the southern boundary of the Linda Valley (Fig. 3). In the vicinity of the Gormanston oval (Fig. 3), the outcropping Great Lyell fault disappears beneath unconformably overlying Pioneer Beds. The unconformity between the Pioneer Beds and underlying Mt. Read Volcanics was intersected in drilling, and core reveals silicification and hematitization at the contact. W.A. Brook and the writer concur that the best target is deeper than levels explored to date, in

058 the vicinity of the inferred impingement of the Great Lyell fault and the Haulage unconformity. The silica and hematite could be upward leakage from a locus of mineralization below.

Detailed logging of all diamond drill core from the Gormanston area should precede exploratory drilling.

5. Linda Valley gold potential

Alluvial gold was widely worked in the Linda Valley and on the flanks of Mt. Owen (to the south of the area covered by Fig. 1), and is inferred by M. Bird to be derived from major faults cutting Ordovician rocks. McDowells P.A., on the north side of the Linda Valley, was apparently the most important bedrock gold deposit exploited. The site of the old workings was tracked down during this study. They comprise a 20m long and 10m wide open-cut dug on the North Lyell fault, which juxtaposed Owen Conglomerate (to the north) with sandstones and mudstones, probably the Pioneer Beds. A stockwork of silicified veinlets carrying limonite after pyrite occurs in the Pioneer sandstones, but assay of five rock-chip samples failed to reveal any gold. Tracing of the North Lyell fault some 200m to the west revealed similarly silicified Pioneer Beds in close proximity to massive hematite alteration of the type common at Mt. Lyell (see above). This observation suggests that the Linda Valley gold mineralization was emplaced at the same time as the Mt. Lyell copper ores, along the eastward extensions of the same structures.

During mapping of the north side of Mt. Owen (Fig. 3), a fault cutting Owen Conglomerate was seen to be followed by a limonite-bearing silicified stockwork closely similar to that a McDowell's P.A, thereby showing that other structures are also mineralized, as predicted by M. Bird.

Detailed reconnaissance of major fault zones north and south of the Linda Valley is recommended, with chip samples taken at all mineralized localities. If appreciable gold values are revealed and mineralized zones appear to be wide enough, drilling might be contemplated in the future. Since the gold-bearing structures do not have the characteristics of near-surface epithermal gold veins, there is no geological reason to suspect that gold values should be better in depth.

6. Concluding remarks

In the light of this revised geological model of the Mt. Lyell district, it is concluded that important exploration potential remains for testing. This potential cannot be appraised by a short-term programme but will require a balanced and sustained exploration effort. It is suggested that future ore search at Mt. Lyell relies more fully on geological reasoning and less on geochemical and geophysical interpretations than in the recent past.

At this stage, it must be concluded that Mt. Lyell still possesses more obvious exploration potential than other parts of the Mt. Read Volcanic belt known to the writer. Its attractiveness is of course increased by proximity to an operating mine.

F. REGIONAL IMPLICATIONS

1. Preliminary statement

The recognition that mineralization at Mt. Lyell took place following deposition of the Gordon Limestone clearly has implications for exploration elsewhere in the Mt. Read Volcanic belt. Wherever base- or precious-metal prospects are present in the belt, field observations should be tested against a Mt. Lyell-type model for ore emplacement, as well as against a conventional volcanogenic model.

This seems to be particularly important wherever mineralization is spatially associated with either major regional structures or an Owen Conglomerate contact. Where these two parameters are coincident, substantial a priori evidence could be considered to support a Mt. Lyell-type model. Such structurally controlled Owen Conglomerate contacts, characterized by abrupt upturning and even overturning of conglomerate beds on the downthrown sides of major faults, are prominent at the Selina and Huxley (Nasty Knob) prospects, both of which were examined briefly by the writer.

2. Selina prospect

The Selina area is structurally complex, and is transected by two or more major north-south faults. The eastern and western pyritic zones are paralleled to the west by a high-angle fault which steepens Owen Conglomerate to nearly vertical against the fault plane. The western pyritic zone is also paralleled on its eastern side by a second steep fault, which juxtaposed sulphide-bearing rocks with the Dora (Jukes) Conglomerate.

At the northern extremity of the western pyritic zone, between the two north-trending faults and delineated at its northern end by a cross-structure, well-bedded, steeply dipping and fine-grained volcaniclastics have been subjected to widespread introduction of chalcedonic silica, albite, chlorite, hematite and magnetite; only minor pyrite and base-metal sulphides are present, although G. Purvis reports a silver value of >20 ppm from a surface rock-chip sample. The silicification and hematite veining in this zone are somewhat reminiscent of the silicified bodies at North Lyell and Comstock. Its proximity to a Great Lyell-type fault suggests the possibility that it also may have acted as a fluid trap and given rise to a North Lyell style of mineralization against or beneath the steeply plunging beds. Evidence for repeated accumulation and overpressuring of hydrothermal fluids below or within the body is provided by widespread hydraulic brecciation. The paucity of sulphide and abundance of hypogene iron oxides in the altered body need not act as a deterrent to exploration when it is recalled that the North Lyell and Lyell Comstock silicified bodies are also essentially sulphide-free.

In addition to geological analogies between Selina and parts of the Mt. Lyell area, two observations support mineralization later than Owen Conglomerate accumulation. First, a prominent patch of chalcanthite staining was observed high on a cliff of Owen Conglomerate along its faulted contact. Its position considerably higher than any volcanic rocks precludes an exotic supergene origin and confirms derivation from sulphides in the Owen Conglomerate itself. Second, highly anomalous base-metal (especially lead) values in soil were encountered by previous workers over a topographically elevated area of Dora Conglomerate, again suggesting derivation from post-volcanic sulphides.

Although this brief examination provided several lines of evidence for geological analogies between the Selina area and Mt. Lyell, especially the North Lyell sector, further geological work would be required to substantiate their similarities and to appraise the merits of drilling for North Lyell-type targets at Selina. Geological work should include detailed mapping of the northern portion of the western pyritic zone, with particular attention payed to major structures and bedding relations in the fine-grained volcaniclastics. With presently available data, the silicified and hematitized outcrop at the northern end of the western pyritic zone would seem to provide the most likely target for high-grade copper ore. If further work accords with this preliminary opinion, the target could be tested with a vertical drill hole collared on the western edge of the outcropping altered body.

It should be remarked, however, that the overall size and the alteration intensity of the Selina system are substantially less than those of Mt. Lyell, both features which may be taken to downgrade the potential of Selina.

3. Huxley (Nasty Knob) prospect

At Nasty Knob, a restricted outcrop of limonitic gossan is present in a narrow embayment of Mt. Read Volcanics bounded by Owen Conglomerate. The embayment is thought to have resulted from cross faulting of the main Mt. Read/Owen contact - the Great Lyell fault. Southwards, in volcanics abutting the Great Lyell fault, lead, zinc and silver geochemical anomalies are reported. However, outcrops of unoxidized sulphides reveal only weak disseminations.

It is concluded that the Nasty Knob occurrence is an example of relatively weak mineralization along a relatively uncomplicated stretch of the Great Lyell fault. It may be considered as a peripheral manifestation of the main Mt. Lyell district.

No work can be recommended at Nasty Knob at this time. The Great Lyell fault between Nasty Knob and the Gormanston Gap does, however, require additional reconnaissance mapping.

4. General recommendations

At this stage, it is recommended that more attention is payed to Ordovician rocks during future exploration in western Tasmania. A literature review of fault patterns affecting the Ordovician, in search of Great Lyell-type situations, would be of value. The review could be combined with a compilation of known mineral occurrences in Ordovician rocks, followed by field checking of selected examples, most importantly those of gold.

Queenstown, Tasmania
9th February, 1984

Richard H. Sillitoe

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5 cm
MT SEDGWICK
WESTERN DOME
BEATRICE DOME
SEDGWICK FAULT
GREAT LYELL FAULT
ZIG-ZAG HILL
Agglomerate Hill
This area is covered with Qpm & interpreted sub-surface geology is shown
Moraine overlying Gordon Limestone
porphyritic lavas & ignimbrite
COMSTOCK VALLEY WITH A VENEER (≈ 50m) OF GLACIAL DEBRIS
PIONEER BEDS
NO MAPPING
TASMAN CROWN
COMSTOCK
Gordon Limestone with approx. 50m of overlying moraine
COMSTOCK FAULT
CAPE HORN
LYELL FAULT
NORTH LYELL FAULT
Anaconda
WESTERN THARSIS
CROWN 3
NORTH LYELL
LYELL BLOCKS
LYELL THARSIS
ROYAL THARSIS
BLAZEY
WEST LYELL
"A" LENS
"B" LENS
PRINCE LYELL
PIONEER FAULT
MT LYELL
M'DOUAL P.A.
KING LYELL GOSSAN
Flow banded brecciated rhyolite
SOUTH LYELL SUB-SURFACE
SOUTH LYELL SHAFT
GORMANSTON
concealed contact of volcanics & Pioneer Beds
Ogl overlain by Qpm
THARSIS OWEN SPUR FAULT
CONSOLIDATED MINING LEASE 30M/80
Area of conflict mapping. Requires remapping to resolve Dip & Ok.
Structural basin of Gordon Limestone underlain by Pioneer Beds & Comstock Tuff. However the area requires mapping - outline shown is very stylised.
silica pyrite mineralisation
The area requires mapping
QUEENSTOWN
A to P
LITTLE OWEN
OWEN SPUR
NORTH OWEN FAULT
OWEN FAULT
OWEN SPUR FAULT
DUKE LYELL
GREAT LYELL FAULT
SOUTH OWEN FAULT
MT OWEN
KING RIVER FAULT
LE
Toe o
Qa Recen
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GOLD FIELDS
GEOLOGICA
OF MOUNT
AND B
Amended by: J. Beddows, June 8
Geology by: W. Brook, Geopacific
Drawn by: L. Underhill, Geograph
Date: 17/3/84

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LEGEND

	Toe of main waste dump
Qa	Recent Alluvium
Qt	Recent talus
Qpm	Pleistocene moraine and glacial deposits, reworked in part
Jdl	Jurassic dolerite
pt	Permian tillite
Ss	Undifferentiated Silurian sediments
Ogl	Gordon Limestone
Oop	Pioneer Beds
	Jukes Conglomerate
Oo	Owen Conglomerate
Єtc	Comstock Tuff
Єls	Sedimentary unit with limestone (marble) lenses, conglomerates, greywackes and marls.
Єbs	Black shales generally with volcanic rocks
Єss	Shales, sandstones and volcanics
Mrs	Miners Ridge Sandstone
v v v	Interbedded vitric tuffs, shales, sandstones and greywackes.
	Well bedded tuffs, agglomerates and minor shale.
	Welded ash - flow tuffs
x x x	"Quartz feldspar crystal tuffs"
Єm	Undifferentiated acid volcanics
a a	Acid Agglomerates
i i	Intermediate agglomerates
+i 1 +i	Crown Hill Andesite - massive or brecciated plagioclase - pyroxene - hornblende porphyry.
+a 1 +a	Quartz feldspar porphyry, massive, flow - banded or brecciated, probably domes.
+a 2 +a	Rhyodacite quartz feldspar chlorite porphyry
+a 3 +a	Quartz feldspar porphyry usually with zenoliths; probably intrusive.
+a 4 +a	Beatrice Dome, weakly magnetic pink feldspar - phyric rhyolite with magnetite - haematite veins.
	Outline of orebody
hb	Haematite - barite alteration
	Silicification
60	Strike and dip
	Facing direction
	Unconformity, possible
	Unconformity, observed
	Outer limit of Buffer Zone
	Drill Hole Collar

Compilation is based on Mount Lyell mine data, Gold Fields EL 9/66 data and Tasmania Mines Department Publications.

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5 cm

GOLD FIELDS EXPLORATION PTY. LTD.

GEOLOGICAL COMPILATION OF MOUNT LYELL MINE LEASE AND BUFFER ZONE

Amended by: J. Beddows, June 85
Geology by: W. Brook, Geopacific Services Pty. Ltd.
Drawn by: L. Underhill, Geographica., S. Freer
Date: 17/3/84

Scale 1:10000

0 250 500m

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