



# **Institute on Lake Superior Geology Thirty-Third Annual Meeting**

WAWA, ONTARIO  
1987

Field Trip Guidebook

## **GEOLOGY OF THE HEMLO DEPOSIT**

Volume 33, Part 4



## Foreword

The excitement over the exploration for gold, as witnessed in the past several years, has largely been driven both by the price of this precious metal and by the successes of finding economic deposits, such as the Hemlo Gold Deposit. A spinoff flurry of activity has also occurred in the past few years. This has involved the significant demand by geologists for field trips to deposits, such as at Hemlo, in order to examine the regional and local geological settings as well as the deposits themselves.

The demand for field trips at Hemlo has resulted in a number of relatively closely spaced trips. It is often not possible to spend sufficient time to produce an independently written field guide for each trip. Hence this field guide has several sections which are very similar to, or have evolved from, field guides published by: CIM, 1984; updated somewhat and jointly republished by CIM and MDD-GAC, 1985; modified notably for GAC-MAC-CGU, 1986; updated for Gold '86, under the watchful eyes of James Pirie; and further updated by myself for ILSG, 1987.

ILSG extends its appreciation to the organizers of Gold '86, particularly James Pirie, and GAC-MAC-CGU for permission to use much of the field guide as it has been previously presented. Sincere thanks are also due to appropriate staff at David Bell (Teck-Corona) Mine, Noranda Incorporated, and Lac Minerals Limited for taking time out to discuss their observations, problems, and solutions with those geologists on yet another Hemlo Field Trip.

*T.L. Muir*  
ILSG  
Toronto  
February, 1987

**Cover Photo:** Aerial view of the Hemlo minesites, taken October, 1984, by Ray Goldie.

# The Hemlo Gold Deposit, Ontario

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# 1 — Regional Field Guide To The Hemlo Area

by G.C. Patterson

## INTRODUCTION

The Hemlo gold deposit occurs in a sequence of Archean supracrustal rocks within the Wawa Sub-province of the Canadian Shield some 770 km NW of Toronto. The deposit underlies Trans-Canada Highway 17 some 35 km east of the town of Marathon on Lake Superior and 4 km west of the intersection with Highway 614 to Manitouwadge (Figure 1).

Three properties covering portions of a single large deposit have been brought into production. Noranda Incorporated initiated production at the Golden Giant Mine in March 1985. Milling rate is currently about 2000 tonnes per day and in 1986, 254 053 oz. gold were produced from 733 413 tonnes of ore with an average grade of 11.53 grams per tonne. The David Bell Mine (Teck-Corona),

officially opened in September 1985, is currently milling about 1000 tonnes per day. Production in 1986 was 52 900 oz. gold from 203 000 tonnes of ore with an average grade of 8.43 grams per tonne. Lac Minerals Limited began producing from their open pit on the Page-Williams Mine Property in August 1985. In December 1985, the 3000 plus tonne per day mill began operation. Production for 1986 was 233 000 oz. gold from 1.23 million tonnes of ore with an average grade of 5.9 grams per tonne. In addition to the development of 3 mines, approximately 100 companies have been carrying out exploration programs in the area.

The purpose of this section of the field trip guide is to describe the regional geology and mineral occurrences and to summarize the exploration history and geology of the Hemlo deposit. The reader is referred to other papers in this volume for more

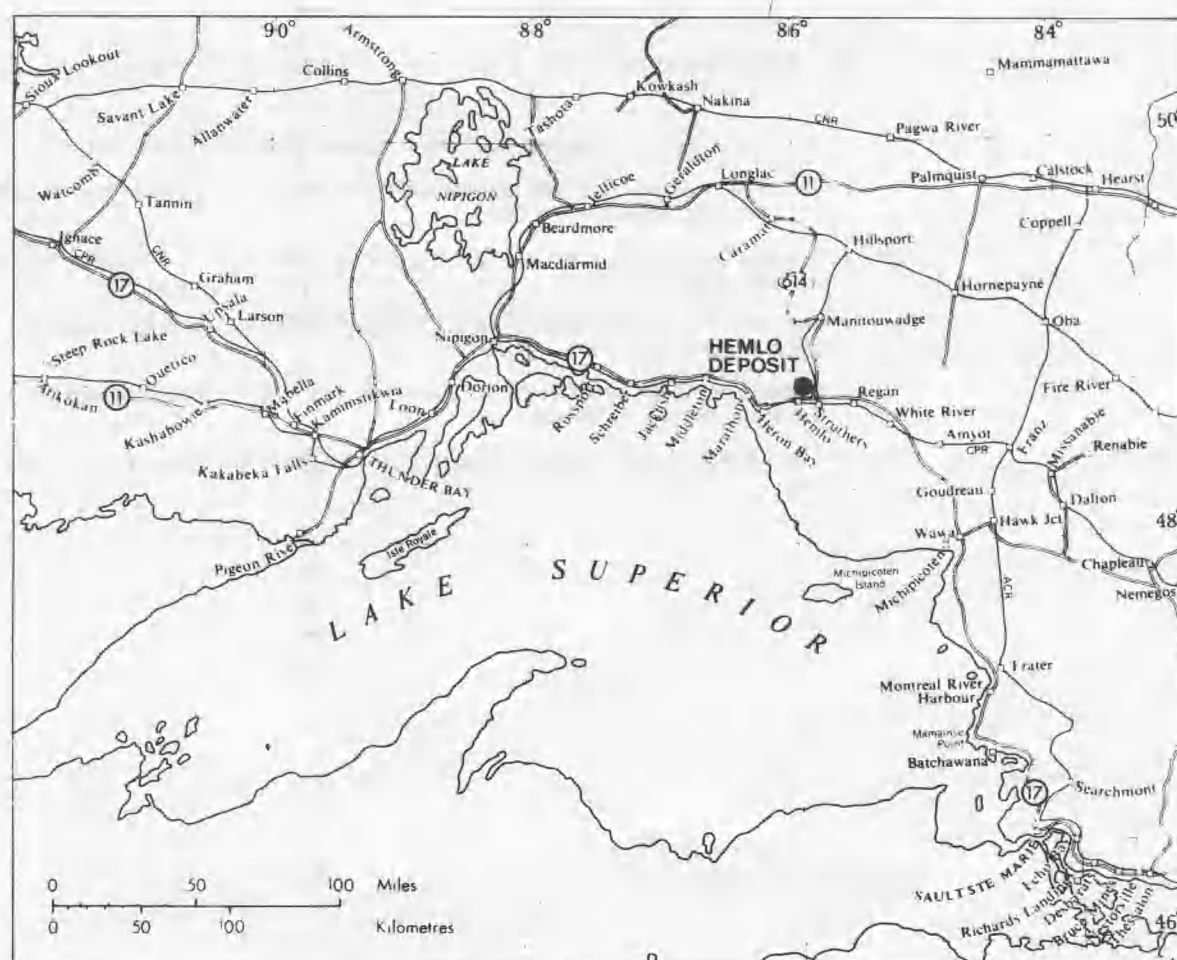


Figure 1. Location map.

detailed information of the geology of the main deposit. Much of the material in this portion of the guide was prepared in 1984 and some outcrops close to the mine sites are no longer available for examination.

## EXPLORATION HISTORY

Exploration began in the Hemlo area in 1869 near the present town of Heron Bay (Figure 2, Stop 3), where 2 veins were discovered by Moses Pee-Kong-Gay (McKellar, 1874). The veins were shown to A. Cyrette and W. Pritchard in 1872, who reported the occurrence to Captain W. Frue (from Silver Islet). A number of shafts were sunk and some ore was shipped (McKellar, 1874).

In the 1920's J. LeCour, Station Agent at Hemlo, sank a number of test pits on a mineralized shear zone (Bel-Air Resources Limited occurrence; Figure 3, Number 16) just north of Hemlo Station. At about the same time, a series of trenches (currently on Golden Sceptre Resources Limited property; Figure 3, Number 15) were dug to the north of Mile-Post 38 on the Canadian Pacific Railway mainline by unidentified persons.

The region was first mapped in 1931 by J.E. Thomson of the Ontario Department of Mines. He recommended 2 areas for exploration: Manitouwadge and northeast of Hemlo. Moses Fisher (who had guided J.E. Thomson to Manitouwadge) made a discovery on the western half of the present Page-Williams Property (Figure 3, Number 9). He showed the discovery to a Mr. Ollmann of Heron Bay. A block of 11 claims was staked by J.K. Williams of Maryland, apparently in partnership with Ollmann, in September of 1945. The adjacent ground (Figure 4), now comprising the International Corona Resources Limited property, was staked by T. Page, M. Bartley, Moses Fisher, A. Halliday, and J.K. Williams. Lake Superior Mining Corporation Limited was formed in 1947 to develop the property, with W. Tomas as President. Work, consisting of mapping, trenching, and diamond drilling, was carried out on both the Williams property and the adjoining Lake Superior Mining Corporation Limited property under the direction of T. Page. In 1951, the Lake Superior Mining Corporation Limited property was optioned to Teck-Hughes Gold Mining Limited. They drilled 6,000 feet of core which outlined a deposit of 89,000 tons at 0.27 ounce gold per ton (Canadian Mines Handbook) on the present Corona West Ore Zone (Figure 3, Number 1). Further drilling was undertaken by Teck-Hughes in 1957 and 1959; however, the company was dissolved in February, 1965.

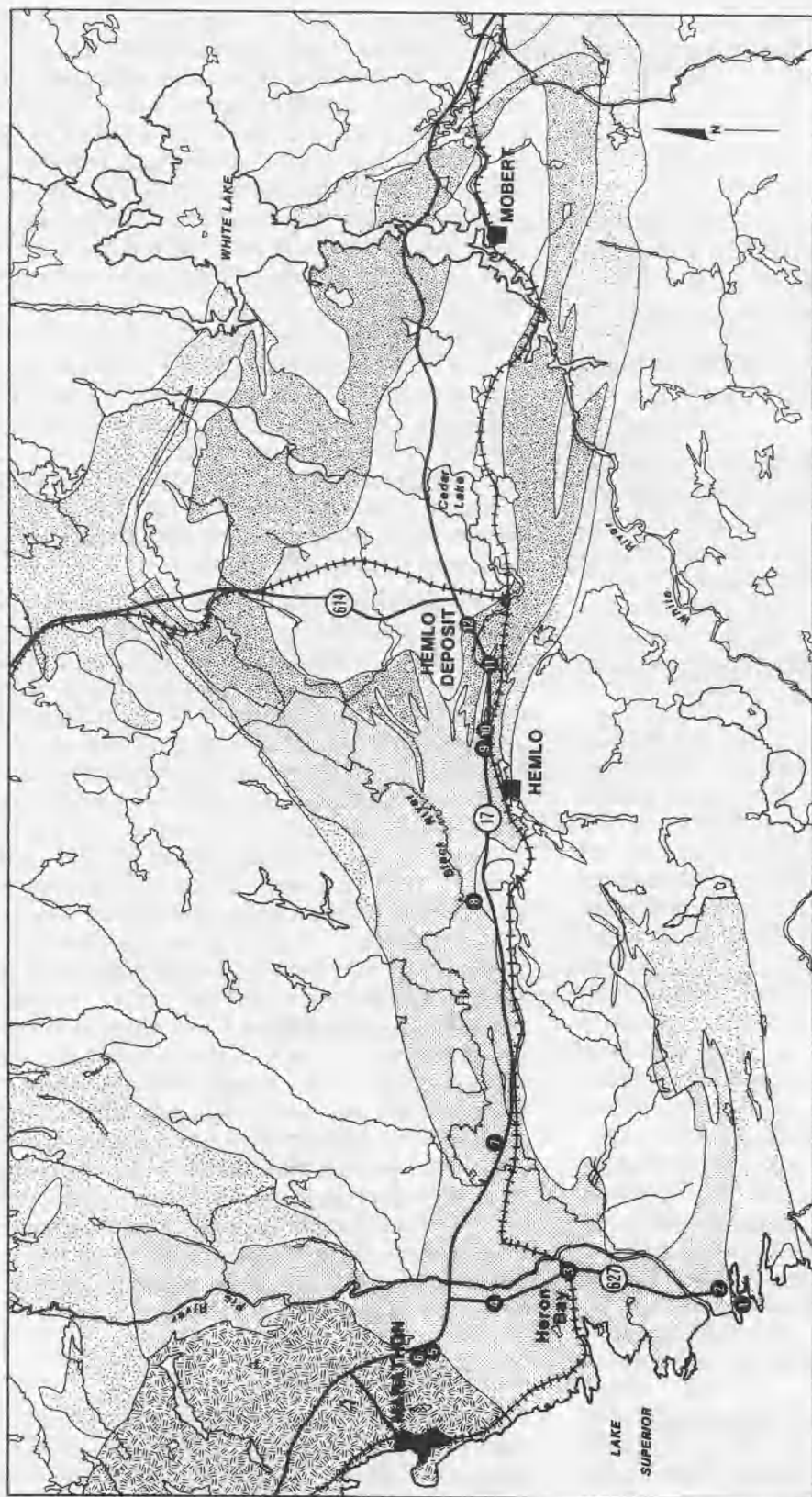
Subsequently, the International Corona Resources Limited property was staked for short periods of time by 4 individual prospectors. No exploration work was filed for assessment credits. In April of 1973, Ardel Explorations Limited staked the property. They completed a further 3 holes and revised the tonnage of the Corona West Ore Zone to 150,000 tons at 0.21 ounces gold per ton (The Northern Miner, February 14, 1974). The company charter of Ardel Exploration Limited was cancelled and the property was restaked by R.G. Newman in 1976. These claims were cancelled in January of 1978.

The area remained open until March of 1980, when it was staked by prospector J. Larche in partnership with D. McKinnon. They optioned the property to Mr. Schiralli, who in turn optioned the property to International Corona Resources Limited. At about the same time, Larche and McKinnon staked and optioned the adjacent ground to Goliath Gold Mines Limited and Golden Sceptre Resources Limited (Figure 4).

An exploration program on the Corona claims under the direction of geologist D. Bell resulted in the discovery of the East Zone (Figure 3, Number 2) in the fall of 1981. In November 1981, Corona entered into an agreement with Teck Corporation whereby Teck would earn a 55% interest in the property by continuing the exploration program to a production decision. The Williams patented claims which adjoin the Corona property to the west were optioned by Lac Minerals Limited in 1981, and in August 1982, Lac announced the discovery of a gold deposit on the claims now termed the Page-Williams Property. It quickly became clear that the Lac deposit could extend downdip northwards on to the Goliath Gold Mines Limited claims. In September 1982, Goliath initiated a drill program to test for the extension and early in the program intersected the spectacular gold grades and widths which confirmed Hemlo as a world class gold deposit. In November 1982, Noranda Mines Limited formed a 50:50 joint venture with Goliath and its co-venturer Golden Sceptre Resources Limited by undertaking to put the Goliath deposit, latterly named the Golden Giant Joint Venture, into production. By the end of 1985, all three properties had commenced gold production.

## GENERAL GEOLOGY

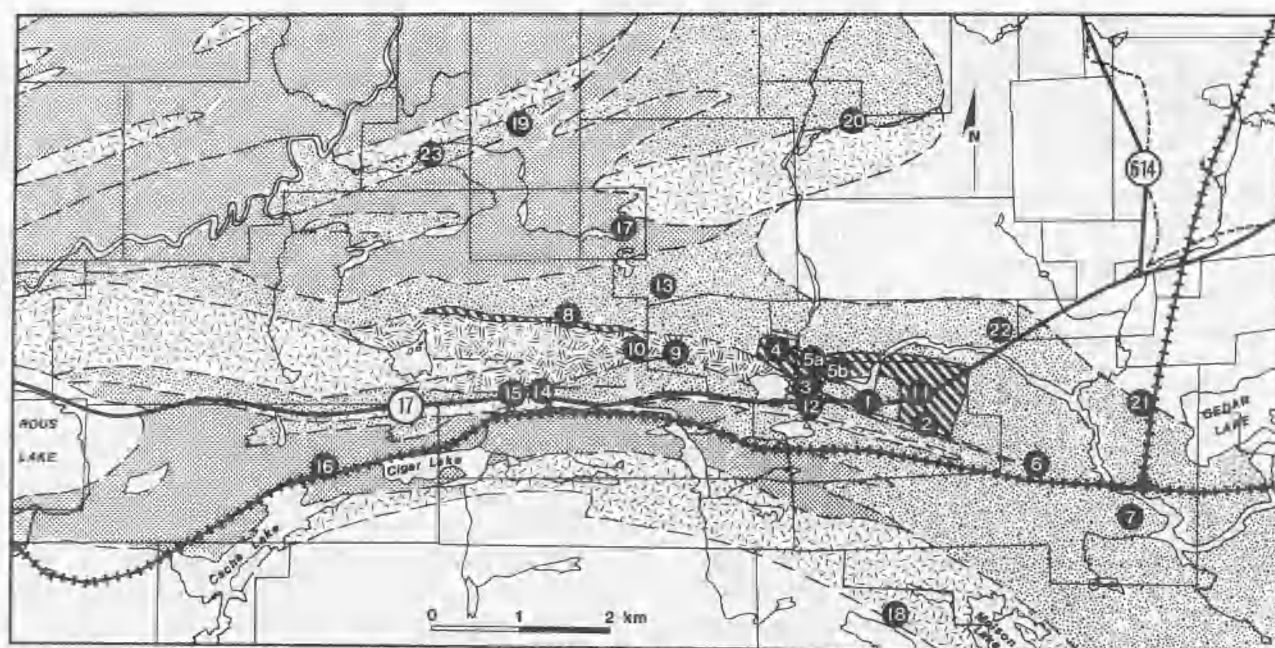
The geology of the Hemlo area (see Figure 2) has been mapped by the Ontario Geological Survey and the former Ontario Department of Mines (Thomson, 1931; Milne, 1967, 1968; Muir 1982a, 1982b; Siragusa, 1985, and Siragusa and Chivers, 1985). This mapping has demonstrated that the Hemlo gold deposit occurs in an east-trending belt of Ar-



AFTER OG8 MAPS 2452, 2439, 2143, 2144, 2145, 2146, 2147, 2088, 2089



Figure 2. Geology of the Hemlo region.



AFTER TERRAE DRAFTING SERVICES, OGS MAP 2450 AND RESIDENT GEOLOGIST'S FILES,  
ONTARIO MINISTRY OF NATURAL RESOURCES, THUNDER BAY

#### ARCHEAN

- GRANITIC ROCKS
- FELSIC METAVOLCANICS (UNSUBDIVIDED)
- CRYSTAL TUFF (QUARTZ-EYE TUFF)
- MAFIC METAVOLCANICS (MASSIVE TO PILLOWED)
- METASEDIMENTS (SILTSTONES, CALC-SILICATES AND PELITES)

UP-DIP PROJECTION OF HEMLO DEPOSIT

OCCURRENCE

#### OCCURRENCES

- |                                                  |                                                                               |
|--------------------------------------------------|-------------------------------------------------------------------------------|
| 1. CORONA WEST ORE ZONE, LAKE SUPERIOR MAIN ZONE | 12. LOWER ZONE, LAKE SUPERIOR SOUTH ZONE                                      |
| 2. CORONA EAST ZONE                              | 13. INTERLAKE DEVELOPMENT OCCURRENCE                                          |
| 3. LAC MINERALS ZONE A (WILLIAMS PROPERTY)       | 14. MUIR ZONE, HIGHWAY ZONE                                                   |
| 4. LAC MINERALS ZONE B (WILLIAMS PROPERTY)       | 15. MILE 38 OCCURRENCE                                                        |
| 5a. GOLIATH MAIN ZONE 5b. TECK 1/4 CLAIM         | 16. BEL-AIR OCCURRENCE                                                        |
| 6. GOLIATH EAST ZONE                             | 17. LAKE SUPERIOR NORTH ZONE                                                  |
| 7. STRUTHERS OCCURRENCE                          | 18. PRICEMORE OCCURRENCE (LOCATION APPROXIMATE)                               |
| 8. SCEPTRE NORTH ZONE                            | 19. DAKOTA ENERGY OCCURRENCE                                                  |
| 9. LAC MINERALS WEST ZONE (WILLIAMS PROPERTY)    | 20. LYNX CANADA (LOCATION APPROXIMATE)                                        |
| 10. FRACTURE ZONE, SCEPTRE SOUTH ZONE            | 21. MoS <sub>2</sub> BEARING VEIN (GOLIATH GOLD MINES LTD)                    |
| 11. BARREN SULPHIDE ZONE                         | 22. MoS <sub>2</sub> BEARING VEIN (GOLIATH GOLD MINES LTD)                    |
|                                                  | 23. MoS <sub>2</sub> BEARING VEIN (CAULFIELD RES LTD<br>LOCATION APPROXIMATE) |

Figure 3. Geology and property outlines in the immediate Hemlo area.

clean metasedimentary and metavolcanic rocks (part of the Wawa Sub-province) forming a broad synform, with granitic intrusions along its axis.

Muir (1982a, 1983) divided the rocks of the Hemlo belt into two main groups near the town of Heron Bay. The northern, Heron Bay Group con-

sists predominantly of intermediate to felsic metavolcanic and metasedimentary rocks. The metavolcanics consist of lava flows and pyroclastic deposits. The coarsest pyroclastic rocks occur near Heron Bay. Towards the east, the pyroclastic rocks gradually become finer grained with a higher com-

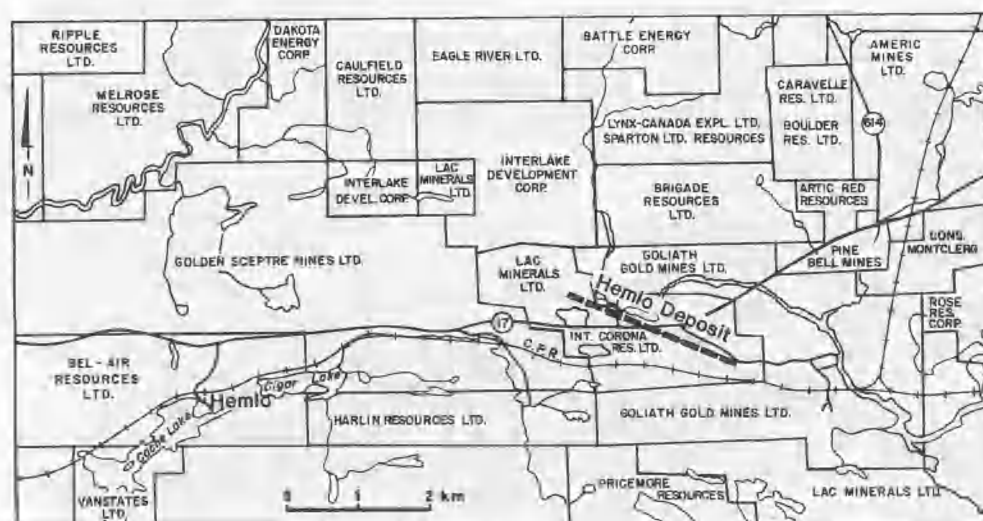


Figure 4.  
Hemlo property  
map.

ponent of re-worked material (tuffaceous fragments). Near Hemlo, argillaceous metasediments interfinger with the tuffs and tuffaceous metasediments. Further to the east, near Struthers, siltstones predominate. The southern, Playter Harbour Group consists of mafic pillowed metavolcanics (high-iron tholeiites) which have been intruded by ultramafic sills.

## STRUCTURAL GEOLOGY

The large scale structure of the Hemlo Belt can be described as a synform with granitic intrusions (Heron Bay Pluton and Cedar Lake Pluton) occurring along the fold axis (Figure 2). In detail, however, the structure is more complicated (Patterson, 1983b). The predominant fabric in the fragmental rocks is the result of a lineation overprinted by a secondary foliation. This lineation appears to show a systematic variation across the southern half of the belt. Near Heron Bay, the plunge of lineation is  $45^{\circ}\text{W}$ ; the plunge gradually steepens to the east, being almost vertical near the hamlet of Hemlo, and then decreases to  $45^{\circ}\text{E}$  near the town of White River.

Minor folding is common with observed closures on a scale of up to 40 m. Foliation is parallel to the fold plane and the lineation parallels the fold axis. Both the lineation and foliation are folded near Heron Bay. A large scale M-fold with a closure of 2 km can be observed on airphotos. Refolded minor folds (mushroom-shaped interference figures) were observed along the access road into Pukaskwa Park. This suggests a number of phases and orientations of deformation.

Brittle deformation (faulting and shearing) commonly occurs along the contact of brittle and ductile rocks, subparallel to bedding. The Hemlo Fault can be traced from Moose Lake westwards to the ham-

let of Struthers (8 km), roughly parallel to the Trans-Canada Highway (17). Northeast of Cigar Lake (see Figure 3), the fault is indicated by 1 to 3 m of chloritic schist.

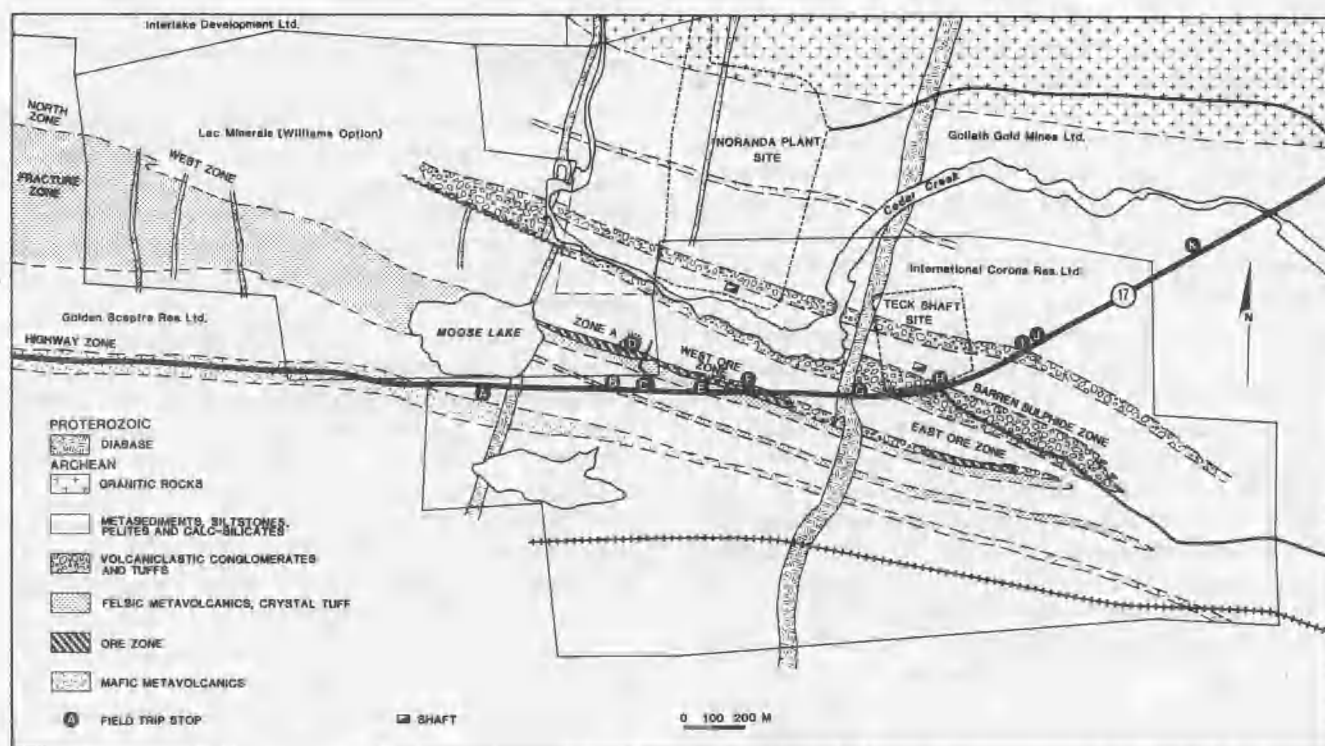
## DEPOSIT STRATIGRAPHY

This section represents a summary based on work by R. Quartermain (Teck Corporation), G. Pierce (Noranda Inc.), and R. Valliant (Lac Minerals Limited). For detailed information the reader is referred to Quartermain et al. (1983), Sheehan and Valliant (1983), and Noranda Staff (1983) and to other papers in this field guide. During the summer of 1983, outcrops representative of typical units were washed, stripped, and mapped as an adjunct to preparation of a 1984 CIM field trip and guidebook.

The general trend of the units is  $100^{\circ}$ , with a dip of  $45^{\circ}\text{N}$  to  $55^{\circ}\text{N}$ ; some isoclinal folding is evident. Top indicators show reversals, with the majority of the units facing north. The base of the sequence is arbitrarily taken to be the southern contact between a thin unit of mafic metavolcanics and metasediments south of Moose Lake (see Figure 5). The possibility of a large scale fold repeating some of the units is illustrated in Figure 5.

The section below describes the highway exposure (see Figure 7); distances are across strike and do not represent true thickness:

- 0-75 m: Mafic metavolcanics consisting of massive to strongly deformed, pillowed lavas. The northern contact of the mafic metavolcanics is the Hemlo Fault.
- 75-175 m: Calc-silicate metasedimentary unit. Originally a finely bedded marl which has been converted by metamorphism to rock composed of calcium-rich plagioclase and amphibole (tremolite to hornblende).
- 175-180 m: Altered crystal tuff (quartz-sericite schist) composed of quartz crystals 2 to 5 mm in size (as much as 10%) in a fine-grained matrix of sericite and quartz, containing minor pyrite and tourmaline. This unit was



AFTER COMPANY MAPS, RESIDENT GEOLOGIST'S FILES, ONTARIO MINISTRY OF NATURAL RESOURCES, THUNDER BAY

Figure 5. *Geology of the Hemlo deposit – Stop 11.*

called the Lake Superior South Zone (Figure 3, Number 12) by Page (1947). At depth, it contains economical gold values (Lower Zone of the Goliath deposit; see Figure 13).

180–220 m: Metasiltstones with minor calc-silicate interbeds, and some magnetite-rich beds as much as 4 cm thick. This unit serves as a stratigraphic marker due to its magnetic response.

220–270 m: Crystal tuff (quartz-eye sericite schists). Locally the unit is bedded, with individual beds defined by the density and size of quartz crystals. The quartz-eyes, up to 3 mm in size, are commonly sheared and deformed (see Figure 15).

270–290 m: The Ore Zone section: The rocks in this unit are feldspathized metasediments, tuffs, and fragmental rocks. It was referred to as the "Lake Superior Shear Zone" by Page (1947) (see Figure 16).

290–390 m: Reworked tuffs with units of pelite and calc-silicate.

390–480 m: Pyroclastic rocks consisting of crystal tuffs and associated conglomerates. The upper section of this unit is a crystal tuff with pyrrhotite and pyrite (locally called the "Barren Sulphide Zone" or the "Sucker Zone").

480–600 m: Pelitic sediments with units of calc-silicate and siltstone (see Figure 17).

600–650 m: Crystal tuffs and conglomerates.

650–900 m: Calc-silicate rocks and siltstones (locally folds with closures of 40 m have been noted).

All rocks in the section are cut by diabase dikes. Bodies of feldspar porphyry, including a relatively coarse-grained variety, have intruded parallel to foliation.

## SIZE AND GRADE OF THE HEMLO DEPOSIT

The combined total of published reserves for the Hemlo deposit is approximately 80,000,000 tons at 0.24 ounces gold per ton. These figures can be broken down as follows:

|                                                                                                   |            |          |
|---------------------------------------------------------------------------------------------------|------------|----------|
| 1. Noranda Inc. (The Globe and Mail, Dec. 20, 1983)                                               |            |          |
| Goliath Property                                                                                  | reserves   | grade    |
|                                                                                                   | (tons)     | (oz/ton) |
| Upper or Main Zone                                                                                | 19 618 410 | 0.29     |
| Lower Zone                                                                                        | 1 643 089  | 0.17     |
| Quarter Claim                                                                                     |            |          |
| Upper Main Zone                                                                                   | 2 235 704  | 0.30     |
| Lower Zone                                                                                        | 187 476    | 0.30     |
| Total                                                                                             | 23 867 679 | 0.28     |
| 2. Lac Minerals Limited (The Globe and Mail, Dec. 14, 1983 and the Northern Miner, Nov. 29, 1984) |            |          |
| Zone A                                                                                            | 3 850 000  | 0.18     |
| Zone B                                                                                            | 38 150 000 | 0.20     |
| Zone C                                                                                            | 5 720 000  | 0.14     |
| Total                                                                                             | 47 720 000 | 0.19     |
| 3. Teck-Corona (The Northern Miner, Oct. 13, 1983)                                                |            |          |
| East Zone                                                                                         | 8 400 000  | 0.36     |

## SUMMARY OF THE MAIN DEPOSIT GEOLOGY

The reader is referred to a number of articles (some included in this volume) which describe in detail individual portions of the deposit. Only a summary is presented here.

The Hemlo deposit (see Figure 5) occurs at the contact between crystal tuffs and metasediments,

where the crystal tuffs wedge out against the metasediments. The metasediments consist of a graded siltstone, pelites, reworked tuffs, and calc-silicate members. The crystal tuffs near the deposit are altered, and contain sericite, tourmaline, potassium feldspar, green mica, barite, and hematite. The pelitic composition of the metasediments may, in part, be due to alteration of sedimentary rocks. The ore-hosting rocks are sericite schists (altered crystal tuffs), siliceous metasediments and fragmental rocks.

The ore minerals consist of pyrite, molybdenite, native gold, stibnite, arsenopyrite, cinnabar, and realgar (see Harris, this volume). The mineralization is zoned both across dip and along strike. The across-dip zonation in the Goliath deposit is from a molybdenite-rich siliceous schist in the hanging wall; to mixed siliceous, baritic, and sericitic schists; to a baritic unit in the footwall. An apparent zonation along strike can be seen when comparing the Goliath and Page-Williams deposits with the Corona East Zone. The Goliath deposit appears to represent a core rich in Au, Mo, Sb, Ba, As, and Hg with a rim (Corona East Zone) rich in Au and Mo. Current grade and tonnage estimates are approximately 80.0 million short tons at 0.24 ounces gold per ton.

### Models for Ore Genesis

Some workers in the area suggest the deposit was syngenetic, having been deposited as a primary sediment, whereas other workers suggest epigenetic, being related to fault systems. There are as yet a number of problems with regards to establishing the timing of ore emplacement relative to deformation. All models can be thought of as a modification of an epithermal system (see Figure 6).

1. Hot spring solution deposits – a chemical sediment rich in metal deposited at or near a vent. A number of modern equivalents have been described in New Zealand (Weissberg, 1969). Both the metal associations (gold, arsenic, antimony, and mercury) and the alteration patterns are similar to Hemlo.
2. Deposition of metal-rich sediments within porous units such as unwelded tuffs, fragmentals, and fault zones – this class of model can be thought of as involving a fissure system associated with hot springs. Examples of deposits of this group include those near Goldfield, Nevada, which occur in tuffs (Boyle, 1979); and the Getchell and Gold Acres deposits, Nevada, which are associated with fault zones (Joralemon, 1975).
3. Deposition of metal within chemically favourable rocks – the Carlin deposit, Nevada is associated with the replacement of limestones

by silica. Similar deposits occur in ultramafic rocks which have undergone carbonatization and later reacted with epithermal solutions (Henderson, 1969).

In comparing the Hemlo deposit to epithermal deposits, there are a number of clear similarities. The metal associations at Hemlo and in epithermal deposits are similar – gold, molybdenum, arsenic, antimony, mercury, and barium are major constituents. Alteration in epithermal deposits consists of silicification, and deposition of tourmaline, sericite, potassium feldspar, biotite, and kaolin. Direct comparison of alteration at Hemlo to that in much younger epithermal deposits is difficult due to the masking of amphibolite grade metamorphism. However, tourmaline, sericite, microcline, and silicification are present. At Hemlo, kaolin-rich rocks may be represented by pelites. Many of the hot spring systems in New Zealand and Nevada are associated with felsic volcanic rocks and porphyry dikes, both of which are present at Hemlo.

It is not clear which of the modifications of the epithermal model is most applicable, or if more than one mechanism was operative. The occurrence of clasts of ore-bearing sediments in fragmental rocks tends to support the assumption that primary metal-rich sediments were formed. However, a large part of the orebody occurs in fragmental rocks or tuffs which would have had a high initial porosity. As well, there are abundant carbonate rocks overlying

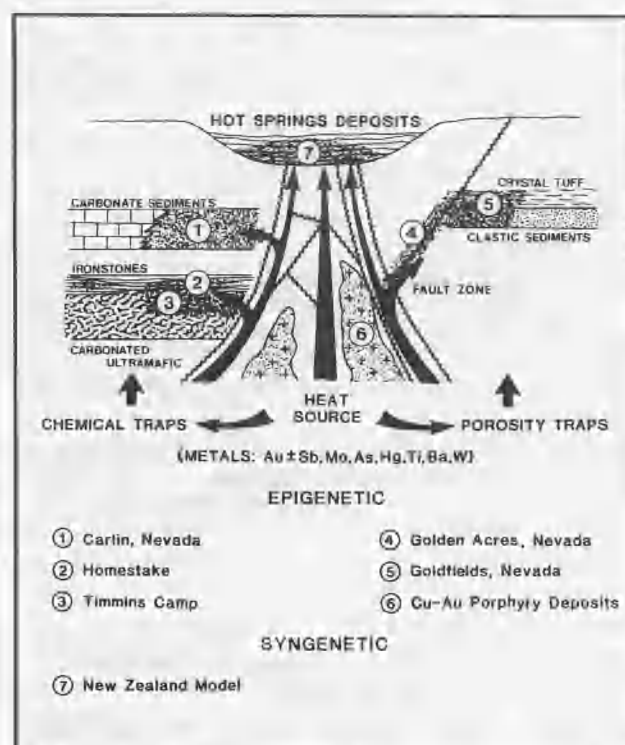


Figure 6. Epithermal model of gold deposit.

the ore zone that could have acted as a concentrating chemical trap for gold.

In this discussion, the role of deformation should not be over-looked. The mineralized horizon occurs at the contact between a brittle unit and ductile unit. Thus deformation focussed on this horizon could have generated porosity which acted as a conduit and structural trap for mineralizing solutions. The role of deformation in the origin or modification of the deposit has not been empirically determined.

## GOLD OCCURRENCES IN THE HEMLO AREA

The occurrences can be divided into four classes.

1. Strike continuations of the main zone mineralization, Golden Sceptre Resources Limited, North Zone and Goliath Gold Mines Limited.
2. Shear-zone-related mineralization such as the Golden Sceptre South Zone, the Lytton Minerals Limited property and possibly the Pryme Energy Resources Limited property.
3. Chemical-sediment-related mineralization such as QUED Resources Limited property, the Knut Kuhner Occurrences and the Barite Group of occurrences.
4. The intrusion related group included the Chavin of Canada Limited and Goliath Mines Limited occurrences.

## GOLDEN SCEPTRE RESOURCES LIMITED

The property extends as a band 3.2 km wide by 9.7 km long to the west of the property of International Corona Resources Limited. The property was optioned to Noranda Exploration Company in November, 1982. Three mineralized zones have been discovered during an exploration program which included geological mapping, trenching, an Induced Polarization survey, and soil geochemistry. One of the zones, the Golden Sceptre Fracture Zone (see Figure 3, Number 10) is located 800 m north of Highway 17, with its eastern boundary adjoining the Page-Williams Property. The Fracture Zone is "hosted" in quartz veins which cut quartz-eye tuff. This zone appears to be a strike extension of mineralization discovered during the 1950s on the western side of the Page-Williams Property (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay). The mineralization consists of native gold, molybdenite, pyrite, and telluride minerals. Initial diamond drilling intersected a number of high grade zones (as much as 3.36 ounces gold per ton) over narrow widths (1.6 to 4.9 feet; George Cross Newsletter,

Number 204; October 25, 1982). An eastern strike extension of the mineralization to the Williams claims (Figure 3, Number 9), appears to be the deposit announced in The Northern Miner Newspaper (September 15, 1983, p. 1).

The second zone is located 150 m north of the first zone (Figure 3, Number 8). It is defined by an east-trending soil geochemical anomaly. Assays of diamond drill core are as follows: Hole 4-21 feet of 0.33 ounce gold per ton; and Hole 19-36 feet of 0.325 ounce gold per ton (The Northern Miner, November 18, 1982).

Drilling carried out during 1983 extended the zone 2.4 km further west (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay) to Botham Lake. Although no assays were reported, references to green mica, molybdenite, stibnite, and pyrite were made.

The third zone, the Highway Zone (Figure 3, Number 14 and Figure 7), was sampled by Muir (1982b) and assayed at 0.32 ounce gold per ton. Mineralization consists of pyrite, native gold, and minor molybdenite, and is hosted in volcanoclastic metasediments. The unit is up to 2 m wide and can be traced from Moose Lake west to "Finger Lake".

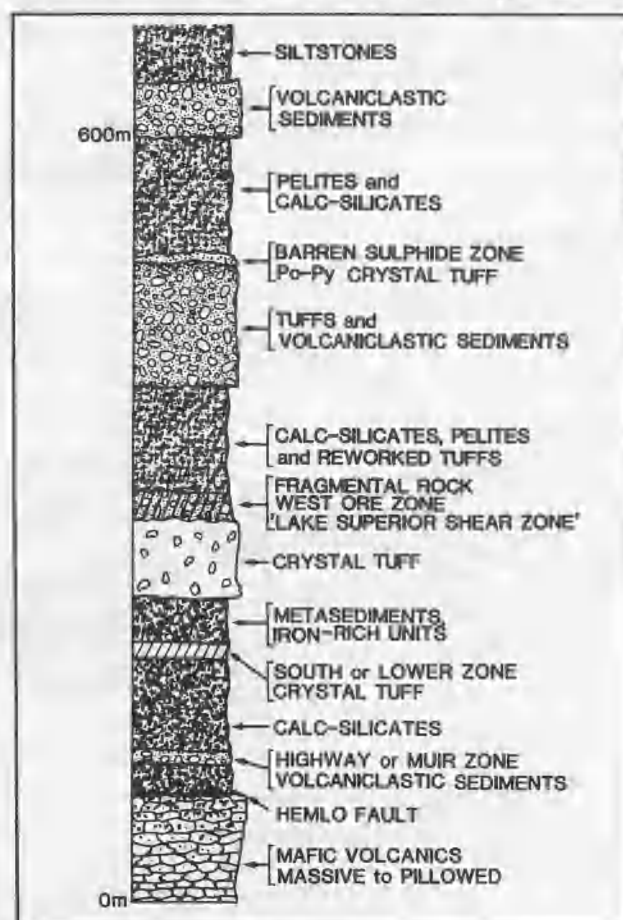


Figure 7. Table of formations along Highway 17 - Stop 10.

which is adjacent to Highway 17, a distance of 3 km. The volcanoclastic metasediment consists of 50% fragments of feldspar porphyry, chert, and altered volcanic rocks, 2 mm to 5 cm in size, which have been stretched as much as 15:1 parallel to foliation. The matrix contains sericite, green mica, and tourmaline.

### GOLIATH GOLD MINES LIMITED

The property surrounds the International Corona Resources Limited property on 3 sides (east, north, and south).

To the east, 100 m south of Struthers, mapping has indicated the presence of molybdenite and pyrite in a sericite schist (Figure 3, Number 7) on strike with the "Corona East Ore Zone". Recent diamond drilling by Noranda Inc. has intersected sericite schist, containing molybdenite and stibnite (Figure 3, Number 6); no assays have been reported (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

A number of quartz veins containing minor molybdenite occur on Highway 17 to the east of the Golden Giant Mine access road (Figure 3, Number 22), and on the Manitowadge Railway spur 1.5 km south of Highway 17 (Figure 3, Number 21). Quartz veins as wide as 10 cm cut metasediments near the contact with the Cedar Lake Pluton. A number of

similar occurrences have been reported on other properties in the area.

### PEEKONGAY PROPERTY - LYTTON MINERALS LIMITED

This property includes those formerly held by Bowhill Gold Mines and Heron Bay Gold Mine. It is located in Pic Township, is centred near the town of Heron Bay and extends from Lake Superior to the Pic River.

The area is underlain by felsic metavolcanics (breccia to tuffs) and mafic metavolcanics. These have been intruded by granitic rocks, and by diabase and lamprophyre dikes. The felsic metavolcanics form part of the Heron Bay Group (Muir, 1982a).

A large scale M-shaped fold approximately 2 km across occurs to the south of the Lytton property. The fold is defined by folded foliation (visible on 1" = 1/2 mile airphotos). A strong east-west lineament occurs just to the north of the town of Heron Bay.

Hartwick et al. (1985), in Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, describe the geology of the property as follows:

"The volcanic succession, which underlies the Peekongay Property, forms part of the Heron Bay Group and is approximately 2 miles (3.2 km) thick on the property. These rocks can be subdivided into three major sequences:

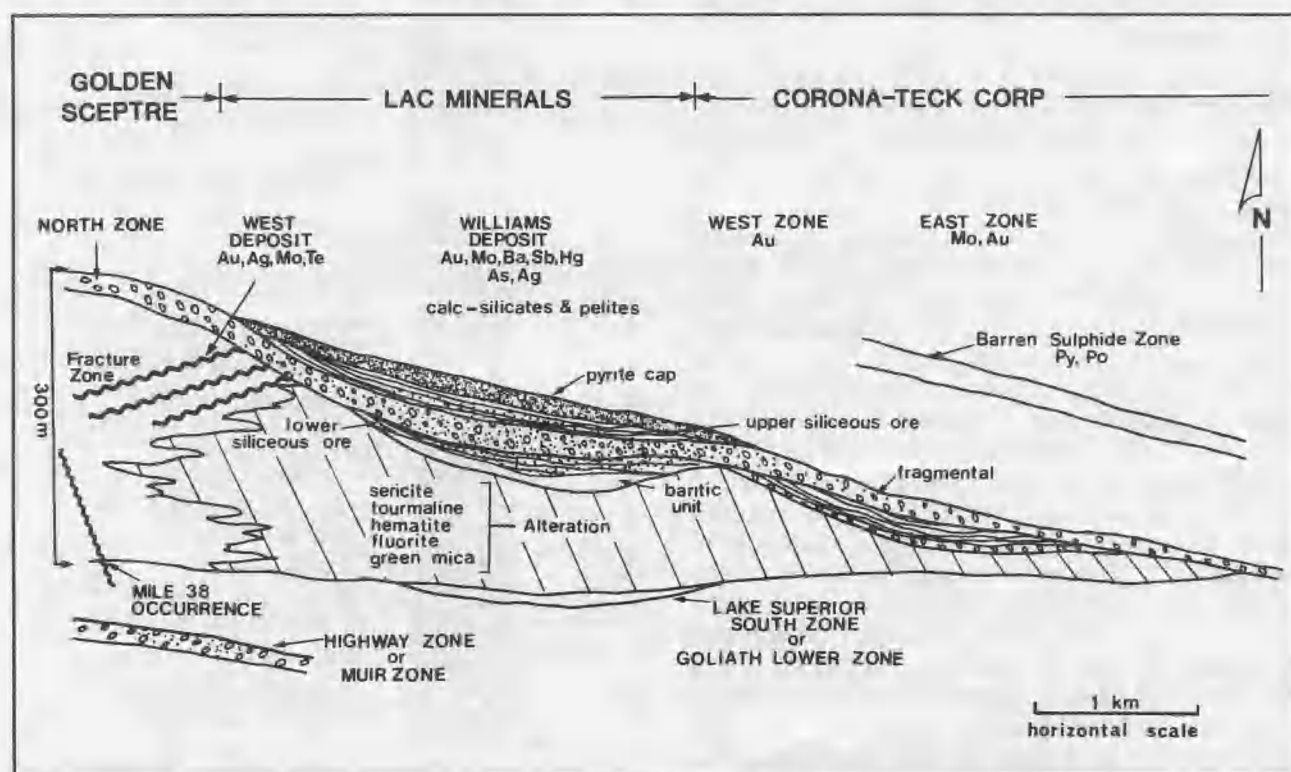


Figure 8. Stratigraphic relationships at the Hemlo deposit.

1. A northern sequence of mafic to intermediate, locally pillowed flows and lesser pyroclastic rocks approximately 3,600 feet (1,100 m) thick. A significant proportion of the mafic to intermediate flows are pervasively silicified giving the outcrops a more "felsic" appearance.
2. A central zone about 2,000 feet (600 m) thick comprising a complex succession of interbedded fine to coarse-grained pyroclastics of intermediate composition with local interbedded volcanoclastic horizons. The "C" Zone occurs near the southern edge of the central zone.
3. A southern sequence of coarse, felsic to intermediate pyroclastics about 5,000 feet (1,500 m) thick. A trend to a more felsic composition, as well as a general coarsening of clast size, appears to occur southwards."

As summarized from Hartwick et al. (1985), in Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, four major environments containing gold mineralization occur on the property:

1. A pyritic, quartz-rich, molybdenite-bearing possibly stratiform unit in mafic to intermediate tuffs ("C" Zone).
2. Vuggy, pyritic quartz-carbonate veins and stringers cutting a possible subvolcanic quartz-feldspar porphyry sill ("Porphyry" Zone).
3. Pyritic, silicified and quartz-sericite-altered, dacitic pyroclastics and, to a lesser extent, mafic to intermediate tuffs (Main Zone, eastern part of North Zone).
4. Quartz-carbonate veins and vein breccias with variable amounts of pyrite, chalcopyrite, galena, sphalerite and tourmaline (Bowhill trench, 1872 shaft area trench, western part of North Zone).

Ore grade intersections over significant widths (i.e., 6 feet (2 m) or greater) have been obtained from the "C" and "Porphyry" Zones. In contrast, the silicified and quartz-sericite-altered pyroclastics, of which the Main Zone is the most prominent, are characterized by geochemically anomalous gold values in the order of 100 to 200 ppb, with locally high values as great as 0.11 oz/ton Au over 3.1 feet (0.95 m), but no ore grade intersections have been obtained, Resident Geologist Files, Ontario Ministry of Northern Development and Mines, Thunder Bay.

Quartz-carbonate veins and vein breccia occur in essentially all lithologies and, although these veins at some places contain gold values greater than 0.40 oz/ton Au, they are very erratic and discontinuous. The continuity, both laterally and vertically, of high grade intersections is very limited.

**Lytton Minerals, Porphyry Zone:** Further detailed work by Derry, Michener, Booth and Wahl identified a mylonite zone along the north contact of a porphyry intrusion 1 km west of Heron Bay. This unit was previously called a thinly bedded hematitic ash tuff marker (B. Pearson, personal communica-

tion, Geological Consultant, Derry, Michener, Booth and Wahl, Toronto, 1985).

The unit is highly foliated and locally folded. It is comprised of fine-grained, red (hematitic) thinly laminated chlorite and felsic layers. In drill core the mylonite grades into a sheared and deformed feldspar porphyry to the south. The porphyry contains 10% white tourmaline. A value of 0.19 oz/ton gold across 23.5 feet has been intersected within the porphyry, near the hanging wall (Hartwick et al., 1985; Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

**Lytton Minerals, C-Zone:** The C-Zone mineralization occurs at or near the footwall of the feldspar porphyry. Mineralization consists of layers and lenses of quartz up to 1 cm thick in a chlorite schist (possibly a sheared mafic metavolcanic). The quartz-rich layers contain molybdenite. Pyrite (5-10%) occurs as 1 to 3 mm cubes which have been deformed and possibly rotated in foliation. The zone appears to cross-cut the mafic metavolcanics and the feldspar porphyry. Late quartz-carbonate veins cut the foliation in the zone. Most of the rocks north of the railway tracks consist of heavily carbonatized mafic volcanics which have a felsic appearance. The best diamond drill intersection obtained was 17.0 feet of 0.19 ounces per ton gold (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

**Lytton Minerals, Main Zone Summary:** The zone consists of a series of sericitic units within felsic metavolcanics and trends at 060° across the property. The moderately foliated sericite schist contains 5 to 10% blue quartzeyes that are up to 2 mm in size. The quartzeyes are deformed parallel to foliation. In the most strongly foliated sections, the quartzeyes are absent and the narrow quartz-rich layers (less than 2 mm) contain molybdenite. Drilling and surface exploration has defined five parallel units. A number of occurrences are known along the zone. The best intersection reported was 4.83 ounces per ton gold across 1.0 foot (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

**Lytton Minerals, Main Zone, Bowhill Mines Trench:** Described by Hartwick et al. (1985), in Resident Geologist's files, Ontario Ministry of Northern Development and Mines, this trench is a section of the Main Zone (located about 1 km west of Heron Bay):

"This trench, excavated by Bowhill Mines in the middle 1930's, is about 200 feet (50 m) long by 30 feet (9 m) deep and 10 feet (3 m) wide. The trench is largely caved in but the pyritic quartz-sericite schist unit is exposed at the end of the carbonate-quartz vein which contains sphalerite, galena and pyrite; a bulk sample of 500 lbs, taken presumably from

this vein material by Bowhill Mines, assayed 0.3 oz Au/ton and 1.5 oz Ag/ton."

Drilling and geochemical work by Lytton Minerals Limited (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay) shows the Main Zone to be depleted in Na and enriched in K, Mo, Au, Zn, Cu. The Main Zone and the carbonate vein are cut by a lamprophyre dike. The carbonate vein contains black tourmaline and molybdenite.

Stripping on the main zone just west of the Bowhill Mines Occurrence (1,100 m west of Highway No. 627, and 200 m south of the Canadian Pacific Railway) has exposed a shear zone which shows evidence of progressive deformation. The earliest phase was largely ductile, with the volcanic fragments within a felsic pyroclastic rock being folded and stretched out parallel to foliation. Next a series of discrete sericite schist zones, 20–200 cm wide and heavily carbonatized, cut across the ductile shear. Carbonate pods within the sericite schist have been deformed. Subsequently, a mafic dyke 30–60 cm wide was intruded into the sericite schist. The dyke contains fragments of sericite schist and has been folded where it crosses the sericite schist zone. The final phase appears to have been brittle deformation, with the formation of quartz–tourmaline veins along the margin of the mafic dyke and in the carbonate pods.

**Lytton Minerals Main Zone, Heron Bay Gold Mine:** Hartwick et al. (1985), in Resident Geologist's files, Ontario Ministry of Northern Development and Mines, describes the property as follows:

"Two shafts are present, one shallow shaft, probably about 8 m deep in the eastern part of the trenched area, and the second shaft, which is about 16 m deep, in the central part of the trenched area. These two shafts are about 40 m apart. Within this trench you will see that the main target has been a carbonate–quartz vein which strikes west–north–westerly. This vein occurs along a fault which cuts the volcanic stratigraphy. The quartz vein carries sporadic gold values; the best result from our sampling is 0.314 oz Au/ton over 0.9 m. This pyritic quartz–sericite unit is located about 25 m south of the trench but is not exposed."

The vein carries black tourmaline, molybdenite, galena, pyrite and minor chalcopyrite. Barite has been identified by X-ray diffraction (Geoscience Laboratory, Ontario Ministry of Northern Development and Mines, Toronto). The felsic metavolcanics are foliated at 065°/50°N and the fragments are lineated at 45°W. The veins are oriented at 095°/90° and cross-cut the metamorphic foliation.

**Lytton Minerals, South Zone:** A sericitic zone similar to the main zone occurs approximately 100 m south of the Heron Bay Gold Mine. Stripping and trenching has exposed quartz–carbonate veins

within a sheared volcanic breccia. The veins contain chalcopyrite, galena, pyrite and tourmaline.

Esso Resources Canada Limited has reported the results of drilling on their property east of Heron Bay. This property is apparently on strike with the Lytton Main Zone. Hole No. 1 encountered an intermediate to feldspar–phyric crystal tuff and lapilli tuff containing contorted foliation and brecciated quartz veins, with pink calcite, pyrite and molybdenite. Assays by Esso Resources Canada Limited returned up to 1,300 ppb gold and 280 ppm molybdenum across 0.6 m, (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

#### **PRYME ENERGY RESOURCES LIMITED AND MARCH RESOURCES LIMITED (MCINTYRE CU-NI SHOWING)**

The property is located 16 km northeast of the junction of the Trans-Canada Highway 17 and the Manitowadge Highway 614 (see Figure 2). The area was first staked by C. Von Klein in 1962 and optioned to McIntyre–Porcupine Mines Limited, who performed geophysical surveys (electromagnetic and magnetic), geological mapping, and drilled 28 holes. In 1964, Caravelle Mines Limited gained control of the group and optioned it to Falconbridge Nickel Mines Limited. It was staked by Pryme Energy Resources Limited and March Resources Limited in July, 1982 and was then optioned to Noranda Mines Limited.

Exploration on the property defined 6 Cu–Ni and Cu–Zn occurrences; the most significant is "Showing Number 2". Two drillholes cut gold-bearing sulphide mineralization in "andesite". Assays are as follows: Hole A<sub>2</sub>–8.2 feet, Cu 1.05%, Zn 0.8%, Ag 0.40 oz/ton, Au 0.24 oz/ton; Hole W<sub>1</sub>–7.0 feet, Cu 2.94%, Zn 2.12%, Pb 0.14%, Au 0.094 oz/ton, Ag 1.54 oz/ton (Assays by Falconbridge Nickel Mines Limited in 1970, Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

A semi-quantitative spectrographic analysis showed the presence of molybdenum. However, a drill program by Noranda Mines Limited was unable to confirm the past results (The Northern Miner, July 21, 1983).

#### **QUED RESOURCES CORPORATION**

The property is located approximately 48 km east–northeast of Marathon and 3 km north of Solong Lake.

G. Siragusa (1984) mapped the area for the Ontario Geological Survey. The property is underlain predominantly by mafic metavolcanics, commonly pillowed with south facing tops. A narrow unit of felsic metavolcanics is exposed in the south-

western portion of the property. The regional attitude of the units is  $125^{\circ}/70^{\circ}\text{S}$ .

Geochemical (Au, Zn, Cu) and Induced Polarization surveys have outlined three anomalous zones trending at  $125^{\circ}$  across the property. These zones were tested by trenching and diamond drilling. The pattern of trenching consists of a "Main" north-south trench (QTIA), 70 m x 800 m long through claims TB 774250 and TB 774251 and a series of smaller trenches made along strike of the anomalous zones on claims TB 77449 and TB 774255.

Zone A occurs in the main trench near the contact between a quartz-feldspar porphyry and mafic metavolcanics. Near this contact, the porphyry has been deformed and converted into a sericite schist. The mafic volcanics are chlorite schists containing pyrite phenocrysts as much as 3 mm in diameter (10% of the unit). The porphyry contains inclusions of mafic metavolcanics and appears to be intrusive.

Zone B is located in the main trench (approximately the centre of claim TB 774251) and consists of a series of quartz veins in a chlorite schist. Pyrite occurs as porphyroblasts up to 2 mm in size adjacent to the vein and for 10 cm into the schist.

Zone C is a highly deformed zone of chert-pyrite-magnetite ironstone, located at the north of the main trench and in several of the smaller trenches. The ironstone has been intruded by feldspar porphyries (now deformed and silicified). The associated mafic metavolcanics are south facing (pillows stretched 2:1). Values of as great as 0.081 ounce gold per ton across 5 m have been reported for the zone (QUED News Release, February 27, 1984). Drilling encountered a number of anomalous zones (100 ppb), the highest of which returned 1 m of 1,785 ppb gold (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

In trench QT3, approximately 100 m west of the north end of the main trench, visible gold was noted in a folded quartz vein hosted by mafic metavolcanic rocks (J. Dumochel, Geologist, Ore Quest Limited, Vancouver, personal communication, 1985).

#### CHAVIN OF CANADA LIMITED

The property is located approximately 40 km north-east of Marathon, between Dead Otter Lake and Highway 614. The area was mapped by Siragusa (1984) for the Ontario Geological Survey. The eastern part of the property is underlain by mafic metavolcanics which have been intruded by a granitic body centred on Dotted Lake. The granitic rocks on the shore of Dotted Lake, near the end of the access road, consist of 20% quartz, 40% plagioclase,

25% K-feldspar and 20% biotite. They are medium-grained, well foliated ( $170^{\circ}/70^{\circ}\text{W}$ ), and are cut by numerous quartz veins.

The geology of the property is exposed in 2 trenches:

1. Approximately 100 m west of Dotted Lake, south of the access road, a trench 100 m x 20 m x 1 m, exposes a shear zone (amphibole-chlorite schist) cutting amphibolites (mafic volcanics). The amphibole schist is up to 1 m wide, fine-grained, well foliated ( $110^{\circ}/90^{\circ}$ ) with chlorite-rich layers containing as much as 2% pyrrhotite. A white, glassy quartz vein, 20-30 cm wide occurs parallel to foliation within the amphibole schist. Only minor pyrrhotite was noted in the quartz vein. The amphibolite host rock is green in colour, weakly foliated ( $160^{\circ}/70^{\circ}\text{W}$ ) and consists of 60% amphibole and 40% plagioclase with minor epidote pods. Assays of the quartz vein and the amphibolite schist returned less than 0.01 ounce gold per ton (Geoscience Lab, Ontario Ministry of Northern Development and Mines, Toronto).
2. 400 m west of Dotted Lake on the south side of the access road, a trench and stripped area, 900 m x 10 m x 5 m, exposes a shear zone (amphibole-chlorite schist) up to 4 m wide cutting pillowed mafic metavolcanics. The schist contains a number of sugary white quartz veins ranging from 30 to 100 cm in width, which have been partially deformed. The veins contain pyrite, molybdenite, chalcopryrite and chloritic pods. The vein and the schist trend at  $160^{\circ}/70^{\circ}\text{W}$ . A number of narrow (10 cm) feldspar porphyry dykes have intruded the amphibolite schist parallel to foliation. The host rock is a pillowed mafic metavolcanic in which the pillows are stretched 2:1. Alteration of the pillows has produced dark rims, 20 to 40 cm in width, and a bleached core. A Logan-type diabase dyke 2 m wide and trending N-S cuts the amphibolite schist 20 m south of the road. Assays (Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay), of up to 3,000 ppb gold and 1,000 ppm Mo have been reported.

#### KNUT KUHNER OCCURRENCE

The occurrence is located 1 km south of Page Lake (locally referred to as "3/4 Mile Lake"), 10 km northeast of the Marathon Airport on the property of Gowganda Resources Incorporated (see Figure 2). The geology of the property was mapped by Milne (1967). The property is underlain by felsic pyroclastic rocks on the west and mafic metavolcanics on the east. Metasediments, graphitic

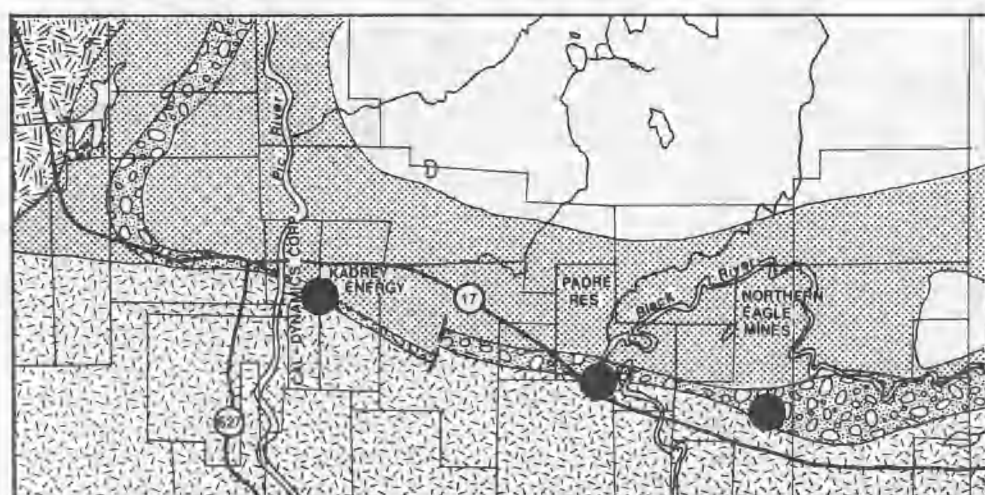


Figure 9. Hemlo area barite occurrences.

#### PROTEROZOIC

Alkalic Intrusive Rocks (Coldwell Complex)

Mafic Volcanics (Pillowed to Massive)

#### ARCHEAN

Monzonite (Gowan Lake Pluton)

Barite Occurrence

Felsic Volcanics (Tuff to Lapilli Tuff)

Metasediments

schists, pelites, cherts, and massive sulphides occur between the felsic and mafic metavolcanic rocks. The results of a lake-bottom-sediment geochemistry sampling program (Geological Survey of Canada, Open File Report 746) show a large copper, lead, zinc, and mercury anomaly, similar to the anomaly at Manitouwadge, centred on Page Lake.

In 1983, drill logs with complete assays from an exploration program by Kerr Addison Mines Limited in 1971 were added to the Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay. The best results were for drillhole KP-71-5 which intersected 18.2 feet of 0.08 ounce gold per ton and 1.16% Zn.

The mineralization encountered occurs as pyrrhotite, sphalerite, and pyrite hosted in felsic metavolcanics. Assays of grab samples returned up to 3,450 ppb gold and 0.73% zinc (Geoscience Laboratories, Ontario Ministry of Northern Development and Mines, Toronto).

Airborne geophysical surveys done by Shell Canada Resources Limited in 1977 showed a number of EM conductors (Resident Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay).

### BARITE OCCURRENCES IN THE HEMLO AREA

A barite-rich horizon has been identified in the Hemlo area by Ore Quest Consultants Limited. The

western end of the horizon is located 10 km east of Marathon (see Figure 9). The baritic unit, which strikes  $095^{\circ}$  and dips  $80^{\circ}\text{S}$ , can be traced by geology and geophysics an additional 6 km east, across properties held by Cal Dynamics Energy Corporation, Kadrey Energy Corporation, Rideau Resources Corporation, Padre Resources Limited, and Northern Eagle Mines Limited.

More recently barite horizons have been reported on the Rideau Resources Limited property (west of Padre Resources Limited), Contact Nexus Resources Limited (east of Northern Eagle Mines), and Silver Standard Limited (east of Kadrey Energy).

On a regional scale, the barite-rich horizon occurs at the contact between mafic pillowed metavolcanics to the south and metasediments and felsic metavolcanics to the north (see Figures 10 and 11). The baritic horizon contains units of massive barite, graphitic schist, green mica schists, carbonate, chert-pyrite, and sericite schist. Geophysically, the horizon is marked by an EM conductor (graphitic schist), Induced Polarization anomalies (pyritic zones), and a break between high magnetics (mafic metavolcanics to the south) and low magnetics (metasediments to the north).

The deposits are being examined by exploration companies both for the relationships between gold and barite in the Hemlo deposit, and for industrial barite potential.

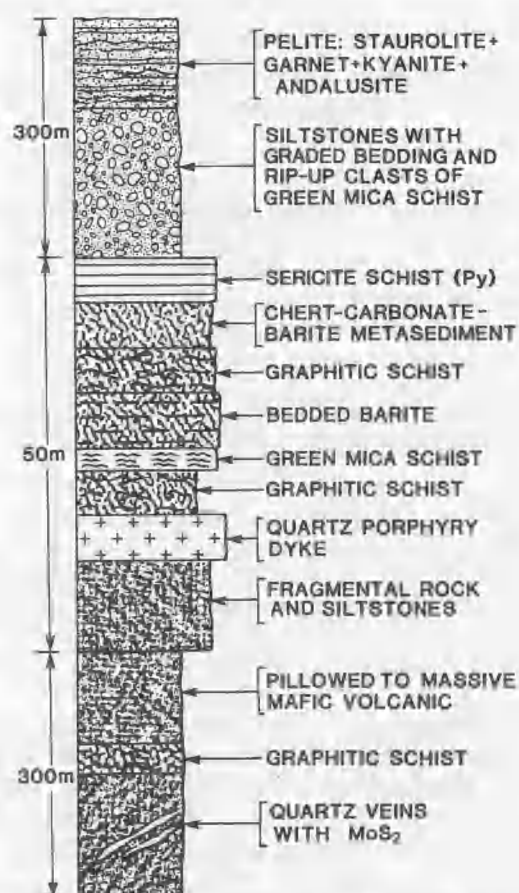


Figure 10. Stratigraphic column for barite occurrences.

### Origin of Barite Deposits

Bedded barite deposits occur in Arkansas, Washington, California, and Nevada (Brobst, 1975). A summary of their geology was reported by Morse (1980):

"The most important commercial deposits are of bedded barite. The principal locations of these deposits are Arkansas, California and Nevada. The barite in these areas is generally dark gray to black and has a characteristic fetid odor when struck with a hammer. The beds, which vary from several inches to over 500 feet thick, occur interbedded with dark chert and siliceous siltstone and shale. In most of the deposits, the barite is laminated. In some areas, barite nodules and rosettes make up a large part of the beds. Many of the beds contain 50 percent to 95 percent barite."

The reader is referred to Shawe et al. (1969) for further details on the Nevada barite occurrences and to Mills (1971) who described the deposits in Arkansas. Deposits of bedded barite have also been reported in the Yukon Territory (Blusson, 1976). These workers suggested a sedimentary origin for the barite, citing as evidence the occurrence of fossils, crossbedding, barite clasts in associated conglomerates, and organic matter in the baritic rocks.

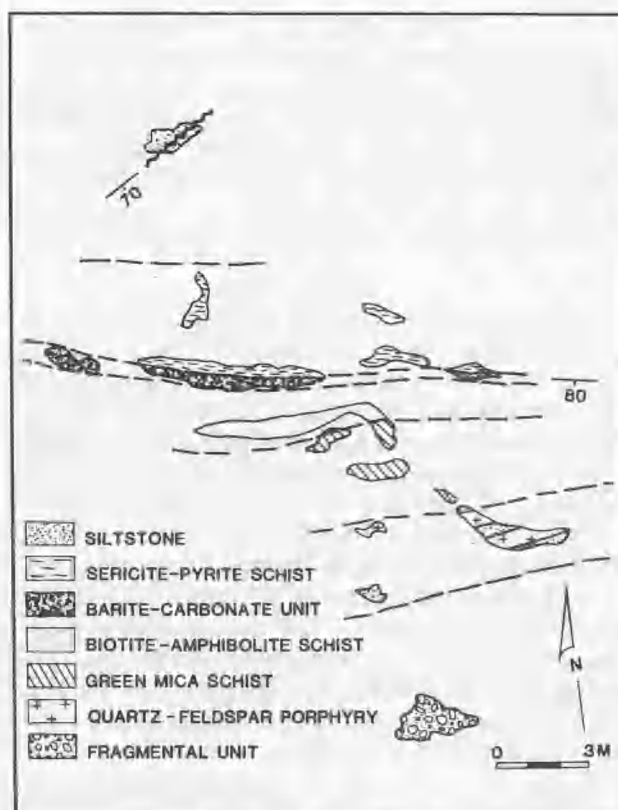


Figure 11. Padre Resources Limited barite occurrence.

A number of other occurrences of bedded barite are also known: in the Archean of Western Australia - the North Pole Deposit (Hickman, 1973); South Africa - Fig Tree Group (Heinrichs and Reimer, 1977); and Zimbabwe-Bulawayan Group (Morrison, 1970). These workers cited similar evidence for a sedimentary origin as did those in the United States, namely primary sedimentary bedding, stratigraphic units that can be traced for several kilometres, and clasts of barite in conglomerates.

Earlier workers in Arkansas (e.g., Scull, 1958) suggested that barite was formed as the result of hydrothermal solutions replacing carbonate. However, most of these occurrences are distal to intrusions that might have been a source of fluids. Barite at Carlin, Nevada occurs in 2 fashions - as enrichments in silicified carbonates, and as veins (Radtke et al., 1980). Barite of both modes of occurrence at Carlin is thought to have formed by replacement of primary carbonate by epithermal solutions.

The barite occurrences at Hemlo appear to be the first Archean occurrences documented in Canada. Barite occurrences south of Timmins, Ontario appear to be Proterozoic in age (I. Cameron, Research Geologist, Geological Survey of Canada, Ottawa, personal communication, 1983) as are occurrences in the Thunder Bay area.

The Ore Quest group of occurrences may be sedimentary in origin: they are finely bedded, inter-fingered with cherts, carbonate, and graphitic schists, and occur in the same stratigraphic position along a strike length of at least 6 km. Rip-up clasts of mica schist, containing a green mica which is associated with the baritic horizon, have been found in siltstones stratigraphically above the baritic horizon.

In comparing the barite at the Goliath deposit to that of the Ore Quest occurrences, there are differences. The most notable difference is the degree of recrystallization in the barite of the Goliath deposit. This has resulted in coarser and occasionally bladed crystals of barite with a whiter colour. Recrystallization has obscured any fine sedimentary textures, which are evident in the Ore Quest occurrences. The general stratigraphy of both occurrences is similar, with the notable absence of crystal tuffs in the Ore Quest occurrences. The presence of a green mica, which appears to be an alteration product, occurs at both locations. The barite in the Goliath deposit tends to be confined to the footwall, adjacent to wider sections of the gold ore zone.

Barite is absent in the Corona East Ore Zone, but massive barite occurs in the deposit on the Page Williams Property. The stratigraphic relations between the Hemlo gold deposit and the Ore Quest barite occurrences is unknown.

Research on the barite deposits is planned by P. Fralick (Lakehead University). Isotopic studies are being done by the Geoscience Laboratories, Ontario Geological Survey, Toronto.

## RESEARCH IN THE HEMLO AREA

In addition to company programs, at the time of writing 23 research projects were being carried out by various Universities, the Federal Government, and the Ontario Provincial Government. These projects can be grouped as follows:

1. Regional Geology: G.M. Siragusa (Ontario Geological Survey) has completed 3 seasons of regional mapping to the east of Muir's (1982a, 1982b) map areas. M. Ferreira (University of Western Ontario) is doing a regional study of the metamorphic petrology.
2. Local Geology: T.L. Muir (Ontario Geological Survey) is continuing detailed mapping from Rous Lake to Highway 614. H. Hugon (University of Toronto) has studied the structural geology in the same area (Hugon, 1984). I. Cameron (Geological Survey of Canada) and K. Hattori (University of Ottawa) have carried out isotope studies on the sulphides and sulphates

of the deposit. D. Harris (Geological Survey of Canada) has studied the ore mineralogy.

Detailed studies of the individual sections of the deposit are also in progress:

(a) Page-Williams Property: R. Barnett (post-graduate, University of Western Ontario) is studying several aspects of the deposit. Three BSc theses have been completed at the University of Western Ontario: P. Neweglowksi - Ore Zone Petrology; K. Powell - Hanging Wall Alteration; and P. Trowell - Gold Distribution in the Williams Deposit.

(b) Teck-Corona deposit: R. Burk (Queen's University) has studied the geology of the deposit.

(c) Golden Giant deposit (Noranda Inc.): R. Kuhns (University of Minnesota) is studying the geology of the deposit. T. Hughes (Carleton University) is studying the metamorphic petrology.

### 3. Exploration Guidelines:

(a) Geochemistry: J.A.C. Fortescue (Ontario Geological Survey) has carried out soil and humic geochemistry studies on the Page-Williams Property. P. Friske (Geological Survey of Canada) is conducting regional lake-bottom-sediment sampling. R. Goad (University of Western Ontario) is investigating regional geochemistry for Noranda Inc.. R. Kristjansson (Ontario Ministry of Natural Resources, Thunder Bay), R. Geddes and G. Jones (Ontario Geological Survey) are carrying out Quaternary geology studies.

(b) Geophysics: P. Sivenas (University of Toronto) is testing an experimental SP (Self-Potential) unit on a number of properties in the area.

## SUMMARY OF EXPLORATION GUIDELINES

### Geological Guides

The Hemlo deposit occurs at the contact between felsic crystal tuffs and metasediments (pelites, calc-silicates, and siltstones) (see Figure 8).

Near the Hemlo deposit, the associated crystal tuffs have been altered to sericite, green mica, tourmaline, and hematite. Similar alteration (sericite and green mica) has been reported from properties on the Heron Bay, Moose Lake and Theresa Lake. The significance of pelites in the area of the deposit is not understood but they may represent alteration products.

## Geophysical Guides

Both VLF and magnetometer methods can be used to trace stratigraphic marker units; the main ore zone did not respond to these methods. Induced Polarization surveys did indicate the presence of the ore zone; however, there are many Induced Polarization responses in the deposit stratigraphy.

## Geochemical Guides

The deposit responds well to both humic gold surveys and "B" soil horizon gold surveys. In humic gold surveys, backgrounds are <14 parts per billion and the anomalies are up to 430 parts per billion (Quartermain et al., 1983). Soil sampling done by R. Newman on the Golden Sceptre Resources Limited property (Resident Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay) indicates anomalies up to 10 ppm associated with the "Fracture Zone" occurrence. Molybdenite in "B" soil horizons also indicates the presence of the deposit.

Further information on geochemical surveys has been presented in the section on "Quaternary Geology - Hemlo Area" by Patterson et al. (1984).

## STOP DESCRIPTIONS - REGIONAL GEOLOGY OF HEMLO AREA (Figure 2)

### ROAD LOG

0.0 km Start - Intersection of Highway 17, Highway 626 (turn-off to Marathon);

6.9 km proceed east along Highway 17 to Highway 627 (turn-off to Heron Bay);

21.4 km turn south then proceed south to Pukaskwa Park checkpoint;

22.0 km take first road west and park in parking lot; take Playter Trail southwest for 500 m to the shore of Lake Superior.

Stop 1 is a large low point just south of the trail.

Note - inside Pukaskwa Park, no hammers please.

### STOP 1: Playter Harbour Group (Muir, 1982a, 1983)

This outcrop is typical of the high-iron tholeiitic basalts of the Playter Harbour Group. A series of south-facing flow units, 10 to 15 m thick, striking at 100° can be identified. These consist of a massive lower unit 5 to 7 m thick and a pillowed top 5 to 8 m thick. The massive unit consists of a basal chill zone, 10 to 15 cm thick, and gradually becomes coarse grained (gabbroic) over a distance of 2 to 3 m. Above this, the massive unit becomes finer

grained and contains irregular and indistinct pillows. The pillows of the overlying unit have chloritic selvages from 5 to 10 cm wide. Variolites are common in the margins of the pillows. Deformation has both flattened (2:1) and lineated (5:1) the pillows.

On the northeast edge of the outcrop, a number of cherty sulfide-rich interflow sedimentary layers, as much as 1 m wide, may be observed. In general, these sediments are highly deformed and intruded by feldspar-porphyry dikes and barren quartz veins.

Proterozoic diabase and lamprophyre dikes also occur in the area.

Excellent exposures of lapilli-tuffs and clastic metasediments can be observed by following the park hiking trail north along the shore of Lake Superior.

23.4 km Return to vehicle; proceed north along park road.

Stop 2 is a large outcrop on both sides of the road.

Note - inside Pukaskwa Park, no hammers please.

### STOP 2: Metasediments of the Heron Bay Group

Exposed on both sides of the highway are highly deformed metasediments typical of the Heron Bay sequence. The metasediments consist of siltstone, commonly with graded bedding and rip-up clasts, and graphitic argillite interbedded with units of tuff or tuffaceous metasediments. Two lineations are evident: 110°/50°W and 118°/20°W. Refolded folds are exposed in the first road-cut north, near the base of a small hill. The fold axis of the secondary folding is 115°/20°W, parallel to one of the lineations.

Drive north along the park road and Highway 627.

Stop 3 is a large outcrop on both sides of the road.

### STOP 3: Felsic Pyroclastic Breccia of the Heron Bay Group

In general, the felsic metavolcanics of the Heron Bay Group consist of coarse pyroclastic breccia that grades into lapilli tuffs and tuff to the east. The felsic pyroclastic breccia at this stop consists of blocks of feldspar-quartz porphyry in a fine grained chloritic matrix with rare blocks of coarse feldspar porphyry and chloritic schist. In general, the blocks range from 15 to 30 cm and volumetrically make up 60 to 80% of the rock. Indistinct bedding is evident on the southwest corner of the outcrop. In cut slabs the blocks are commonly lineated as much as 10:1 with only minor flattening in the plane of foliation.

On the northeast side of the road-cut a narrow shear (110°/80°S), filled with lineated carbonate lenses, cuts the pyroclastics. Coarse pyrite occurs

adjacent to the shear. Similar shears host the Heron Bay Gold Mine vein (200 m west of the Lecour's Store); see section on "Gold Occurrences in the Hemlo Area". A diabase dike, 5 m wide, cuts through the outcrop.

*35.4 km Continue north along Highway 627.*

*Stop 4 is the first outcrop south of the power lines.*

#### **STOP 4: Mafic Metavolcanics of the Heron Bay Group**

Complete south-facing metavolcanic flow units, consisting of hyaloclastite, pillows, and massive units with flow banding, are exposed. The flow units are 9 m thick; flattening of the pillows is at 110°, flow banding at 080°, and lineation of the pillows is at 080°/35°W. Interflow sediments, consisting of sulfide-bearing graphitic schists, are exposed under the first power line tower west of the highway.

*37.2 km Continue north along Highway 627 to Highway 17.*

*40.6 km Stop 5 is 3.4 km west, just west of the power lines.*

#### **STOP 5: Dunlop Cu-Ni-Mo Occurrence**

This occurrence is located within the Coldwell Alkalic Complex. A summary of the exploration history was given by Muir 1982a:

"W.B. Dunlop holds five surveyed claims numbered TB 104118 to TB 104122 inclusive. The claims straddle Highway 17 and are underlain by gabbro and contact-metamorphosed pyroclastic rocks. Interest in the area originated in the early to middle 1950's with the blasting of a rock cut for Highway 17 (Trans-Canada Highway) which revealed gabbro mineralized with chalcopryite and pyrite extending over an area about 61 m by 15 m (Assessment Files Research Office, Ontario Geological Survey, Toronto.)

"Kinnasco Exploration and Mining Limited originally held the ground and in 1955 a preliminary self-potential survey was undertaken along with five exploratory X-ray diamond drill holes. The self potential survey outlined an anomaly 610 m by 38 m (Assessment Files Research Office). Diamond drilling (amount unreported) intersected massive pyrite and chalcopryite in four out of five holes. One intersection assayed 3.5 percent copper over 3 m, and another assayed 1.2 percent copper over 10 m (Assessment Files Research Office). Ten diamond drill holes totalling 1,928 m were subsequently drilled in 1956. Most of the holes intersected medium- to fine-grained gabbro, highly metamorphosed sedimentary rocks, and minor monzonite. Massive and disseminated sulphides consisting mostly of pyrrhotite, pyrite and minor chalcopryite, were intersected in all of the holes (Assessment Files Research Office).

"In 1961, International Nickel Company of Canada Limited restaked the lapsed claims and completed a gravimetric survey over the main showing (Assessment Files Research Office). The claims subsequently lapsed. In 1962, Conwest Exploration Company Limited made a preliminary investigation of the property, and in 1964 sank two diamond drill holes totalling 306 m. The best assays from this core gave nil values for gold, 0.03 ounces silver per ton, and 0.59 percent

copper over 3 m, averaging 0.31 percent copper throughout (data on file at the Assessment Files Research Office, Ontario Geological Survey, Toronto). The claims are currently registered under W.B. Dunlop.

"The gossan zone in the roadcut has undergone considerable weathering since 1956. Flat-lying contact breccia forms the host for the mineralization. Although some mineralized zones reportedly ran 2 percent copper over widths of up to 1.5 m (Assessment Files Research Office, Ontario Geological Survey, Toronto), a grab sample selected by the writer, containing chalcopryite and pyrite, assayed 0.85 percent copper and negligible lead, zinc, and nickel. A few traces of molybdenite were seen during the field examination."

The Coldwell Complex (1,044 b.y. old, Mitchell and Platt, 1982a) consists of 3 centres of intrusion: (1) gabbro, ferroaugite, and syenite - forming the eastern margin of the complex; (2) biotite gabbro, nepheline syenite - Pic Islands and Neys Peninsula; and (3) syenite and quartz syenite - on the north and west side of the complex. At this stop, centre (1) gabbros with abundant inclusions of wallrock cut metasediments, and a breccia occurs along the contact (southwest end of outcrop). The gabbro has been intruded by ferroaugite syenite.

The sulphide assemblage pyrite, chalcopryite, and molybdenite is typical of Coldwell Complex mineralization. It has been suggested that mineralization resulted from assimilation of sulphide-rich wallrocks (Naldrett, 1966).

*42.3 km Continue west on Highway 17.*

*Stop 6 is on the south side of the highway, near the centre of a long low outcrop.*

#### **STOP 6: Layered Gabbros of the Coldwell Complex**

This stop was described by Mitchell and Platt (1982b):

"The gabbros are composed of olivine (Fo 67-43), augite, plagioclase (An 60-35) and minor orthopyroxene (En 55-66). The orthopyroxene may be a product of assimilation of Archean metasedimentary rocks, a xenocryst derived from the pyroxene hornfels thermal aureole or a relict high pressure phase. The gabbro has been extensively prospected for its copper potential as accumulations of pyrrhotite and chalcopryite, with minor pentlandite, cubanite, pyrite, bornite, arsenopyrite and mackinawite (Watkinson et al., 1973; Lum, 1973) are common."

The excursion stop is close to the contact between the gabbro and the ferroaugite syenite. Many pegmatites of ferroaugite syenite cut the gabbro at this locality. The gabbro contains variable amounts of Archean xenoliths. Here the gabbro shows all transitions from massive homogeneous gabbro to rocks with well developed igneous layering. The layers are not traceable over long distances and do not serve to outline the structure of the gabbro intrusion.

*53.8 km Proceed east on Highway 17.*



Figure 12. Rous Lake gravel pit.

54.8 km Stop 7 is 1 km east of the Black River bridge, walk 1 km north along drill road.

#### STOP 7: Northern Eagle Barite Occurrence (Figure 9 and Figure 10)

See under "Barite Occurrences in the Hemlo Area". Permission is required to visit this occurrence.

66.8 km Continue east along Highway 17 to Rous Lake Pit Road; turn north for 1.5 km.

#### STOP 8: Rous Lake Gravel Pit (Figure 12)

The geology of the Rous Lake Borrow Pit (Figure 12) was described by K.G. Fenwick, Mineral Resources Co-ordinator, North Central Region, Ministry of Natural Resources, Thunder Bay (unpublished report; Resident Geologist's Files, Ontario Ministry of Northern Development and Mines, Thunder Bay).

"During the past six years this borrow pit has become famous as the "Galloping Pit near Marathon" (The Times-News (Thunder Bay), June 20, 1973, p. 4). Due to this interest and possible geotechnical problems, the Regional Geologist's Office was requested to research the pit.

"In the mid-fifties, this borrow pit was established to provide sand as a roadbase for the construction of Highway 17 (R.J. MacLean, written communication). An air photograph, taken in 1962, indicated that the pit was 277 m (910 feet) long in the southeast direction, 181 m (595 feet) wide in the east-west direction and approximately 5 m (18 feet) deep (depth measured in the field). The pit, in 1962, was closed in regards to the Black River which is 33 m (100 feet) north of the pit. The next available photograph was in 1971 and a marked change has occurred in the pit. The pit wall, in its north end, has been broken through to the Black River. The pit is now approximately 29 m (95 feet) deep. The table below will emphasize the pit's growth.

|      | East-West Direction |        | Southeast Direction |        |
|------|---------------------|--------|---------------------|--------|
|      | Feet                | Metres | Feet                | Metres |
| 1962 | 595                 | 181    | 910                 | 277    |
| 1971 | 900                 | 274    | 1,150               | 351    |
| 1974 | 1,050               | 320    | 1,250               | 381    |
| 1976 | 1,150               | 351    | 1,290               | 393    |

"The pit, presently, is fairly stable in (its) north and west sides. Therefore, the main growth areas are in the southeast direction and in the northwest canyon.

"Since we do not have any information on when the pit began to move, we can only figure out its horizontal movement in the time period from 1971 to 1976. Therefore, the pit has grown in the east direction at approximately 16 m (50 feet) a year and in the southeast direction at approximately 6 to 10 m (20 to 33 feet) a year. This land movement has engulfed portions of two roads and a considerable amount of tree land."

A field visit of the study area indicated that the top 8 m (25 feet) in the pit is composed of a coarse silt to very fine sand. The interlayered clay and silty fine sand in the lower 21 m (70 feet) forms a cyclic sequence consisting of approximately 23 cm to 182 cm (9 inches to 92 inches) of clay. There were twenty-six clay-sand cycles noted in the pit. George Burwasser (written communication) states:

"The sand unit is deposited in 2 to 5 layers of trough-cross laminated beds each separated by a minute lamination of silt. These are conformably overlain by 1 to 3 platy beds of intercalated very fine sand and clay which are, in turn, overlain conformably by 2 or 3 platy beds of clay containing the classical "light-dark" sequential relationship of varves, including microboudinage features and current stirred inclusions. A sharp erosional contact marks the uppermost clay surface of the cycle.

"Water has been noted flowing from the walls in all corners and sections of the pit. The water flowage from the southeast portion of the pit and the northwest canyon appears to be the fastest and in greater volume than in the rest of the pit. It is believed the Rous Lake, which is 975 m (3,000 feet) to the southeast of the pit, is the main source of water to the southeast canyon. The topographic map of the area indicates that Rous Lake is 900 feet above sea level, the river flowing west out of Rous Lake is 850 feet above sea level and that the Black River is 800 feet above sea level. A small unnamed lake, 1.5 km (1 mile) west of the pit may be contributing water to the northwest canyon. This lake is located between 800 foot and 850 foot contours on the topographic map (Marathon 42 D/9E). It also appears that the rain water, run-off from the spring melt etc., percolates down through the fine sand and then flows along the tops of the impermeable clay layers into the pit from all sides.

"A study of the surficial maps (Boissoneau, 1965; Zol-tai, 1965) indicated that a 6.4 km (4 mile) wide, east and northeast trending lacustrine deposit of varved clay, silt, fine

sand and sand underlies the area. This deposit, which is approximately 80 km (50 miles) long is bisected by the Black River for its entire length. An important point, noted on the surficial maps, is that Rous Lake is the only lake of any major size, located on this lacustrine deposit. Therefore, a major water source is needed, for this problem to occur.

"The water flowing out of the pit and into the Black River is heavily sediment laden. As a result, the walls of the pit are being continuously undercut, as this material flows out. The water west of the entrance to the pit, in the 1974 and 1976 photos, is extremely cloudy in comparison to water to the east of the entrance. A rough calculation indicates that approximately 1.5 million tons of sand, silt and clay has been transported out of the pit by water between 1976 and 1962."

Stop 8 illustrates some of the problems encountered in the area by basal till sampling programs.

*74.8 km Return to Highway 17 and proceed east;*

*76.7 km continue past a microwave tower on south side of highway.*

*Stop 9 is on the north side of highway, just east of a small bush road; the Canadian Pacific Railway tracks are just south of Highway 17 at this point.*

#### **STOP 9: Mile 39 Occurrence**

A shear zone, 5 m wide, occurs at the contact between metasediments to the west and a syenitic intrusion to the east. Within the shear, sericite-chlorite schist contains pyrite and minor chalcopyrite. Grab samples assayed at the Geoscience Laboratories, Ontario Geological Survey, Toronto, returned 0.04, 0.10, <0.01 and <0.01 ounce gold per ton.

This shear (Figure 3, Number 15) may be part of a large fault structure which cuts the felsic metavolcanics that form the footwall rocks of the Hemlo deposit (G. Pierce, project geologist, Noranda Mines Limited, personal communication, 1983).

*77.1 km Stop 10 is on the north side of Highway 17, just north of an abandoned loop of Highway 17.*

#### **STOP 10: Muir Zone or Highway Zone (Figure 7)**

See section on the "Golden Sceptre Resources Limited" property for a description of the occurrence. Walking to the east along the north side of Highway 17, a series of felsic metasediments and calc-silicates cut by feldspar porphyry sills can be observed. At the east end of Finger Lake (referred to as "Cigar Lake" by the Ontario Ministry of Transportation and Communications) the contact between massive mafic metavolcanics to the south and metasediments to the north is exposed. The contact is marked by a 3 m wide zone of chloritic schist (possibly a sheared mafic dike) referred to as the Hemlo

Fault (see Figure 7). The zone can be traced parallel to stratigraphy for 8 km (Bartley and Page, 1958). Locally, feldspar porphyry sills have been intruded into the zone, and have been partially replaced by tourmaline (grab sample returned less than 0.01 ounce gold per ton; Geoscience Laboratories, Ontario Geological Survey, Toronto).

*78.8 km Proceed east along Highway 17 to the St Lambert Drill Road, just east of Moose Lake, Moose Lake,*

*79.4 km north side of Highway 17 - St Lambert Drill Road*

*80.4 km Teck Access Road.*

#### **STOP 11: Hemlo Deposit Stratigraphy (Figure 5 and Figure 7)**

This section is based, in part, on the unpublished field trip guidebook, prepared by R. Quartermain, Teck Corporation (see Section 4 of this guidebook).

*Stop 11A. Outcrop on south side of Highway 17, directly south of Moose Lake.*

#### **STOP 11A: Metasediments**

On the south side of Highway 17, just south of Moose Lake, a roadcut exposes thinly-bedded metasilstones and calc-silicate rocks. These are cut by a diabase dike at the east end of the outcrop. A pyrite-rich unit may be an eastern extension of the Muir Zone (a grab sample returned 0.01 ounce gold per ton; Geoscience Laboratories, Ontario Geological Survey, Toronto).

*Stop 11B. Outcrop 200 m west of St Lambert's Drill Road on north side of Highway 17.*

#### **STOP 11B: Contact Between Metasediments And Felsic Metavolcanics (Figure 13) Lower, Or Lake Superior South, Ore Zone, Now Partly Covered**

At this outcrop, the contact between metasediments, cut by feldspar porphyry sills, and a quartz-eye sericite schist, containing pyrite, minor molybdenite, tourmaline, and green mica, is exposed (see Figure 13). The contact shows a number of tight folds and boudinaged quartz veins. Assays of quartz-eye sericite schist from the lower zone of the Goliath deposit returned 0.32, 0.02 and (5 samples) <0.01 ounce gold per ton (Geoscience Laboratories, Ontario Geological Survey, Toronto). This unit is not ore-bearing to a down-dip distance of 1,000 m (R. Quartermain, project geologist, Teck Corporation, personal communication, 1983).

*Stop 11C. Outcrop just west of the St Lambert's Drill Road on north side of Highway 17.*

### STOP 11C: Porphyry Sills Cutting Metasediments

Two types of porphyry sills cut the metasediments in this outcrop. The first type consists of 40% fine feldspar phenocrysts in a fine grained groundmass. The second type consists of 20% coarse feldspar phenocrysts, commonly with magnetite at the core, in a fine biotite-rich matrix. On the south side of the highway the metasediments contain thin (2–3 cm wide) magnetite-rich bands.

*Stop 11D. Proceed 100 m north along St Lambert's Drill Road; the "A" Zone pit can be viewed to the west.*

### Stop 11D: The Page-Williams Property "A" Zone Pit

*Note – permission to visit this locality must be obtained from Lac Minerals Limited. The original trench is shown in Figure 14 and has now been mined out.*

*Stop 11E is 500 m east of St Lambert's Drill Road on north side of Highway 17.*

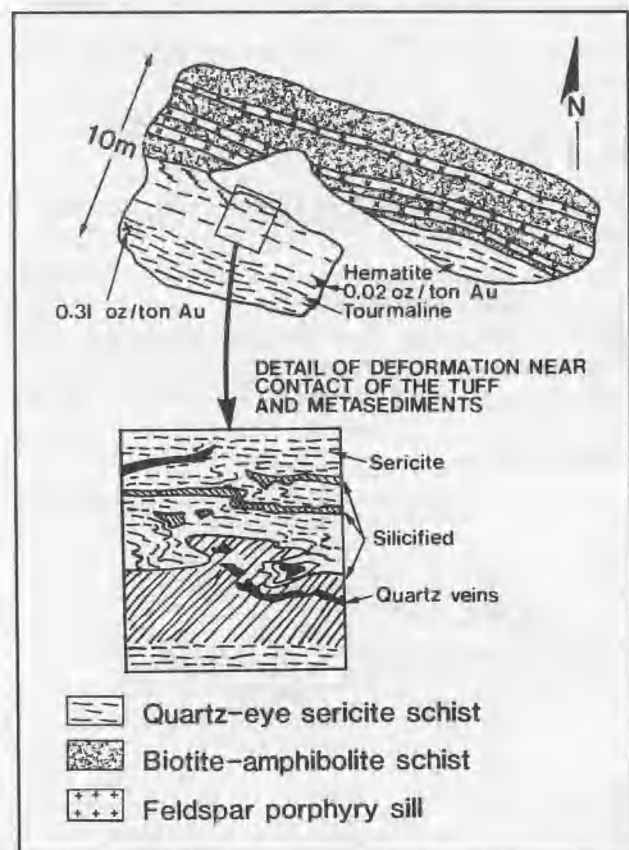


Figure 13. Lower or South Ore Zone – Stop 11B.

### STOP 11E: Footwall Quartz-Sericite Schist (Figure 15, now partly covered)

The outcrop consists of a fine grained quartz-eye sericite schist (tuff) cut by feldspar porphyry sills. The unit thickens to 450 m at a distance of 2 km to the west, and thins to the east. Bedding-like features are defined by variations in the number of quartz eyes. A small-scale fold is also present.

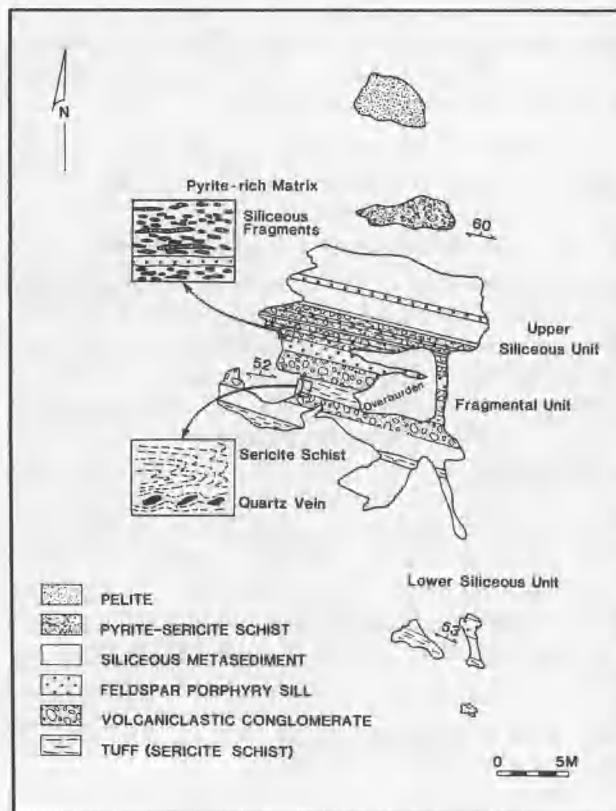


Figure 14. Lac Minerals Limited trench – Stop 11D.

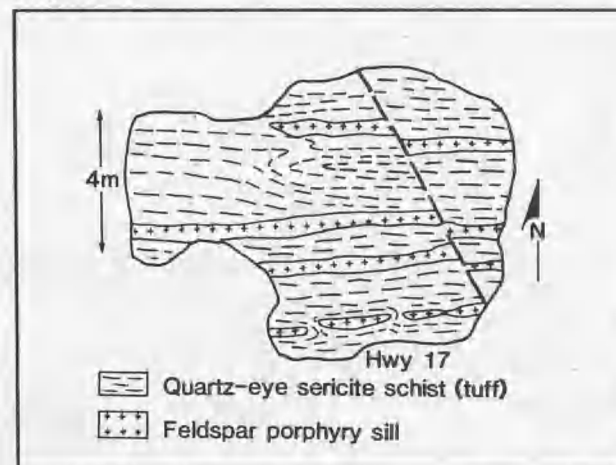


Figure 15. Footwall quartz eye sericite schist – Stop 11E.

Stop 11F is 600 m east of St Lambert's Drill Road on the north side of Highway 17.

#### STOP 11F: Corona West Ore Zone (Figure 16, now partly covered)

This unit consists of a quartz-sericite schist with lapilli-sized siliceous fragments. On the west side of this outcrop, the rock contains molybdenite, pyrite, and green mica. A drill hole near this location assayed 0.1 ounce gold per ton across 20 feet (Resident Geologist's Files, Ontario Ministry of Natural Resources, Thunder Bay). A feldspar porphyry sill cuts the north side of the outcrop.

Stop 11G is on the north side of Highway 17 just before a gentle northward bend in the road.

#### STOP 11G: Volcaniclastic Conglomerate

The northern end of the outcrop is a folded pelitic metasediment, containing staurolite and garnets. The southern end is a mylonitized volcaniclastic conglomerate. The volcaniclastic conglomerate consists of 10 to 20% indistinct and deformed green clasts, in a pink matrix containing 5% quartz-eyes, 10% feldspar crystals, and 85% fine siliceous material. In drill core this unit was found to contain a clast of molybdenite-rich siliceous ore, with visible gold (R. Quartermain, project geologist, Teck Corporation, personal communication, 1983). The diabase dike which separates the Corona East and Corona West Ore Zones is exposed 10 m to the east.

Stop 11H is along the north side of Highway 17, opposite the Cedar Creek Road.

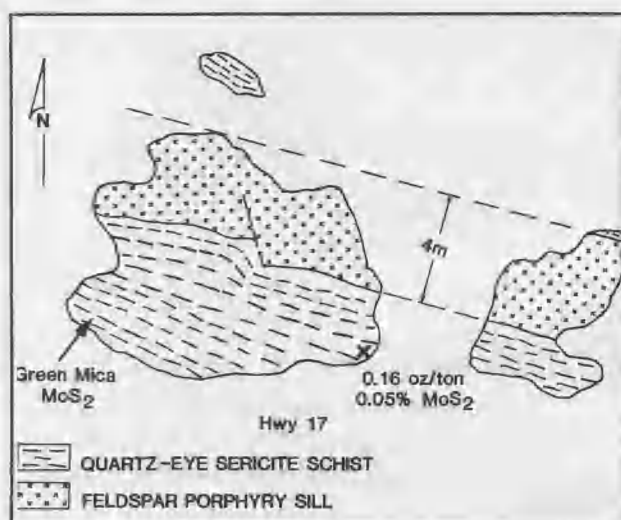


Figure 16. Corona West Ore Zone — Stop 11F.

#### STOP 11H: The Barren Sulphide Zone (Figure 17)

The western part of this outcrop consists of quartz-eye tuff locally referred to as the "Barren Sulphide Zone". Disseminated pyrite and pyrrhotite occur for 5 m on either side of the contact with overlying metasediments. The conductive unit can be traced by VLF EM and serves as a stratigraphic marker horizon. In many places the tuff contains sericite and minor green mica. Deformation is most intense along the contact between tuff and metasediments; the state of strain can be observed in a boudinaged mafic dike. Within the Barren Sulphide Zone, bedding in the tuff is at an angle of 20 to 30° to the metamorphic foliation, and sulphides occur within the plane of foliation. Grab samples returned assays of 0.51, 0.02, and (5 samples) <0.01 ounce gold per ton (Geoscience Lab, Ontario Ministry of Natural Resources, Toronto).

The eastern part of the outcrop consists of folded and boudinaged, calc-silicate and pelite beds in metasiltstone (see Figure 17). The pelite contains garnet, staurolite, sillimanite, cordierite, and anthophyllite. The calc-silicate rock consists of calcium-rich amphibole, commonly on the margins of boudins and layers, and calcium-rich plagioclase.

Stop 11I is about 200 m east on north side of Highway 17, just west of the guard post.

Stop 11J is the first outcrop on the north side, east of the last stop (11I).

#### STOP 11I and 11J: The Upper Volcaniclastic Unit

This unit consists of deformed clasts of quartz-feldspar porphyry and chlorite schist. Bedding is defined by the percentages of clasts within the beds. Cut slabs show the clasts to be flattened in the plane of foliation by 3:1 and extended parallel to lineation as much as 10:1. Lineation is parallel to the axis of minor folds at a trend of 070°E.

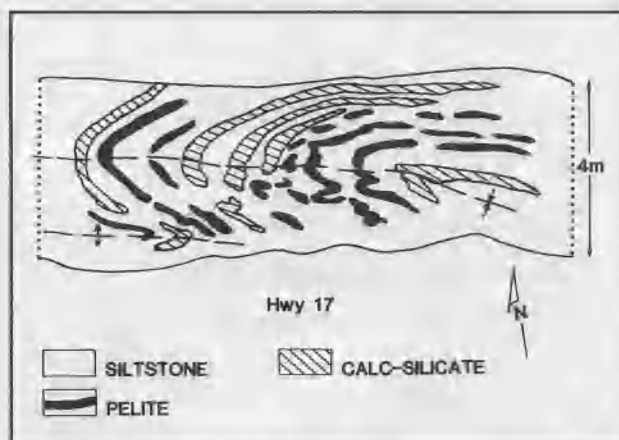


Figure 17. Pelitic calc-silicate metasediments — Stop 11H.

Stop 11K is the first outcrop west of Cedar Creek.

### Stop 11K: Folded Metasiltstones

A unit of thickly-bedded metasiltstone forms a re-clined antiformal syncline plunging to the east. The fold is best observed on the south side of Highway 17. Note that the metasiltstones display both foliation and bedding. Foliation is consistent at 120°/50°N and the bedding defines the synformal fold. Rip-up clasts within the metasiltstone have been rotated into the foliation plane. A feldspar porphyry dike, which has been boudinaged, occurs near the nose of the fold, and a metamorphosed gabbro dike cuts the metasediments near the north-east end of the roadcut.

81.8 km Stop 12. Proceed east along Highway 17 to the Golden Giant Mine Access Road – Stop 12 is just to the east.

### STOP 12: Contact Between Metasediments and the Cedar Lake Pluton

Just to the east of the Golden Giant Mine Access Road the contact between the Cedar Lake Pluton and metasediments is exposed. Hornblende-biotite granodiorite has intruded the metasediments parallel to foliation as a series of dikes extending over a distance of 500 m. A quartz vein, 10 to 20 cm wide, containing molybdenite and pyrite, is located on the north side of the outcrop. Some of the joint surfaces in the metasediments are coated with fluorite. Joint surfaces in the granodiorite contain epidote and bluish chlorite.

### ACKNOWLEDGEMENTS

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## 2 — Golden Giant Joint Venture Properties

by Noranda Exploration Company, Toronto Office and Hemlo Field Office Staff

### INTRODUCTION

This review of the regional and detailed geological setting of the Golden Giant gold deposit is based on the results of diamond drilling and geological observations during the past 3 years.

The Golden Giant Joint Venture key land holdings at Hemlo include a group of 156 claims comprising the Golden Sceptre and Goliath Gold Properties. The Goliath Property hosts the main orebody, and the Golden Sceptre Property may represent an extension of the same stratigraphic sequence along strike. Joint ventures with Brigade and Interlake complete the Golden Giant Joint Venture's claim holdings in the mine area.

The Golden Giant deposit is essentially a portion of a single larger deposit segmented by property boundaries with current reserves, including the Quarter Claim, estimated to be 19.1 million tonnes averaging 10.1 g/t Au.

### GENERAL GEOLOGY

The host rocks for the Hemlo gold deposit belong to the Heron Bay metavolcanic belt (termed the Hemlo belt by some authors), situated within the Archean Abitibi-Wawa-Shebandowan Subprovince. This Subprovince forms the southern margin of the Superior Province of the Canadian Shield that also hosts the gold deposits of Timmins, Val d'Or, and Kirkland Lake.

The Heron Bay belt comprises a steeply-dipping volcanic-sedimentary succession from 8 to 20 km wide and striking east-west for a length of 40 km. This belt of rocks is flanked to the north, east and south by granite-gneiss terrains of the Gowan Lake, White Lake and Pukaskwa Gneissic Complexes. The Proterozoic Port Coldwell Syenite intrusive complex truncates the volcanic belt on the north-west, but toward the southwest the volcanic rocks are known to extend under Lake Superior.

In the vicinity of Hemlo the rocks of the Heron Bay belt have been metamorphosed to amphibolite facies. Gradational contacts are found with the adjacent gneissic terrains.

There were two phases of felsic plutonism. The earlier recognized includes a swarm of concordant porphyry sills that intruded the felsic volcanic rocks in the vicinity of the deposit and may be synvolcanic. The later are post-tectonic granitic stocks and batholiths which intruded the core of the syncline. One of the smallest of these is the Cedar

Creek Stock that outcrops 800 m north of the Golden Giant deposit. Younger Proterozoic diabase dikes that trend northerly cross-cut all the lithologies.

The Heron Bay belt is believed to be a large synclinal structure made up of mafic and felsic volcanic suites. These rocks are overlain by felsic volcanoclastic rocks and calcareous sediments which contain the known mineralization of the gold ore zone and are considered to represent a transitional facies between the lower volcanic suite and an upper, thick metasedimentary core. They occur principally on the south limb of the syncline.

The synclinal structure is less clearly defined towards the west and Lake Superior. As the sedimentary basin pinches out westward, a volcanic succession predominates. In plan the belt may be subdivided laterally into an eastern sedimentary domain and a western volcanic domain.

The axis of the syncline partly coincides with a major northeast-trending fault zone, the Heron-Black River shear. A number of subsidiary fault systems appear to be related to this main shear-fault. It is truncated a short distance northeast of the ore deposit by the Cedar Creek Pluton.

Golden Giant properties cover a nearly complete stratigraphic cross-section from the lower basal volcanic member of the succession upwards to the upper sedimentary strata. Figure 18 shows a preliminary generalized stratigraphic column for the syncline in the Joint Venture area. A number of the key aspects of these enclosing rocks to the Hemlo deposit will be examined during the field excursion on the Golden Giant Joint Venture properties.

### STOP DESCRIPTIONS — GOLDEN GIANT

The aim of the Noranda portion of the tour is to examine various stratigraphic sections that are accessible. It should be noted that the Deposit No. 1 ore zone occurs from a depth of -275 to -1075 m on the Goliath claims property, however along strike comparable sections can be observed on the Golden Sceptre claims located 4 km west of the deposit area. The field stops (Figures 19a, b) selected for the tour demonstrate the various units that occur westward from the main deposit.

#### STOP 1: Cache Lake Formation — Canadian Pacific Railway west of Rule Lake

The Canadian Pacific Railway, just west of Rule Lake (called Cigar Lake by the Department of

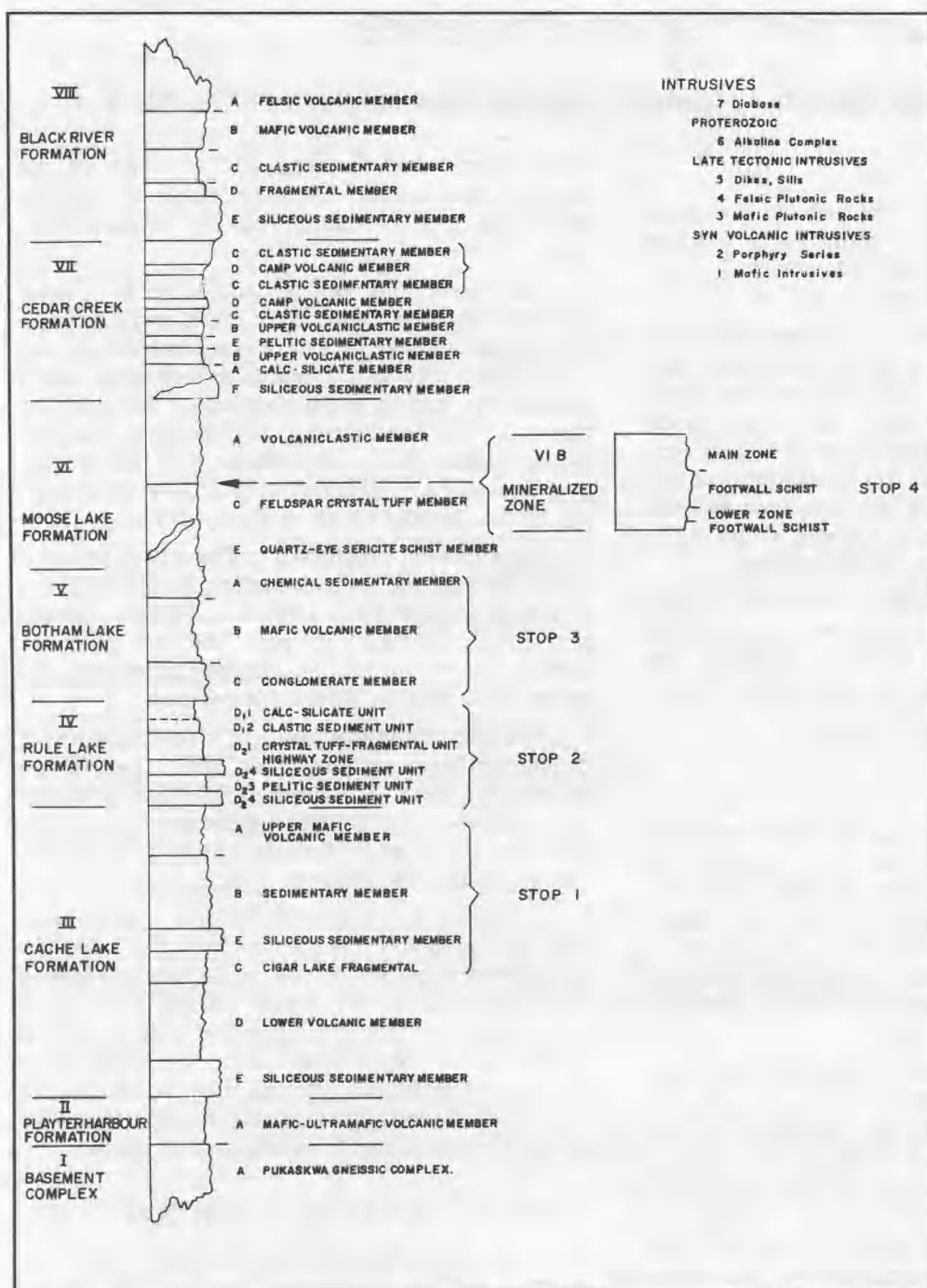


Figure 18.  
Preliminary composite  
stratigraphic column.  
Golden Giant Area.

Highways) near the turn-off to Botham Lake, provides a good cross-section of the upper portion of the Cache Lake Formation.

Proceeding southwest along the tracks, one first encounters amphibole-feldspar gneisses of the Upper Volcanic Member (mafic volcanics). These rocks are underlain by well-bedded quartzofeldspathic metasediments of the Clastic Sedimentary Member (Figure 18). Further along the railroad track is an exposure of garnetiferous schist, belonging to the Pelitic Unit of the Clastic Sedimentary Member. A feldspar porphyry sill 5-10 metre

wide occurs at the extreme western portion of the outcrop.

Near Cigar Lake the railway track bends and runs east-west parallel to the regional strike. The track follows the assumed fault contact between the Clastic Sedimentary Member and the underlying Cigar (Rule) Lake Fragmental. An outcrop at the bend in the tracks consists of coarsely interlayered fragmentals and well-laminated clastic sediments. The fragmental horizons consist of highly stretched intermediate to felsic fragments, with ratios of 10:1 common, within a fine-grained intermediate matrix.

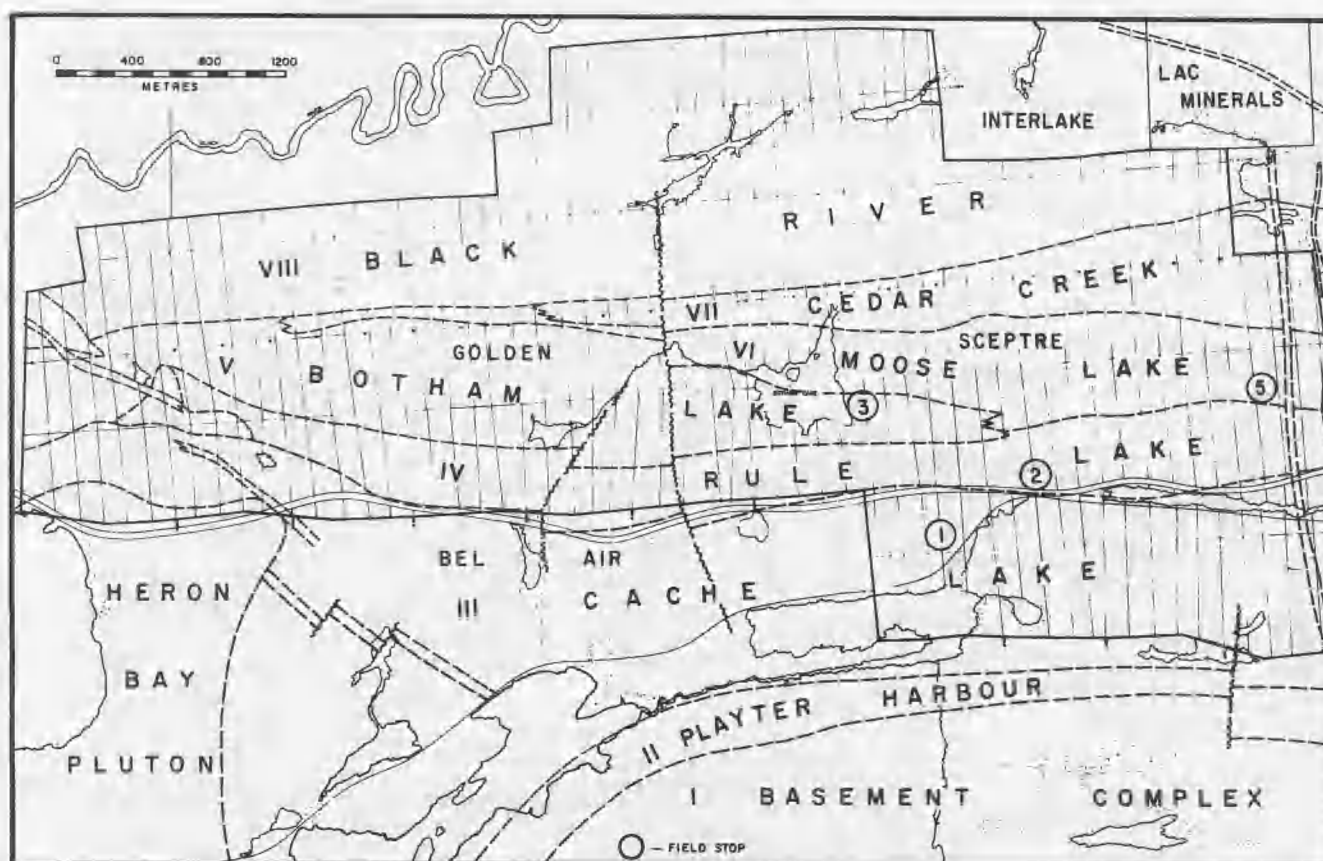


Figure 19a. Field stops on Goliath and Golden Sceptre properties (west half).

A better exposure of the Cigar (Rule) Lake Fragmental is found on the south side of the tracks approximately 100 m further to the west.

#### **STOP 2: Rule Lake Formation – Trans-Canada Highway, near Rule Lake (Stop 9 in Patterson)**

Returning to the Trans-Canada Highway from the section through the Cache Lake Formation and facing north, one sees, on the left hand side, an intrusive contact between a "syenitic" feldspar porphyry and altered clastic metasediments of the Rule Lake Formation. The porphyry is believed to be associated with a major north-west trending fault known as the Botham Lake Shear Zone. The porphyry is highly hematized and epidote-filled fractures are common.

To the right, towards Cigar (Rule) Lake, is an extensive area of outcrop representing the lower portion of the Rule Lake Formation, including a mineralized felsic fragmental unit known as the Highway Zone. Feldspar porphyry sills are conspicuous within this portion of the formation and occur in swarms, with individual sills being generally less than 0.5 m in thickness.

Further east along the exposure, opposite Rule Lake, one can observe the contact between the Rule Lake and Cache Lake Formations.

#### **STOP 3: Botham Lake, Moose Lake Formations – Botham Lake Road**

To the west of the outcrop of the "syenitic" feldspar porphyry is a four-wheel-drive dirt road which leads to Botham Lake. The road is within a valley which marks the trace of the Botham Lake Shear Zone mentioned in Stop 2. Several small outcrops of feldspar porphyry are exposed along the road.

Approximately 200 m south of Botham Lake is an outcrop of the Conglomerate Member of the Botham Lake Formation. The outcrop contains moderately coarse intermediate fragments, up to 40 cm in length, within a hornblende-rich mafic matrix.

Along the south shore of the lake are well-developed pillowed basalts of the Mafic Volcanic Member of the Botham Lake.

A tractor trail follows the east shore of Botham Lake to the Hydro Transmission Line just north of the lake. Along the road are exposed mafic frag-

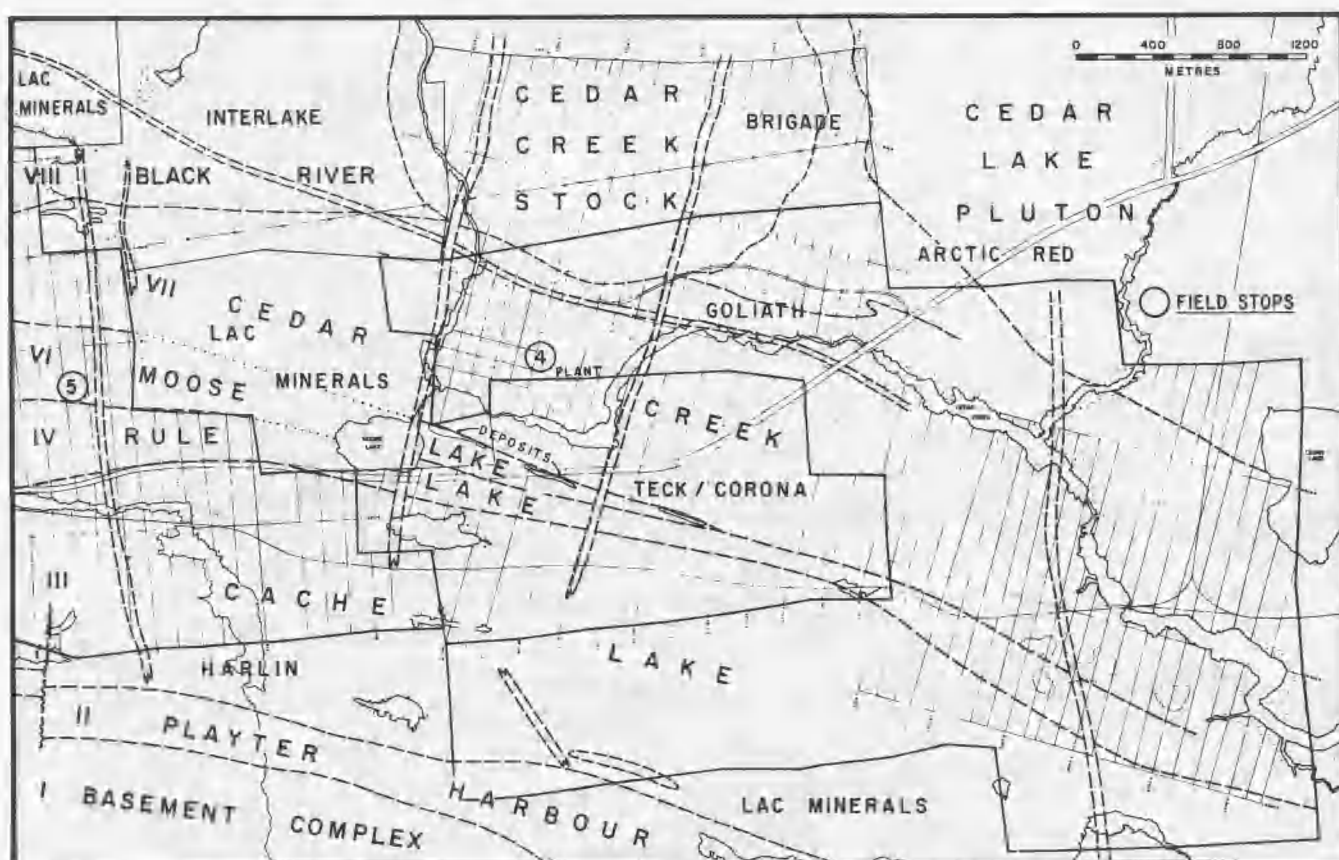


Figure 19b. Field stops on Goliath and Golden Sceptre properties (east half).

mentals, intrusions, and garnetiferous pillowed basalts of the Mafic Volcanic Member.

On a point of land halfway along the eastern shore of Botham Lake, is a large outcrop of the Feldspar Crystal Tuff Member of the Moose Lake Formation. The exposure consists of a broadly interbedded sequence of feldspar crystal tuff and coarser felsic fragmental rocks. This unit, approximately 4 km to the east, hosts the Au-Mo-Ba mineralization and associated alteration of the Golden Giant Joint Venture Deposit No. 1.

To the north of the quartz-feldspar porphyry is the Sceptre Volcanic Member of the Moose Lake Formation. The volcanoclastic fragments are generally not as coarse and a greater sedimentary component is present than in the more typical sections on the eastern portion of the Golden Sceptre claim block.

#### STOP 4: Plant Site and Golden Giant Shaft Dump

This stop allows for a brief view of the mine and mill site.

Rock samples from the shaft muck have been set aside for visitors of the tour. They are from the

Moose Lake Formation which hosts the ore and are from a depth of approximately 620 m.

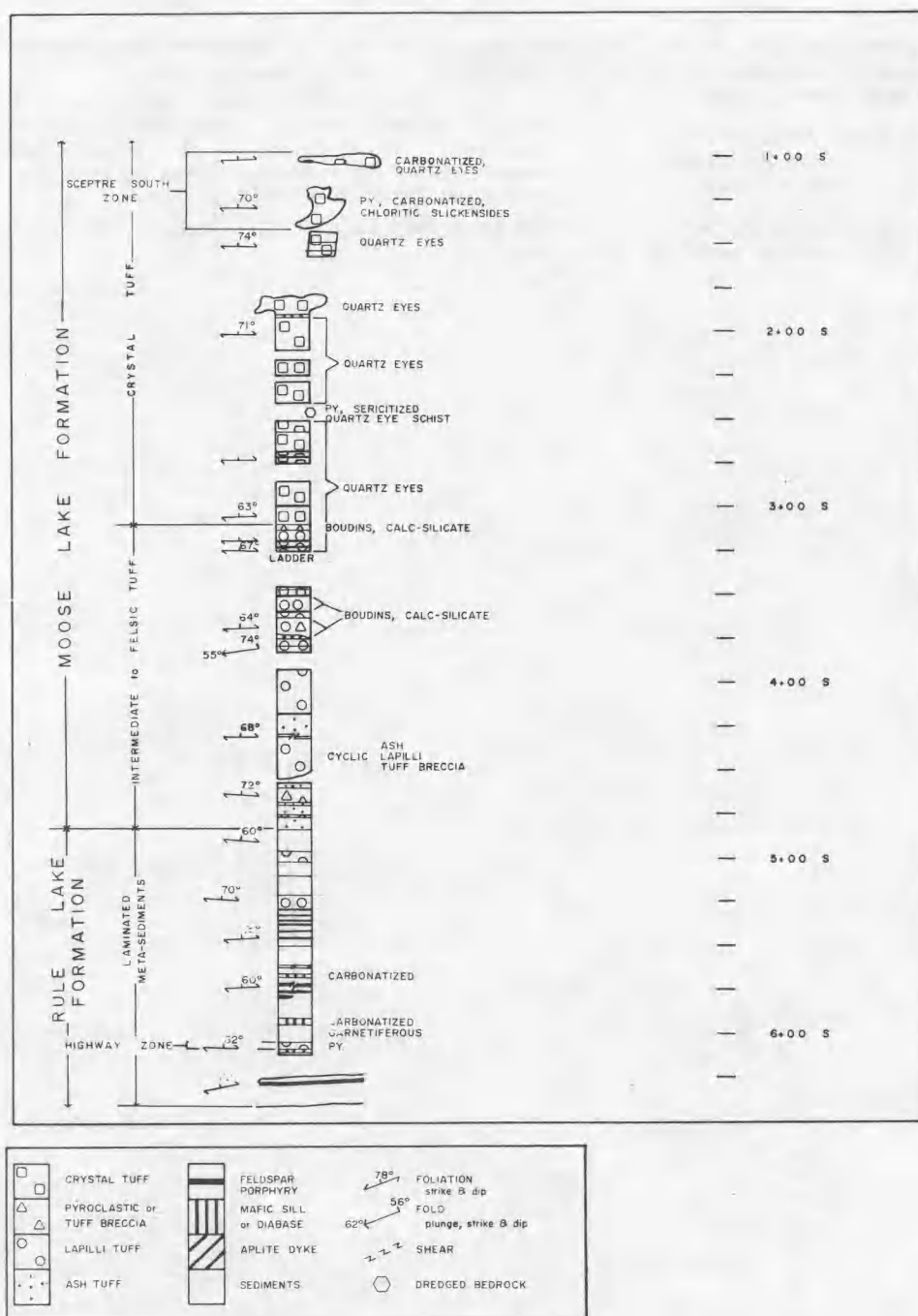
#### STOP 5: Golden Sceptre Trench (Line 4W)

The trench, located 120 m west of the Golden Sceptre/Williams Claim boundary, provides a stratigraphic section (Figure 20) across the lower two-thirds of the Moose Lake Formation felsic pyroclastic rocks. Altered stratigraphic equivalents of these rocks host the Hemlo Au-Mo-Ba deposit, some 2 km to the east.

In summary, from south to north, the trench exposes well-bedded clastic sediments of the footwall Rule Lake Formation (quartz-feldspar-biotite schist), a transition zone from clastic sediments to felsic pyroclastic rocks through interlayering, and massive to poorly bedded fine to coarse felsic pyroclastic rocks (tuff, lapilli tuff, minor-tuff breccia). The entire sequence has been intruded by sills and dikes of feldspar porphyry, aplite and several types of mafic intrusions.

Sedimentary units are generally well-bedded and locally exhibit grading and cross-stratification. A narrow, pyritic felsic lapilli tuff horizon is exposed at the south end of the trench, within the footwall Rule Lake Formation sediments. This horizon has been termed the "Highway Zone" by virtue of its

Figure 20.  
Geology Golden  
Sceptre trench  
Line 4 + 00 West.



very local and erratic Au mineralization. Thin layers of calc-silicate rock occur throughout the sedimentary and pyroclastic sequences.

Pyroclastic units are massive to poorly bedded and, where coarse enough, obviously fragmental. The finer pyroclastic lithologies and the matrix to coarse pyroclastic units are consistently feldspar porphyritic and increasingly quartz porphyritic towards the north. The north end of the trench encroaches on the "South Zone", a broad area of erratic Au-Mo mineralization that does not appear to

be stratabound. The "North Zone", a stratabound zone of siliceous tuffs carrying Au and Mo, occurs approximately 200 m to the north.

#### ACKNOWLEDGEMENTS

This paper is reproduced in part from Paper 7 of the CIM Geology Division guidebook (Noranda Exploration Company, 1984) by permission of the Canadian Institute of Mining and Metallurgy. It was critically re-reviewed by R.I. Thorpe, Geological Survey of Canada.

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### 3 — Golden Giant Mine Geology

by P. Brown, R. Friesen, P. Kennedy, R. Kusins and K. McNena

## INTRODUCTION

In a little more than two years from the time Noranda Inc. signed an agreement to explore and develop the Golden Giant Mine, the first development blast in ore took place in December, 1984. Prior to then, Noranda Exploration Co. Ltd. had completed 82,635 m of diamond drilling, comprising 109 holes at a cost of \$10,588,326. This resulted in a "drill indicated" ore reserve of 19.1 million tonnes grading 10.11 g/t gold and 0.1% molybdenite. Simultaneously, construction of the surface buildings and shaft sinking had also started.

Since that initial blast, development of the first and second stoping blocks from 4,900 Level to 5,000 Level, and 4,750 Level to 4,875 Level is well underway. Mine-related geological responsibilities are now handled by Hemlo Division mine geologists.

As of December 31, 1985, 324,853 tonnes of ore have been processed from blasthole development and stoping. This ore has yielded 3,040 accountable kilograms of gold (97,741 oz). Average grade for the year was 11.00 g/t.

Underground diamond drilling is underway in order to more accurately locate and delineate the orebody for development and ore reserve calculation purposes.

Average monthly drilling is about 1,000 - 1,500 m. It has been found that in the upper portions of the mine currently being developed, there is close correlation of the original surface and underground drilling with respect to ore location, grade, and thickness. Earlier suspicions of unusually uniform grade distribution have thus been confirmed. Consequently, initial ore delineation is taking place on a 25 m grid both along strike and down dip.

As for stope development, it has so far been fairly easy to visually distinguish the hangingwall and footwall ore-waste contacts, although verification is made by routine chip and muck sampling. Being able to visually determine ore from waste has proven to be a big advantage considering the accelerated pace of, and priority given to stope development.

The following is a brief geological description of the Golden Giant orebody.

## MINE GEOLOGY

### Stratigraphy (Figure 21)

The stratigraphy in the mine area is dominated by east-trending, north-dipping members of the Moose Lake and Cedar Creek formations. Two stratabound zones of mineralization have been outlined within the Moose Lake Formation along its lower and upper contacts.

### Moose Lake Formation

To date, very little underground development outside of ore has occurred within the Moose Lake formation. Therefore, the majority of observations about this formation are from surface and underground drilling. This formation is subdivided into

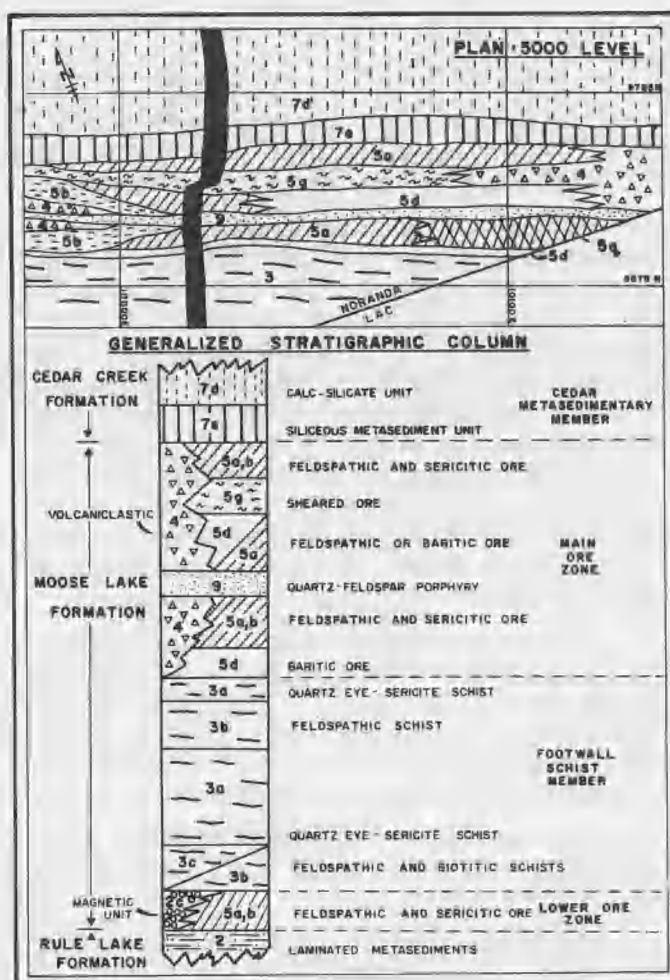


Figure 21. Generalized plan of 5000 level and schematic stratigraphic column.

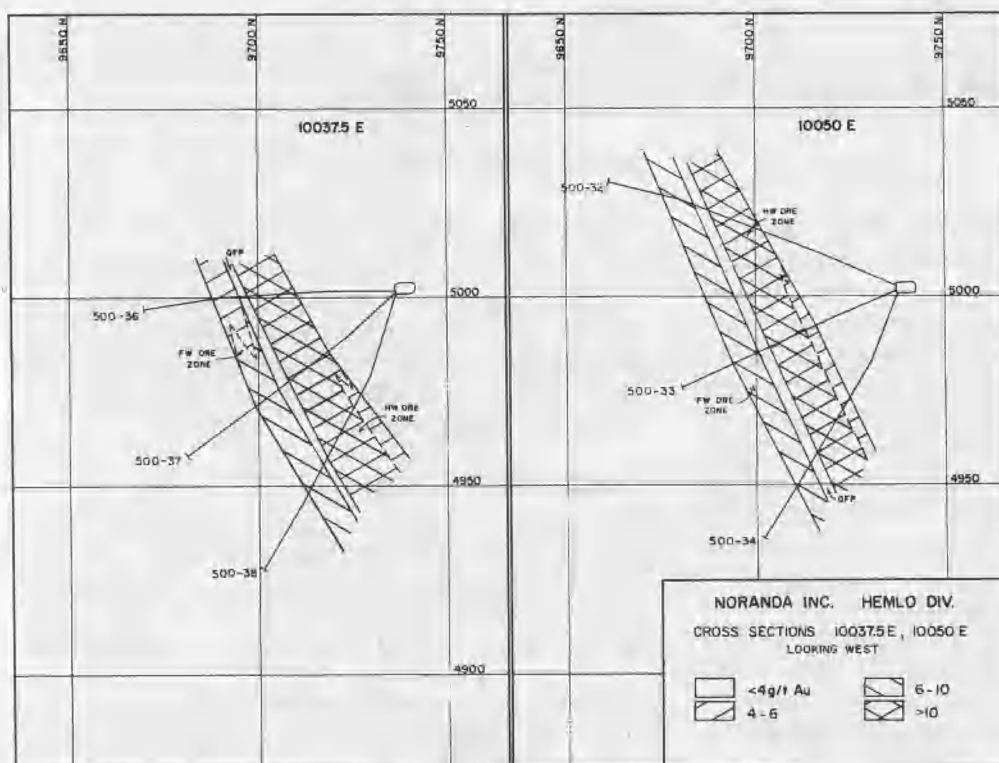


Figure 22. Grade contours by section.

four members which from south to north are: (1) Lower Mineralized Zone, (2) Footwall Schist, (3) Lower Volcaniclastic member, (4) Main Ore Zone.

The Lower Mineralized Zone often marks the contact between the Rule Lake and Moose Lake formations in the deposit area. This lower zone has ore types similar to those of the Main Ore Zone, discussed in greater detail in the next section. The Footwall Schist Member, which typically structurally overlies the lower zone, comprises quartz-eye, feldspathic and biotitic schists. The quartz-eye schist, which dominates this member in the mine area, is a quartz-sericite schist that contains distinctive quartz grains or eyes. Common accessory minerals within this schist are rutile, tourmaline, green mica, and pyrite.

The feldspathic schist is massive to weakly schistose and largely consists of feldspar and quartz with lesser sericite. This unit is in many cases weakly porphyritic in texture and contains highly altered feldspar crystals. Locally the unit is hematized and/or potassium-rich and is then pink to red in colour.

The biotitic schist is comprised of sericite schist and biotite-rich bands and may represent an altered sediment.

The Lower Volcaniclastic Member structurally overlies the Footwall Schist Member. This member, along with the stratigraphically coincident Main Ore Zone, forms the upper part of the Moose Lake formation. This volcaniclastic member is character-

ized by fragmental rocks containing both feldspar porphyry and grey microcrystalline felsic fragments, and is weakly mineralized with 2% pyrite, minor molybdenite, and anomalous gold values in the 1 – 2 g/t range. It has been subdivided into fine, coarse and sericitized fragmental rocks. At some localities the sericitized fragmental rock contains very colourful green mica.

The Main Ore Zone occurs within the Moose Lake formation, along its contact with the Cedar Creek formation. This stratabound zone of pyrite, barite, molybdenite and gold mineralization averages 22 m in thickness. The ore zone has a complex relationship with the Lower Volcaniclastic Member which may overlie, underlie, or bisect this horizon.

#### Cedar Creek Formation

The Metasedimentary Member of the Cedar Creek Formation structurally forms the immediate hangingwall of the deposit and is comprised of four main rock units in the immediate vicinity of the ore. These units are: (1) sericitic, (2) siliceous, (3) pelitic, and (4) calc-silicate. The contacts between the various rock types are often gradational and are thought to reflect decreasing alteration away from the ore zone. The immediate hangingwall rocks of the deposit are siliceous and sericitic units that have a combined thickness of 5–10 m and typically contain 3% pyrite and minor pyrrhotite, arsenopyrite, realgar and stibnite.

The siliceous unit grades into the calc-silicate member, which locally contains thin pelitic laminae. These pelitic laminae are rich in staurolite, kyanite and garnet.

### Intrusions

Feldspar porphyry bodies, mafic sills, diabase dykes and minor quartz veins are common intrusions in the vicinity of the deposit. Feldspar porphyry sills range in thickness from a few centimeters to more than 3 m and are particularly abundant within the ore zone and the feldspathic schist of the Footwall Schist Member. Northerly trending diabase dykes are common in the mine and cut all rock units including the ore zone. Quartz veins and pods occur as erratic patches, often displaying a boudinage structure, within the ore zone and the siliceous and sericitic units of the immediate hangingwall sequence. In places these quartz pods contain abundant realgar and stibnite.

### MINERALIZED ZONES

The Main Ore Zone of the Golden Giant Mine strikes at an azimuth of  $115^\circ$  and dips north at  $60-70^\circ$  along a defined strike length of 100-650 m (Figure 23). It extends eastward onto the Teck-Corona property and westward onto the Lac Minerals property. The deposit is also open at depth to the northwest below a depth of 1,000 m. It ranges in thickness from 3-40 m and is characterized by tabular sheet-like regularity.

A second zone, the Lower Mineralized Zone is 2-5 m thick and is located 40-80 m stratigraphically below the main orebody. Limited surface diamond drill data showed a number of narrow erratic ore-grade values within this lower zone. Further underground diamond drill exploration is planned.

Both mineralized zones contain a diverse mineralogical suite which is dominated by quartz, feldspar, sericite, pyrite, barite, molybdenite, and vanadium-rich muscovite. Common accessory minerals include realgar, stibnite, cinnabar, and arsenopyrite. Molybdenite is the best visual indicator for the presence of gold. Pyrite content does not show a marked correlation with gold, and therefore cannot be relied upon to accurately determine ore/waste contacts. Gold occurs principally as microscopic grains of native gold along silicate grain boundaries. However, occasional visible native gold occurs either within quartz pods or along fractures, indicating some remobilization has taken place.

Based on mineralogical associations, the wide variety of ore types within the Main Ore Zone can be placed into three main classes: (1) feldspathic 5a, (2) sericitic 5b, and (3) baritic 5d. The blue-grey, highly competent feldspathic ore typically con-

tains 3-10% pyrite, 0.1% molybdenite, and gold values in the 10-15 g/t range. It varies texturally from massive to layered to fragmental, and may also be sheared (5g). On the 5,000 Level (Figure 21), the feldspathic ore is more siliceous towards the east and contains a number of disrupted quartz veins (5g). Gold values tend to be high within the more siliceous and sheared sections of the feldspathic ore, with values in the 15 - 20 g/t range.

The sericitic ore is typically lower grade than the siliceous ore, with values of about 6 g/t Au. In this ore type, pyrite and molybdenite define discrete layers within the sericite schist. Sericitic ore is commonly found at the extremities of the deposit.

Baritic ore contains 20 - 50% barite, 10% pyrite, and trace to 0.1% molybdenite. Molybdenite is usually restricted to the quartz-rich portions of the baritic ore. In places this ore type takes on a "fragmental" appearance with molybdenite-bearing quartz and feldspar grains contained within a baritic matrix. Baritic ore is generally low grade, with assays commonly 6 g/t Au.

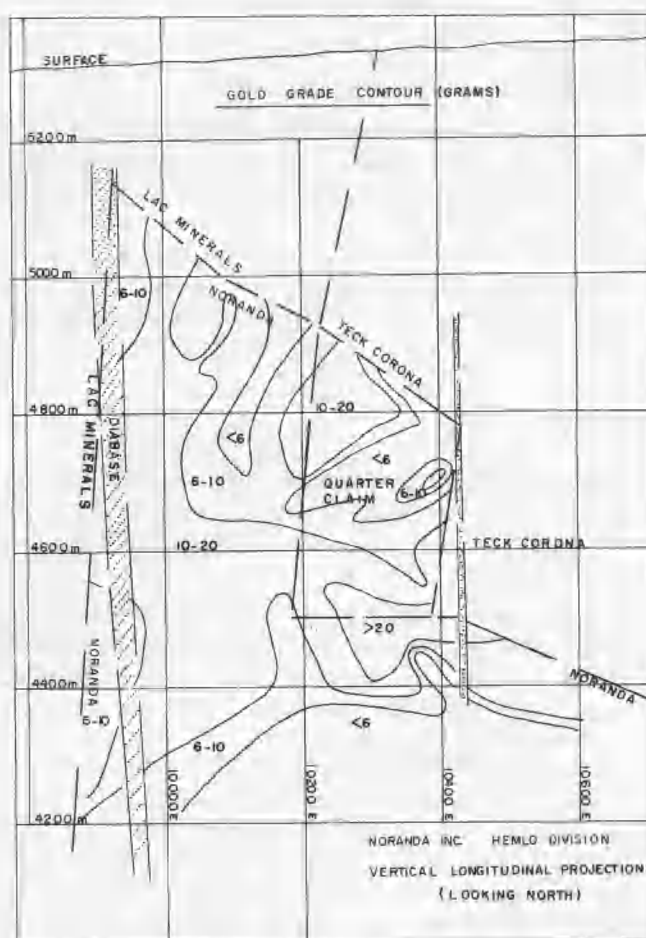


Figure 23. Contoured gold values (grams).

The Main Ore Zone has been divided into footwall, waste, and hangingwall zones for mining purposes. In general, the footwall zone tends to be more baritic and somewhat lower grade than the hangingwall zone. The central waste zone is comprised of a number of rock types dependent on location within the deposit. Rock types commonly forming this zone are quartz-feldspar porphyry (QFP), mafic fragmental rock and very low grade sericitic ore. The hangingwall ore is typically feldspathic in nature and relatively high grade.

## ORE RESERVES AND GRADE DISTRIBUTION

Ore reserves for the Golden Giant orebody (not including the lower mineralized zone), as determined from surface diamond drill exploration, amount to 19.1 million tonnes grading 10.11 g/t Au, 0.1% Mo, and 1.5 g/t Ag. The basic parameters used in determining these reserves were:

1. cut off grade: 2.7 g/t Au;
2. cutting formula: All Au assays cut to 34.29 g/t Au (1 oz/short ton);
3. minimum mining width: 3.0 m;
4. diabase dikes included in reserves.

Although the Main Orebody exhibits unusually consistent gold values overall, preliminary assay data from 5,000 Level indicates that distinct zones can be delineated by grade within the orebody (Figure 22). Further data along strike and from lower levels may provide useful information regarding structural aspects of the orebody, e.g., shears, off-sets, plunge, etc.

## STRUCTURE

Structural features observed to date at the Golden Giant Mine have centred mainly on the 5,000 Level development, and, as such, represent only a small portion of the orebody.

The east-striking, north-dipping horizon and immediate hangingwall and footwall zones on the 5,000 Level exhibit a moderate to strong schistosity. A biotitic schistose unit (5g) has been mapped within the hangingwall portion of the ore zone. This unit is believed to represent a shear zone which cuts a portion of the ore stratigraphy and may be post-ore (Figure 21). The shear zone is mineralized with gold, barite, calcite, quartz, realgar, stibnite, and anhydrite. Immediately adjacent to this unit is a brecciated zone consisting of feldspathic ore with barite-rich fracture fillings. This is currently believed to represent brecciation associated with the shear zone.

Lineation in the above mentioned area plunges steeply to the west. Similar trends are present in the longitudinal section showing contoured gold values (Figure 23).

The most persistent structural feature observed throughout the immediate hangingwall and ore horizon are moderately- to well-developed boundins (footwall access is not presently available). The calc-silicate layers, shear zone (5 g), quartz lenses, mafic sills, and higher grade ore lenses show the characteristic pinch and swell features associated with this structural style.

A few shallow, east-plunging "Z-shaped" drag folds (1 - 2 m) have been observed within the immediate hangingwall rocks and along the footwall contact of the porphyry sill within the main ore zone.

Mapping has resulted in the identification of several joint sets within the immediate ore zone on the 5,000 Level. Two prominent sets are northerly (steeply east dipping) and easterly (shallowly south dipping). Additional data are needed before any definite statements can be made regarding their effect on proposed mining methods.

## DISCUSSION

Much work is required before any definitive answers can be given to the numerous questions still being asked about the Golden Giant orebody. However, a number of important features have been observed pertaining to the genesis of the deposit. These include:

1. mineralogy of the ore;
2. ore textures;
3. mineral zonation within the orebody;
4. hangingwall and footwall alteration;
5. presence of two mineralized horizons;
6. relationship between the Lower Volcaniclastic Member and the Main Mineralized Zone;
7. mine and regional stratigraphy.

Examination of these features and ideas from our own staff, government and academic sources, have led to consideration of a number of possible genetic models at present:

1. Structurally controlled mineralization. The proximity of the orebody to major regional lineations, the presence of shearing within the main zone on 5,000 Level, minor folding (possibly sympathetic) along the hangingwall contact, and possible repetition of units all indicate that mineralization may be structurally controlled, i.e. related to tight folding and/or faulting.
2. Porphyry system mineralization. The orebody may be peripheral Au-Mo mineralization

around the tongue of a large intrusive system. The Footwall Schist Member may represent the altered remains of the intrusion, surrounded on both sides by mineralized zones.

3. Exhalite or near-surface hydrothermal mineralization. Uniform gold distribution, layering within the orebody, associated low-temperature hydrothermal minerals such as realgar, stibnite, and cinnabar, and the location of the deposit along a major volcanic-sedimentary contact are all possible indications that the orebody is the result of large-scale syn-volcanic hydrothermal mineralization.

As the mine is in its early stages of development, these ideas and models are preliminary in nature and will be expanded on in the future. In considering genetic models it must, however, be kept in mind that answers may or may not be found on any single Hemlo mine property. Rather, the deposit as a whole must be considered.

#### ACKNOWLEDGEMENTS

This paper was critically reviewed by R.I. Thorpe, Geological Survey of Canada.

## 4 — The Geology Of The Teck-Corona Mine Area

by R. Quartermain

### ABSTRACT

The David Bell (Teck-Corona) Mine at Hemlo, Ontario contains geological reserves of 8.6 million tonnes grading 12 g/t Au. The stratabound mineralization is hosted by chert and silty felsic tuff and occurs at the contact between felsic volcanics to the south and clastic sedimentary rocks to the north. Native gold occurs as discrete grains 10 – 50 micrometres in diameter that are intimately associated with molybdenite and pyrite. The mineralogy of the ore horizon; gold, with Fe-Mo-Ba-Sb-Hg-As sulphides/sulphates, is similar to that of the metalliferous brines of the hydrothermal Ohaki pools of New Zealand. Initial observations indicate the Corona mineralization is synvolcanic.

### INTRODUCTION

The 17 claim Teck-Corona gold property is located 35 km east of Marathon, Ontario along the Trans-Canada Highway. The main Transcontinental line of the Canadian Pacific Railroad crosses the southern part of the Corona property. Hemlo, a former railroad station, is located 4 km west of the property and a 115 kV power line is located one kilometre north of the property.

Drilling of the deposit commenced on January 15, 1981 and was completed with hole 244W on September 17, 1983 for a total of 60,000 m of AQ, BQ and NQ core. The best intersection of the de-

posit was in hole 218W, which graded 27 g/t Au for a length of 11.3 m, with higher assay values cut to 34 g/t Au.

### HISTORY

Gold was first discovered in 1944 in a shear zone north of Moose Lake. Eleven claims were staked and patented over the discovery, referred to as the Williams Option. In 1947, Lake Superior Mining Corporation Limited staked the present International Corona Resources Limited and Goliath Gold Mines Limited properties east of the Williams Option. Between 1947 and 1978 the property was held by 15 individuals and 5 companies. A deposit of 150,000 tons (136,000 tonnes) grading 0.21 oz/ton Au (7.2 g/t) had been delineated by 1978. Teck-Hughes, the forerunner of Teck Corporation, optioned the property and carried out limited drilling in 1951 and again between 1957 and 1959.

It is appropriate at this point to address the question: why did the extensive ore zone go undetected for so long? On the Corona property, gold mineralization outcrops only in the West Zone and is lower in grade. From the vertical longitudinal section (Figure 24) one can see that the mineralization in the West Zone is confined to a small tabular sheet near surface. The original drilling carried out in the 1940's and 1950's was confined to this zone. When drill holes failed to intersect ore immediately along strike and down dip, drilling was terminated.

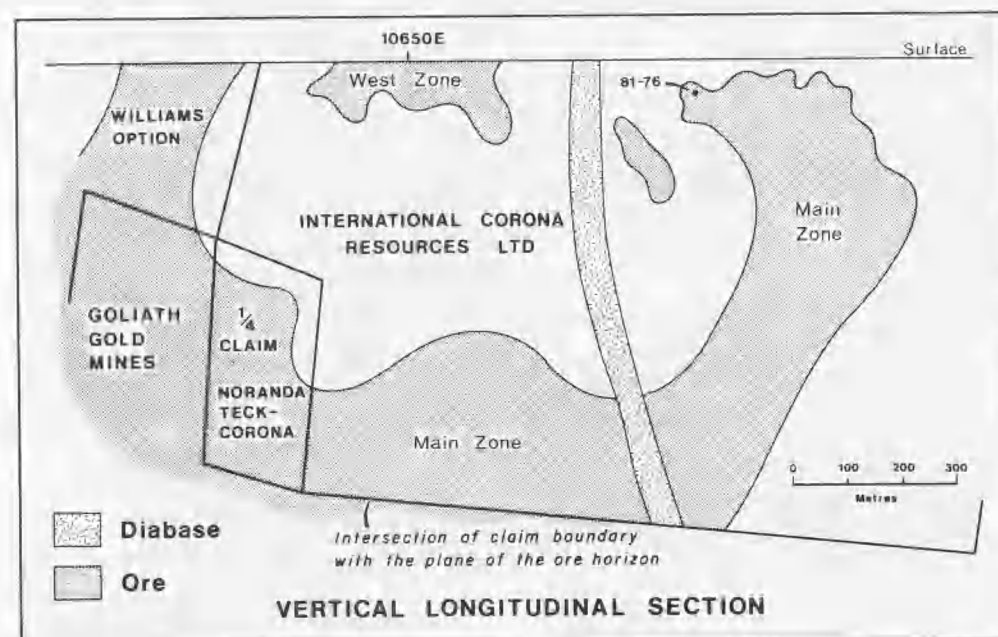


Figure 24. Vertical longitudinal section, Teck-Corona Mine.

No wildcat holes were attempted and the Main Zone remained undetected.

In 1980, Don MacKinnon and John Larche staked a number of claims in the Hemlo area, 17 of which were optioned to Corona Resources Ltd. A closely spaced drilling program supervised by D. Bell increased the tonnage of the West Zone. Drilling was extended to the east pursuing anomalous gold values, and on May 8, 1981, after 8,000 m of drilling, hole 81C76 intersected 3 m assaying 11 g/t Au at a depth of 50 m. This was the first intersection of the Main Zone, which extends along strike and down dip onto the Goliath, Lac and possibly Golden Sceptre properties.

In December, 1981, Teck Corporation entered into an agreement with Corona Resources Ltd to place the property into production for a 55% ownership interest. Drilling to the end of 1982 defined reserves of 1.1 million tonnes, a figure which was increased significantly by the 1983 drilling.

## REGIONAL GEOLOGY

The Hemlo gold deposits lie in the east-west trending Schreiber-White River greenstone belt of the Archean Abitibi-Wawa-Shebandowan Subprovince of the Superior Province of the Canadian Shield. The Hemlo portion of this belt is 40 km long and 30 km wide. It forms a broad synform with a volcanoclastic to epiclastic sedimentary core flanked by mafic volcanic rocks. Two major stratigraphic entities in the belt are recognized by Muir (1982,

1983), namely the Playter Harbour and Heron Bay Groups. The former is composed of tholeiitic basaltic flows and tuff. The latter is a diverse assemblage of tholeiitic basalt, calc-alkaline intermediate to felsic tuff, minor coarse pyroclastic rocks and sedimentary rocks of volcanic derivation.

A broad facies change is evident in the Heron Bay Group, from a proximal, pyroclastic depositional environment at Heron Bay to a distal epiclastic one east of Hemlo. The horizon hosting the Hemlo mineralization occurs at the interfingering of volcanic rocks and volcanoclastic sediments in the west with epiclastic wacke to the east.

## LOCAL GEOLOGY

Locally the rocks strike N73°W and dip 50 to 60° north (Figure 25). Preliminary top determinations indicate the strata young northward. Bedding ( $S_0$ ) and schistosity ( $S_1$ ) are parallel for the most part. The stratigraphic sequence on the property has been divided into three formations: Rule Lake, the ore hosting Moose Lake and the Cedar Creek. Further study is required to determine if these three formations constitute an actual type section. The geological map (Figure 26) of the property, schematic stratigraphic column (Figure 27) and following text are coded with stop numbers which correspond to the detailed stop descriptions at the end of the text.

The Rule Lake Formation is composed of mafic tuff (hornblende-rich) with minor interbeds of greywacke and arkose(?). The formation is under-

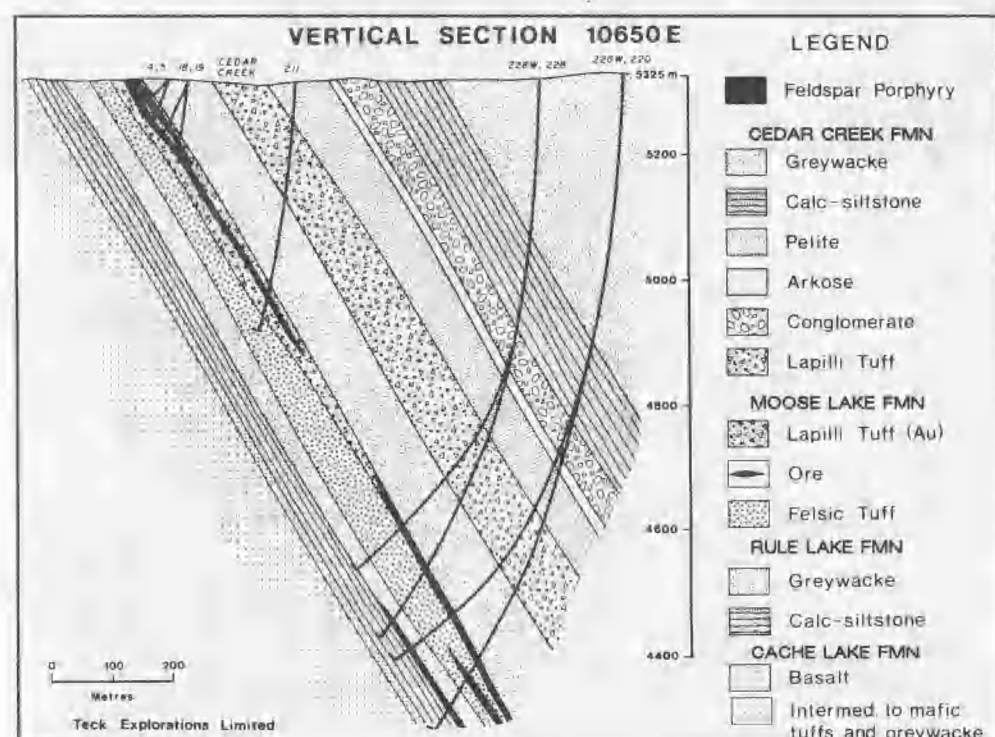


Figure 25. Vertical section (10650E), Teck-Corona Mine.

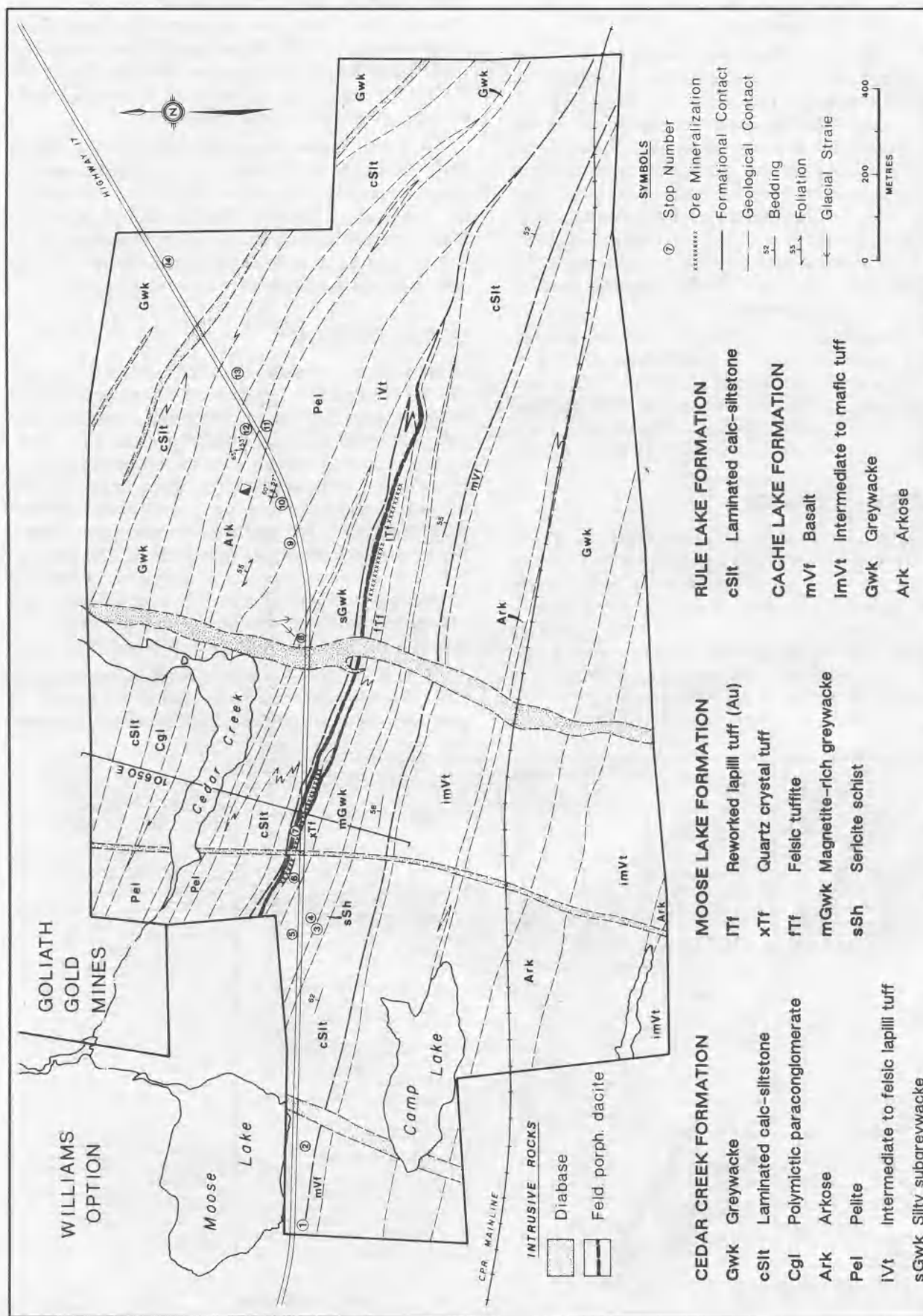


Figure 26. Geology of the Teck-Corona Property.

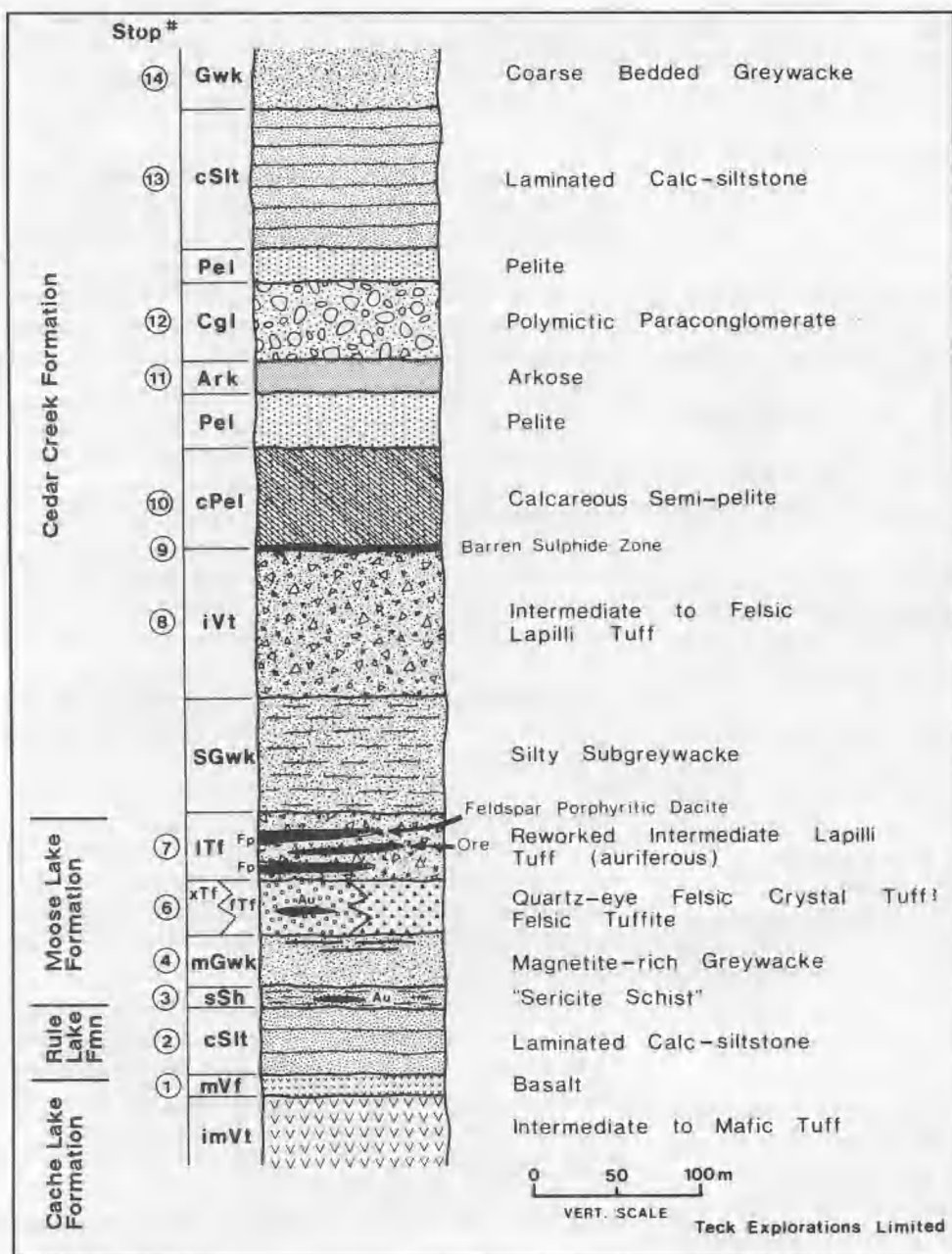


Figure 27.  
Stratigraphic column,  
Teck-Corona Mine.

lain by basalt (Stop 1) of the Cache Lake Formation which is a regional magnetic marker.

The base of the Moose Lake Formation consists of interbedded siltstones and calc-siltstones (Stop 2), which in turn are overlain by thickly-bedded greywacke. A quartz-sericite schist, developed at the contact between these two lithologies, is referred to as the "Lower Zone" (Stop 3). At the upper contact of the greywacke, 1 cm thick layers of magnetite at approximately 50 cm intervals occur across a width of 15 m. This portion of the greywacke has been termed "Iron Formation" in the field (Stop 4), though it bears no resemblance to a typical Superior-type banded iron formation.

The greywacke is overlain by felsic volcanic rocks: quartz-eye crystal tuff and quartz-eye rhyolite (Stop 6) at the west end of the property, grading eastward into tuffite. The auriferous rocks overlie the felsic units. They consist of two units: the siliceous ore horizon and enclosing reworked, gold-enriched, intermediate lapilli tuff (Stop 7).

The Cedar Creek Formation is composed of coarse clastics, siltstones, pelites and wackes. A unit of reworked felsic pyroclastic rocks containing ore fragments(?) extends across the property (Stop 8). A barren sulfide zone (Stop 9) occurs at the contact between the pyroclastic rocks and the overlying pelites (Stop 10). A thin arkose unit (Stop

11) underlies a paraconglomerate (Stop 12) composed of feldspar porphyry dacite clasts and minor exotics. The paraconglomerate has a characteristic magnetic signature and extends onto adjacent properties. Thinly bedded calc-siltstones (Stop 13) are overlain by more than 1,200 m of massive to thickly-bedded, homogeneous wacke (Stop 14).

## MINERALIZATION

The David Bell (Teck-Corona) Mine produces from a mineralized zone which extends onto the adjacent Goliath and Williams properties. This mineralized zone has a continuous strike length of more than 2.5 km, extends at least 1.5 km down dip, and contains geological reserves on the order of 70 million tonnes grading 6 g/t Au. The Teck-Corona portion of this zone contains 8.6 million tonnes grading 12 g/t Au.

The style of gold mineralization varies along this extensive zone and, on a smaller scale, across the Corona property. Gold occurs at five stratigraphic positions on the property. It is found in isolated molybdenite-rich wisps and ore clasts(?) in the reworked felsic pyroclastic rocks which form part of the hangingwall. The 'D' zone is a small tabular sheet 25 m into the hangingwall above the central portion of the Main Zone. The 'B' zone is a small lens located 40 m into the footwall and the 'C' or 'Lower Zone', located 80 m in the footwall of the Main Zone, contains more than 500,000 tonnes of ore. The 'A' or Main Zone contains 90% of the reserves on the property. Near surface, the Main Zone is enclosed by auriferous reworked lapilli tuff. This tuff assays 0.1 to 2 g/t Au across its entire width.

At the east end of the property, the gold in the Main Zone occurs as discrete native gold grains 10-50 micrometres in diameter intimately associated with pyrite and molybdenite. Lithologically, the host is a finely laminated silty felsic tuff comprised of intercalated quartz lamellae and quartz-microcline-sericite lamellae. The mineralized horizon averages 3 m in thickness and contains up to 10% disseminated sulphides.

Down dip to the west, the horizon thickens to 13 m and is no longer finely laminated; instead, it is more siliceous, sericitic and contains coarse-grained clear quartz which has some resemblance to recrystallized chert. Where the zone is thickest, it contains 1 m to 2 m intervals of coarse barite and quartz (more than 40% barite) with correspondingly high gold (60 g/t) and molybdenite (0.5%) contents. The horizon has as much as 10% disseminated sulphides. Bull quartz veins cutting the mineralization are usually barren.

## DISCUSSION

Textural evidence indicates that the mineralization and the feldspar porphyritic dacite sills(?) intruding the mineralized zone predate amphibolite facies metamorphism and the development of the regional fabric.

Sericitic alteration associated with the mineralization is developed in the hangingwall and more extensively in the footwall. From west to east across the property, the footwall felsic volcanic rocks thin from 30 m to 3 m, and the ore zone thins correspondingly and decreases in grade. At the east end of the property, the felsic volcanic rocks, ore zone and sericitic alteration all terminate.

Such observations can be used to support either a syngenetic or epigenetic origin for the mineralization. The sericitic alteration enveloping the ore horizon and the presence of additional stratigraphically-controlled mineralized zones might be cited as evidence for epigenesis. On the other hand, the uniform distribution of gold in the eastern part of the Teck-Corona deposit and almost complete lack of visible native gold is not typical of structurally controlled epigenetic gold deposits. In drill hole 240 at 722.5 m, an "ore clast" was noted in the reworked felsic pyroclastic unit. This clast contains molybdenite and a 1 mm speck of visible native gold. It is believed the fragment originated from the mineralized horizon and, if so, is compelling evidence for a syngenetic origin for the deposit. Similar molybdenite-bearing fragments are common within the reworked felsic pyroclastic unit but are not found in the other stratigraphic units.

The closest modern analogy to the geological environment represented by the rocks hosting the mineralization at Hemlo is that at Wairaki, New Zealand. Syngenetic and epithermal gold are being deposited in volcanic sinters and hydrothermal pools along with a host of other low temperature minerals (Ewers and Keays, 1977), many of which have been identified in the Teck-Corona deposit.

## STOP DESCRIPTIONS — TECK-CORONA

The following stops are keyed to the geological map (Figure 26) and the stratigraphic column (Figure 27), David Bell (Teck-Corona) Mine. They also duplicate stops of Patterson (Section 1 of this guidebook) as indicated.

### Stop 1: Basalt, Upper Cache Lake Formation

A foliated amphibolite composed of hornblende and feldspar with minor quartz and biotite outcrops south of the highway. The unit has an average thickness of 15 m and is a good regional marker because of its magnetic signature. A chloritic shear zone 1 m wide occurs below the hangingwall contact

of this unit and is best observed 850 m west of the stop. The fine-grained, laminated texture exhibited by the unit suggests that it may have originally been a basalt flow.

**Stop 2: Calc-Siltstone, Rule Lake Formation (Patterson - Stop 11A)**

Thinly bedded siltstone with intercalated green, slightly calcareous amphibole-rich beds occur at this location. Ten metres east and two metres north of the picket, notice the lithified siltstone solution breccia along a bedding plane.

**Stop 3: Lower Zone "Sericite Schist", Moose Lake Formation (Patterson - Stop 11B)**

Thickly bedded greywacke occurs on the north part and "quartz-sericite schist" on the south part of this exposure. To the east the quartz-sericite schist results from the alteration of the greywacke, along the calc-siltstone contact. It is characterized by a depletion of Fe, Mg and Ca, and to a lesser degree of Na and an enrichment in Si, K, Au and Mo. Grab samples have returned anomalous gold values. Ore is encountered at this zone 1,000 m down dip. A number of pygmatically folded bull quartz veins and quartz knobs traverse this unit and may represent deformed dewatering channelways. Molybdenite and green mica are visible at this exposure.

**Stop 4: Iron Formation in Greywacke, Moose Lake Formation**

Layers of magnetite one centimetre thick are intercalated with 20 cm layers of greywacke across a distance of 10 m. This interval has a distinct magnetic signature and extends across the property. It bears no resemblance to a typical Superior-type banded iron formation. Note the intense small scale deformation exhibited by the magnetite-rich bands.

**Stop 5: Feldspar Porphyritic Dacite, Moose Lake Formation (Patterson - Stop 11C)**

At this locality note the two varieties of sills (low-angle dykes) on the property, intruding greywacke. The A-type porphyry, one metre south of the picket, contains 20% feldspar phenocrysts about 5 mm diameter, often with magnetite centres, in a feldspar-quartz groundmass. This footwall porphyry is 1 m thick and extends across the property. Down dip, the porphyry transgresses up stratigraphy. The B-type porphyries occur in both the hanging and footwall, and range from 0.1 m to 10 m in thickness. Two thick B-type porphyries intrude the auriferous horizon (Stop 7).

**Stop 6: Quartz-Eye Porphyritic Felsic Crystal Tuff, Moose Lake Formation (Patterson - Stop 11E)**

At this locality, the felsic tuffs exhibit bedding and are highly foliated. Elsewhere this unit is silicified, massive and may contain either pervasive molybdenite or hematite. In thin section it is trimineralic, being composed of microcline, quartz and sericite. The quartz-eyes are dominantly recrystallized and display undulatory extinction and variable degrees of flattening. The outcrop is cut by a number of B-type feldspar porphyry sills.

**Stop 7: Ore Horizon - Corona West Zone, Upper Moose Lake Formation (Patterson - Stop 11F) (Please do not bulk sample this outcrop)**

This is a surface exposure of the ore-hosting lithology. The unit outcropping has been identified as a reworked intermediate lapilli tuff. It consists of lapilli-sized feldspar porphyritic dacite augens and lesser exotic clasts supported in a quartz-feldspar-biotite matrix. Abundant metamorphic biotite indicates the unit originally had a sedimentary component. The unit is sericitized in places and this alteration is associated with a depletion of Fe, Mg and Ca, and of Na to a lesser degree, and an enrichment of Si and K. The unaltered biotite-rich tuff has anomalous gold (0.2 to 2 g/t Au), although gold is slightly depleted in the altered sericite-rich tuff. Black tourmaline and rutile are associated with the sericite alteration. At the southwest corner of the exposure, note the molybdenite and emerald green vanadian mica. Drill hole 9 intersected 3.5 g/t Au across a width of 5 m, 15 m downdip from this location.

**Stop 8: Felsic Lapilli Tuff, Cedar Creek Formation (Patterson - Stop 11G)**

This unit is readily distinguishable from the other hangingwall lithologies by the absence of mafic minerals. It is composed of quartz and feldspar with accessory white mica, sulphides, calcite and hematite. The unit varies both in composition and texture across its 80 m thickness. In places it is fine-grained and compositionally an arkose. Elsewhere it is conglomeratic with feldspar porphyritic dacite cobbles. At this locality, clasts have been stretched considerably and appear as discontinuous lenses. Seventy metres east of this locality, the unit exhibits coarse feldspar porphyritic fragments in a small exposure north of the highway. This unit contains as much as 10% calcite and a few percent hematite across thicknesses of 10 m to 20 m. The unit contains ore fragments and native gold-molybdenite wisps which return interesting, yet uneconomic, assay values. An alternate viewpoint is that the native gold-molybdenite rich fragments are

boudined and augened quartz-molybdenite veins. If so, these "veins" are selectively located because they have only been found in this clastic unit, on the basis of the 244 holes drilled to date.

At the east side of the exposure a north-south striking diabase dyke 40 m thick bisects the ore horizon. A staurolite-rich pelite lens occurs on the top of this exposure. Both euhedral staurolite porphyroblasts and those which have been elongated in the regional foliation direction are present. They indicate that maximum metamorphic temperatures were attained during the waning stages of the development of the regional fabric. Also note the two glacial striae directions. Striae of the first set at 160 degrees are cut by a second more dominant set at 230 degrees.

#### **Stop 9: Barren Sulphide Zone, Cedar Creek Formation (Patterson - Stop 11H)**

Stratigraphically, this sulphide-rich zone occurs at the contact between the reworked felsic pyroclastics to the south and overlying pelites to the north. The zone consists of 10 cm to 20 cm of massive pyrrhotite-pyrite at the contact with 10% disseminated sulphides extending 10 m into the hanging (pyrrhotite-pyrite) and footwall (pyrite-pyrrhotite). This contact may represent a disconformity in the stratigraphic sequence. The zone is an excellent geophysical marker, responding to SP, IP, EM, and magnetic surveys.

#### **Stop 10: Calcareous Semi-Pelite, Cedar Creek Formation**

A massive foliated pelite at this stop contains as much as 20% pervasive tremolite, as laths, and boudinaged and folded calc-silicate beds. Porphyroblasts of staurolite, sillimanite and garnet, and cordierite clots occur in outcrop, and kyanite has been observed in thin section. Mineral assemblages suggest maximum metamorphic conditions of 600 degrees Celsius and 5 Kbar.

At the picket, note the east-trending (109 degrees), plunging (57 degrees), overturned, tightly-folded syncline with a northeast-dipping axis (60 degrees). Closure can be seen 2 m south of the picket in both the pelites and boudinaged calc-silicate beds, which exhibit finely laminated bedding. Top determinations can be made from the pelite beds, which have fine-grained clastic bases fining upward into muddier material which is now the garnet-staurolite-mica rich porphyroblastic portion. This exposure indicates that intense structural deformation has occurred within the strata hosting the deposit.

The other point to note at this locality is that the cordierite porphyroblasts, indicative of high tem-

perature and low pressures, and which may be related to the intrusion of the Cedar Lake Pluton, are aligned along the regional foliation direction, oblique to bedding. One interpretation would be that the regional fabric developed after the intrusion of the Cedar Lake Pluton.

As you walk up section from this point, note the increasing abundance of tremolite.

#### **Stop 11: Arkose, Cedar Creek Formation**

This well bedded unit is composed of quartz and feldspar with lesser micaceous minerals. It contains a few percent disseminated sulphides. It has been designated as an arkose in the field.

#### **Stop 12: Polymictic Paraconglomerate, Cedar Creek Formation (Patterson - Stop 11I)**

This matrix-to clast-supported conglomerate is 30 m thick and extends onto adjacent properties. It has a characteristic magnetic signature as a result of a few percent disseminated magnetite in the groundmass. This unit is comprised of feldspar porphyritic dacite cobbles (60%) with lesser siltstone (15%) and cherty (5%) clasts. The clasts are aligned in a northwesterly direction and flattening is on the order of 4:1. Cobbles may be as large as 15 cm by 25 cm.

#### **Stop 13: Calc-Siltstone Cedar Creek Formation (Patterson - Stop 11J)**

Thin bedded to laminated siltstone has calc-silicate interbeds comprised of hornblende and calcite. These calc-silicate beds are 1 cm to 3 cm in thickness and occur rhythmically over a 150 m thickness. The calc-silicate beds are believed to be primary features and may represent thinly-bedded carbonate/silicate facies iron formation in the much thicker wacke sequence.

#### **Stop 14: Thick Bedded Greywacke - Siltstone, Cedar Creek Formation**

Thickly bedded siltstone caps the Corona stratigraphic sequence and extends at least 1,200 m into the hanging wall. The siltstone is composed of fine-grained, equigranular feldspar-quartz-biotite with occasional coarser clastic greywacke interbeds. On the north side of the highway and 100 m east of this locality, the strata have been folded into an easterly plunging antiformal syncline. Bedding strikes north-south while clasts in coarser beds have been rotated 60 degrees into the foliation direction.

#### **ACKNOWLEDGEMENTS**

The stratigraphy on the Corona property was recognized and defined by the geologists who have worked on the project since 1981. These include David Bell, John Dadds, Bruce Durham, Peter Folk

and Peter Brown. Stan Saunders' keen eyesight spotted the ore-bearing fragment in drill hole 24D. The author is indebted to the staff of Teck Explorations Limited who have assisted with the preparation of this paper. This paper is reproduced from paper 5 of the CIM Geology Division guidebook (Quartermain, 1984) by permission of the Canadian Institute of Mining and Metallurgy. It was critically re-viewed by R.I. Thorpe, Geological Survey of Canada.

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## 5 — The Page-Williams Property

by P.C. Walford, R. Weicker, and R. Guthrie

### INTRODUCTION

LAC Minerals' Page-Williams deposit is one of three economic orebodies found to date within a narrow sequence of rocks that cross Highway 17 some 30 km east of the Town of Marathon. The deposit is on the Williams Option of eleven patented claims and two unpatented fractional claims adjacent to the Golden Giant deposit being mined by Noranda Inc. The reserves for the property are 47 million tonnes grading 6.2 g/t Au.

### AREA GEOLOGY

The area geology was most recently described by Muir (1982, 1983, 1985). In the vicinity of the Page-Williams property, the supracrustal rocks were divided into the Playter Harbour and Heron Bay Groups. All economic deposits of the camp to date are in the latter. Metamorphosed sedimentary and volcanic rocks with minor intrusions comprise the Heron Bay Group that dips to the north and structurally overlies the Playter Harbour Group. The LAC Minerals, Noranda and Teck-Corona deposits are all hosted by one volcanic and sedimentary package of rocks in the Heron Bay sequence.

Most intrusions in the vicinity are relatively thin sills and dykes ranging in age from synvolcanic to postmetamorphic and in composition from felsic to

mafic. The felsic porphyritic sills and dykes and later mafic diabases and lamprophyres cut the ore zones. Larger granitic plutons and gneiss complexes are found 1 km or more to the south, northeast and northwest of the deposit.

The main orebody has been divided into 2 zones for mining purposes (Figure 28). The A-Zone in the east of the property dips at 60° into Noranda ground an average of 250 m below surface. It has a strike length of 250 to 300 m, a maximum width of 25 m, and comprises approximately 10% of the property's ore reserve. The upper part of this zone is being mined by open pit and the remainder from underground. The B-Zone is the western extension of this mineralization at depth and down a westerly plunge. The B-Zone is still open to depth and along strike 1000 m below surface, it comprises most of the deposits reserves.

Another major concentration of gold on the property is the C-Zone in the west end. This is a series of gold-bearing structures that differ in geometry, mineralogy and geology from the main zone. The relationship of the main zone to the C-Zone is not completely understood at this time.

### METAMORPHISM

The deposit and hosting rocks have undergone regional metamorphism to the amphibolite grade. Garnet, kyanite, staurolite, sillimanite, andalusite

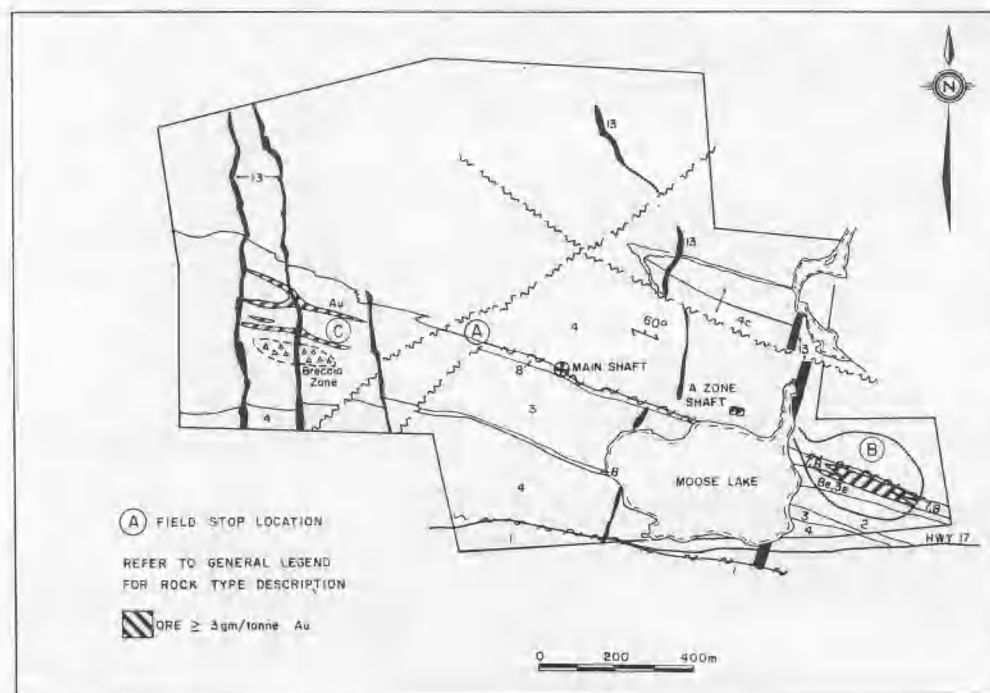


Figure 28.  
Geology map of the  
Page-Williams  
Property.

| LEGEND                                                  |                                             |
|---------------------------------------------------------|---------------------------------------------|
| <b>INTRUSIVE ROCKS</b>                                  |                                             |
| 14                                                      | lamprophyre                                 |
| 13                                                      | diabase                                     |
| 12                                                      | mafic amphibolite                           |
| 11                                                      | intermediate                                |
| 10                                                      | felsic intrusive                            |
| 9                                                       | felsic porphyry                             |
| <b>ALTERED and MINERALIZED ROCKS</b>                    |                                             |
| 8                                                       | muscovite schist                            |
| 7                                                       | biotite-rich rock                           |
| 6                                                       | siliceous or feldspar-rich rock             |
| 5                                                       | limonite-rich rock, $\geq 30\% \text{ Ba}$  |
| <b>ROCKS of POSSIBLE VOLCANIC or SEDIMENTARY ORIGIN</b> |                                             |
| 4                                                       | metasedimentary rocks                       |
| 3                                                       | metafelsic rocks                            |
| 2                                                       | metaintermediate rocks                      |
| 1                                                       | metamafic rocks                             |
| <b>QUALIFIERS</b>                                       |                                             |
| c                                                       | lapilli-size fragments                      |
| e                                                       | quartz eyes                                 |
| f                                                       | feldspar megacrysts                         |
| h                                                       | schistose                                   |
| k                                                       | banded                                      |
| l                                                       | laminated                                   |
| m                                                       | brecciated                                  |
| r                                                       | red colouration                             |
| s                                                       | siliceous or feldspathic alteration         |
| t                                                       | amphibole-carbonate bands                   |
| <b>MINERALS</b>                                         |                                             |
| Ba                                                      | barite                                      |
| Mo                                                      | molybdenite                                 |
| Py                                                      | pyrite                                      |
| <b>SYMBOLS</b>                                          |                                             |
| ---                                                     | fault or shear zone                         |
| ///                                                     | Gold mineralization $\geq 3\text{gm/tonne}$ |

Table 1. Legend for geology maps.

and other metamorphically formed minerals are present in the metasedimentary rocks. One mafic dyke set is syn or premetamorphic and contains garnet. These metamorphic minerals are most common in sediments within 30 m of the main zone, a footwall zone and folded epiclastic felsic rocks to the north of the property. Locally, the metamorphic minerals are concentrated in beds or layers, in cleavages, and adjacent to quartz veins. Two possible sources for these minerals are being considered. One is the metamorphic reaction of sediments with favourable bulk compositions and the other is as a result of hydrothermal alterations. The possibility exists that both are present.

## STRUCTURE

The structural geology of the deposit is complex, with both brittle and plastic deformation over more than one episode having been imposed on the rocks (Hugon, 1984). The structural style appears to be that of slices of rocks retaining their overall integrity with adjoining rocks. However, within these slices, folding, transposition, attenuation and shearing have produced laminated and fragmental rocks. The laminations may not always represent original bedding (H. Poulson, personal communication). In general, the high degree of deformation has produced textures and features whose origins could be interpreted as being either primary or tectonically derived. For instance, fragmental textures pro-

duced by primary deposition, transposition, brecciation and alteration are evident in the surrounding rocks.

Two distinct periods of folding are recognized on the property. The earliest is now isoclinal and may be refolded. Strong axial cleavage is developed in the sediments in this fold system that has axial planes parallel to compositional layering and foliation which usually dips steeply to the north and strikes  $288^\circ$ . These folds, some mineral lineations and other structures including the orebody have a distinct overall plunge to the west, at approximately  $45^\circ$ . Some structures plunge shallowly to the east and in part, can be attributed to a post ore period of folding along an east-west axis. There is evidence of weak folding between the two aforementioned folding events. Mafic to felsic dykes exhibit some cross-cutting relationships and boudinage, rotation and folding (T. Muir, 1985). The dykes, shears and faults are concentrated on the LAC property between the sediments immediately adjacent to the hangingwall of the ore zone and mafic volcanics 300 m to the south. From the sequence of dykes and other geological features, this deformation zone appears to have been active over a considerable span of time. The predominant movement is dextral (Hugon, 1984). Undulations in the plunge of the orebodies is likely the result of interference between two roughly parallel, but oppositely plunging deformational events.

## GEOLOGY

On the LAC property, the orebody is structurally overlain by metasedimentary rocks and a felsic epiclastic unit of volcanic origin (Figure 28). Both this felsic unit and that underlying the main zone are in contact with metasediments that contain staurolite, kyanite, and garnet.

The metasediments are usually fine grained greywackes although argillites and coarser clastic rocks are present. Typically, the greywacke sediments contain calcsilicate layers conformable to layering. These calcsilicate layers assist in defining structure as good marker beds are absent. Repetition of identical metasediments on the south contact of the felsic unit hosting the orebody may be the result of large scale folding.

The contact between the orebody and the metasediments is transitional. Muscovite usually replaces biotite and feldspar until the metasediments grade into a muscovite schist that forms the hangingwall of the orebody. Increasing abundances of pyrite, arsenopyrite and native gold accompany this transition. The muscovite-rich metasediments, bleached metasediments and schist vary from 1 to 30 m in thickness. On the west end of the deposit, they are thickest and are particularly rich in realgar,

stibnite, cinnabar and molybdenite (Figure 31). These minerals occur as films in the plane of foliation, as quartz vein accessory minerals and as fracture controlled minerals in the schist and boudinaged quartz veins.

In the central portion of the A-Zone, a nearly continuous zone of massive pyrite with pyrrhotite and arsenopyrite as much as 0.3 m thick is found adjacent to the ore in the schist (Figure 31). This massive pyrite with low gold values follows the schist-metasediment contact fairly closely whereas the ore grade material tends to diverge to the south in an easterly and westerly direction away from the middle of the orebody.

## ORE ZONE ROCKS

Most of the economic gold values in the A-Zone are in fine grained, sometimes siliceous-looking rock composed primarily of strain twinned microcline and plagioclase feldspars variably altered to muscovite. The native gold is usually microscopic, however, it can be coarse near quartz veins. Common accessory sulphide minerals are pyrite, molybdenite, stibnite, realgar and cinnabar. These minerals along with titanite, ilmenite, biotite, tourmaline and carbonate, can be quite coarse-grained

in quartz veins within the feldspathic ore. Several antimony, arsenic, vanadium, barium and mercury minerals have been identified by D.C. Harris (this volume).

Barium occurs within microcline feldspar, less commonly in white mica and as the barite-quartz matrix in fracture zones within the orebody (D. Harris, this volume). Thick massive zones of barite are not present in the A-Zone though they are present at depth. Barite is concentrated in the footwall zone of the A-zone orebody. Massive deformed barite units are present in the footwall which can be interpreted as being beds or veins. Definite fracture controlled barite does exist in the footwall rocks and the orebody.

The feldspathic ore commonly has a brecciated or fragmental texture with pyrite forming most of the matrix. The gold and feldspathic ore in plan is the shape of an "H" with the maximum thickness of ore occurring where the hangingwall and footwall lenses join.

On the east, the two limbs of ore are separated by a distinct fragmental rock with a biotite-rich matrix and lapilli sized felsic to mafic fragments. The origin of this rock is uncertain. It is pervasively mineralized with pyrite, and green vanadian mica.

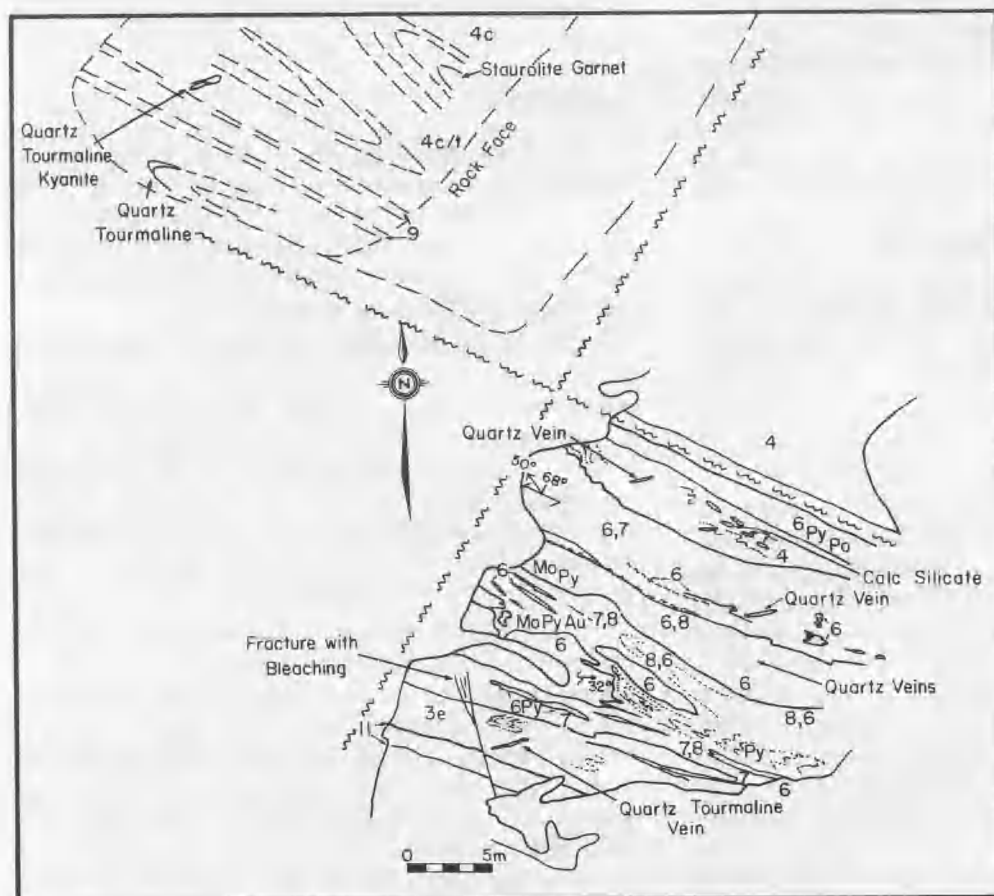


Figure 29. The "Heritage" outcrops.

Low gold values are common with erratic high values. Contacts with ore grade schistose material above and below it are gradational. Muscovite is replacing biotite and feldspar. Garnet and rare kyanite are present in a fairly featureless foliated feldspar quartz unit. Biotite rock without fragments is found above the eastern hangingwall lens and between the hangingwall and footwall lenses on the west. This rock may be a metasediment, but does not have the typical calcsilicate layers. It appears to grade into the feldspathic ore rock.

## FOOTWALL ROCKS

The immediate footwall rock is a quartz feldspar porphyry of likely volcanic origin altered to a large extent to quartz eye muscovite schist with typical green vanadian mica and tourmaline. Gold values drop off rapidly away from the ore zone in the quartz eye rocks. Typically, the schist grades into grey quartz feldspar porphyry then pink porphyry with usually a distinctive fragmental texture. Some of these bodies contain fracture controlled molyb-

denite mineralization with gold. Microcline is the most common feldspar in these rocks. The red alteration is controlled in part by fractures and barren smokey quartz veins that cross-cut molybdenite mineralization. Some of the red alteration may be hematitic.

The schists and pink porphyritic zones are cut by dykes of various compositions. Most intermediate and felsic dykes are usually no more than 2 m thick and at a low angle to foliation. Most mafic dykes, including diabase and lamprophyres tend to crosscut foliation and layering following steeply dipping north south joints.

## ALTERATION AND MINERALIZATION

The gradational nature of most contacts between the ore-bearing feldspathic rocks and surrounding rocks appears to be the result of replacement of original lithologies by a highly potassic solution. The microcline, native gold, molybdenite, vanadium, antimony and arsenic minerals are intimately related and formed as part of the same event. Post

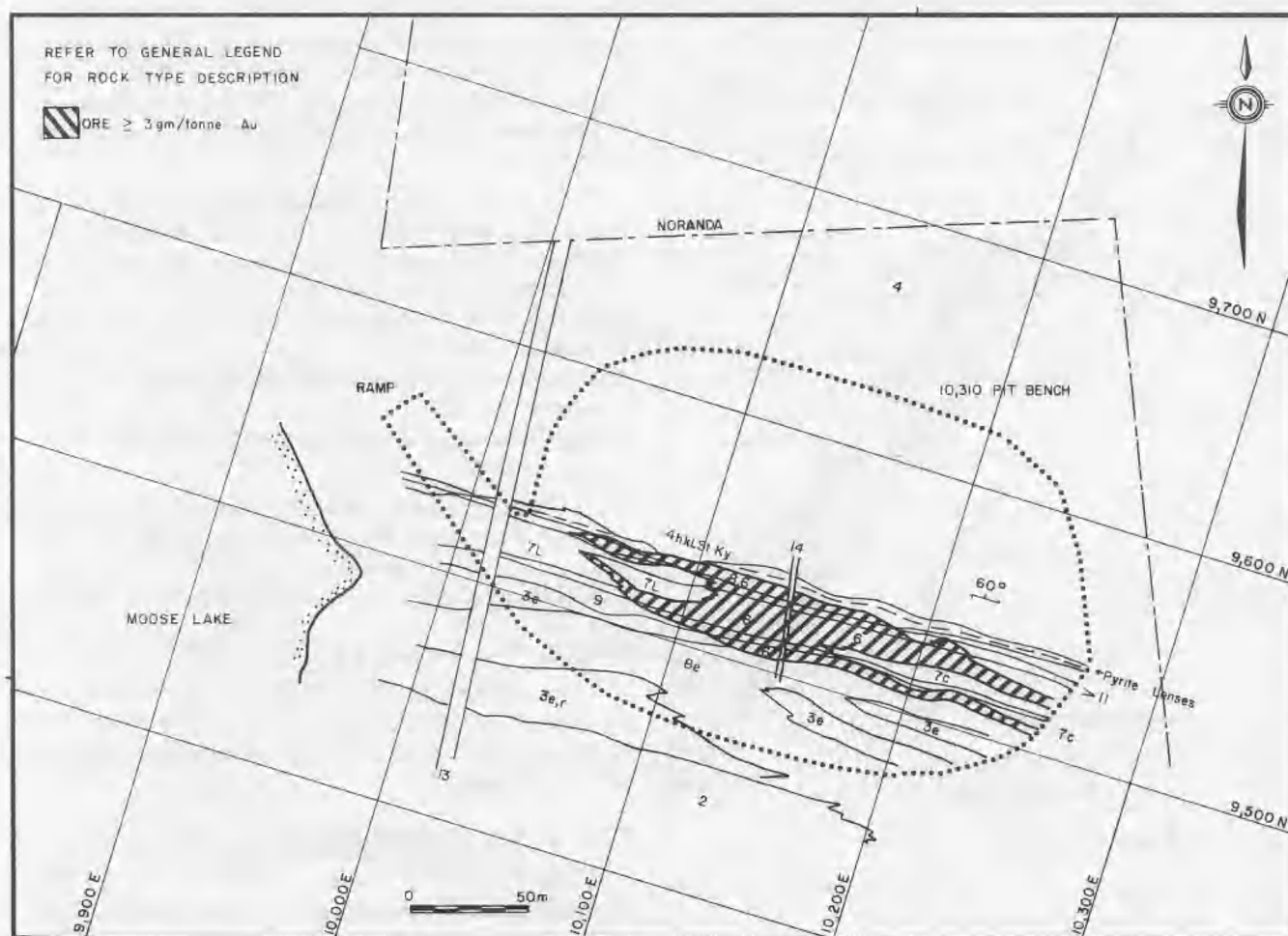


Figure 30. "A" Zone open pit plan.

Post metamorphic alteration and gold mineralization along fractures is usually local. Fractures containing zeolites, prehnite, calcite and epidote are well developed in the metamorphosed mafic rock. Folded veins of quartz and microcline contain minor epidote, calcite, anhydrite and fluorite.

tallic epithermal minerals forming during a deformational event.

The origin of the deposit is not clear. While a syngenetic model could explain some features of the deposit, present evidence suggests that structurally controlled potassic mineralization in a long lived deformation zone must be given serious consideration.

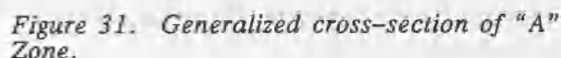
**Stop A: The "Heritage" outcrops (Figure 29)**

The most southern outcrop has examples of the feldspathic and siliceous rocks which comprise the majority of the A and B ore Zones. The outcrop is 800 m along strike from the A-Zone pit and an equal distance up-dip from the B-Zone ore. The feldspathic rock here is not of economic grade but does contain significant gold values where it is well mineralized with molybdenite and pyrite. The highly deformed nature of the rocks is evident as is east-west fault.

**Note:** It is requested that no hammering of these outcrops take place as once mining of the A-Zone pit is complete, no other examples of ore zone type mineralization will exist on surface on this property.

Descriptions of the A-Zone pit tour will have to be tailored to the geology available at the time. If it is not possible to tour the pit, alternative outcrops will be viewed.

The C-Zone is a series of gold in felsic rocks equivalent to the structural footwall rocks of the main zone. Tour description will have to be tailored from available exposures after current mining activities cease.



## ACKNOWLEDGEMENTS

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## 6 — Mineralogy Of The Main Hemlo Gold Deposit

by D.C. Harris

### SUMMARY

The main Hemlo gold deposit consists of several en echelon mineralized zones extending 2900 m in length, 1300 m in vertical height and ranging from 3 to 45 m in width. The David Bell (Teck-Corona) mine, the Golden Giant mine operated by Noranda Inc. and the Page-Williams mine of Lac Minerals are located along these zones. Also of interest, but as much as 40 m beneath parts of the main ore zone, is a lower zone of erratic gold values that has economic potential. Several other gold-bearing zones have been recognized in the vicinity of the main deposit.

The published tonnages indicate reserves of at least 525,000 kg of gold in the main ore zone. This figure ranks the Hemlo deposit in a tie for second place with the "Golden Mile" deposit at Kirkland Lake among the largest single deposits of gold ore known in Canada. The largest is the Hollinger-McIntyre vein system at Timmins.

The deposit contains a diverse assemblage of minerals that indicates a close association of Au with Mo, Sb, As, Hg, Ti, V and Ba. Native gold is the principal source of Au, with minor but, in places, significant amounts of aurostibite. Native gold grains contain up to 22.1 wt.% Hg and up to 29.1 wt.% Ag. Aurostibite is commonly associated with native antimony, stibnite, berthierite, native arsenic, realgar and gudmundite. Molybdenite is the sole source of molybdenum and its presence defines the limits of the ore zones. Cinnabar and aktashite are the principal mercury-containing minerals and they occur only in the central barite-rich part of the deposit. Other mercury-bearing minerals are tetrahedrite and sphalerite (with as much as 27.5 wt.% Hg). These minerals occur both outside as well as in the central barite-rich zone. Vanadium is found principally within dark grass green vanadian muscovite (with as much as 8.5 wt.%  $V_2O_5$ ), which has been incorrectly identified as roscoelite. Its presence, like that of molybdenite, is indicative of the main ore zone. Barite is the principal barium mineral and occurs mainly within the orebodies owned by Noranda and Lac Minerals. In selected drill core, barite is the dominant mineral phase and accounts for as much as 70% of the sample. The second major barium-containing mineral is a barian-microcline. This mineral is widespread and is a major gangue phase. In certain "layers", it is the principal barium-bearing constituent. Rutile is also widespread and within the ore zone it contains

as much as 5.6 wt.%  $V_2O_5$ , 6.5 wt.%  $Sb_2O_3$  and 2.3 wt.%  $WO_2$ .

### INTRODUCTION

In 1983 a mineralogical study of the main Hemlo gold deposit was initiated to determine a) the minerals present, b) the textural features of the ore and associated gangue minerals, c) the mineral zonation of the deposit, d) the effects of metamorphism and tectonic deformation on the minerals, and to e) contribute to a model on the genesis of the ore. Some preliminary data on the International Corona (now Teck-Corona) and Noranda's Golden Giant orebodies were reported at the 1984 joint annual meeting of the Geological Association of Canada and the Mineralogical Association of Canada (Harris, 1984) and a more complete listing of the minerals throughout the main Hemlo gold deposit were given by Harris (1986). The purpose of this paper is to present an updated listing of all the known minerals, their chemical compositions and some data on their distribution within the deposit.

### SAMPLES AND METHOD OF INVESTIGATION

Representative split drill core from 25 holes within the main mineralized zones of Teck-Corona, Noranda and Lac Minerals were selected at intervals of one metre or less. The locations of the drill holes are shown in Figure 32. This figure is a simplified schematic illustration of the deposit and was prepared mainly from data released to the public and from plans provided by the various exploration companies. It is not to be interpreted as representing the exact dimensions of the deposit, the precise positions of the property boundaries, or as demonstrating that the ore zones constitute a continuous orebody. Insufficient data are available at this time to show that the main ore zones are on the same stratigraphic horizon. The locations shown on the map for the drill holes represent their intersection with the hangingwall of the main zone on each property. The drill hole designations TC, NTC, GG and W stands for Teck-Corona, Noranda Teck-Corona, the Golden Giant property of Noranda Inc. and the Williams Claim of Lac Minerals Ltd., respectively. Sampling within the drill core was based on the available gold assays and visual examination. Each selected core sample measured 5 to 10 cm in length. Polished sections, and in some cases polished thin section were prepared from each specimen. To date, more than 800 polished sections and

110 polished thin sections have been studied. These sections were first examined under a petrographic microscope to identify some of the minerals by their optical properties, but most identifications were made by combining results obtained from an electron microprobe equipped with an energy dispersive analyzer, from quantitative electron microprobe analysis and from X-ray powder diffraction techniques.

## THE HEMLO DEPOSIT

The Hemlo gold deposit is a stratabound deposit consisting of a series of en echelon mineralized lenses or zones which extend for a length of 2900 m and for 1300 m vertically (or more than 2 km down dip). These lenses range in thickness from 3 to 45 m (Figure 32). The ore zone strikes at an azimuth of 115° and dips north at 50 to 70°. The only outcrops are on the Williams claim (Lac Minerals Ltd.) where an open pit is located. The deposit is currently being mined by three companies, Teck-Corona Operating Corporation, Noranda Incorporated and Lac Minerals Limited. The eastern portion of the deposit is the property of Teck-Corona and

contains estimated reserves of 8.6 million tonnes grading 12 g/tonne Au (See Quartermain this volume). On this property, gold has been recognized in five stratigraphic positions. It is found 1) in isolated molybdenite-rich wisps or ore clasts (?) in the hangingwall, 2) in the "D" zone, which is a small tabular sheet located 25 m into the hangingwall above the central portion of the main zone, 3) in the "B" zone, which is a small lens located 40 m into the footwall, 4) in the "C" or "lower zone", which contains more than 500,000 tonnes of ore and is located 80 m in the footwall of the Main zone and 5) the "A" or Main Zone, which contains 90% of the reserves on the property. The Teck-Corona ore zone extends westward onto the Golden Giant property, where the ore reserves, as determined from surface drilling, have been calculated at 19, 137, 148 tonnes grading 10.11 g/tonne Au, 0.1% Mo, 1.5 g/tonne silver and 10 to 13% barite (Friesen *et al.*, 1985). A second, narrower (2-5 m) mineralized zone is located below the main zone, and limited surface drilling has indicated erratic gold values. The main ore zone is open at depth below 1000 m to the northwest. The western portion of the Hemlo deposit is the Williams Claim (Lac Min-

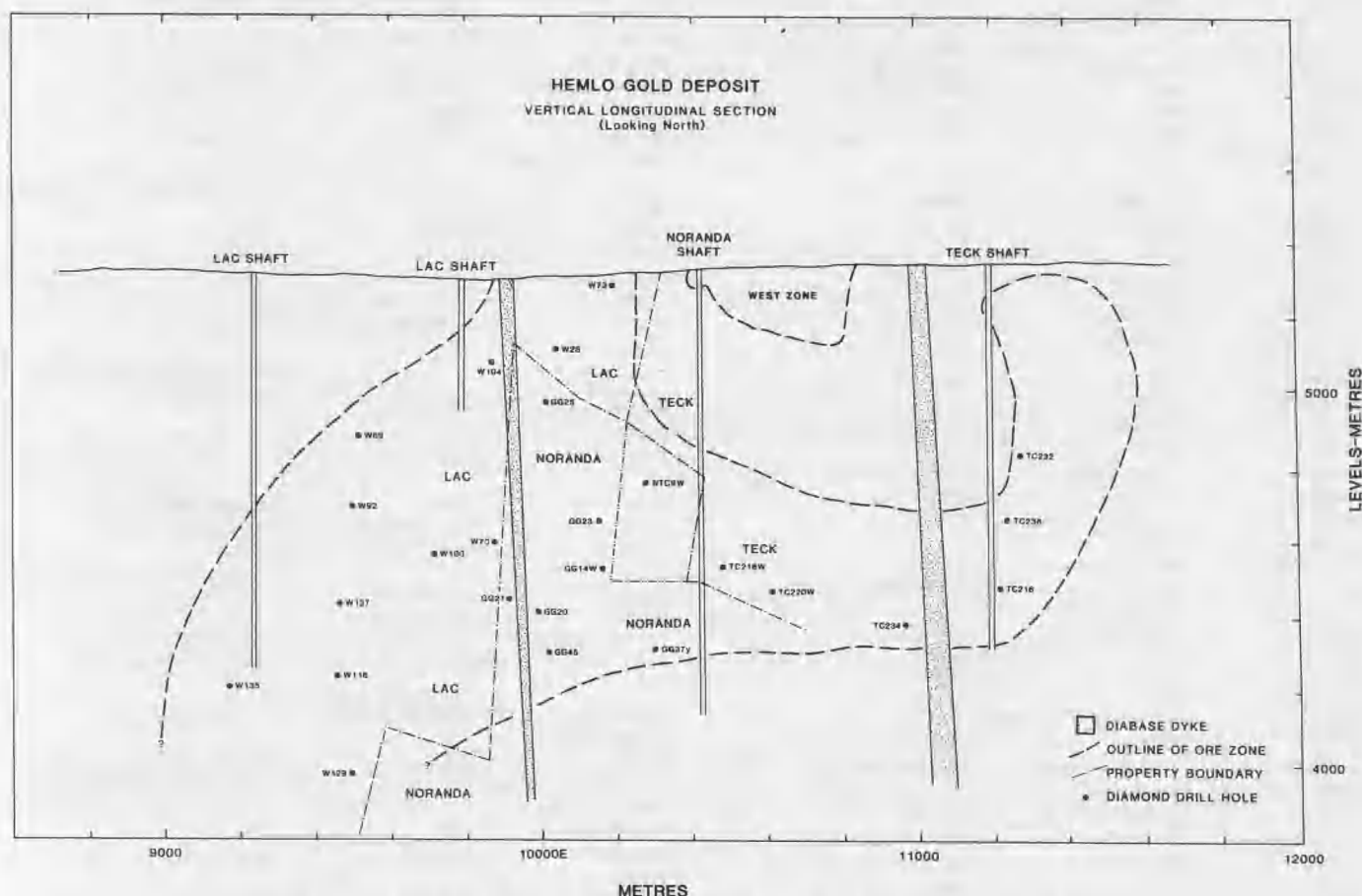


Figure 32. Vertical longitudinal section, drill holes examined.

erals Limited). The "A" zone part of Williams Claim in the south-eastern part of the property extends from surface to a vertical depth of approximately 465 m at the Golden Giant property boundary. To the northwest of this is the "B" zone, which is at present known to extend to a depth of at least 1100 m (Valliant, 1985). The continuity and northwest plunge of the "B" zone below 1100 m has not been defined to the claim boundaries. The probable ore reserves of the "A" zone are 3.8 million tonnes at a grade of 5.3 g/tonne Au, of which about 753,000 tonnes can be mined by open pit. The "B" zone contains possible ore reserves of 39.3 million tonnes grading 5.3 g/tonne Au (Knoll, 1985). The combined tonnages shows that the main Hemlo deposit contains approximately 525,000 kg of gold, but judging from normal in-

crease with time in production plus reserves in the early history of mining districts, it is likely that the final estimate will climb to a much higher figure. Recent comparisons of gold deposits in Canada (Cranstone, 1985) reveal that the Hemlo deposit will at least tie for second with the "Golden Mile" at Kirkland Lake, Ontario as among the largest single deposits of gold known in Canada. The largest is the Hollinger-McIntyre vein system at Timmins, Ontario.

## DETAILED MINERALOGY

The minerals identified in the main Hemlo ore zones are listed in Table 2. They are classified as common, less common, and rare, as determined by their frequency of occurrence in the samples exam-

Table 2. The minerals in the main Hemlo gold deposit. The formula listed for each Hemlo mineral is the most representative for that species in the deposit.

| ORE MINERALS     |                                                                         |                                                                                                            |                          |                    |          |
|------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------|--------------------|----------|
| Species          | Simplified formula                                                      | Hemlo                                                                                                      | Species                  | Simplified formula | Hemlo    |
| Common           |                                                                         |                                                                                                            | Common                   |                    |          |
| Native Gold      | Au                                                                      | Hg0.0-22.1, Ag0.0-29.1                                                                                     | Clausthalite             | PbSe               | PbSe     |
| Pyrite           | FeS <sub>2</sub>                                                        | FeS <sub>2</sub>                                                                                           | Wurtzite                 | (Zn,Fe)S           | (Zn,Fe)S |
| Molybdenite      | MoS <sub>2</sub>                                                        | M <sup>0</sup> S <sub>2</sub>                                                                              |                          |                    |          |
| Sphalerite       | ZnS                                                                     | Hg0.0-27.5, Fe0.0-1.9                                                                                      | SILICATES, ETC. MINERALS |                    |          |
| Arsenopyrite     | FeAsS                                                                   | FeAsS                                                                                                      |                          |                    |          |
| Stibnite         | Sb <sub>2</sub> S <sub>3</sub>                                          | As0.0-4.8                                                                                                  |                          |                    |          |
| Tetrahedrite     | (Cu, Fe, Zn) <sub>12</sub> Sb <sub>4</sub> S <sub>13</sub>              | Hg0.0-18.6, Ag0.0-8.9                                                                                      |                          |                    |          |
| Tennantite       | (Cu, Fe, Zn) <sub>12</sub> As <sub>4</sub> S <sub>13</sub>              | Hg0.0-15.2, Ag0.0-8.3                                                                                      |                          |                    |          |
| Zinkenite        | Pb <sub>6</sub> Sb <sub>14</sub> S <sub>27</sub>                        | As0.0-11.5                                                                                                 |                          |                    |          |
| Realgar          | As <sub>2</sub> S <sub>3</sub>                                          | Sb0.0-0.5                                                                                                  |                          |                    |          |
| Cinnabar         | HgS                                                                     | HgS                                                                                                        |                          |                    |          |
| Aktashite        | Cu <sub>6</sub> Hg <sub>3</sub> As <sub>4</sub> S <sub>12</sub>         | Cu <sub>6</sub> Hg <sub>3</sub> (As, Sb) <sub>4</sub> S <sub>12</sub>                                      |                          |                    |          |
| Less common      |                                                                         |                                                                                                            |                          |                    |          |
| Aurostibite      | AuSb <sub>2</sub>                                                       | AuSb <sub>2</sub>                                                                                          |                          |                    |          |
| Chalcocopyrite   | CuFeS <sub>2</sub>                                                      | CuFeS <sub>2</sub>                                                                                         |                          |                    |          |
| Pyrrhotite       | Fe <sub>1-x</sub> S                                                     | Fe <sub>1-x</sub> S                                                                                        |                          |                    |          |
| Galena           | PbS                                                                     | PbS                                                                                                        |                          |                    |          |
| Nativeantimony   | Sb                                                                      | As0.0-1.3                                                                                                  |                          |                    |          |
| Berthierite      | FeSb <sub>2</sub> S <sub>4</sub>                                        | Mn0.0-13.4                                                                                                 |                          |                    |          |
| Bournonite       | PbCuSbS <sub>3</sub>                                                    | As0.0-6.0                                                                                                  |                          |                    |          |
| Boulangerite     | Pb <sub>9</sub> Sb <sub>4</sub> S <sub>11</sub>                         | As <sub>2</sub> .2-5.8                                                                                     |                          |                    |          |
| Native Arsenic   | As                                                                      | As                                                                                                         |                          |                    |          |
| Gersdorffite     | NiAsS                                                                   | Fe1.4-14.9                                                                                                 |                          |                    |          |
| Parapirotite     | TlSb <sub>6</sub> As <sub>5</sub> S <sub>8</sub>                        | TlSb <sub>6</sub> S <sub>8</sub>                                                                           |                          |                    |          |
| Routhierite      | TlHgAsS <sub>3</sub>                                                    | Cu <sub>1-0</sub> Tl <sub>1-0</sub> Hg <sub>2-0</sub> (As <sub>1-4</sub> Sb <sub>0-8</sub> )S <sub>8</sub> |                          |                    |          |
| Altaite          | PbTe                                                                    | PbTe                                                                                                       |                          |                    |          |
| Twinnite         | Pb(Sb, As) <sub>2</sub> S <sub>4</sub>                                  | Pb(Sb <sub>1-2</sub> As <sub>0-8</sub> )S <sub>4</sub>                                                     |                          |                    |          |
| Orpiment         | As <sub>2</sub> S <sub>3</sub>                                          | Sb0.0-5.0                                                                                                  |                          |                    |          |
| Geocronite       | Pb <sub>14</sub> (Sb, As) <sub>6</sub> S <sub>23</sub>                  | Pb <sub>14</sub> (Sb <sub>3-0</sub> As <sub>3-0</sub> )S <sub>23</sub>                                     |                          |                    |          |
| Rare             |                                                                         |                                                                                                            |                          |                    |          |
| Native Silver    | Ag                                                                      | Ag                                                                                                         |                          |                    |          |
| Hemlo No. 1      | -                                                                       | T <sub>10-2</sub> Ag <sub>0-4</sub> Au <sub>0-6</sub> Sb <sub>2-0</sub> S <sub>2-0</sub>                   |                          |                    |          |
| Chalcocite       | CuSbS <sub>2</sub>                                                      | CuSbS <sub>2</sub>                                                                                         |                          |                    |          |
| Jamesonite       | Pb <sub>4</sub> FeSb <sub>6</sub> S <sub>14</sub>                       | Pb <sub>4</sub> FeSb <sub>6</sub> S <sub>14</sub>                                                          |                          |                    |          |
| Gudmundite       | FeSbS                                                                   | FeSbS                                                                                                      |                          |                    |          |
| Ullmannite       | NiSbS                                                                   | NiSbS                                                                                                      |                          |                    |          |
| Coloradoite      | HgTe                                                                    | HgTe                                                                                                       |                          |                    |          |
| Galkaite         | (Cs, Tl)(Hg, Cu, Zn) <sub>6</sub> (As, Sb) <sub>4</sub> S <sub>12</sub> | -                                                                                                          |                          |                    |          |
| Melinite         | NiTe <sub>2</sub>                                                       | NiTe <sub>2</sub>                                                                                          |                          |                    |          |
| Tvalchrelidzeite | Hg <sub>12</sub> (Sb, As) <sub>8</sub> S <sub>18</sub>                  | Hg <sub>12</sub> (Sb <sub>4-7</sub> As <sub>3-3</sub> )S <sub>18</sub>                                     |                          |                    |          |
| Baumhauerite     | Pb <sub>3</sub> As <sub>4</sub> S <sub>9</sub>                          | Pb <sub>3</sub> (As <sub>2-2</sub> Sb <sub>1-6</sub> )S <sub>9</sub>                                       |                          |                    |          |
| Cubanite         | CuFe <sub>2</sub> S <sub>3</sub>                                        | CuFe <sub>2</sub> S <sub>3</sub>                                                                           |                          |                    |          |
| Seligmannite     | PbCuAsS <sub>3</sub>                                                    | PbCu(As <sub>1-52</sub> Sb <sub>0-48</sub> )S <sub>3</sub>                                                 |                          |                    |          |
| Dufrenoyite      | Pb <sub>2</sub> As <sub>2</sub> S <sub>5</sub>                          | Pb <sub>2</sub> (As <sub>1-17</sub> Sb <sub>0-9</sub> )S <sub>5</sub>                                      |                          |                    |          |
| Calaverite       | AuTe <sub>2</sub>                                                       | AuTe <sub>2</sub>                                                                                          |                          |                    |          |
| Pararealgar      | AsS                                                                     | not analyzed                                                                                               |                          |                    |          |
| Stibarsen        | SbAs                                                                    | SbAs                                                                                                       |                          |                    |          |
| Breithauptite    | NiSb                                                                    | NiSb                                                                                                       |                          |                    |          |

ined. Because the Hemlo deposit contains a diverse assemblage of minerals and is mineralogically zoned, this classification is applicable in an overall sense, but not to individual parts of the deposit. As well, ore minerals other than pyrite, which account for less than 1% of the deposit, are fine grained and difficult to recognize. Therefore, normal quantitative measuring techniques such as image analyzers are not practical. For the minerals identified at Hemlo, the simplified mineral formulas (Fleischer, 1983) and their specific compositions when these have been determined, are also listed in Table 2.

The mineralogy and chemistry of the Hemlo deposit indicate a close association of Au with Mo, Sb, As, Hg, Tl, V and Ba. In Table 3, an elemental listing of minerals is presented, together with a relative estimate of their contribution of particular elements.

*Pyrite* is the most abundant sulphide and its mode of occurrence gives the ore a stratified appearance. It occurs in two modes, as coarse sub-

hedral to anhedral deformed aggregates up to 3 mm in maximum dimension which are concentrated in "layers" up to 1 m thick, and also as fine grained euhedral grains less than 200  $\mu\text{m}$  in maximum dimension which are finely disseminated throughout the silicate ground mass.

*Native gold* is the principal gold phase, although gold also occurs in minor to trace amounts of aurostibite and rarely as calaverite and the unidentified Hemlo No. 1 mineral. Native gold occurs as free grains between 1 and 20  $\mu\text{m}$  in size along quartz-feldspar grain boundaries, as inclusions in, or rimmed with, native arsenic, cinnabar, stibnite, sulphosalts and aurostibite and as blebs along fractures in pyrite. Megascopically, visible native gold is rare. The native gold contains as much as 22.1 wt.% Hg and as much as 29.1 wt.% Ag. It varies in composition from sample to sample and sometimes from grain to grain within the same polished section. The averaged composition of 89 grains from polished sections throughout the deposit is Au 86.2, Hg 6.5, and Ag 5.9 wt.%. Most gold grains are low in silver

Table 3. Elemental listing of minerals and their relative abundance in the Hemlo gold deposit.

|            | Major                                                                                             | Minor                                                                                                                                                                                                               | Trace                                                                                |
|------------|---------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
| Gold       | Native Gold                                                                                       | Aurostibite                                                                                                                                                                                                         | Hemlo No. 1<br>Calaverite                                                            |
| Molybdenum | Molybdenite                                                                                       | -                                                                                                                                                                                                                   | -                                                                                    |
| Antimony   | Stibnite<br>Zinckenite<br>Tetrahedrite                                                            | Native antimony<br>Boulangerite<br>Bournonite<br>Chalcostibite<br>Gudmundite<br>Berthierite<br>Aurostibite<br>Ullmannite<br>Rutile (up to 6.5 $\text{Sb}_2\text{O}_3$ )<br>Twinnite<br>Parapierrotite<br>Geocronite | Jamesonite<br>Stibarsen<br>Breithauptite<br>Tvalchrelidzeite<br>Pyrochlore-type      |
| Arsenic    | Realgar                                                                                           | Orpiment<br>Native arsenic<br>Gersdorffite<br>Tomichite<br>Arsenopyrite<br>Routhierite<br>Geocronite<br>Aktashite<br>Tennantite                                                                                     | Seligmannite<br>Dufrenoyite<br>Pararealgar<br>Baumhauerite<br>Cafarsite<br>Stibarsen |
| Mercury    | Cinnabar<br>Aktashite                                                                             | Tetrahedrite (up to 18.6)<br>Tennantite (up to 15.2)<br>Native gold (up to 22.1)<br>Sphalerite (up to 27.5)<br>Routhierite                                                                                          | Tvalchrelidzeite<br>Coloradoite                                                      |
| Thallium   | Parapierrotite<br>Routhierite                                                                     | -                                                                                                                                                                                                                   | Hemlo No. 1<br>Galkhaite                                                             |
| Vanadium   | Muscovite<br>(up to 8.5 $\text{V}_2\text{O}_5$ )<br>Rutile (up to<br>5.6 $\text{V}_2\text{O}_5$ ) | Tomichite                                                                                                                                                                                                           | Cafarsite<br>Garnet<br>Hematite                                                      |
| Barium     | Barite<br>Microcline (up to<br>16.6 BaO)                                                          | Muscovite (up to 2.0 BaO)                                                                                                                                                                                           | Tomichite                                                                            |

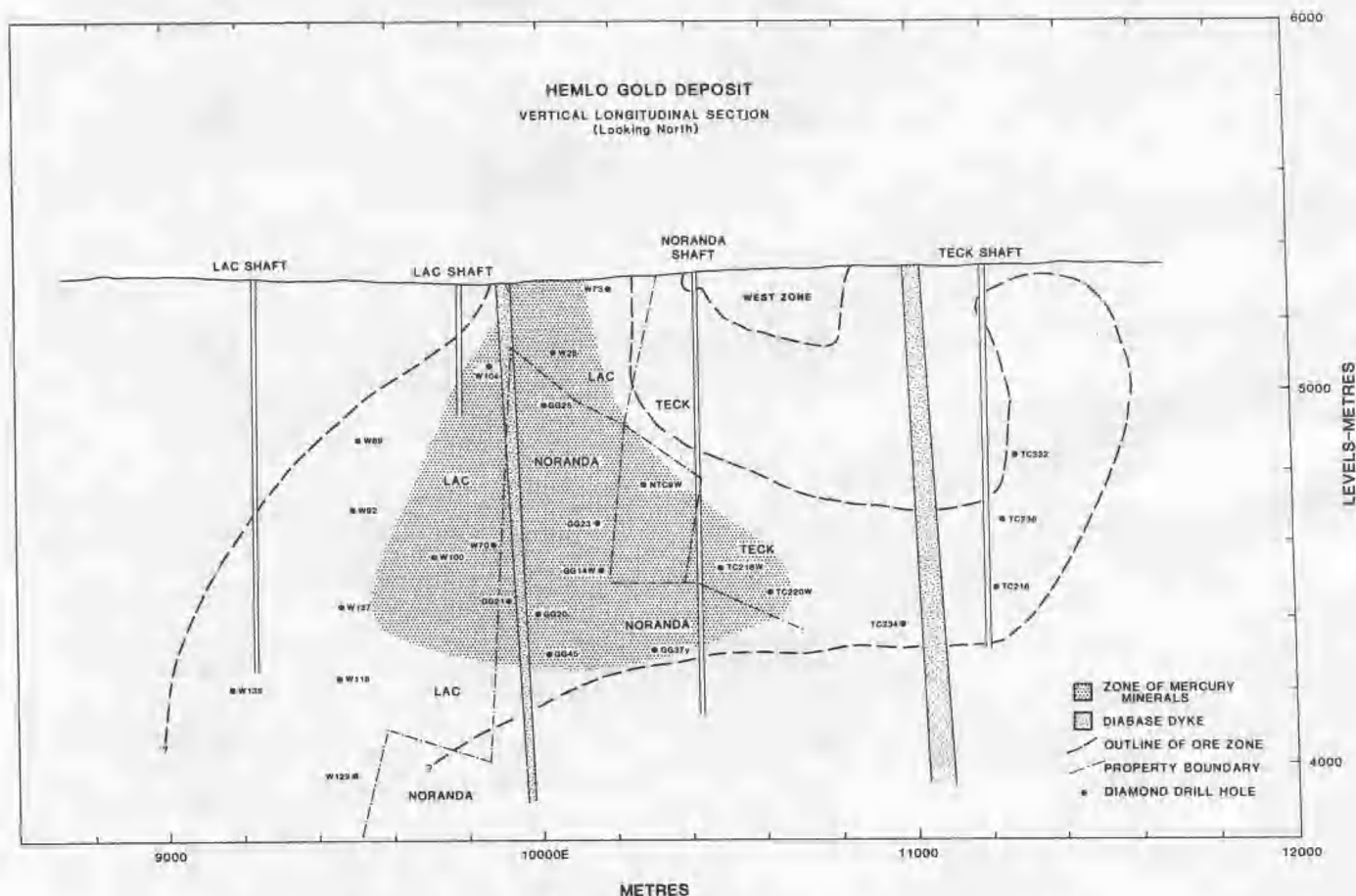
contents, with the highest values obtained in samples collected from the northwest down-plunge extension of the Lac orebody. There is no marked correlation between gold assays and pyrite-rich samples. The best indicator of gold is molybdenite. Some of the highest gold assays are obtained from zones that contain highly fractured, boudinaged, quartz veins enriched in a mineral assemblage of realgar-cinnabar-stibnite. These zones occur principally in the Noranda and Lac orebodies.

Mercury and thallium minerals are closely associated. The mercury minerals *cinnabar* and *aktashite* are the most abundant. They occur in the central and thickest part of the deposit, which extends vertically from the surface outcrops on the Lac orebody to a depth of 1000 m along the northwest down-plunge extension and laterally along strike to the east onto the Teck-Corona property at a point slightly beyond hole 220W (Figure 33). At this latter locality the deposit has narrowed to 10 m and barite is absent. Other mercury-bearing minerals are sphalerite (as much as 27.5% Hg), native gold and tetrahedrite-tennantite. These minerals occur outside, as well as within the central orebody.

It is worth noting that the mercury-rich sphalerite has a colour virtually the same as that of the iron-poor variety, ranging from pale yellow to colourless. Microprobe analysis shows that the mercury occurs as isomorphous substitution for zinc and X-ray determinations showed an increase in the unit-cell parameter. A search of the literature indicates that the most mercury-rich sphalerite (38 wt.%) was found in the Galkhaya deposit, USSR, (Gruzdev, 1975).

The thallium minerals, parapirotite and routhierite are rare in the deposit and, because of their similar optical properties to cinnabar, are difficult to recognize.

*Molybdenite* is widespread throughout the deposit and, as noted earlier, is the best indicator of gold. It occurs mainly in association with silicate minerals, but occasionally as inclusions in pyrite and, less frequently, in barite. The molybdenite occurs as individual euhedral crystals and as platy masses parallel to the foliation of the ore. A few fine grains of native gold (<2 µm) were found to occur as inclusions within molybdenite flakes and interstitial to the platy masses.

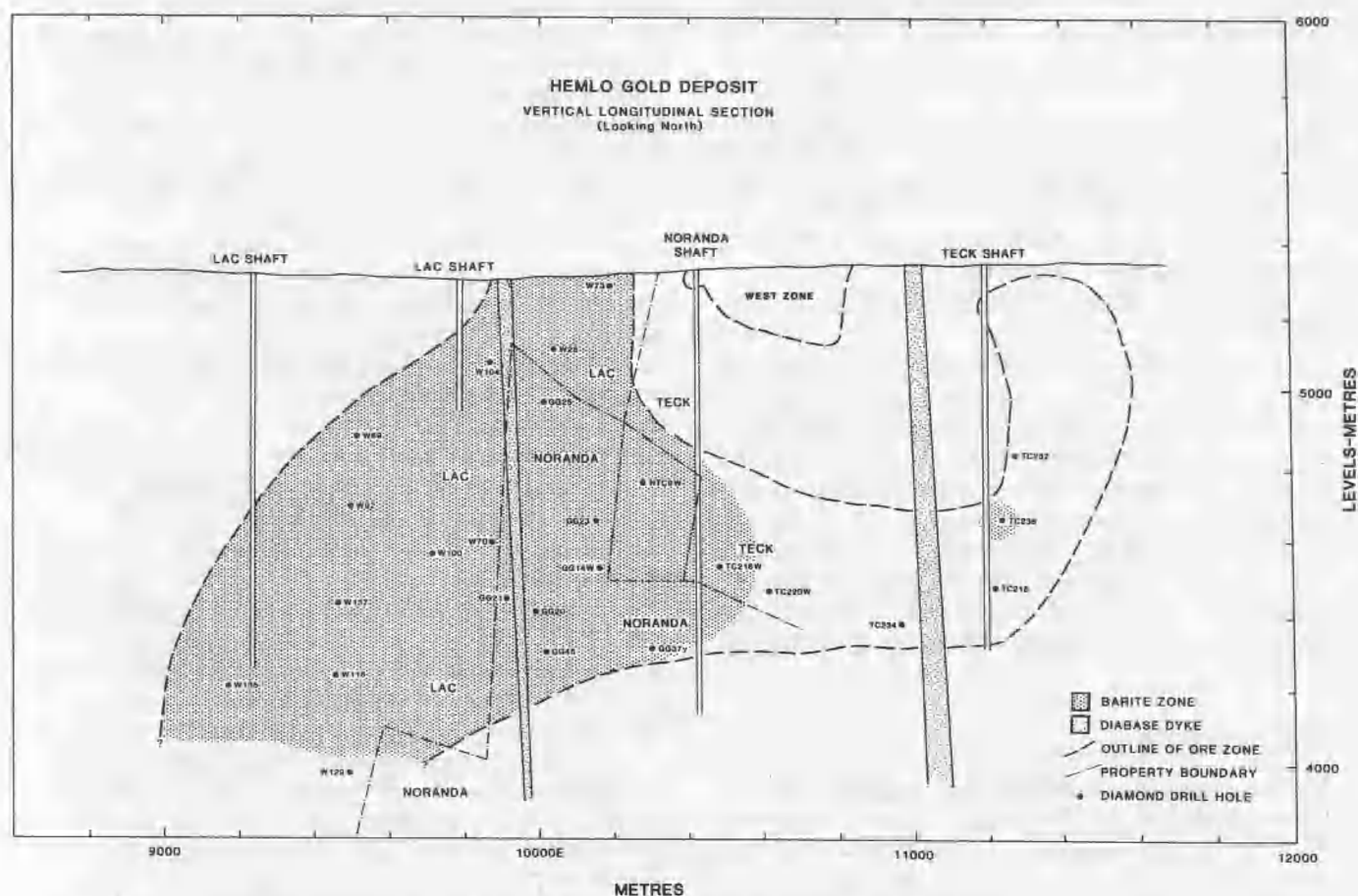


The *antimony* and *arsenic* minerals account for the largest number of ore minerals found within the deposit. Isomorphous substitution between these elements contributes to variable compositions for the sulphosalt minerals. The formula listed for each mineral in Table 2 is the most representative for a particular species in the Hemlo ore. Stibnite, zinkenite and tetrahedrite are the most widespread antimony phases. Stibnite is the most abundant of these and is readily visible in some hand specimens, particularly in boudinaged quartz veins in which it occurs as disseminations and as masses concentrated along the peripheries of the boudins. Realgar is the most abundant arsenic species and its presence gives an orange colour to quartz-rich hand specimens. Tennantite is a minor phase, but in some drillholes, in particular from the northwest down-plunge extension of the Williams Claim, it is a major arsenic mineral. Native arsenic and native antimony generally occur in the same samples, sometimes in association with aurostibite, berthierite, realgar, stibnite and gudmundite. As reported by Barton (1971), berthierite, gudmundite, and aurostibite are stable only under conditions of relatively low sulphur activity. These minerals, and

their association with native arsenic and native antimony in the Hemlo ore, clearly indicate that the ore-forming conditions were sulphur-poor.

Arsenopyrite is widespread, and occurs mainly as small euhedral crystals (<200  $\mu\text{m}$ ) in the silicate gangue matrix. It is not a principal arsenic mineral in the main ore zone. However, in the hangingwall it is the only arsenic-bearing mineral and in places is very abundant.

The *gangue minerals* in the deposit are essentially quartz, mica, feldspar and barite. Barite is a major constituent and occurs in zones in which it ranges from massive (up to 70% coarse barite) to thin fracture fillings and disseminations. In some drillholes, barite only occurs in the lower part of the ore zone, in other drillholes it occurs throughout the width of the ore zone and in the east orebody of Teck-Corona it is extremely rare (Figure 34). Barite has also been identified in units below the Williams ore zone (McIlveen, 1983). Microprobe analyses of barite from holes W135 and W70 of Lac Minerals indicated SrO contents from 0.5 to 7.2 wt.%,



*Mica* is widespread and occurs as sericite, muscovite, vanadian muscovite and less commonly as phlogopite-biotite. Sericitic alteration associated with the mineralization is developed in the hangingwall and more extensively in the footwall. In the ore zone sericite is widespread, but the feldspar in the ore shows very little sericitic alteration. Muscovite and vanadian muscovite are the most abundant mica minerals, and vanadium contents are as great as 8.5%  $V_2O_5$ . The vanadian muscovite is easily recognized by its light to dark grass-green colour. The vanadian muscovite has been identified in all ore-bearing zones throughout the deposit. As in the case of molybdenite, the vanadian muscovite appears to be an indicator of gold. Phlogopite and biotite occur in isolated thin zones and more work is necessary to determine whether they are primary or secondary in origin.

*Feldspar*, with barite and quartz, is a major gangue mineral. It is mainly microcline and barium-bearing microcline, and less commonly albite. Most microcline is of the barian variety, containing up to 9.4% BaO in the mineralized zone and up to 16.6% BaO in some samples from the hangingwall units. The barium content of microcline in the ore is very variable and backscattered electron images show crystal growth zoning and the irregular distribution of barium. Next to barite, microcline is the most important barium-bearing species, and in some "layers" it is the principal mineral of barium. In thin section, some microcline grains are readily distinguished by their characteristic cross-hatch twinning, whereas others show no twinning. Only microprobe analyses can determine if the microcline is the barian variety. Albite is rare and occurs with microcline and quartz in narrow zones. All feldspar throughout the deposit exhibits very little sericitic alteration.

*Rutile* is widespread as anhedral to subhedral grains as much as 2 mm in maximum dimensions, but most grains are less than 200  $\mu m$ . Some rutile grains are partially to nearly completely altered to titanite. Microprobe analyses show that rutile in the mineralized zone contains as much as 5.6  $V_2O_5$ , 6.5  $Sb_2O_3$  and 2.3  $WO_3$ . This isomorphous substitution of V, Sb and W in rutile appears to be the first reported and, with regards to the Hemlo deposit, the rutile composition indicates the presence of the ore zone.

## DISCUSSION

Various genetic models have been suggested for the mineralization at the Hemlo gold deposit. Elements of these models include a) a syngenetic origin of mineralization, b) an exhalite or near surface epithermal system, c) a structurally controlled mineralization, and d) a porphyry system of

mineralization. The earlier field observations reported by Quartermain (this volume) favoured a syngenetic origin because of the "ore clast" in the reworked felsic pyroclastic unit and the consistent distribution of gold in the finely laminated Teck-Corona ore. Recent geochemical and isotopic studies by Cameron and Hattori (1985) indicated that native gold, pyrite and barite were deposited contemporaneously, and therefore favoured a syngenetic depositional model. Because of the mineralogical and chemical similarities of the Hemlo ore to sinters formed by two hot springs in New Zealand, Goldie (1985) suggested that the Hemlo gold was precipitated subaerially along with silica, sulphur, arsenic, antimony, mercury and thallium.

A number of laboratory and field studies are currently underway and a clearer understanding of the nature of the Hemlo gold deposit should evolve in the near future. The results from current mineralogical studies should help to define the model. These studies have demonstrated such features as: 1) the extremely diverse nature of the mineralogy and geochemistry of the ore which has some similarities to, but is much more complex than, known hot spring - type deposits reported to date; 2) the textural relations of the interstitial barite with the silicate gangue minerals; for example, the lack of ore minerals (except minor pyrite) as inclusions in the barite, the near absence of barite in the Teck-Corona portion of the deposit, and the cross-cutting barite seams as found in the underground developments; 3) the metasomatic nature of the barian microcline, the vanadian muscovite and the V-Sb-W-bearing rutiles, all of which help define the ore zone as a "lithological" unit and seem to favour a hydrothermal origin; 4) the fact that molybdenite is a principal ore mineral and is directly correlated with gold, which can be interpreted to indicate a relationship to a porphyry system; 5) the increased presence of base metal minerals and the near absence of mercury in the Lac ore within the north-west down-plunge extension may be indicative of higher temperature deposition and perhaps indicates the direction from which the ore fluids ascended; 6) the mineralogical similarities between the main ore zone and the "lower zone" on the Noranda property indicates a common genetic origin; 7) the realgar-cinnabar-stibnite-rich boudinaged quartz veins in the central barite-rich part of the deposit are suggestive of an epithermal-hydrothermal origin; 8) the mineralogy of the aurostibite-bearing zones are indicative of conditions of low sulphur fugacity; 9) recent studies by Hugon (1984) have demonstrated that the deposit is within a dextral shear zone and hence structural factors may have played an important role in the localization of the deposit; 10) the presence of kyanite in the hangingwall unit has led many researchers to in-

interpret an amphibolite grade metamorphism for the deposit. This is in direct contrast with the relatively low temperature (less than 300°C) mineral assemblages that are found within the deposit. The occurrence of poikiloblastic to fragmental kyanite in a sericitic schist containing pyrite, sphalerite, cinnabar, native antimony, stibnite, tetrahedrite, berthierite, native arsenic, realgar and arsenopyrite in a drill core from hole W104 at a depth of 249.1 to 249.5 m indicates that the kyanite possibly predates the ore minerals.

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