A REAPPRAISAL OF THE MT. LYELL

COPPER DEPOSITS, TASMANIA:

IMPLICATIONS FOR EXPLORATION

A report prepared for GOLD FIELDS EXPLORATION PTY. LIMITED.

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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 volcan-
ism, 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 mineraliz-
ation, 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

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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 mineral-
ization 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 explor-
ation. 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.

A. <u>INTRODUCTION</u>

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
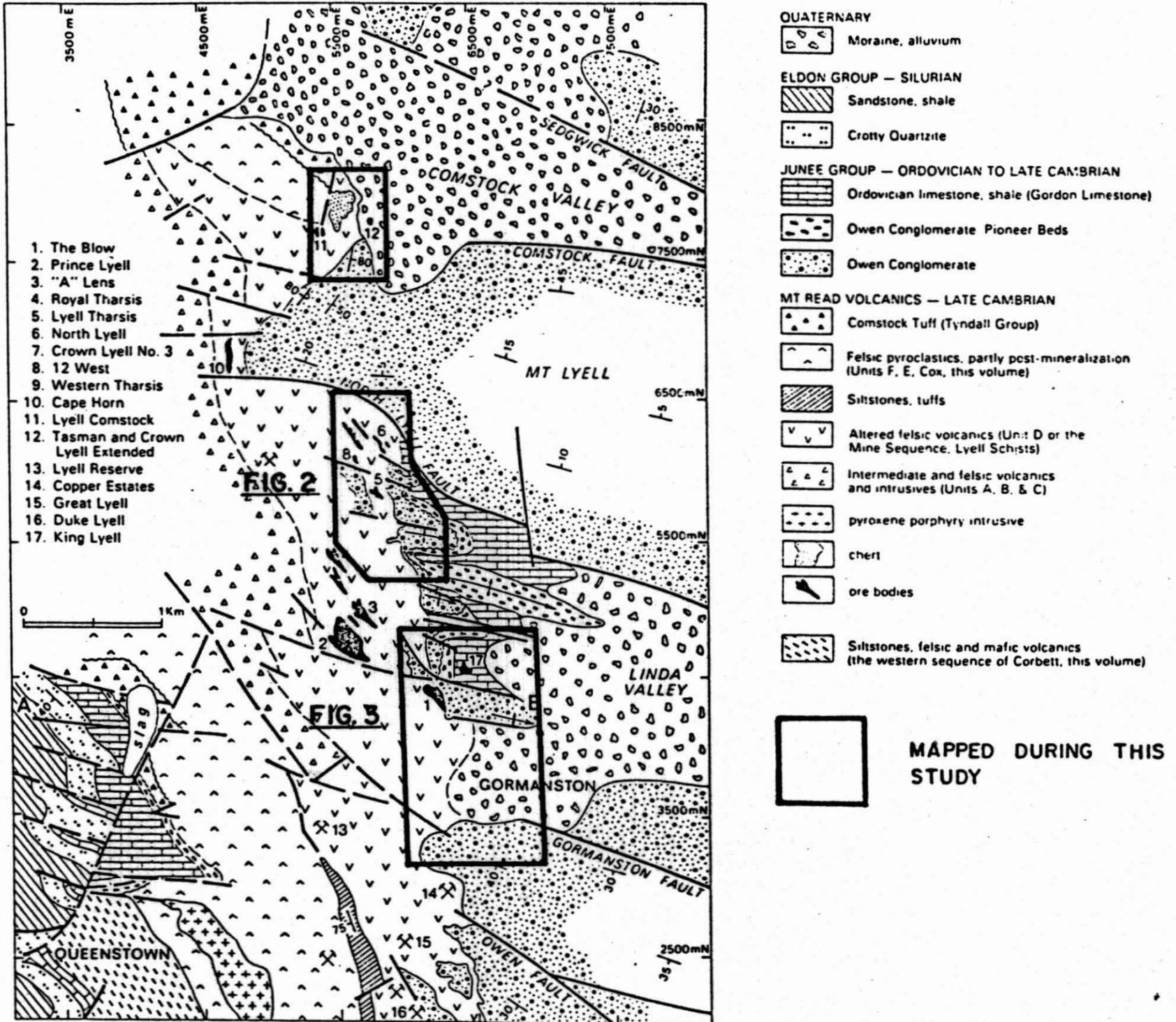
Figure 1: General location Map, Mt. Lyell area

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them freely on numerous occasions. The study (and, in partic-
ular, Figures 4 and 5) depended heavily on M. Bird's encyc-
lopaedic 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 discu-
ssions. 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 mineral-
ized 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

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 brecciat-
ion, 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 super-
ficial 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

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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! Dissemin-
ated 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

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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

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 funda-
mental control over localization of orebodies. Mineral-
izing 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

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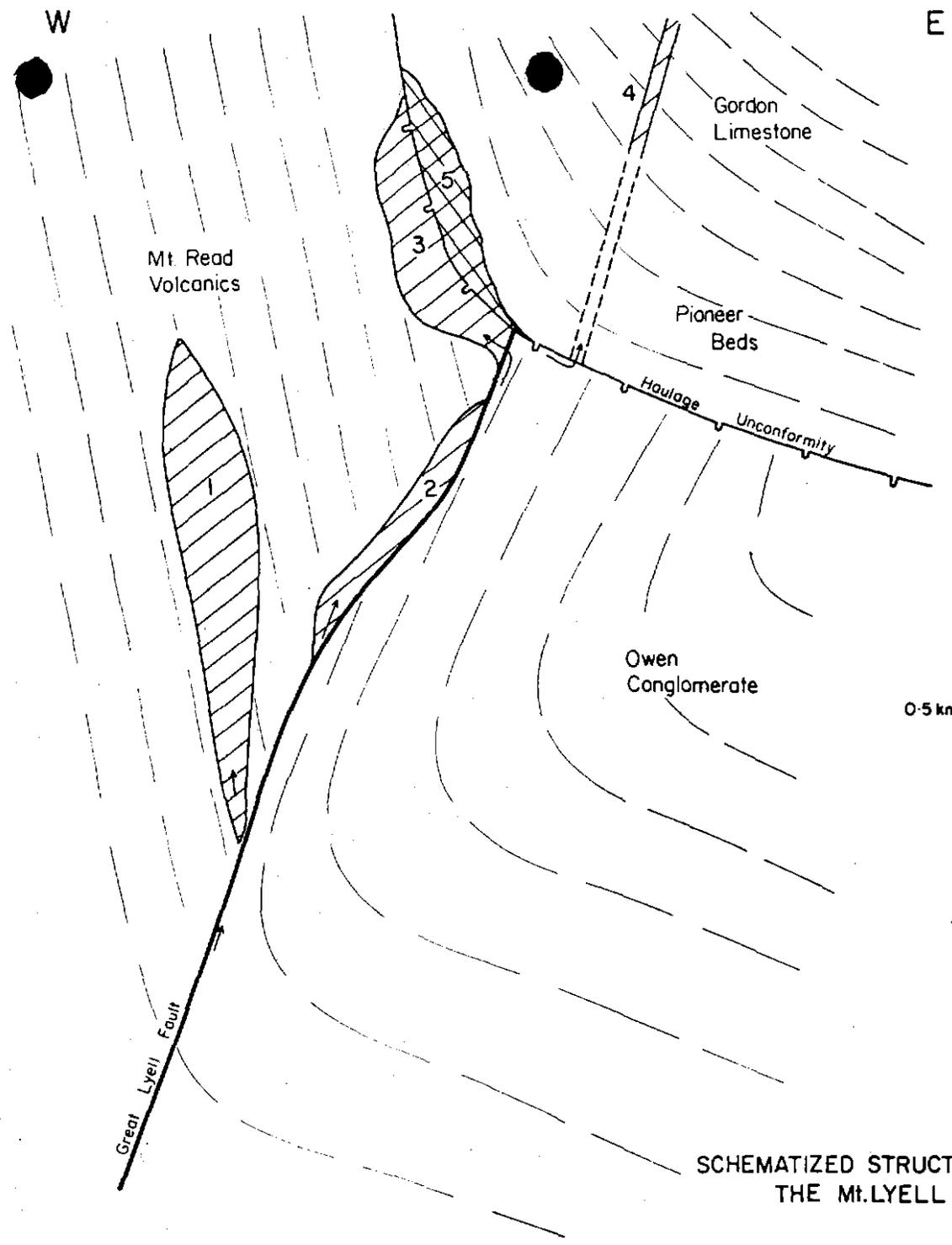
An alternative model, not favoured at this time by the writer, bears no relationship to Mt. Read volcanism, and embodies a fluid supply by either basin dewatering (perhaps of the Owen-filled graben) or as a result of unlocalized intrusive activity (possibly of Early Devonian age).

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

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1 PRINCE LYELL TYPE

2 BLOW TYPE

3 NORTH LYELL TYPE

4 LYELL BLOCKS TYPE

5 MASSIVE SILICIFICATION

→ FLUID FLOW LINES

Gordon Limestone

Mt. Read Volcanics

Pioneer Beds

Haulage Unconformity

Owen Conglomerate

0·5 km | Approx. Scale

Great Lyell Fault

SCHEMATIZED STRUCTURAL SETTINGS OF
THE Mt. LYELL ORE TYPES

|← 5 cm →|

FIG. 6

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 expl-
oration 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 implicat-
ions 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, partic-
ularly 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 mineral-
ization 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 under-
ground 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 struct-
ures 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 uninterr-
uptedly 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

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 mineral-
ization below.

Detailed logging of all diamond drill core from the Gorman-
ston 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 Conglomer-
ate (to the north) with sandstones and mudstones, probably
the Pioneer Beds. A stockwork of silicified veinlets
carrying limonite after pyrite occurs in the Pioneer sand-
stones, 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 at
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 characterist-
ics 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 mineraliz-
ation 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 uncomp-
licated 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
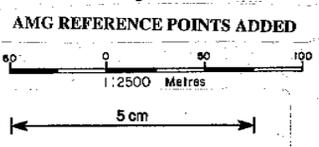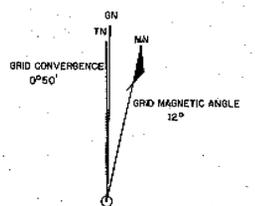
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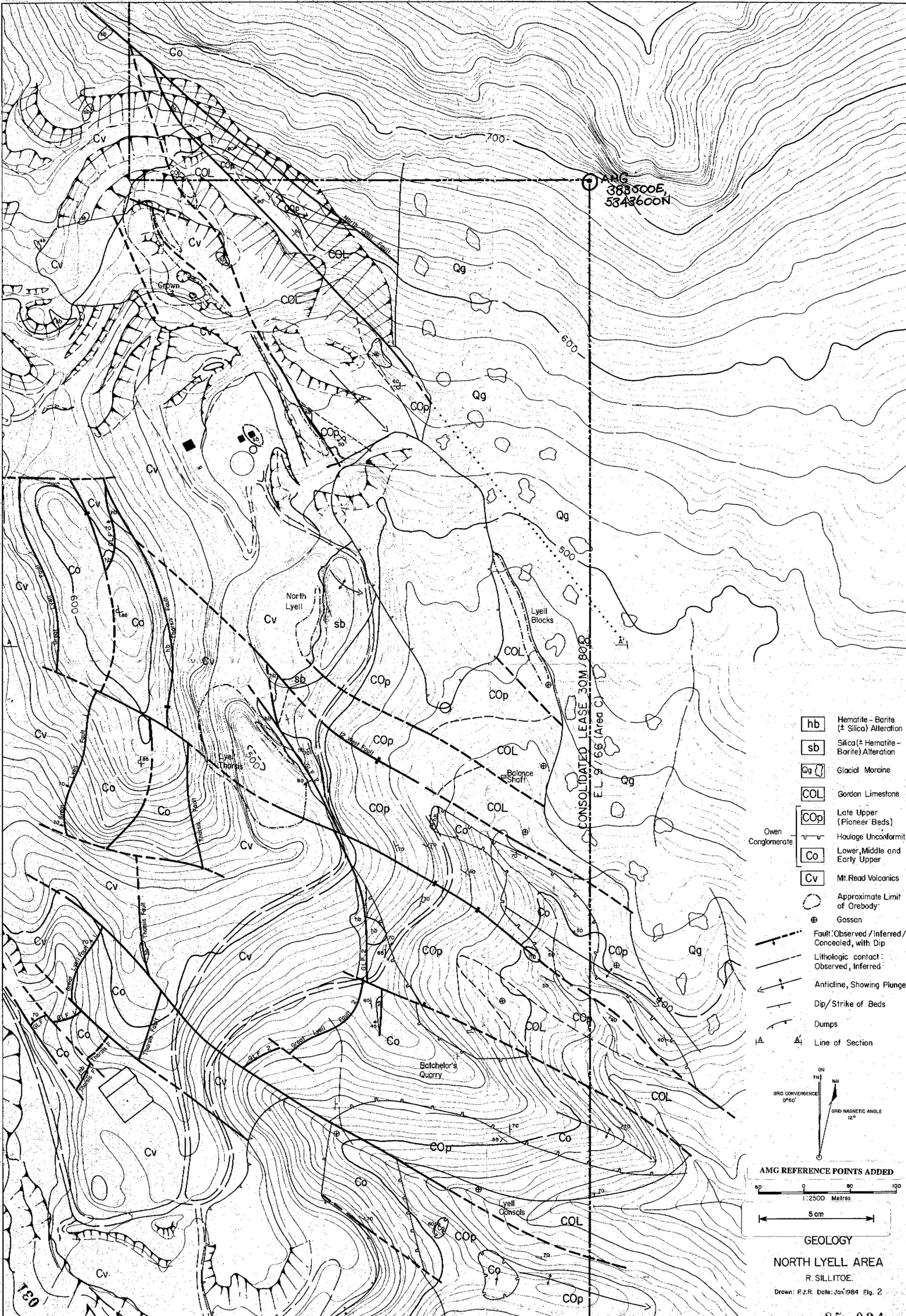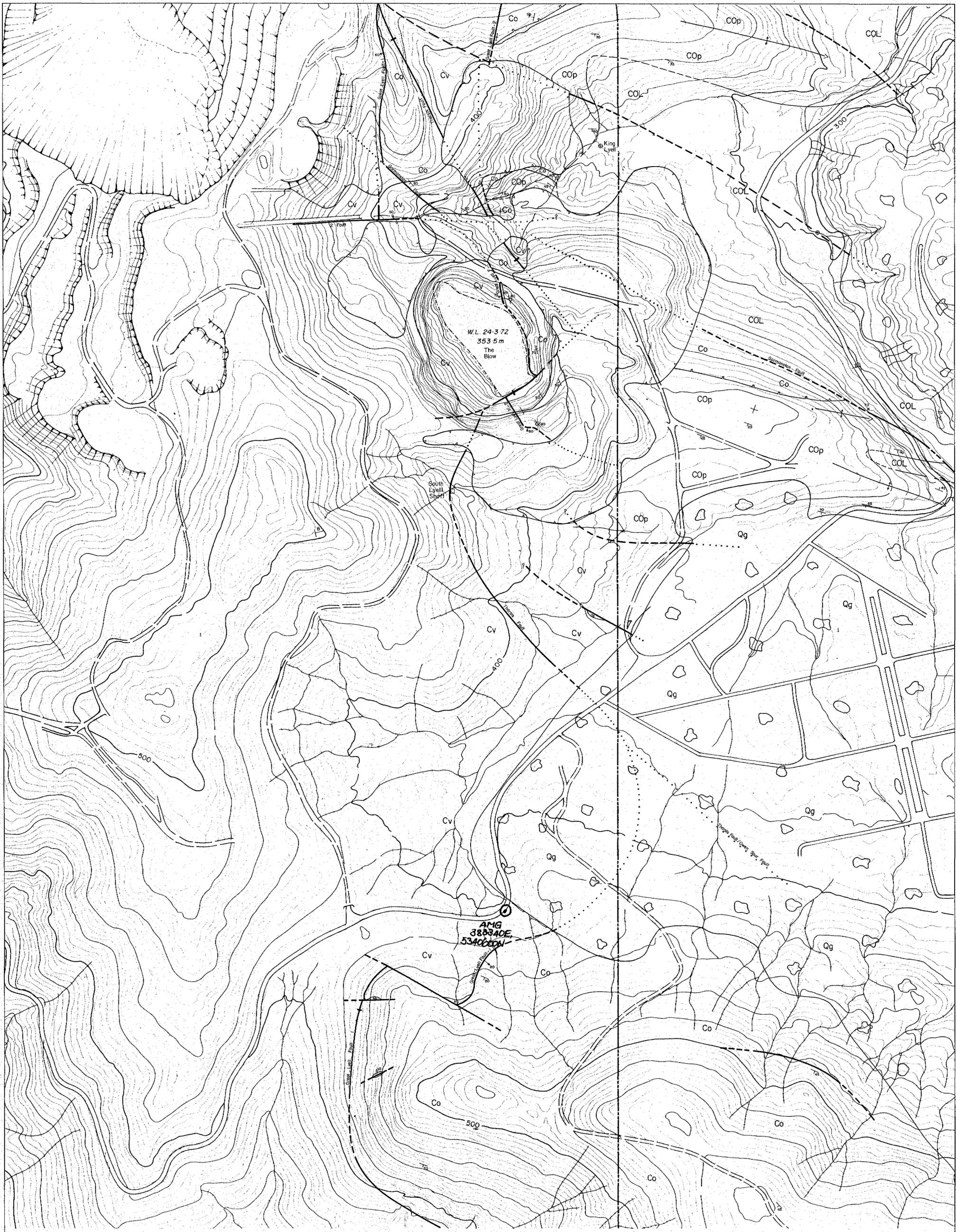
GEOLOGY

NORTH LYELL AREA

R. SILLITOE.

Drawn: P.J.R. Date: Jan 1984 Fig. 2

Legend:

hb	Hematite – Barite (± Silica) Alteration
sb	Silica (± Hematite – Barite) Alteration
Qg	Glacial Moraine
COL	Gordon Limestone
COp	Late Upper (Pioneer Beds)
	Haulage Unconformity
Co	Lower, Middle and Early Upper
Cv	Mt. Read Volcanics

Owen Conglomerate

- Approximate Limit of Orebody
- Gossan
- Fault: Observed / Inferred / Concealed, with Dip
- Lithologic contact: Observed, Inferred
- Anticline, Showing Plunge
- Dip / Strike of Beds
- Dumps
- Line of Section

AMG REFERENCE POINTS ADDED

1:2500 Metres

5 cm

GRID CONVERGENCE 0°50'
GRID MAGNETIC ANGLE 12°

AMG 383500E, 5348600N

CONSOLIDATED LEASE 30M 80Q

E.L. 9/66 (Area C)

85-2469

85 034

GEOLOGY
GORMANSTON AREA
R. SILLITOE.
Drawn: P.J.R. Date: Jan 1984 Fig. 3

W.L. 24·3·72
353·5 m
The Blow

King Lyell

South Lyell Shaft

AMG 385840E, 5340000N

Legend

hb	Hematite - Barite (± Silica) Alteration
sb	Silica (± Hematite - Barite) Alteration
Qg	Glacial Moraine
COL	Gordon Limestone

Owen Conglomerate
COp	Late Upper (Pioneer Beds)
	Haulage Unconformity
Co	Lower, Middle and Early Upper
Cv	Mt. Reed Volcanics

Approximate Limit of Orebody
Gossan

Fault: Observed / Inferred / Concealed, with Dip
Lithologic contact Observed, Inferred
Anticline, Showing Plunge
Dip/Strike of Beds
Dumps
Line of Section

1:2500 Metres
50   0   50   100
5 cm

GRID CONVERGENCE
GRID MAGNETIC ANGLE

AMG REFERENCE POINTS ADDED

032

85-2469

85 035

SECTION THROUGH NORTH LYELL OREBODY

R. SILLITOE

Drawn: P.J.R. Date: Jan 1984 Fig. 4

NB. Refer to Fig. 2 for Legend

1:2500 Metres

5 cm

033

85.033

85-2469

SECTION THROUGH SOUTH LYELL OREBODY

R. SILLITOE

Drawn: P.J.R. Date: Jan 1984 Fig. 5
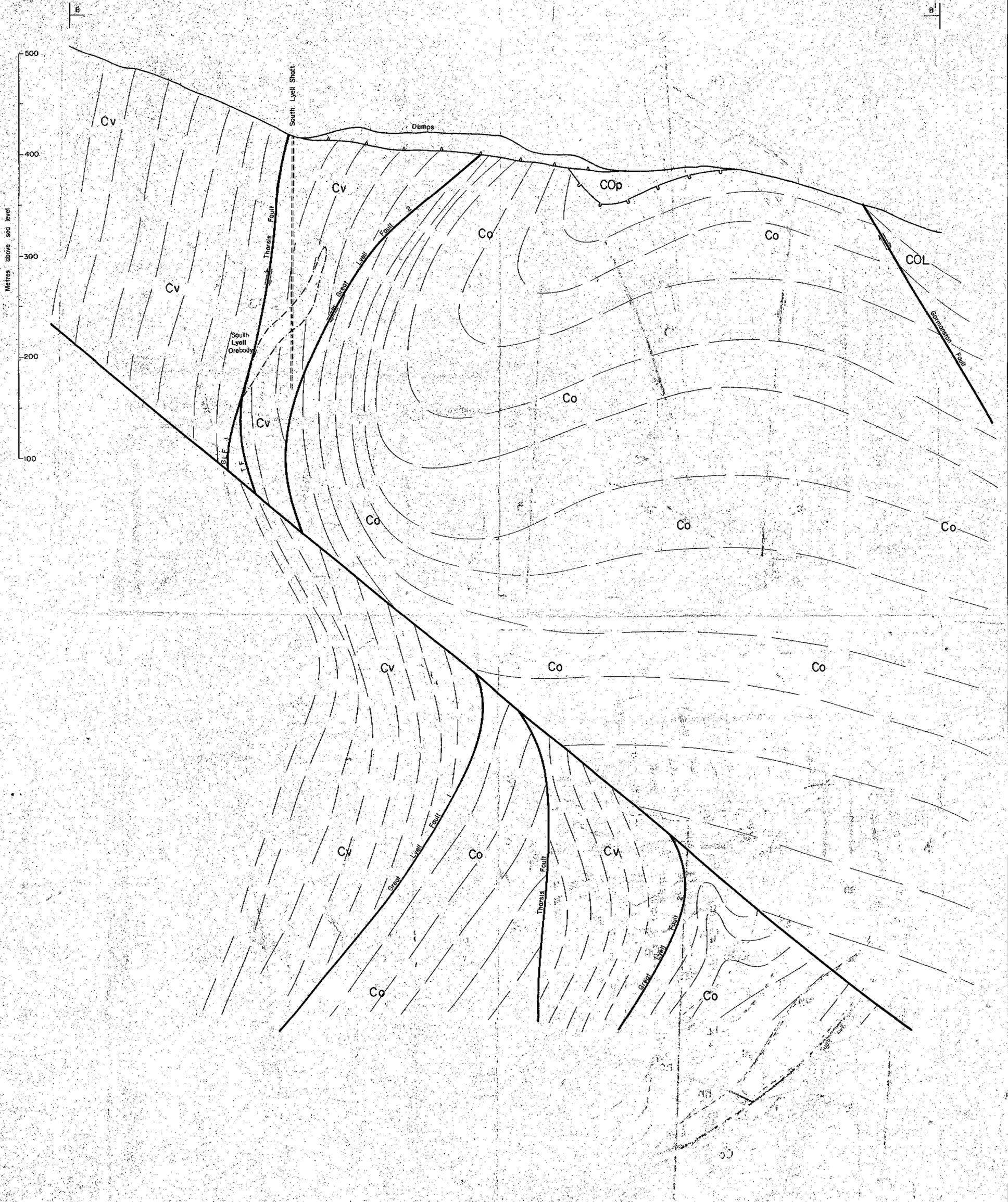
NB. Refer to Fig. 3 for Legend