

GEOLOGY AND GOLD DEPOSITS OF THE HEMLO AREA REVISED EDITION



Compiled and Edited by

T.L. Muir, B.R. Schnieders and M.C. Smyk

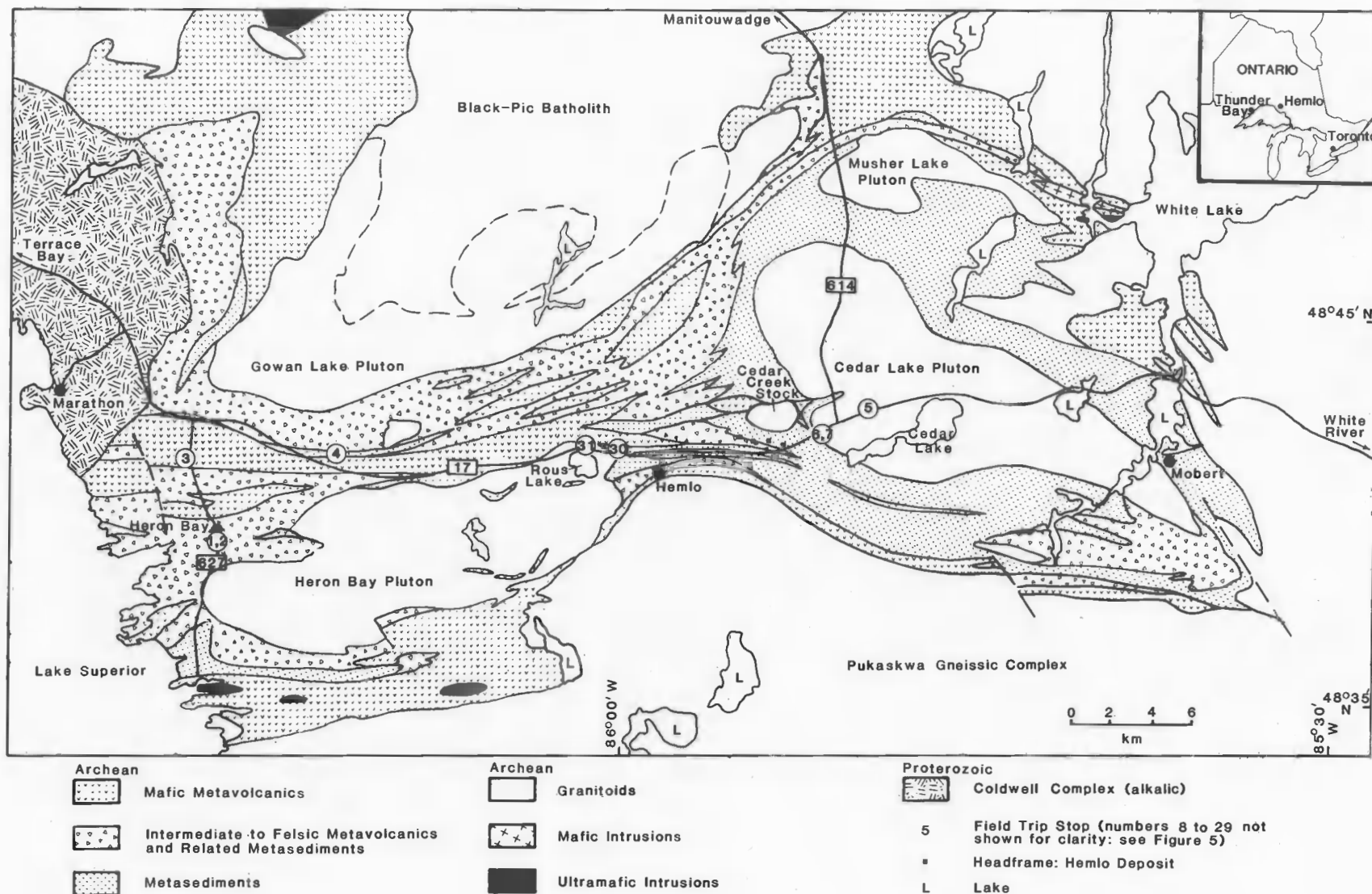


Figure 14. Location map (inset) and regional geology of the Hemlo-Heron Bay area. STOPS 1 to 7, and 30, 31 are indicated. Other stops are shown on Figures 18 and 19. (Modified after OGS maps 2220, 2439, 2452, P.2701, P.2702, P.2738, P.2739).

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Compiled and Edited by

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Cover Photograph: Hemlo camp gold mines, summer 1989.
Photograph courtesy of Ray Ettinger.

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GEOLOGY AND GOLD DEPOSITS OF THE HEMLO AREA

PART 1: INTRODUCTION

by

T.L. Muir, B.R. Schnieders and M.C. Smyk

The Hemlo gold deposit is located roughly 35 km east of the Town of Marathon, Ontario, and lies, in part, beneath the Trans-Canada Highway (Highway 17) (see Figures 14 and 19 on inside front and back covers, respectively, and Figure 21). Estimates, in 1989, indicated there were at least 80 million tonnes of ore at an average grade of 7.7 g/t Au (Harris 1989). The deposit is currently being mined by three companies: Teck-Corona Operating Corporation (David Bell Mine), Hemlo Gold Mines Inc. (Golden Giant Mine), and Williams Operating Corporation (Williams Mine). All 3 mines were ranked in the top 50 gold producers in the world in 1992. Their standings were: Williams Mine, 17th; Golden Giant Mine, 19th; and David Bell Mine, 49th. Collectively, they would have placed 8th, accounting for almost 4% of the total production of the top 50 gold producers.

Annual production from the 3 mines has totaled over 1 million ounces for the last 6 years (1989-1994) (Figure 1), for a total production, since commencing operations in 1985, until the end of 1994, of almost 9.5 million ounces (see Table 1). Production for the last 5 years has accounted roughly for over one-half of Ontario's gold production and roughly one-quarter of Canada's gold production. The total contained ore-grade gold of the deposit (mined and remaining) is about 20.69 million ounces based on data as of January 1, 1994. Ore reserve and grade estimates (as of January 1, 1995) are presented in Table 2.

Table 1: Hemlo Deposit Gold Production: 1985-1994

YEAR	DAVID BELL MINE	GOLDEN GIANT MINE	WILLIAMS MINE	TOTAL OUNCES
1985	20,989	98,155	10,369	129,513
1986	52,888	254,545	198,515	505,948
1987	130,122	369,300	256,809	756,231
1988	218,333	336,700	378,827	933,860
1989	312,190	378,400	494,127	1,184,717
1990	318,098	435,300	594,128	1,347,526
1991	295,284	443,438	518,703	1,257,425
1992	210,121	451,403	496,920	1,158,444
1993	215,188	422,528	492,251	1,129,967
1994	192,217	446,850	445,320	1,084,387
TOTALS	1,965,430	3,636,581	3,885,969	9,488,018

Table 2: Ore Reserve and Grade Estimates

	Ore Reserves (tonnes)	Grade (g/t Au)
David Bell Mine ¹	4,956,219	10.86
Golden Giant Mine ²	10,582,000	11.10
Williams Mine ³	30,890,000	5.72

¹ Mineable and diluted ore reserves, Dec. 31, 1994; P. Desautels, Chief Geologist, David Bell Mine, Teck-Corona Operating Corporation, personal communication, 1995.

² Total ore reserves as of Dec. 31, 1994; R. Kusins, Chief Geologist, Golden Giant Mine, Hemlo Gold Mines Inc., personal communication, 1995; includes tonnages of 9 504 463 t @ 11.38 g/t Au (Golden Giant Deposit No. 1), and 1 077 176 t @ 8.74 g/t Au (Quarter Claim).

³ Total proven and probable diluted ore reserves as of Dec. 31, 1994; J. Gray, Senior Production Geologist, Williams Mine, Williams Operating Corporation, personal communication, 1995.

The delineation of the Hemlo deposit in the early 1980s spurred an exploration blitz of the Schreiber-Hemlo greenstone belt. Several years later, although much more is known about the area, no other economic gold deposit has been found. However, the presence of a major gold deposit within any belt carries with it the substantial possibility that additional deposits remain to be discovered.

This field trip guide deals mainly with the geology of the Hemlo deposit vicinity, but touches on some other interesting occurrences as far west as Heron Bay. The field trip guide includes updated and detailed descriptions of the Exploration History of the Hemlo area, brief overviews of the Regional Geology of the Hemlo area and the Hemlo deposit, a description of the geology of the Golden Giant Mine and Golden Sceptre orebody (both of Hemlo Gold Mines Inc.), and a detailed Road Log for the Hemlo-Heron Bay area. Although originally written for the GAC-MAC-SEG Toronto '91 meeting, the guide has been updated, and serves as a 3-day planned overview of the Hemlo deposit, or reference for a more detailed, self-guided tour.

We had initially hoped that contributions by staff from all 3 mines in the Hemlo camp, using a common basis for documenting observations, would permit a preliminary 3-dimensional configuration of the deposit to be envisaged, particularly in terms of element and mineral distributions as well as lithologic, structural, metamorphic, and alteration features. This would have involved a significant additional work-load for geological mine staff, and, as such, it is unfortunate that the deposit component from 2 of the mines cannot be represented here. However, a description of the central and westernmost part of the deposit is presented, in this field guide, by staff at the Golden Giant Mine (see Part 6). Papers by Walford, Stephens *et al.* (1986), and Walford, Weicker, and Guthrie (1986) provide the most recent, detailed descriptions of the Williams Mine, as does the paper by Burk *et al.* (1986) for the David Bell Mine. Readers will find additional information on surface and subsurface geological features of the Hemlo deposit area in other field guides prepared by Patterson (1984), McMillan and Robinson (1985), Harris (1986a, 1986c), Harris and Muir (1987), and Smyk *et al.* (1990).

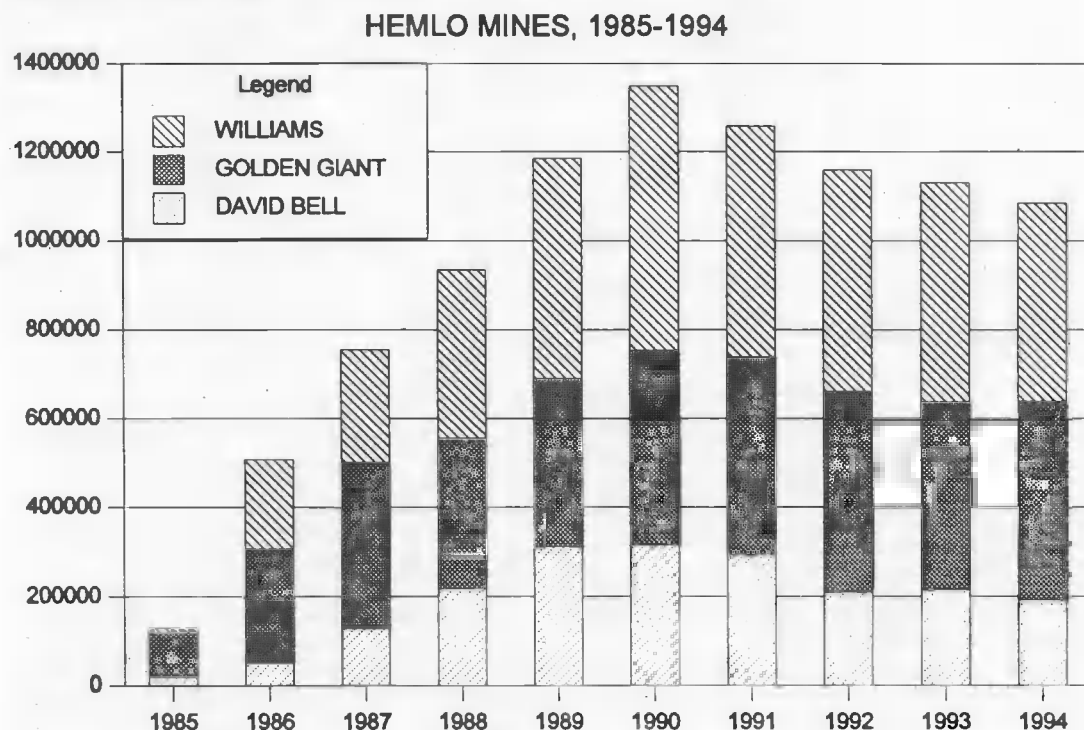


Figure 1. Hemlo camp gold production from 1985 (initiation) to 1994.

PART 2: EXPLORATION HISTORY

by

B.R. Schnleders and M.C. Smyk

Exploration in the Hemlo area dates back to 1869 when gold was discovered by Moses Pee-Kong-Gay near the present town of Heron Bay. Bell (1873) reported activity there: pits and shafts were reportedly sunk on auriferous quartz veins and a small amount of ore was shipped (*The Weekly Sentinel*, Port Arthur, Ontario, March 1, 1889; McKellar 1874).

In the 1920s, J. LeCours, a station agent with the Canadian Pacific Railway at Hemlo station, sank test pits on a mineralized shear zone "a few hundred feet north of the station" (Bartley and Page 1957), 6 km southwest of the Hemlo deposit. Reported assays ranged from 0.22 to 4.16 ounces gold per ton (*The Fort William Daily Times Journal*, Fort William, Ontario, July 12, 1927; July 25, 1927). As reported by Thomson (1933), a test pit was sunk on a mineralized shear zone, but no gold values were obtained. Additional work and assays for occurrences north and south of the railway were also described (*Canadian Mining Journal*, August 12, 1927). At about the same time, a group of claims was staked on a small quartz vein just north of mile post 38 (measured from White River) on the railway. Some low gold assays were obtained, but no further work was done (Bartley and Page 1957).

J.E. Thomson mapped the area in 1930 and 1931 for the Ontario Department of Mines (Thomson 1931, 1933). He recommended several areas, including the area northeast of the Hemlo station and another around Manitouwadge Lake, for further exploration.

In 1937, Bowhill Mines explored in the vicinity of Heron Bay and shipped a 500 lb. (227 kg) test sample which returned 0.30 ounce gold per ton and 1.53 ounces silver per ton (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

In the early 1940s, Zeb and Simon Moses of Heron Bay noticed "shiny minerals" in the rocks on the north side of Moose Lake while checking Zeb's father's (Peter Moses) trapline. They told Peter Moses who prospected and collected samples from the area in 1944 (Peter Moses, prospector, Marathon, personal communication, 1990). Moses discovered a siliceous, mineralized shear zone approximately one-half mile (0.8 km) north of mile post 37 on the railway (Bartley and Page 1957). Samples returned assays up to 0.415 ounce gold per ton (Bartley and Page 1957; 1958). Peter Moses apparently brought the showing to the attention of Harry Ollmann of Heron Bay, who in turn interested Dr. Jack K. Williams of Maryland. Eleven claims were staked in 1945: five were recorded in Ollmann's name in August, 1945, and six were recorded in Williams' name in September, 1945 (Mining Recorder's Files, Ministry of Northern Development and Mines, Thunder Bay). The eleven claims they staked and started exploring, in 1945, became known as the Ollmann-Williams property. Gold values were encountered in a large shear zone and during the next year, stripping, trenching, and diamond drilling were conducted. The program of X-Ray diamond drilling was unsuccessful mainly due to the inefficient operation of the machine (Page 1948), and thus, likely, poor core recovery.

In the spring of 1946, consulting geologist Trevor Page staked a group of claims adjoining the Ollmann-Williams property on the east. These claims, together with others staked by associates including Moses Fisher (J.E. Thomson's guide), became part of the property held by Lake Superior Mining Corporation Limited (Bartley and Page 1957, 1958). Samples collected by Page on the newly staked ground assayed from trace to 0.13 ounce gold per ton whereas samples from the Ollmann-Williams property reportedly returned up to 0.49 ounce gold per ton (Prospectus, Lake

Superior Mining Corporation Limited, 1947). In 1947, Lake Superior Mining Corporation Limited was formed and carried out mapping, trenching, chip and channel sampling, and X-Ray diamond drilling on both properties under the direction of Page. Fifteen and thirteen X-Ray diamond drill holes were drilled on the Ollmann-Williams and Lake Superior properties, respectively, on what was termed the Lake Superior Shear Zone (Page 1947a, 1948). This drilling tested the shear zone over approximate strike lengths of 600 m and 500 m on the Ollmann-Williams and Lake Superior properties, respectively, and established the lateral continuity of the mineralized shear zone over at least three kilometres on both properties (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

Page (1947b) initially recognized that:

"The main mineral-bearing structure consists of a quartz porphyry that has undergone intense alteration through shearing, silicification and sericitization."

Page (1948) later stated:

"The Hemlo Fault is considered to be the most important structural feature as it appears to bear a close relationship to the Lake Superior Shear Zone in which all present gold discoveries of economic interest have been found. With it also are associated porphyries similar to those of the shear zone. Probably the greatest feature to date has been the use of the fault in locating the projection of the ore-bearing zone."

Page (1949) suggested that the Hemlo Fault was continuously traceable over a distance of 13 km and the Lake Superior Shear Zone for over 11 km.

W.L.Greer, Resident Geologist, Department of Mines, Port Arthur, Ontario noted in a memorandum, dated June 24, 1949 (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay):

"Further drilling and trenching should be done, particularly to the east of the present drilling. Here, about 400 feet to the east, a north-south trending diabase dike cuts across the shearing at right angles. It is possible the gold values may be better concentrated in the shear zone for a few hundreds of feet on either side of the diabase."

Ollmann and Williams' initial grubstake money was exhausted during the drilling program, and the pair decided to pool their eleven claims for the purpose of patenting. Harry Ollmann died in December 1947 and the eleven claims were put in Williams' name in trust by mutual consent (*Financial Post*, August 3, 1987). Other groups, including Northern Canada Mines Ltd., had staked presumed strike extensions of the mineralized zones to the east of the properties (Page 1948). In 1948, Lake Superior Mining Corporation Limited drilled four holes to the southeast, south of Cedar Lake (see Figure, inside front cover) on claims staked by Zeb Renshaw; no assays were reported (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

Exploration on the Lake Superior Mining Corporation property continued into the spring of 1949, at which time diamond drilling had indicated a mineralized zone with a strike length of 900 feet (275 m), an average width of 6.5 feet (2 m) and an average grade of 0.256 ounce gold per ton (*Northern Miner*, April 21, 1949). This zone was later reported to have a strike length of only 200 feet (61 m) (*Northern Miner*, June 9, 1949).

Bartley and Page (1957) noted discrepancies between drill core and drill sludge assays in two drill holes and stated that it was a significant feature:

"In one case, core assays returned 0.327 ounce gold across 8.3 feet [2.5 m] while 30 feet [9.1 m] of sludge returned 0.243 ounce [gold per ton]. In the second case, core returned

0.315 ounce gold [per ton] across 5.0 feet [1.5 m], and sludge returned 0.594 [ounce gold per ton] across 25 feet [7.6 m]."

Page (1949) related the mineralization to the observed structure:

"The 'Hemlo Break' is probably part of the Heron Bay Break which is recognized as one of the large structural features associated with the Precambrian geology in this section of the Canadian Shield. Porphyry bodies with which mineralization of economic importance is associated have been guided in their emplacement by this regional structural pattern."

Lake Superior Mining Corporation Limited had diversified their exploration program and discovered radioactive zones (including the Herrick occurrence) adjacent to its original property and south of mile post 36 (*Northern Miner*, June 9, 1949). Deeper diamond drilling was initiated in the fall of 1949 and eventually 10 holes, totalling 3761.5 feet (1146.5 m), were drilled (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay). A mineralized zone containing 31 543 tons to a depth of 300 feet (91 m) with a calculated width of 8.8 feet (2.7 m) and a cut grade of 0.22 ounce gold per ton was outlined (*Northern Miner*, May 18, 1950). Trenching of the strike extension of the mineralized zone to the east near the Struthers railway station was undertaken in 1950 when land position was secured by Lake Superior Mining Corporation Limited (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

In 1951, Teck-Hughes Gold Mining Limited optioned the Lake Superior property and completed 6 diamond drill holes totalling 2733 feet (833 m) (Mining Recorder's Files, Ministry of Northern Development and Mines, Thunder Bay) in addition to the over 6000 feet of drilling completed to that time by Lake Superior Mining Corporation Limited. The size of zone No. 1 (formerly the 'A' zone) was increased to 76 653 tons at a grade of 0.27 ounce gold per ton (*Northern Miner*, January 25, 1951). One of the holes missed what is now the main Hemlo ore zone by less than 30 m (Patterson 1985). The prevailing US\$35 per ounce gold price and the relatively low grade precluded further work for the next few years. In 1957, Teck Exploration Company Ltd. carried out some packsack diamond drilling. Seven holes totalling 289 feet (88 m) were drilled in the footwall mineralized zone ('B zone') which returned values ranging from trace to 0.04 ounce gold per ton (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

M.W. Bartley and T.W. Page wrote a geological report on the Hemlo area (Bartley and Page 1957) for the Canadian Pacific Railway and stated:

"The section from Hemlo to Struthers has received considerable prospecting attention to date, and its potential depends mainly on further exploration ...".

Cusco Mines Ltd. optioned the ground from Lake Superior Mining Corporation Limited in 1958 and carried out diamond drilling to test the main mineralized zone which contained an estimated

71 000 tons averaging 0.22 ounce gold per ton within a zone 550 feet (168 m) long, 10 feet (3 m) thick, and 300 feet (91 m) deep (*Northern Miner*, October 23, 1958). The program's results were "inconclusive" but sufficient mineralization was encountered to maintain interest (*Northern Miner*, November 5, 1959).

As no exploration had recently been undertaken on the Williams property, a caution (lien against title) was filed on the eleven claims, in 1955, by Harry Ollmann's brother to protect his interest. Williams died that year and his lawyers attempted in vain to clear up the partnership agreement. The caution was stricken from the claim block in 1970 (*Financial Post*, August 3, 1987, p.1-2).

The Lake Superior property had been staked intermittently by prospectors during the 1960s. Walter Baker, accompanied by his son, Nelson, prospected west of the Williams ground in 1961, on what became the Golden Sceptre property. Several gold discoveries were made on surface and gold was panned in the sandy loam overburden (Nelson Baker, prospector, personal communication, 1990). These occurrences were investigated in the next few years with trenching and X-ray drilling, in part funded by Fred Jowsey. Visible gold was reported in the drill cores (Lefolii 1987). Stairs Exploration and Mining Company Ltd. funded a program of soil sampling and prospecting in 1964 and 1965 conducted by H. Hansen and D. Michano (Harris Hansen, prospector, personal communication, 1990).

The Lake Superior property was staked by J.E. Halonen in 1973 for Ardel Explorations Ltd. who drilled three holes totalling 789.9 feet (241 m) (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay). The deposit tonnage was increased to 150 000 tons grading 0.21 ounce gold per ton above 60 feet (18 m) depth (*Northern Miner*, November 8, 1973). Ardel dropped the claims and was later followed by Cypress Resources Ltd.

Claims were staked by R.G. Newman in 1976 west of the Williams property and investigated by Copper Lake Explorations Ltd. in 1977. Soil and rock geochemical sampling succeeded in identifying a zone of anomalous gold values (up to 10 000 ppb) roughly coincident with the contact between metasedimentary and quartz-feldspar-porphyritic rocks (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

T.L. Muir of the Ontario Geological Survey mapped the Heron Bay and Hemlo areas in 1977 and 1978, respectively (Muir 1982a, 1982b). In addition to summarizing the area's exploration activity and economic potential, Muir reported an occurrence, presently referred to as the "Highway Zone", in altered felsic metavolcanic rocks several kilometres west of the main Hemlo deposit. This occurrence is probably in the vicinity of the mile post 38 discovery of the 1920s. A grab sample returned 0.32 ounce gold per ton and 0.48 ounce silver per ton (Muir 1982b). Claim stakers and explorationists would later base much of their land acquisition during the staking rush on Muir's maps.

Various accounts of the recent developments in the Hemlo camp have been offered by Patterson (1983, 1984), Knoll (1984), Hart (1985a, 1985b), Lefolii (1987) and Bittler (1988), among others. The following synopsis draws upon these and other sources, published and unpublished, including the Resident Geologist's Files (Ministry of Northern Development and Mines, Thunder Bay).

Beginning in December, 1979, prospectors Donald McKinnon and John Larche staked the claims surrounding the 11 patented Williams claims. The two men agreed to pool their claims in a partnership and unsuccessfully tried to find a potential optioner. In September 1980, an optioner was finally found in the form of Corona Resources Ltd., a Vancouver-based junior exploration company which later became International Corona Resources Limited. Following preliminary linecutting and geophysical surveys in late 1980, Corona began a \$600 000 drilling program, in January 1981, under the supervision of consulting geologist, David Bell. In March, R. Hughes and F. Lang optioned 156 of the partnership's claims which lie to the east and west of the Williams and Corona properties. These claims were put into the holding of their companies, Golden Sceptre Resources Ltd. and Goliath Gold Mines Ltd., who subsequently relinquished controlling interest to Noranda Exploration Company Ltd.

In May, 1981, representatives of LAC Minerals Ltd. visited Corona's drill site and exchanged information pursuant to a possible joint-venture agreement. While negotiations with Williams'

widow in Maryland for the Williams property were ongoing, diamond drilling was stepped back to the east of the outlined deposit. Drill hole 76 intersected a 10.5-foot (3.2 m) section grading 0.209 ounce gold per ton at a depth of 336.5 feet (102.5 m). This new, separate zone was the main Hemlo orebody. By August, 120 drill holes totalling 43 000 feet (13 106 m) had delineated 750 000 tons of rock grading 0.10 ounce gold per ton in the 'West' zone and had begun to indicate the much larger reserves of the 'East' or main zone (*Northern Miner*, August 13, 1981). Corona shares, buoyed up by the new discovery, soared from less than \$2 to \$34 by year-end. The Hemlo gold rush, ultimately involving 180 companies, ensued. Over 7000 new claims were staked in the area by the end of 1982.

Both Corona and LAC had been actively negotiating for the Williams property. In July, Mrs. Williams accepted LAC's offer. Corona, citing a breach of a fiduciary agreement, sued LAC for ownership of the Williams claims. Teck Corporation subsequently entered into a joint venture agreement with Corona in December, 1981 to develop what would become the David Bell Mine, presently controlled by the Teck-Corona Operating Corporation.

In August 1982, LAC announced the discovery of the deposit on their property, which would become known as the Page-Williams Mine. Drilling by Goliath Gold Mines intersected the northward-dipping extension of the ore zone. The Goliath part of the deposit became, after a joint venture with Noranda Exploration Company Limited, the Golden Giant Mine. In January, 1987, ownership of the Golden Giant Mine was gained by Hemlo Gold Mines Inc. by acquiring Golden Sceptre Resources Limited, and Goliath Gold Mines Limited (*Canadian Mines Handbook*, 1987-88, p.185). The major shareholder of Hemlo Gold Mines Limited is Noranda Inc. By the end of 1985, all three mines had commenced gold production.

In March 1986, after several months of testimony, the Supreme Court of Ontario awarded the Page-Williams Mine to International Corona Resources Ltd. LAC appealed the decision to the Ontario Court of Appeal but continued to operate the mine under conditions imposed by the court. The Ontario Court of Appeal upheld the earlier decision in October, 1987. The Supreme Court of Canada later granted LAC the right to appeal the provincial court ruling. In August, 1989, the Supreme Court of Canada awarded the Page-Williams Mine, Canada's largest gold producer, to Corona which shortened the name to the Williams Mine. In July, 1982, Homestake Mining Company took over Corona Corporation and thus acquired 50% interest in the Williams and David Bell Mines. The remaining 50% interest is still held by Teck Corporation.

PART 3: REGIONAL GEOLOGY

by

T.L. Muir, B.R. Schnieders and M.C. Smyk

The geology of the Hemlo area has been mapped by Thomson (1931, 1933), Bartley and Page (1957), Milne (1967, 1968), Muir (1982a, 1982b), and Siragusa (1984a, 1984b, 1985a, 1985b). This regional mapping (refer to Figure 14 on inside of front cover) shows that the Hemlo deposit occurs within a generally east-trending, mixed assemblage of Archean metavolcanic and metasedimentary rocks sandwiched between major granitoid bodies. These supracrustal rocks are part of what is termed the Schreiber-Hemlo greenstone belt of the Wawa subprovince.

Muir (1982a, 1982b, 1983) tentatively subdivided the Heron Bay-Hemlo part of the greenstone belt into two groups: (1) the southern Playter Harbour Group, comprising mainly tholeiitic mafic flows with subordinate, intercalated, intermediate to felsic tuffs and siltstones; and (2) the northern Heron Bay Group comprising mainly dacitic and rhyolitic calc-alkalic pyroclastic rocks and reworked equivalents, and tholeiitic basalts. A perceived progressive decrease in grain and fragment size, together with a general increase in the proportion of volcanoclastic and epiclastic sedimentary units toward the east, was interpreted in terms of a volcanic complex, centred in the Heron Bay area, that shed material into a distal basin to the east (Muir 1982b, 1983).

Subsequent to this interpretation and the discovery of the main part of the Hemlo deposit in 1981, more detailed mapping indicated the presence of a felsic volcanic pile in the vicinity of Hemlo (Brown *et al.* 1985). U-Pb geochronology has since shown that the volcanic piles at Hemlo and Heron Bay are notably different in age, being, respectively, 2772 Ma and 2695 Ma (Corfu and Muir 1989a). This suggests a simple proximal/distal facies model may not be appropriate. Consequently, Corfu and Muir (1989b) proposed that an extensive structural break (*i.e.*, the Hemlo fault) may separate 2 different assemblages of supracrustal rocks, although they pointed out this model poses its own problems.

In keeping with the above alternative model, Williams *et al.* (1991) have proposed a redefinition of the general construction of the supracrustal rocks east of the Coldwell Complex. In their scenario, the Hemlo fault as seen on Highway 17 near the Hemlo deposit, is extended west, between the Gowan Lake and Heron Bay plutons to the Coldwell Complex, and southeast to east-southeast from the Highway 17 location to the east end of the Schreiber-Hemlo greenstone belt. The extent and position of the fault is speculative at this stage and is not shown on the map (inside front cover). The supracrustal rocks are subdivided into the Heron Bay assemblage, south of the Hemlo Fault, and the Hemlo-Black River assemblage, north of the fault. Muir (1988) presented differences and similarities between lithological and structural features of the supracrustal rocks to the north and south of the Hemlo fault in the vicinity of the Hemlo deposit. Pan *et al.* (1991) maintain that there is a geochemical uniformity throughout the supracrustal rocks, to the north and south of the Hemlo fault several kilometres to the east of the Hemlo deposit, which, they suggest, favours a single tectonic environment, not a juxtaposition of suspect terrains. More detailed field work and additional geochronologic results are required to resolve this issue.

In any case, recent detailed mapping in the vicinity of the Hemlo deposit, and elsewhere in the Hemlo-Heron Bay part of the Schreiber-Hemlo greenstone belt, indicates that the interpretation and delineation of "groups" and simple facies changes in this belt is incompatible with the degree and style of deformation now recognized (*e.g.*, see Part 7).

U-Pb geochronology from zircon crystals indicates that there are 3 main generations of

granitoid plutonism in the Hemlo-Heron Bay area: ~2719 Ma, ~2688 Ma, and ~2678 Ma (Corfu and Muir 1989a). The following ages are from Corfu and Muir (1989a). To the south of the belt lies the Pukaskwa Gneissic Complex which consists mostly of weakly foliated to gneissic phases of tonalite and granodiorite (2688 Ma) with pegmatite and aplite dikes. A marginal zone (2719 Ma) possibly up to 1 km thick, exhibits a weak mylonitic fabric generally oriented parallel to the contact with the supracrustal rocks. Within this part of the greenstone belt lie two major granodioritic plutons: the Heron Bay Pluton (2688 Ma) to the west, and the Cedar Lake Pluton (2688 Ma), with the smaller, satellite Cedar Creek Stock (2684 Ma), to the east. To the north of the belt lies a granitoid gneiss complex, the Black-Pic Batholith (Milne 1968), which is separated from the belt by the crescent-shaped granodioritic to quartz monzonitic Gowan Lake Pluton (2678 Ma).

The metamorphic grade ranges locally from greenschist to amphibolite facies. The variations reflect the proximity to granitoid batholiths and/or the superposition of up to several episodes of metamorphism and hydrothermal alteration (Kuhns 1988; Kuhns *et al.* 1994; Corfu and Muir 1989b; Pan and Fleet 1992). The rocks of the Hemlo deposit area have undergone amphibolite facies regional metamorphism.

In the vicinity of the Hemlo deposit, Muir and Elliott (1987) and Muir *et al.* (1988) identified at least four generations of structures produced by at least two deformation events: (1) an early phase resulting in small-scale F_1 folds and possible low-angle normal or thrust faults; (2) a major, regional, second phase producing small- to large-scale, tight to isoclinal, generally northwest- to north-northwest-plunging F_2 folds, along with a penetrative axial planar schistosity and differentiated layering (S_2), possibly associated with sinistral shearing and mylonitization; (3) dextral shear which locally resulted in s-c-c' mylonitic rocks and small- to medium-scale, generally northeast- to east-plunging, F_3 folds with axial planar schistosity and crenulation cleavage (S_3); and (4) small-scale F_4 kink folds and brittle faults. A somewhat different structural history has been given in Kuhns (1986, 1988), Kuhns *et al.* (1994) (see Part 6), and Michibayashi (1991).

The interrelationship of structural elements and intrusive bodies in the vicinity of, and within, the ore zone at Hemlo suggests that intrusions such as the Cedar Lake Pluton and associated(?) dikes were likely emplaced after F_1 , during the late stages of, or after, F_2 , but before F_3 (see Muir 1993). The relationships between structural and metamorphic elements within the deposit remain somewhat controversial because of the complex, polymetamorphic/metasomatic character of the ore zone (*e.g.*, see Parts 5 and 6).

U-Pb geochronology of titanite, rutile, and monazite (Corfu and Muir 1989b) reveals a number of interesting features. Outside of an ill-defined broad zone of alteration and mineralization associated with the Hemlo deposit, titanite ages range from 0 to 10 Ma younger than zircon ages, averaging about 6 Ma younger. However, within this broad zone, titanite ages range from 13 to 15 Ma younger than zircon ages. Rocks outside the zone contain essentially no rutile, whereas many of the rocks within this zone do contain rutile crystals (and in one case, monazite) which are about 25 to 40 Ma younger than the titanite crystals. This suggests that an episodic or protracted thermal history has occurred within this zone, which lies within one of several high-strain zones (Corfu and Muir 1989b; Hugon 1986). However, it can be argued that this possibility can only be tested if rutile is also present, and dated, in rocks outside of the zone.

All of the aforementioned Archean rocks are intruded by much younger Proterozoic intrusive rocks including up to several ages of diabase dikes, and younger lamprophyre and alkalic dikes that are most likely temporally associated with the alkalic Coldwell Complex, centred west of Marathon. The Coldwell Complex has been dated at 1108 ± 1 Ma for early gabbroic and syenitic phases, and ~1099 Ma for late granitoid phases (Heaman and Machado 1987).

PART 4: PEEKONGAY PROPERTY

by

B.R. Schnieders and M.C. Smyk

The Peekongay property is located in Pic Township, centred near the town of Heron Bay, and extends from Lake Superior to the Pic River. It includes the sites of the former Heron Bay Mine and the mineralized Bowhill Mines test trench, and is currently held by V. Stenlund. The property has also been referred to as the Bowhill Mines property, the Stenlund property, and the Lytton Minerals property. The carbonate-quartz vein of the Heron Bay Mine outcrop (described below; see Stop 1 of road log as well) represents one type of gold mineralization that was discovered early in the history of sporadic exploration of the area, which began in the late 1860s. Recently, additional exploration, to the west, within 3 km of the Heron Bay Mine, has identified other gold occurrences and mineralized zones.

Lytton Minerals Limited optioned the property from Stenlund in 1982 and conducted 3 phases of diamond drilling, to May 1985, totalling approximately 40 000 feet (12 192 m) from 53 holes (Resident Geologist's Files, Schreiber-Hemlo District, Thunder Bay). The drilling resulted in the outlining of some additional gold-bearing zones, termed the "Porphyry Zone" and the "C Zone", as well as further delineating the "Main Zone" and a mineralized zone termed the "South Zone". The Main Zone includes mineralization in the Heron Bay Mine and the Bowhill Mines trench.

MINERALIZATION TYPES

Hartwick *et al.* (1985) described 4 major types of gold mineralization on the Peekongay property, which are summarized below, from Patterson (1986):

- "(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)."

The gold mineralization and mineralized zones are further described by Patterson (1986) based on the report of Hartwick *et al.* (1985).

"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 (0.91 m), but no ore grade intersections have been obtained.

"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."

Discontinuous and erratically distributed quartz-carbonate veins and stringers have been observed by the authors over a strike length of 2 km in the Heron Bay area.

The individual zones are described in more detail below.

MAIN ZONE MINERALIZATION

The Main Zone mineralization includes the old Heron Bay Mine site, and the old Bowhill Mines Trench site. As summarized by Patterson (1986):

"The zone consists of a series of sericitic units within felsic metavolcanic rocks and trends at 060° across the property. The moderately foliated sericite schist contains 5 to 10% blue quartz eyes that are up to 2 mm in size. The quartz eyes are deformed parallel to foliation. In the most strongly foliated sections, the quartz eyes 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 feet."

East of the Peekongay property, Esso Minerals Canada Limited reported results from a mineralized zone on strike from the Main Zone, with assays up to 1300 ppb Au and 280 ppm Mo across 0.6 m (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay).

Heron Bay Mine

The abandoned Heron Bay Mine is located adjacent to the community of Heron Bay, and is approximately 200 m west of Highway 627, and 30 m south of the CP Railway. The exploration history of the old mine dates back to 1869 with the discovery of veins by Moses Pee-Kong-Gay (Roland 1887). Two shafts (the eastern one is 8 m deep and the western one is 16 m deep), and some open cuts were developed in 1873 and 1874. Ore was apparently shipped and processed (McKellar 1874; Strickland 1979; Patterson 1984).

A carbonate-quartz vein, up to 1 m thick, is exposed on an approximately 70 m long stripped outcrop, in which 2 shafts are separated by about 40 m (see Road Log, Figure 16). The vein strikes at 270° to 300°, dips 70°N to vertical, and is hosted within a shear zone which cross-cuts the volcanic stratigraphy obliquely. The foliation within the metavolcanic rocks strikes from 245° to 262° and dips from 50° to 64°N. Mineral lineations trend 250° and plunge from 32° to 38°W.

The carbonate-quartz vein contains abundant ankerite (up to 70%) and black tourmaline, galena, chalcopyrite, pyrite, sphalerite, and molybdenite. Barite has also been identified (Patterson 1986). Patterson (1984) described the vein material thus:

"Samples of vein material, when slabbed, show several generations of vein development: (a) barren white quartz; (b) carbonate-rich; (c) tourmaline- and sulphide-bearing; (d) banded quartz-carbonate and barite."

Gold values within the vein are erratic and sporadic. Patterson (1984) reported a chip sample returned 0.22 ounce per ton Au and 3.00 ounces per ton Ag across 0.82 m. Grab samples, by the authors, of dump material assayed up to 0.04 ounce per ton Au. Samples from nearby pyritic quartz-sericite units assayed up to 0.314 ounces per ton Au over 0.9 m (Resident Geologist's Files, Ministry of Northern Development and Mines, Thunder Bay). Earlier workers reported that, at the

Number 1 shaft, predominantly copper-, zinc-, and lead-bearing minerals were found, along with gold and silver. However, at a depth of 35 feet (10.87 m), a rich "deposit" of gold and less copper was discovered (Resident Geologist's Files, Schreiber-Hemlo District, Thunder Bay).

The host volcanic rocks consist of interbedded, fine- to coarse-grained, pyroclastic rocks of intermediate to felsic composition. The metavolcanic rocks display intense shearing and alteration (bleaching) on the north side of the vein. The pyroclastic breccia is commonly matrix-supported except for the very coarse fragmental section. Two predominant clast types are present: a whitish quartz-porphyrific variety and a mafic, chloritic type containing feldspar phenocrysts. A sample of a quartz-porphyrific fragment within the altered zone, taken by the authors, assayed 102 ppb gold (Geoscience Laboratories, Ministry of Northern Development and Mines, Toronto).

Bowhill Mines Trench

The Bowhill Mines trench is within the Main Zone and is located about 1 km west of the town of Heron Bay. The following description of the trench is taken from an assessment file report submitted by Hartwick *et al.* (1985), for Lytton Minerals Limited:

"This trench, excavated by Bowhill Mines in the middle 1930s, is about 200 feet (60 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."

The following section is from Patterson (1986):

"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 dyke. The carbonate vein also contains black tourmaline and molybdenite.

"Stripping on the main zone just west of the Bowhill Mines Occurrence (1100 m east 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."

PORPHYRY ZONE

The following section is from Patterson (1986):

"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 (W.N. Pearson, personal communication, 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 sheared and deformed feldspar porphyry to the south."

The porphyry apparently contains 10% white quartz veins from 1 to 5 cm thick with minor pyrite and 3 to 5% black tourmaline. Diamond drilling intersected a 23.5 foot section within the porphyry near the hanging wall and had a grade of 0.19 ounces per ton Au (Patterson 1986).

C ZONE

The following section is from Patterson (1986):

"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 metavolcanic rocks 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."

SOUTH ZONE

The following section is from Patterson (1986):

"A sericitic zone similar to the main zone occurs approximately 100 m south of the Heron Bay Mine. Stripping and trenching has exposed quartz-carbonate veins within a sheared volcanic breccia. The veins contain chalcopyrite, galena, pyrite and tourmaline."

PART 5: HEMLO DEPOSIT OVERVIEW

by

B.R. Schnieders, M.C. Smyk and T.L. Muir

The Hemlo deposit is situated within supracrustal rocks in a southern bifurcated segment of the eastern part of the Schreiber-Hemlo greenstone belt. Page (1947a, 1947b, 1948, 1949) was the first geologist who recognized the Hemlo Fault as an important structural feature and identified the close co-planar relationship the fault had with the Lake Superior Shear Zone. He also recognized that all the gold discoveries at that time were hosted by the Lake Superior Shear Zone, and stated that the zone had been traced on surface for over 12 kilometres. Page also noted that the gold mineralization was associated with felsic porphyritic bodies and that the emplacement of these porphyries was related to a major structure which he termed the "Heron Bay-Hemlo Break".

The Hemlo deposit largely lies at or near the contact between felsic to intermediate quartz-feldspar-phyric rocks (pyroclastic and subvolcanic(?) varieties) and metasedimentary rocks. Here, the rocks generally strike at 290° to 295° and dip between 60° and 70° to the northeast. Hugon (1984) presented evidence that the Hemlo deposit is contained within a major ductile, dextral, shear zone. He interpreted that the deposit occupies the most intensely deformed, central portion of a large-scale, wide zone of ductile, oblique thrusting (Hugon 1986).

The Hemlo deposit is presently interpreted by the authors as being largely hosted within 290°-striking, highly strained, transposed, and juxtaposed, lithotectonic supracrustal segments, which lie in a generally east-striking greenstone belt. The deposit has not been demonstrated to be stratiform or stratabound. Sporadically distributed, anomalous gold mineralization has been noted, several kilometres southeast and east-southeast of the Hemlo deposit on the Lac Minerals Limited, White River property, as being spatially associated with sericitic and pyritic rocks within what is interpreted as a brittle-ductile shear zone (Pan and Fleet 1988, 1989, 1990; Pan 1990).

Underground mapping and drilling have demonstrated the existence of parallel mineralized zones within both the metavolcanic and metasedimentary rocks, as well as mineralized zones which transect the metavolcanic-metasedimentary contact. The Hemlo deposit orebodies, collectively, extend for a strike length of about 3.7 km, a depth of 1.35 km, and an approximate down-plunge distance of 2.5 km (see Figures 21 and 22). The main mineralized zone extends for a strike length of about 2.9 km, and a down-dip distance of 2.5 km (Harris 1989). The thickness of the main mineralized zone ranges from about 2 m in the David Bell Mine (Burk *et al.* 1986) to 50 m in the Williams Mine (Walford, Stephens *et al.* 1986).

Several types of ore are delineated in each of the 3 mines, based largely on the predominant mineral(s) and/or textures present. Commonly, because of extensive metasomatism and deformation, the mineralized zones comprise rocks of equivocal protolith(s). Alteration, collectively, is in the form of widely various degrees of microclinization, sericitization, biotitization, silicification, carbonatization, albitization, pyritization, and tourmalinization. Significant amounts of barite of equivocal origin are locally present. Bright green vanadian muscovite (Harris 1989) is commonly present in the altered rocks, as is molybdenite. At least two ages of quartz veins can be found within the ore zones: some veins display considerable folding, attenuation, boudinage, and dismemberment, whereas others display minimal deformation. In some cases, outside the ore zone, there are numerous quartz veins which tend to display a lower degree of deformation.

Collectively, the ores are enriched in Au, Mo, Sb, Hg, As, Tl, V, and Ba. Gold is commonly disseminated along with molybdenite. Native gold grains are mercury rich and occur along

quartz-feldspar and pyrite grain boundaries and fractures, as well as inclusions in, or rimmed with, several varieties of sulphide minerals including, rarely, pyrite and molybdenite (Harris 1989). Visible gold is not common overall, but does occur within quartz veins in feldspathized, molybdenite-bearing rocks, along molybdenite-green-mica-bearing fractures, in stibnite- and cinnabar-bearing quartz pods, and rarely in fractures in some of the plagioclase-porphyrific dikes. Molybdenite is the second most abundant sulphide, after pyrite, and occurs as fine- to very fine-grained, foliation-parallel blades, euhedral crystals, and platy masses mostly in association with silicate minerals, chiefly feldspar and quartz (Harris 1989).

During the past decade, since the discovery of the Hemlo gold deposit as it is now delineated, various metallogenic models have been proposed. As summarized by Patterson (1984), Harris (1986b, 1989), Corfu and Muir (1989b), and Muir (1993), earlier workers favoured syngenetic, exhalative models in which mineralization was penecontemporaneous with volcanism (*e.g.*, Cameron and Hattori 1985; Goldie 1985; Quartermain 1985; Valliant and Bradbrook 1986). Later workers suggested a porphyry deposit model (*e.g.*, Kuhns 1986, 1988; Kuhns *et al.* 1994; Johnston and Smyk 1992; Johnston *et al.* in press), structural/hydrothermal models (*e.g.*, Burk *et al.* 1986; Hugon 1986; Walford *et al.* 1986), and a skarn model (*e.g.*, Pan and Fleet 1991, 1992). It is interesting to note that the earliest observations in the Hemlo camp, made by Page (1947a, 1947b, 1948, 1949), invoked a close relationship between regional structure, local faults and shear zones, porphyries, alteration, and gold mineralization.

Geochronologic evidence, coupled with field and underground observations, attest to the difficulty in clearly defining the timing of the gold mineralization relative to deformation events, the regional metamorphic event(s), and hydrothermal alteration events (Corfu and Muir 1989b). This is also evident by the variety of differing observations, some apparently in conflict, reported by Burk *et al.* (1986), Kuhns (1986), Hugon (1986), Walford, Stephens *et al.* (1986), Muir and Elliott (1987) and Muir (1993). Muir and Elliott (1987) suggested that apparent conflicts in observations may be a result, in part, of comparing features related to different deformation and/or alteration and/or metamorphic events. They also noted that dextral shear zones did not everywhere control the site of mineralization and that the deposit has been affected possibly by two generations of structures, including at least some of the dextral-shear-related deformation.

In reviewing the various Hemlo genetic models, Harris (1989) stated that more recent research and evidence led to the recognition of features which tend not to favour the earlier syngenetic models but more strongly support ore deposition by hydrothermal fluids within or near a ductile shear zone. The Hemlo deposit has been ductilely deformed. Neither a temporal association between a porphyry intrusion(s) and the mineralizing event(s) nor a temporal association between the mineralizing event(s) and early ductile shearing has yet to be clearly established. In addition, disagreement exists as to whether the deposit formed prior to regional metamorphism (Kuhns 1986; Kuhns *et al.* 1994), pre- or syn-metamorphism (Burk *et al.* 1986), or post-metamorphism (Walford, Stephens *et al.* 1986; Pan and Fleet 1991, 1992). Muir (1993) has summarized some of the points that are consistent or inconsistent with the various depositional models proposed for the Hemlo deposit. The complex geological history of the Hemlo area has led to some incongruous observations or interpretations which only much-needed, careful, and detailed additional studies may help to resolve.

The past 15 years have resulted in a spectrum of geological observations, interpretations, and proposed models. Currently, no single genetic model adequately explains all of the complexities of the Hemlo deposit. It is possible that a combination of more than one model or the development of a new model may be required to account for the formation of the Hemlo deposit. Genetic models can be useful exploration tools but must be used with caution. The Hemlo deposit was "overlooked" for over 30 years, possibly in part, because it did not fit classic genetic gold deposit models.

PART 6: GEOLOGY OF THE GOLDEN GIANT MINE AND GOLDEN SCEPTRE OREBODY

by

Robert Kusins, Albert Chong, Paul Johnston, Doug McIlveen and Ken McNena

INTRODUCTION

The Golden Giant Mine is located 35 km east of Marathon, Ontario (Figure 2) and lies within the central part of the much larger Hemlo deposit. Three separate mining operations have been established on the deposit since its discovery in 1981. The Golden Giant Mine has been in production since April, 1985 and has produced 1 436 163 ounces of gold from 3 892 218 tonnes mined as of December 31, 1989. Current reserves, as of December 31, 1990, stand at 16 227 290 tonnes at 11.01 g/t, or 5.269 million contained ounces (178 662 kg).

The Hemlo deposit is situated within a "sequence" of moderate to locally high-grade clastic and volcanic rocks of the Schreiber-Hemlo greenstone belt. This belt ranges from 8 to 20 km in width and is part of the east-trending, Schreiber-White River section of the Wawa Subprovince within the Superior Province of the Canadian Shield (Muir, 1982a, 1982b).

The following descriptions and summary are taken, in part, from a field trip guide book prepared for the 8th IAGOD Symposium (Brown *et al.* 1990). A previous field guide covered additional features (Brown *et al.* 1986). Stratigraphic terminology in Part 6 of this field guide is used informally by Hemlo Gold Mines Inc. and Noranda Exploration Limited.

MINE GEOLOGY

The "stratigraphy" in the mine area as shown on the surface plan (Figure 3), has been subdivided into four major formations. From south to north they are the Cache Lake, Rule Lake, Moose Lake, and Cedar Creek formations. The Moose Lake formation is the most important economically as it hosts the main Hemlo deposit and a number of other mineralized zones. These formations represent a package of rocks approximately 3 km thick within the lower part of the Heron Bay group. Rocks in the mine area strike at 115° and dip 65° northeast.

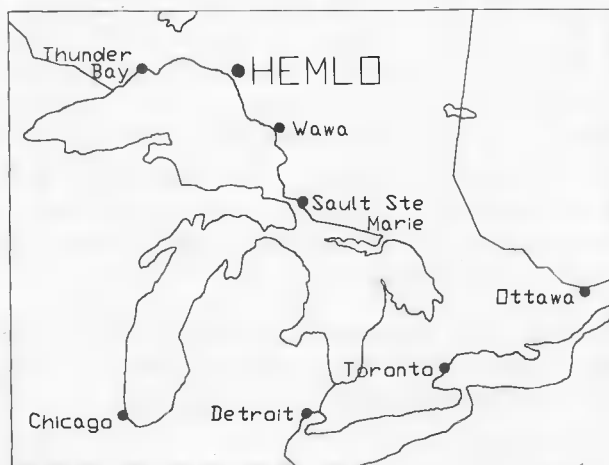


Figure 2. Location map of Hemlo.

The Cache Lake formation, which forms the structurally lowermost unit of the "stratigraphy", comprises mafic metavolcanic schists and granofels. In the deposit area, this formation is about 150 m thick. It was used as a distinct marker during initial deep exploration drilling of the deposit. Drill holes were normally stopped once they reached this formation, being deemed through the potentially favourable ore zones. The formation tends to be more highly sheared and contains hematite-filled fractures adjacent to its contact with the overlying Rule Lake formation.

The Rule Lake formation consists of laminated metasedimentary schists and gneisses. The total thickness of this formation is about 150 m in the mine area. The basal portion of the formation is dominated by amphibole-feldspar-biotite gneiss, whereas the upper portion is comprised of calc-silicate-rich metasedimentary rocks which commonly contain kyanite, staurolite, and garnet adjacent to the structurally overlying contact. This formation is comprised of rock types similar to the Cedar Creek formation and there is no observable difference between the two.

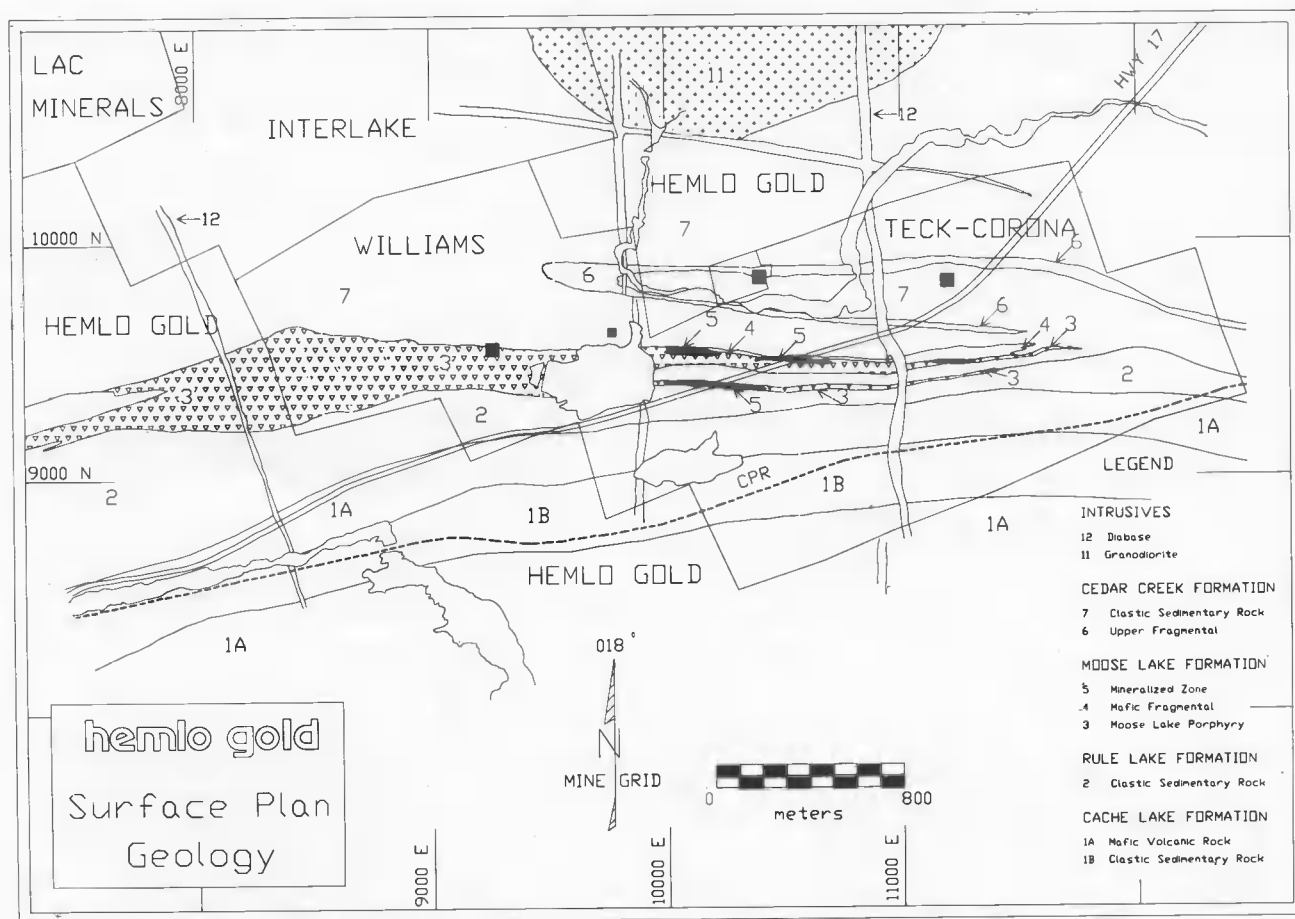


Figure 3. Geological compilation of the Hemlo camp (modified after Kuhns 1988).

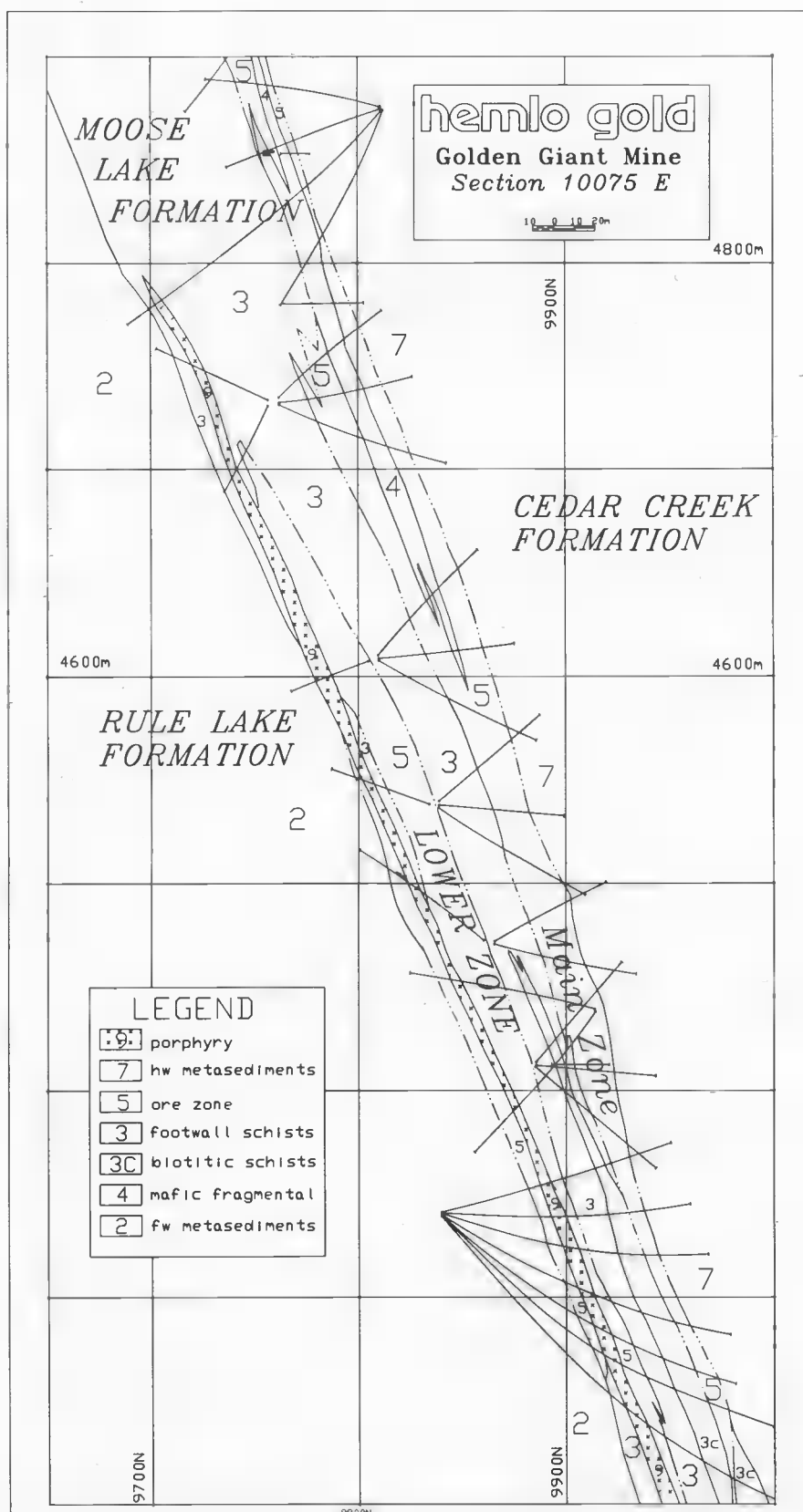


Figure 4. Generalized cross-section through the Golden Giant orebody.

The Moose Lake formation within the Golden Giant Mine, shown on a typical cross-section (Figure 4), can be subdivided into four units which, from south to north, are:

- (1) Lower Mineralized Zone;
- (2) Footwall Schists;
- (3) Mafic Fragmental;
- (4) Main Ore Zone.

The Footwall Schists are interpreted to have been derived largely from the Moose Lake Porphyry, which is a variably altered and deformed quartz-feldspar porphyry that constitutes much of the Moose Lake formation. This formation attains thicknesses up to 100 m in the mine area, and up to 400 m to the west of the deposit area. The formation pinches to the east until the Cedar Creek formation structurally overlies the Rule Lake formation. In this area, the transition between the Cedar Creek and Rule Lake formations is marked by an 8 m thick silicate and oxide facies iron formation.

Moose Lake Formation

Lower Mineralized Zone (Unit 5) The Lower Mineralized Zone, normally located along the contact between the Moose Lake and Rule Lake formations, forms a mineralized zone from 1 to 20 m thick. The thicker part of this zone, located in the lower western part of the orebody, is commonly uneconomic due to low gold grades. Locally though, the zone may contain economic gold grades over thicknesses of 3 m.

Economic mineralization within the Lower Mineralized Zone tends to be more restricted to the lower levels in the mine, generally in areas where the Main Ore Zone has begun to pinch out. Typical ore thicknesses are in the 2 to 5 m range, with this zone representing 2.2 million tonnes of the stated reserves. The predominant rock types are very similar to those in the Main Ore Zone and include feldspathic and sericitic varieties which locally may be baritic and/or pyritic. Gold mineralization tends to be less dependant on rock type in comparison to the Main Ore Zone.

Plagioclase porphyry sills, which essentially bisect the orebody along its length, are common within the zone and locally make either the hanging wall and/or footwall lenses uneconomic to mine. Overall, sills range in thickness from less than 1 m to in excess of 10 m.

Footwall Schists (Unit 3) The Footwall Schists generally structurally overlie the Lower Mineralized Zone, but it is common to get a thin zone developed on the underlying footwall side of the Lower Mineralized Zone. This unit typically is comprised of Quartz Eye Schist (Subunit 3a), Feldspathic Schist (Subunit 3b), and Biotitic Schist (Subunit 3c). It forms the structural footwall to the Main Ore Zone.

Subunit 3a dominates the Footwall Schist in the mine area and is comprised of quartz-muscovite±feldspar schists with distinctive 1 to 3 mm quartz lenses or "eyes" and, locally, fewer plagioclase eyes. This Quartz Eye Schist subunit, which is part of the Moose Lake Porphyry, may also contain minor tourmaline, anhydrite, green mica and pyrite. Adjacent to Unit 5 zones of mineralization, the subunit may be weakly mineralized, containing up to 5% pyrite, minor molybdenite, and gold values in the 1 to 5 g/t range.

Subunit 3b, termed Feldspathic Schist, is massive to weakly schistose and is comprised predominantly of feldspar, quartz, and lesser amounts of muscovite. Lenticular plagioclase eyes are common. Locally, generally in proximity to diabase intrusions, this subunit may be hematized and/or potassium-rich resulting in a pink to red colouration. Contacts between this subunit and

either the Quartz Eye Schist and plagioclase porphyry sills may be quite gradational. In the lower levels of the mine, the unit becomes more porphyritic in appearance and it is often difficult to establish discrete contacts between the Feldspathic Schist and plagioclase porphyry sills. The subunit locally is weakly mineralized with pyrite and molybdenite occurring within hairline fractures.

Subunit 3c, termed Biotitic Schist, consists of a quartz-biotite-muscovite schist which generally lacks quartz or plagioclase eyes. This subunit, which is not present in the upper levels of the mine, becomes more abundant in the lower levels, locally marking the strike extension of, or being proximal to, weakly mineralized zones within the Footwall Schists. This subunit may represent less altered metasedimentary rocks or a fine-grained Mafic Fragmental rock.

Mafic Fragmental Unit (Unit 4) The Mafic Fragmental Unit occurs between the Footwall Schists and the structurally overlying metasedimentary rocks of the Cedar Creek formation. The unit comprises lenticular fragments of feldspar porphyry, quartz granofels and biotite schist within a strongly foliated biotitic matrix. The distribution of this unit shows an overall antipathetic relationship with the Main Ore Zone, pinching out at depth and to the east and west of the Golden Giant orebody (Walford, Weicker *et al.* 1986; Burk *et al.* 1986). The predominant subunit is a Biotitic Fragmental (4a) having an average composition of 40% quartz, 24% biotite, 8% plagioclase, 7% actinolitic hornblende, 3% tremolitic hornblende, and 7% pyrite (Kuhns, 1988). The unit locally contains economic grades of gold mineralization but, in general, only contains anomalous gold values.

Other subunits within the Mafic Fragmental Unit consist of Sericitized Fragmental (4b) and Fine-grained Fragmental (4c). The Sericitized Fragmental commonly occurs as an altered zone between Biotitic Fragmental and ore units. It is characterized by the replacement of biotite with muscovite, and an increase in the amount of green mica, pyrite, molybdenite and gold. The Fine-grained Fragmental is generally difficult to distinguish from clastic metasedimentary rocks of the Cedar Creek and Rule Lake formations.

Main Ore Zone (Unit 5) The Main Ore Zone comprises several distinctive subunits that are characterized on the basis of mineralogy. In general, Main Ore Zone subunits contain molybdenite and tend to be either feldspathic or sericitic. Accordingly, the two most common subunits are Feldspathic Ore (5a) and Sericitic Ore (5b).

Subunit 5a consists of quartz-microcline granofels with 10% pyrite, 0.1% fine-grained molybdenite, and 1 to 3% green mica. The molybdenite gives the rock its characteristic blue-grey colour. Subunit 5a is commonly further sub-divided into high- and low-pyrite-barite-bearing varieties corresponding chemically to low- and high-aluminum contents, with pyrite-barite content increasing at the expense of microcline. Baritic-Feldspathic Ore (5d) contains fragments of Feldspathic Ore surrounded by a Au-Mo-poor granoblastic matrix of barite and/or pyrite. Siliceous Ore (5q) consists of a mixture of fine-grained feldspar, molybdenite, and quartz occurring in massive layers 0.5 to 5 m thick.

Pyrite occurs as very fine-grained, euhedral to anhedral crystals within the ore, and as coarser grains in the matrix of feldspathic ore that has undergone brittle deformation. There is no direct correlation between gold grades and pyrite content, although, in general, as the pyrite and barite contents of the ore increase, the gold grades decrease.

Molybdenite and green mica (vanadian muscovite) are the best visual indicators for the presence of gold mineralization. Gold occurs in native form along silicate grain boundaries (Brown

et al. 1985) and along pyrite-gangue grain boundaries (Harris 1986b). Visible gold has been observed in most subunits but is most commonly noted in feldspar-quartz pods or biotitic shears within the ore. The feldspar-quartz pods that occur in the green-mica-molybdenite-rich subunit may contain titanite, cinnabar, realgar, stibnite, sphalerite, pyrite, and molybdenite.

Cedar Creek Formation (Unit 7)

The Cedar Creek formation consists of a diverse group of clastic metasedimentary rocks which can be divided into 14 subunits (Kuhns 1988). The two most common subunits intersected by the mine workings at the Golden Giant Mine are Calc-silicate Subunit (7d) and Altered Sericitic Subunit (7e). The Calc-silicate Subunit is predominant and consists of brown to black, laminated and banded, fine-grained, granoblastic-textured, foliated, quartz-biotite-feldspar schist. This schist is interbanded with medium to dark green, amphibole-feldspar-biotite granofels. The unit may also contain minor kyanite, garnet, and staurolite. There appears to be an increase in abundance of alumino-silicate minerals proximal to the Moose Lake formation. The calc-silicate-rich bands become predominant in the lower levels of the mine. Some sections within the subunit consist of massive calc-silicate crystals, and commonly contain pyrite and pyrrhotite mineralization.

The Altered Sericitic Subunit is a pyritic, quartz-muscovite-feldspar schist spatially associated with the Main Ore Zone. It is fine grained, granoblastic textured, light brownish grey to grey, laminated and foliated, and exhibits gradational contacts with other units and subunits, of which it may be an altered or bleached equivalent. The average composition of the subunit is 46% quartz, 26% muscovite, 13% pyrite, 10% microcline, and 4% plagioclase (Kuhns 1988). Kyanite, is locally common. This subunit is slightly anomalous in gold and contains rare grains of molybdenite, green mica, and arsenopyrite. Pods consisting of quartz or feldspar are locally present, and may contain minor realgar and stibnite.

Intrusive Rocks

Intrusive rocks found in the Hemlo stratigraphy are divided into four units.

Feldspar-porphyrific, quartz monzonite and monzodiorite sills, referred to as Unit 9, occur as thin to thick (0.5 to 30 m), nearly concordant intrusions within and structurally below the Main Ore Zone, and less commonly in the hanging wall metasedimentary rocks. The sills occur individually or in swarms containing up to 20 sills, and are commonly foliated. Thicker sills (5 to 30 m) generally exhibit minor to moderate sericitization of feldspar crystals, and in places are cut by quartz+orthoclase+fluorite veins.

A particularly interesting intrusion occurs in the central part of the deposit, as observed on 4600 level (Figure 5). Here, an elliptical porphyry plug occupies the axis of a flexure in the geologic units. The plug plunges to the northwest at about 60° as outlined on the gram-metre-value longitudinal section (Figure 6). The intrusion shows a general transection from footwall to hanging wall with depth in relationship to the Main Ore Zone. The ore zone adjacent to this porphyry body is relatively thin.

Basaltic to dacitic sills, known as Unit 10, occur throughout the mine area. They are thin (5 to 50 cm) and cut all mineralization and alteration associated with the deposit. These "mafic sills", as they are commonly referred to in the mine terminology, are, on average, composed of 35 to 40% biotite, 35 to 40% hornblende, 10% plagioclase, 0 to 10% microcline, and 0 to 10% quartz, with minor zoisite, pyrite, magnetite, calcite, and titanite (Kuhns 1988).

The third main intrusive unit is the Cedar Creek Stock which is a small, oval, granitoid intrusion located about 800 to 850 m north of the Main Ore Zone. This intrusion is 2.5 by 1.5 km in surface extent, and its southern margin is subconcordant with the upper metasedimentary schists. The stock consists mainly of a medium-grained, hypidiomorphic-granular rock which has an average composition of 25 to 35% quartz, 15 to 35% plagioclase, 10 to 25% microcline, 10 to 20% hornblende, and 1 to 5% biotite, with minor magnetite, titanite, and apatite.

Diabase dikes represent Proterozoic mafic intrusions which cut the strata at high angles. These dikes, referred to as Unit 12, are composed mostly of pyroxene and plagioclase. Typically they exhibit gabbroic textures internally and grade outward to chilled margins. Four main diabase dikes cut the Main Ore Zone and range in thickness from 1 to 30 m.

Level Plan Descriptions

4750 Main Drift The 4750 Level drift plan (Figure 7) covers the main access to the Golden Giant orebody adjacent the shaft area, including both the hanging wall and footwall rocks. The hanging wall metasedimentary rocks in this area are composed mostly of Unit 7d "calc-silicates" with interbanded metapelites that are either garnetiferous (subunit 7a), or characterized by garnet-staurolite±kyanite/sillimanite (subunit 7b).

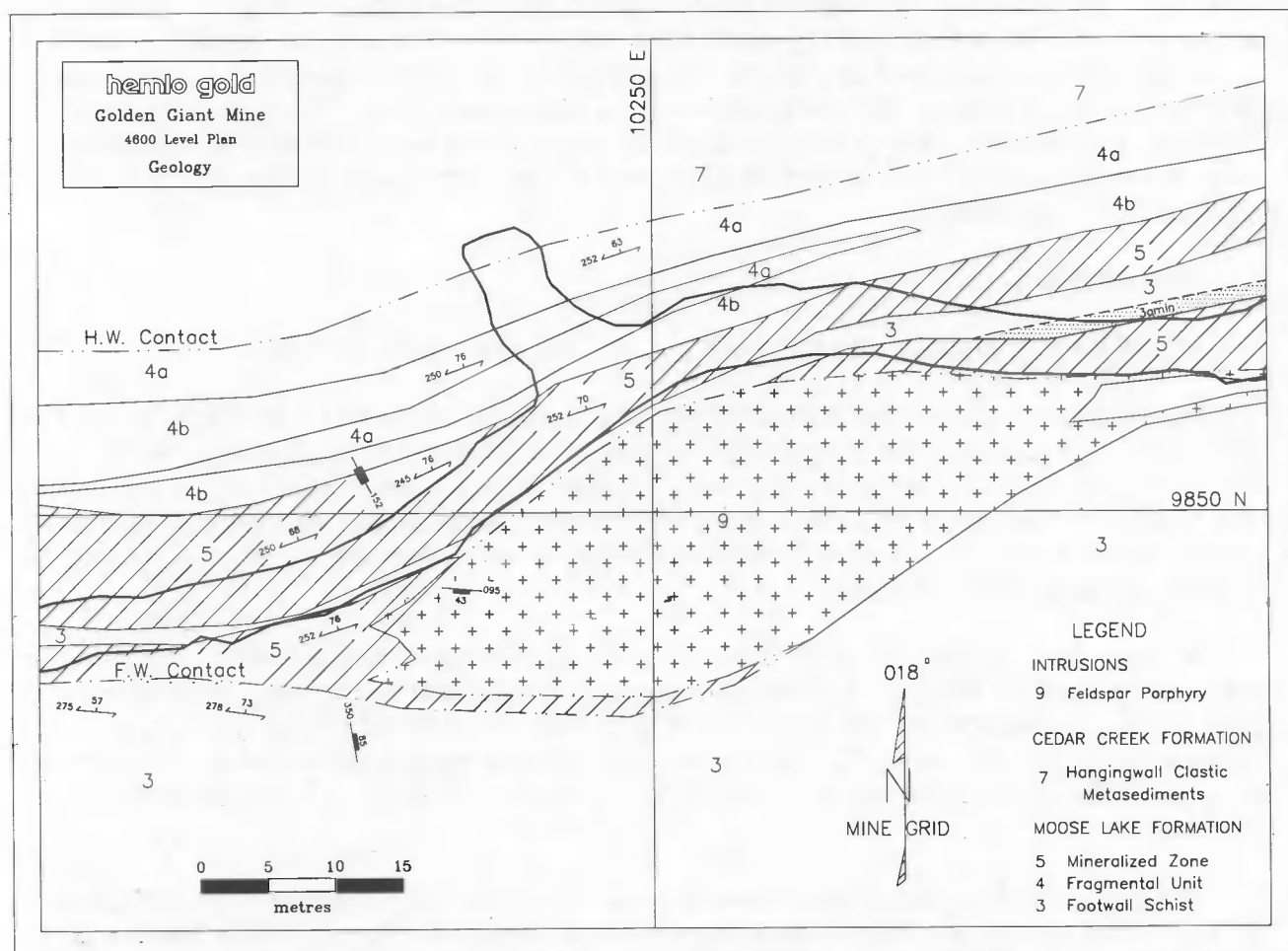


Figure 5. Level plan of part of the 4600 level showing the elongate plagioclase porphyry intrusion.

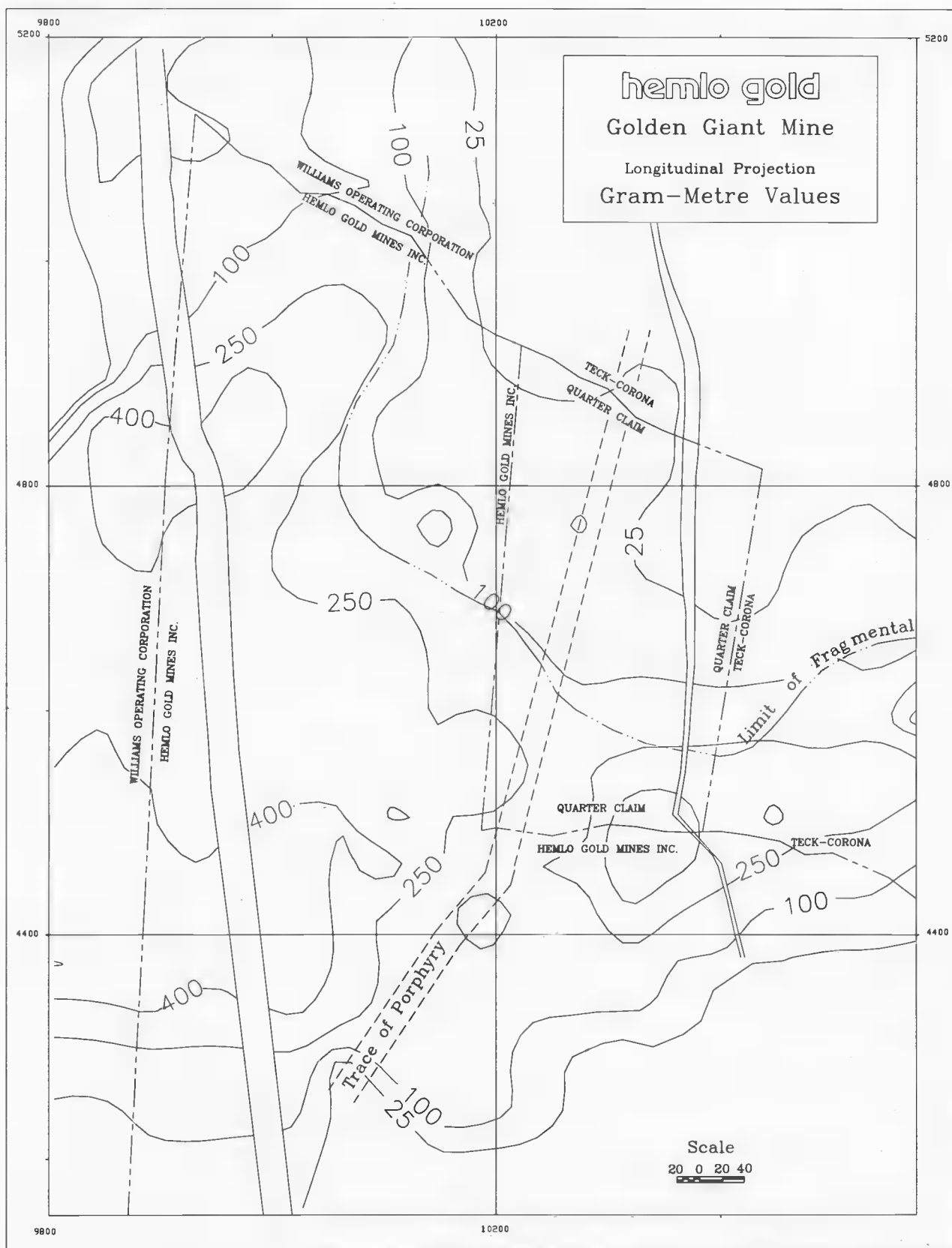


Figure 6. Longitudinal projection of the Golden Giant orebody showing gram-metre contours (Au grade by ore thickness in gram-metre/tonne values).

Moving south, or structurally downward through the strata, subunit 7e is encountered structurally above, and adjacent to, the Main Mineralized Zone. The quartz-muscovite-feldspar schist (subunit 7e) is almost everywhere found in this stratigraphic position, and is thought to represent the upper part of an asymmetrical, sericitic alteration envelope surrounding the Main

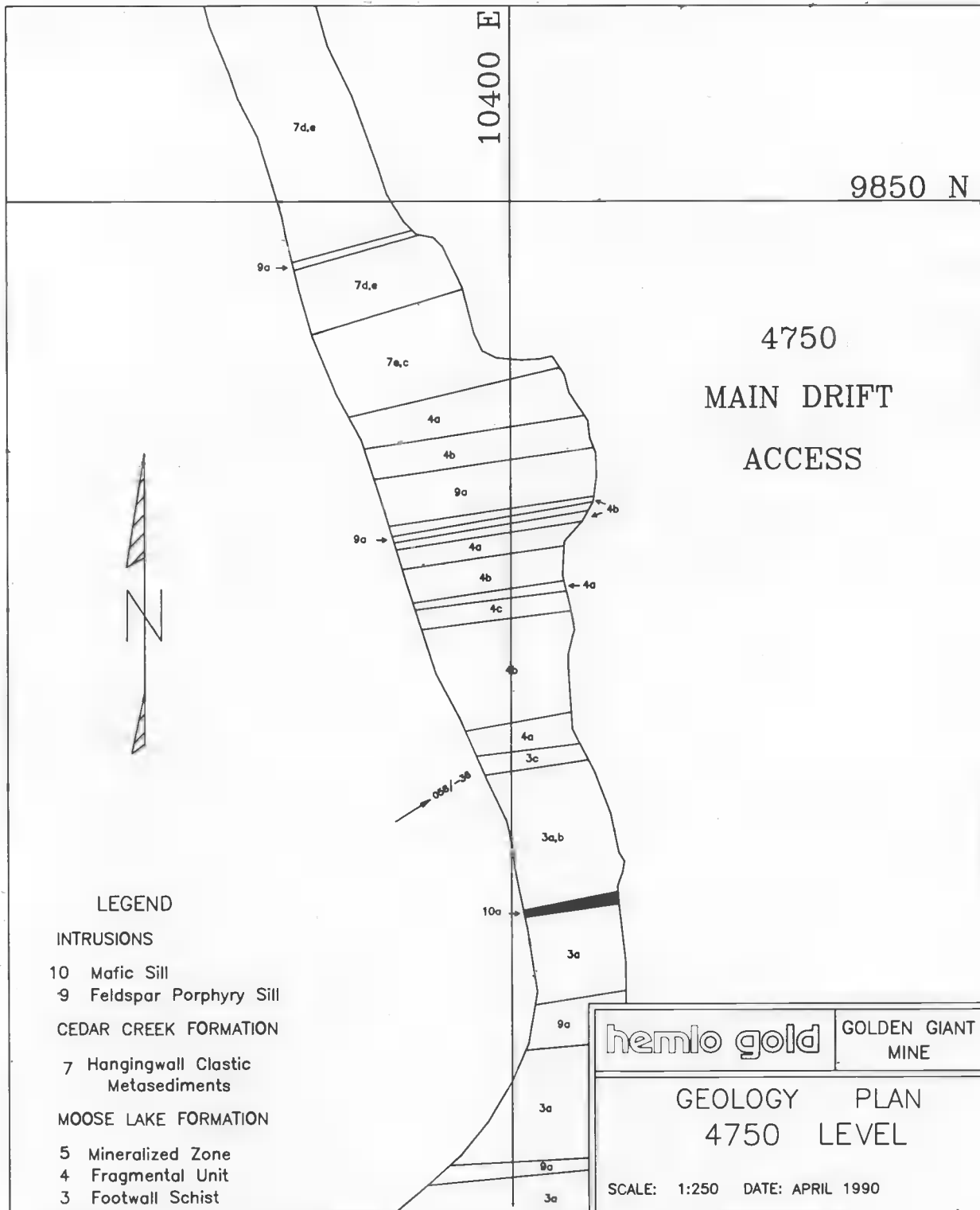


Figure 7. Geology plan of the 4750 main access drift.

Mineralized Zone. It is weakly mineralized, most obviously with pyrite, but studies show that it is also enriched in most of the ore-related minor elements (Ba, Ag, Hg, As, Sb). This unit also shows a very strong, pervasive planar foliation, the same as seen in the ore zone, indicating the sericitic alteration was developed prior to, or at the same time as, metamorphism and tectonism. Chip

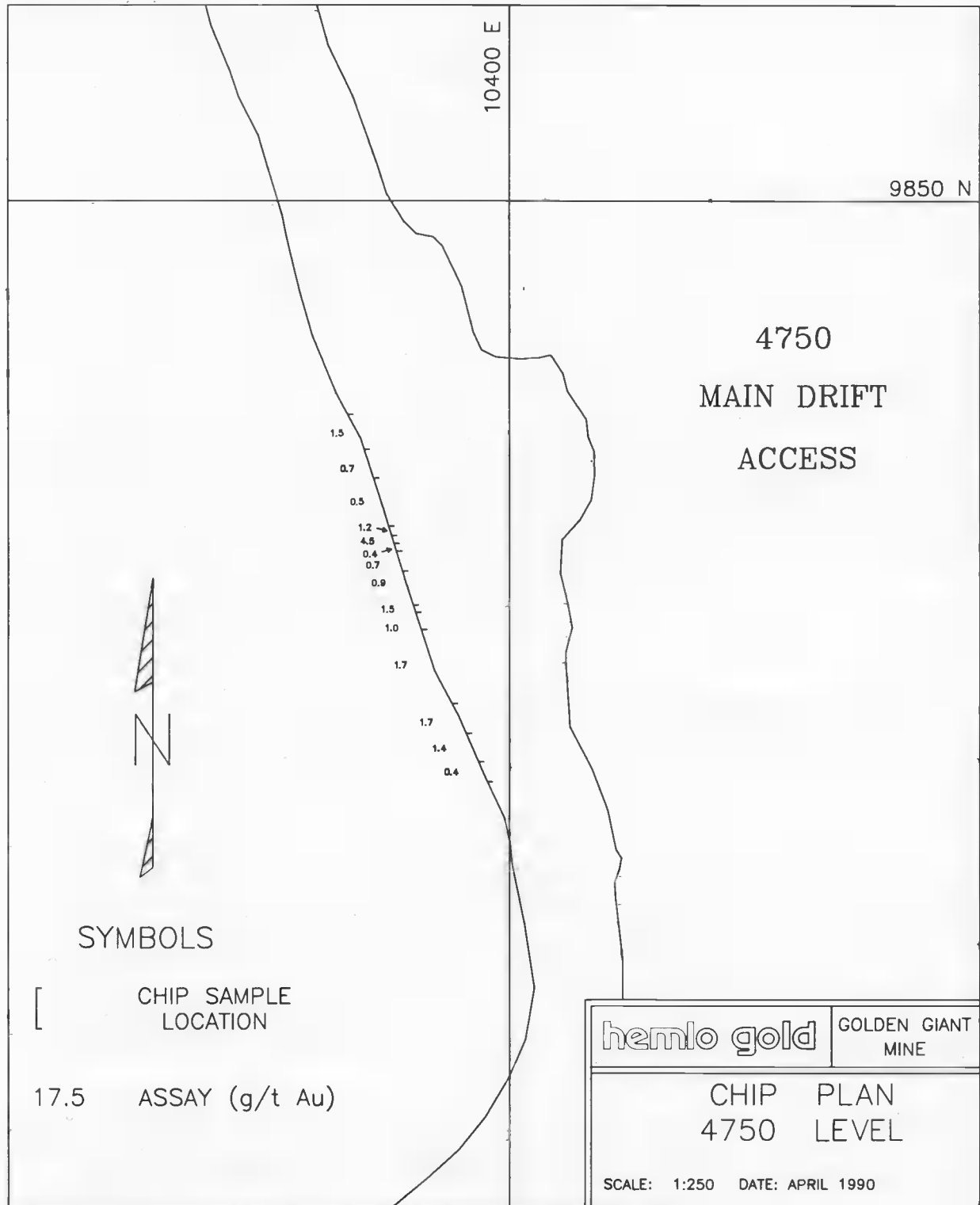


Figure 8. Assay plan of the 4750 main access drift.

sample grades (Figure 8) show anomalous gold values which are typical of Unit 4. These values are insufficient to meet minimum mining requirements currently set at 2.8 g/t Au over 3.0 m.

Moving southward again, into the footwall schist, subunit 3a is encountered. This quartz-muscovite-feldspar schist is the most common variety of Unit 3, and is characterized by lenticular quartz eyes and lesser plagioclase eyes, and commonly contains tourmaline crystals. This unit is rhyolitic in chemical composition (Kuhns *et al.* 1986) and is interpreted as being an altered porphyry intrusion which is part of the Moose Lake Porphyry. It is interbanded with subunit 3b, which is microcline-rich and contains lenticular plagioclase eyes. This buff to pink rock is marked by potassium enrichment, a decrease in muscovite, and a more massive texture. Plagioclase-porphyrific intrusions (Unit 9) and "mafic sills" (Unit 10) extensively cut the footwall schist throughout the extent of the Hemlo deposit. Here, feldspar-porphyrific, quartz-monzonite sills (subunit 9a), and fine-grained dacitic sills (subunit 10a) can be examined.

4700 Sublevel Plan - 0W, 2W Crosscuts The 4700 Sublevel plan (Figure 9) covers the 0 West and 2 West crosscuts located approximately half-way down dip on the Golden Giant part of the deposit, just west of the upper part of the orebody within the Quarter Claim. The ore at this location occurs as 2 lenses, termed hanging wall ore lens and footwall ore lens, separated by a body of subeconomic, Unit 4, quartz-mica-feldspar-amphibole schist. The hanging wall metasedimentary rocks are poorly exposed, as cutting into them with drift walls causes excessive dilution.

The ore exposed in the crosscuts and sill drifts is typical of the Golden Giant orebody, with occurrences of Feldspathic Ore (5a), Sericitic Ore (5b), and Baritic Ore (5d). The footwall ore lens is predominantly Baritic Ore, which is typical for most of the Golden Giant orebody. It contains some quartz-rich material (subunits 5d, 5q) and is cut by numerous "mafic sills" (subunit 10a). The body of Unit 4 quartz-mica-feldspar-amphibole schist separating the 2 ore lenses consists of, in part, a very representative example of the Biotitic Fragmental subunit 4a. At the contact between this body of Unit 4 and the footwall ore lens, is an occurrence of footwall schist that contains an unusual amount of green mica.

The hanging wall ore lens shows a distinct lack of barite and is typically composed of more Sericitic Ore (5b) as opposed to Feldspathic Ore (5a). The hanging wall contact of this ore lens is marked by the presence of the Calc-silicate Subunit (7d), with the more typical Altered Sericitic Subunit (7e) found further within the hanging wall.

Small-scale folding is observable within the footwall ore lens. Tight, eastward plunging Z-shaped folds with axial planes parallel to foliation are most common. Brittle units such as plagioclase porphyry sills and mafic dikes are boudinaged. However, there is no predominant elongation direction. Overall, the ore zone at this location shows moderate to strong tectonic disruption as indicated by the folding visible in the footwall ore lens, boudinage of mafic sills (subunit 10a), and offsets along cross-cutting fractures. The degree of tectonic disruption is greater here as compared to the rest of the Golden Giant orebody, due, in part, to the lenticular nature of the ore. Parts of the orebody that are composed solely of Unit 5 generally show less tectonic disruption.

Grade distribution within the footwall ore lens at this location (Figure 10) is typical of the deposit. The footwall lens shows lower-than-average grades as compared to the hanging wall lens, due to increased amounts of barite and pyrite which tend to dilute the gold content.

Observations

To date, the following observations have been made concerning the principal features of the Golden Giant orebody:

1. Overall, the Main Ore Zone is neither demonstrably stratiform nor strata-bound. Non-economic mineralization generally has the same form as the Main Ore Zone. High-grade subzones within the Main Ore Zone tend to show transecting relationships, from footwall to hanging wall, with increasing depth in section and from east to west in plan. These same transecting relationships are exhibited by the plagioclase porphyry sills, whereas the relative orientation of the mafic sills is too irregular to permit a valid generalization.
2. Ore is hosted within a variety of lithological units. Protoliths are very difficult to determine as a result of the high degree of metamorphism and deformation, but are thought to be represented by mudstones, as well as felsic and mafic volcanic and volcanoclastic rocks. The distribution of the Mafic Fragmental Unit shows an antipathetic relationship to the distribution of the ore.
3. The predominant style of mineralization in the Golden Giant orebody is disseminated gold and molybdenite within rocks containing the assemblages microcline-quartz, muscovite-quartz, biotite-microcline-quartz, and rarely, calc-silicate minerals. A secondary, minor style of mineralization consists of gold, stibnite, and cinnabar within deformed quartz pods and veinlets.
4. High gold grades within the Main Ore Zone are related to high relative abundance of molybdenum and vanadian muscovite (green mica). Low gold grades are noted in Main Zone Ore subunits containing abundant coarse pyrite and/or greater barite contents.
5. Ore-related elements found in spatial association with the Au and Mo mineralization include Hg, Ag, Ba, As, Sb, V, Zn, and locally minor W, Te, and Tl. Studies indicate strong spatial correlation between Au, Ag, and Mo as the principal disseminated ore type, and Au, Hg, and Sb as a minor, quartz pod (remobilized) ore type (Kuhns 1988).
6. Ore is hosted within amphibolite facies metamorphic rocks, and mineralization preceded peak metamorphism. This is indicated by the presence of kyanite and sillimanite in the hanging wall metasedimentary rocks adjacent to the ore zone and by gold grains in contact with prograde kyanite (Kuhns 1988).
7. Alteration consists of an interior potassic (microcline/biotite) zone with localized silicification and pyritization, a surrounding sericitic/phyllitic (muscovite±pyrite) zone, and an outer, discontinuous aluminosilicate (kyanite) "halo" (Figure 11). Secondary alteration consists of calc-silicate (actinolite/tremolite) zones in and around the mineralized rocks; a weak, widely distributed, fracture-controlled, sericitic alteration (bleaching); a secondary aluminosilicate (fibrolite) zone coincident with the kyanite zone; and local carbonate alteration associated with parts of the barren hanging wall rocks or locally within biotitic subunits within the Main Ore Zone.
8. Mineralized zones are spatially associated with a highly deformed and mineralized quartz eye porphyry (footwall schist), and numerous post-mineralization feldspar porphyry sills and dikes related to the Cedar Creek Stock and Cedar Lake Pluton.
9. At least 3 deformational events have been recognized in the Hemlo area (Kuhns 1988):
 - (i) Pre-peak metamorphic isoclinal folding and faulting. This first event is recognized by the presence of isoclinal folds through which a penetrative metamorphic fabric has developed.
 - (ii) Syn-peak metamorphic isoclinal folding and post-peak metamorphic ductile-brittle shearing and associated drag folding. The second folding event is indicated by the presence of isoclinal folding of the metamorphic fabric and refolding of F_1 generation structures. The ore zones and non-mineralized country rocks are strongly foliated and exhibit dextral mylonitic and cataclastic textures attributed to post-peak metamorphic, ductile-brittle shearing.
 - (iii) Late brittle faulting. Brittle deformation is indicated by multiple, well-developed, angular fault breccias and clayey to rock flour-rich gouge zones which are developed subparallel to the regional metamorphic fabric.

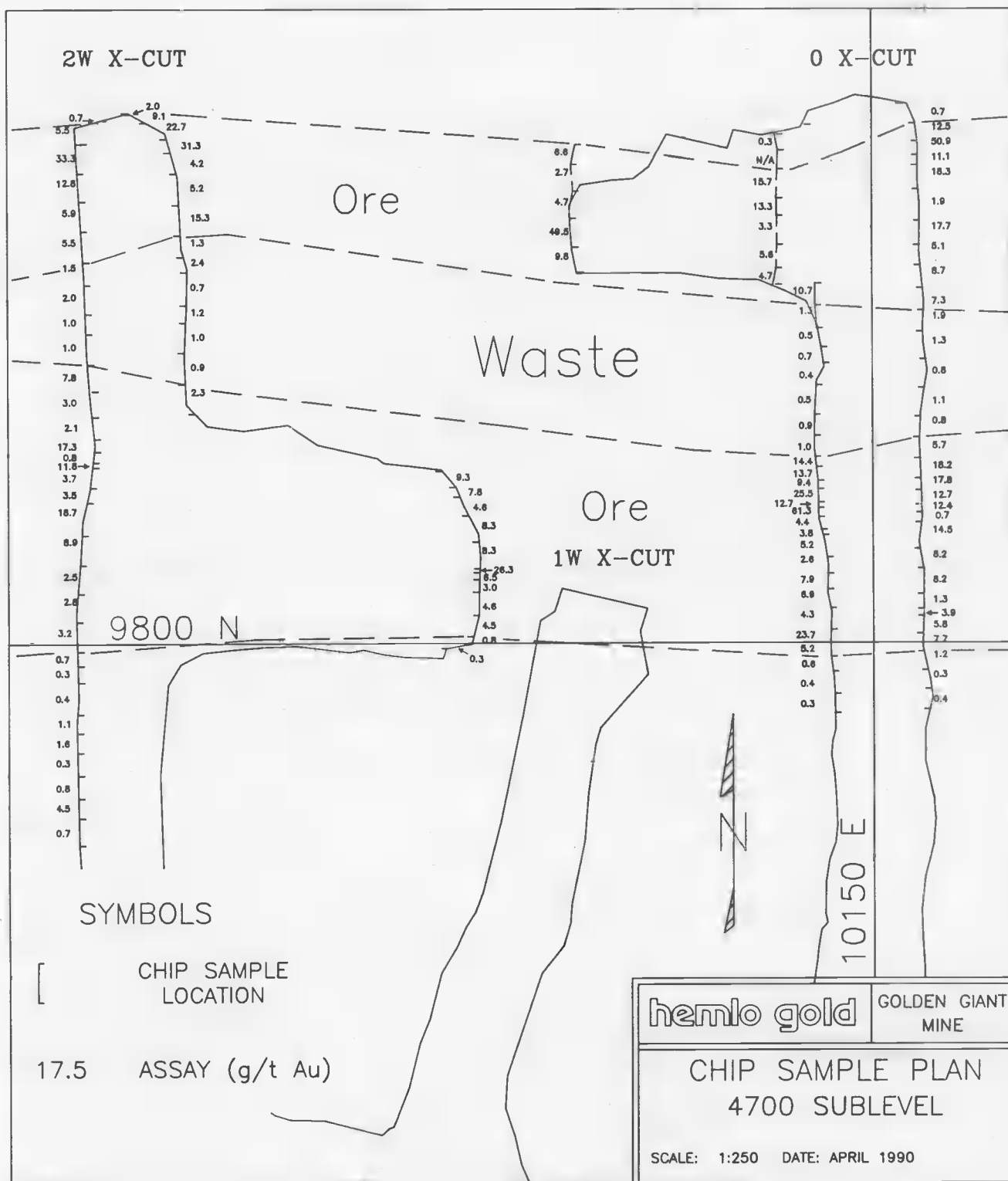


Figure 10. Assay plan of the 4700 level.

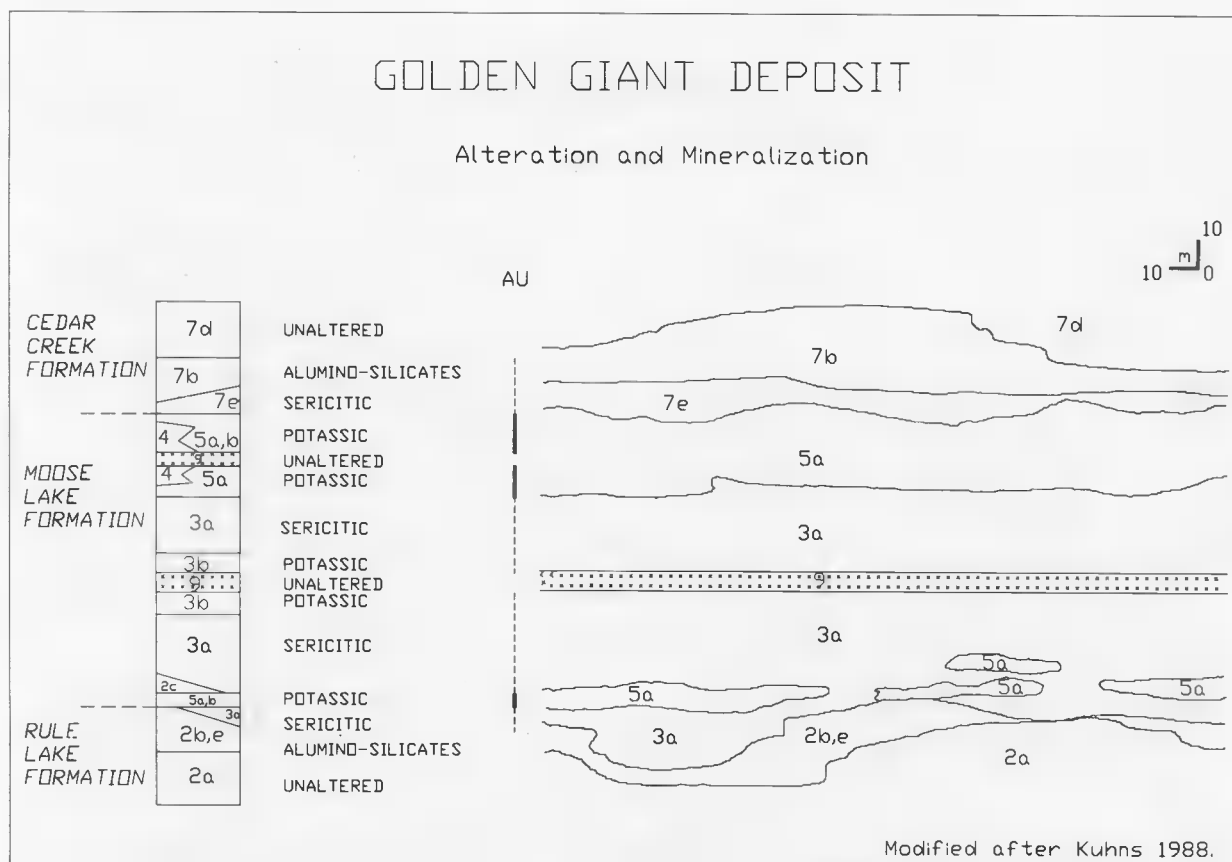


Figure 11. Generalized spatial relationships of alteration and mineralization characteristics of the Golden Giant orebody. Modified after Kuhns (1988).

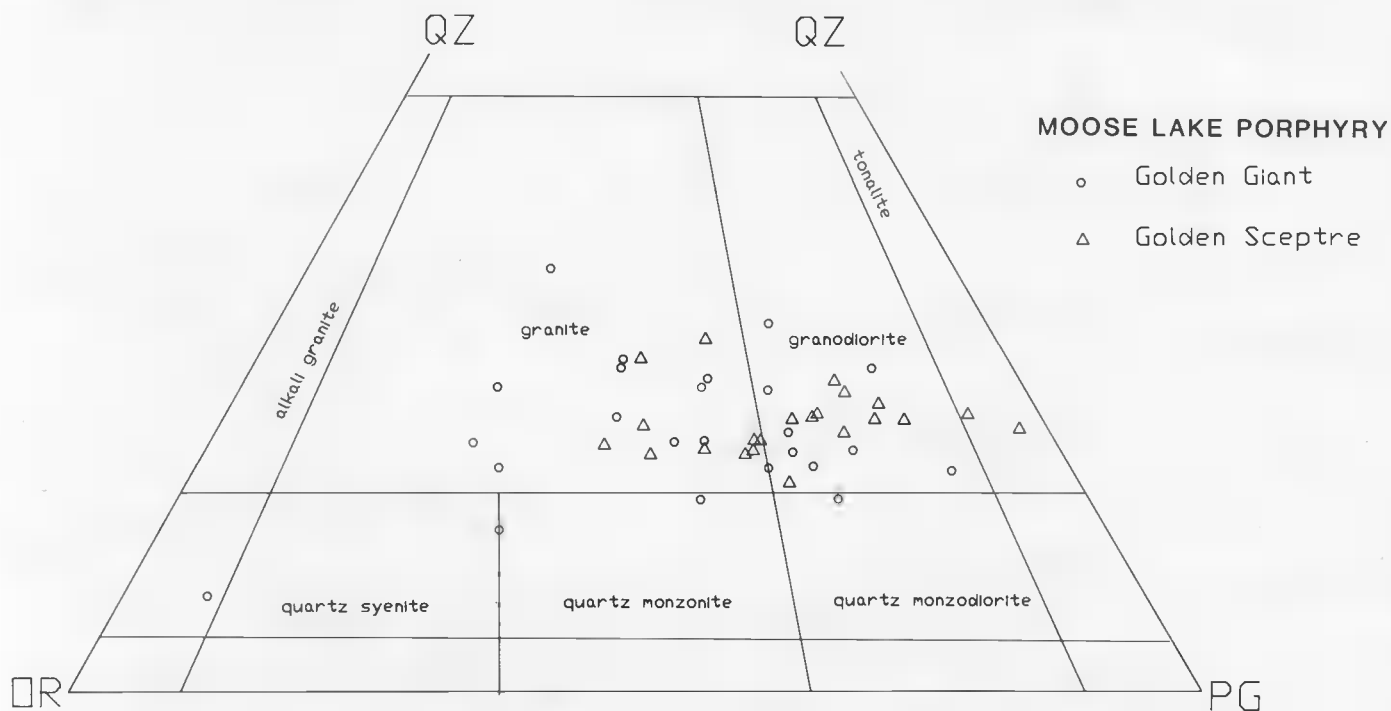


Figure 12. Normative orthoclase (OR), plagioclase (PG), and quartz (QZ) plot for the Moose Lake Porphyry from the Golden Giant and Golden Sceptre areas. Modified after Kuhns (1988).

GOLDEN SCEPTRE PROPERTY

In the summer of 1990, Hemlo Gold Mines Inc. began open pit mining of the North Zone of the Golden Sceptre property. Mining was carried out in conjunction with a quarrying operation that was to provide rockfill for a tailings dam expansion project.

The Golden Sceptre pit/quarry is situated about 1.5 km west of the Golden Giant minesite. Numerous, weakly mineralized zones have been identified on the Golden Sceptre property. The most promising of these zones, referred to as the North Zone, is currently being mined. Approximately 180 000 tonnes at a grade of 2.6 g/t Au will be extracted from the North Zone and milled at the Golden Giant Mill.

The North Zone occurs within a package of probable clastic metasedimentary and felsic metavolcaniclastic rocks. Host rock protolith determination is difficult due to deformation and alteration. North of the mineralized zone, rock types are more obviously sedimentary, consisting of metamorphosed equivalents of sandstone, pelite, and minor conglomerate.

The Moose Lake Porphyry body (Golden Sceptre porphyry of Kuhns, 1988), lies about 100 m south of the Golden Sceptre pit. Kuhns (1988) recognized three textural varieties of the Moose Lake porphyry on this property, which comprise: a predominantly unaltered, minimally strained, feldspar porphyry; a weakly foliated, mica-bearing, feldspar porphyry; and a minimally altered and strained quartz porphyry. Normative quartz+orthoclase+plagioclase abundances indicate a granite to granodiorite composition (Figure 12). Variation in composition is likely due to alteration (Kuhns 1988). Comparable rocks found within the Moose Lake Porphyry may be found in the Footwall Schist of the Golden Giant orebody and have been referred to as the Golden Giant porphyry (Kuhns 1988).

North Zone mineralization is characterized by stockwork molybdenite-filled fractures accompanied by feldspar and biotite alteration. The most obvious alteration occurs as fine-grained, feldspathic selvages about molybdenite-(±green mica)bearing fractures. Biotite is commonly developed beyond the feldspathic alteration. Carbonate is pervasive throughout the entire mineralized zone.

The stockwork zone has been slightly flattened parallel to the regional foliation. Feldspathic margins of fractures oriented perpendicular to foliation are wider and folded relative to contiguous linear fractures oriented parallel to foliation (Figure 13). Complex cross-cutting relationships between mineralized and unmineralized fractures and overprinting of alteration suggests multiple fracturing and mineralizing events.

Visible gold is observed along the molybdenite- and green mica-bearing fractures and within the feldspathic alteration rind. There is a direct relationship between gold mineralization and the amount of molybdenite and green mica. Where molybdenite stockwork fracturing is intense, gold grades in excess of 15 g/t Au have been measured. Euhedral, black tourmaline crystals occur along fractures bearing molybdenite + green mica±pyrite. The tourmaline grains are randomly oriented within the fracture planes and in some cases are boudinaged. Randomly oriented tremolite and carbonate crystals within vein-like structures or discrete lenses cross-cut the feldspar rinds and molybdenite-green-mica-bearing fractures.

DISCUSSION

Geological relationships evident on the Golden Sceptre property have been useful in understanding the Hemlo deposit. The similarities and differences between the Golden Giant and Golden Sceptre orebodies are discussed below.

The gold grade of the Golden Sceptre orebody is much lower than that of the Golden Giant orebody. In the Golden Sceptre orebody, gold mineralization is confined to narrow fractures dispersed throughout large volumes of barren rock, whereas in the Golden Giant orebody, mineralization is contained in a zone of pervasively and intensely fractured, feldspathized, and subsequently strained rocks.

Intense sericitic alteration typical of the Golden Giant orebody is not developed on the Golden Sceptre property. Since the competency of the host rocks has not been reduced by sericitization, strain is much lower on the Sceptre property than on the Golden Giant property.

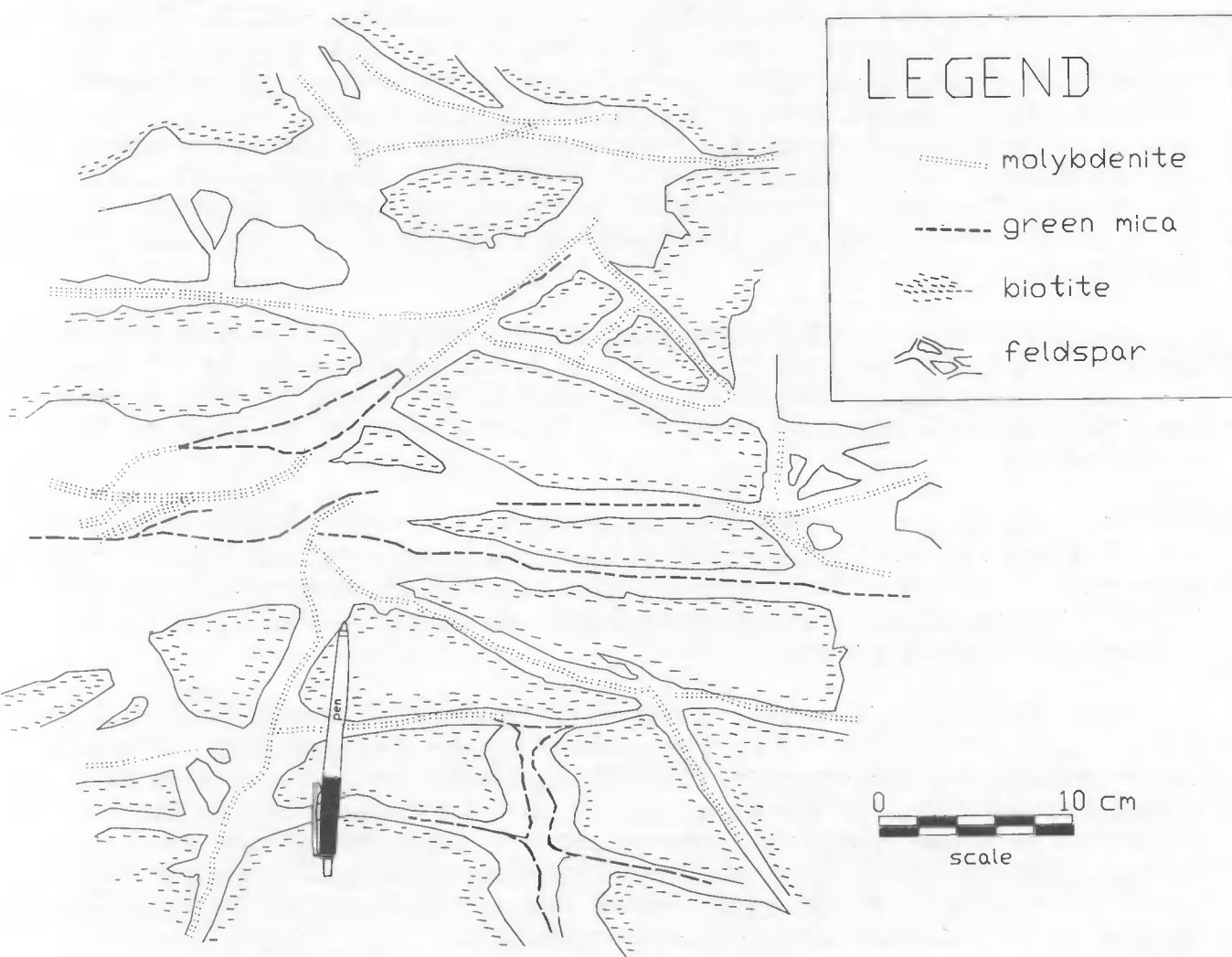


Figure 13. Tracing from a photograph showing the style of alteration and mineralization of the Golden Sceptre orebody.

The 2 orebodies display similar mineralogy. Both deposits show the same relationship between gold grade and the abundance of green mica and molybdenite. Feldspathic alteration is associated with gold mineralization on both properties, however, it is not as intense or pervasive on the Golden Sceptre property.

The Hemlo deposit is commonly described as a disseminated gold-molybdenum deposit, implying that gold and molybdenite are evenly distributed throughout the ore zone. Close examination of ore at a hand sample scale reveals that molybdenite (and gold where observed) is concentrated along anastomosing seams and vein structures within pervasively feldspathized rock. It is becoming apparent that the style of mineralization of the Golden Sceptre and Golden Giant orebodies is similar. The Golden Giant orebody represents a much more altered, and mineralized, equivalent of the Golden Sceptre orebody.

Golden Sceptre mineralization exhibits the same spatial relationship to felsic rocks as does the Golden Giant mineralization. The occurrence of the Golden Giant orebody at the interface between quartz-eye schist (Moose Lake Porphyry) and pelitic metasedimentary rocks is now well established. Although the Golden Sceptre North Zone orebody is not in direct contact with the Moose Lake Porphyry, it is proximal to it. Other mineralized zones on the Golden Sceptre property occur within the Moose Lake Porphyry. Except for differences in strain, the parts of the Moose Lake Porphyry at the Golden Sceptre property and in the Golden Giant Mine are very similar in appearance.

There has been much dispute over the origin of the Moose Lake formation and many different protoliths have been suggested to explain favoured genetic models. It is tempting just to declare Hemlo a rock-hosted deposit and be done with it. Whatever the origin of the Moose Lake formation, it empirically is the locus of hydrothermal alteration and mineralization.

SUMMARY

The Hemlo deposit has undergone a complex geological history which makes genetic modelling of the orebody rather difficult. One of the key points that has been recognized is that the distribution of the ore zones is strongly controlled by the presence of the Mafic Fragmental unit which has resulted in well-defined contacts between ore and host rocks. The distribution of the Mafic Fragmental unit shows an antipathetic relationship with the gold mineralization and may have provided, or represented, an extension of a suitable site for focussing mineralization. In addition, the plagioclase porphyry intrusions commonly follow the same trends as the higher gold grades, indicating a strong spatial association and source for the mineralizing event.

Hemlo Gold Mines Inc. is committed to an ongoing, detailed examination of the Hemlo deposit and surrounding area. This commitment, in the form of exploration drilling, structural and geochemical studies (both in-house and academic), three-dimensional computer-aided modelling, and sharing of information with neighbouring operations, will help towards a better understanding of this world-class gold deposit.

PART 7: ROAD LOG FOR THE HEMLO-HERON BAY AREA

by
T.L. Muir

INTRODUCTION

The road guide in this volume incorporates over 30 stops, many of which are not part of the actual field trip. It is hoped that the guide will provide an opportunity for subsequent self-guided tours by other geologists. Stops intended for a 3-day overview trip are flagged with an asterisk (*) and cover many of the features in the Hemlo area, and some of the features in the Heron Bay area. The additional stops are intended to provide a more complete picture. **It is mandatory to obtain permission from the appropriate mining and exploration companies to examine outcrops that are not on the highway right-of-way.** Such stops are indicated.

Over the last ten years, many of the exposures in the Hemlo area have undergone partial to radical face-lifts, including obliteration. Those outcrops in the immediate vicinity of the mines have been the most susceptible, but even the highway exposures have undergone at least three phases of modification since the late 1970s, largely due to road construction. The latest and most extensive phase involved the removal, during the 1989 field season, of up to 2 m of the exposures back from either side of the highway for safety, drainage, and esthetic(?) reasons. This resulted in the loss of many features that have hitherto been shown on previous trips (*e.g.*, Patterson 1984; Quartermain 1985). The outcrop descriptions provided in this guide have been updated, as much as possible, to reflect what is observable. Additional information, based on previous exposures, is provided and so noted. A few further changes in outcrop or road configuration have occurred since the original publication of this guide in 1991. All Stops have had metal (claim) tags with embossed Stop numbers attached to the outcrops (somewhere) for cross-referencing with the field guide.

The 3-day field trip version begins in Heron Bay (Figure 14, inside front cover) with an examination of pyroclastic rocks, typical of this section of the greenstone belt, at the Peekongay property, which is one of the more interesting gold occurrences outside of the Hemlo area. Following this, the Northern Eagle property, located about 21 km west of the Hemlo deposit, can be examined. Here alteration and mineralogy are similar to that of the Hemlo deposit, with the notable exception that gold (and possibly molybdenite) is present only in low and erratically distributed amounts.

Next, at the outskirts of the Hemlo deposit area (see Figure 18), the Homestake property can be visited, in order to view a variety of features and to provide an opportunity to discuss the relevance to the Hemlo deposit. Finally, a visit to the erratically auriferous, low-grade Highway Zone and to the Hemlo fault zone, which is near and subparallel to Highway 17 for several kilometres, should complete Day 1.

The second day of the planned field trip includes: a detailed examination of the tectono-stratigraphic section through the Hemlo deposit along Highway 17; a visit with the staff of the Williams property to see some exposures that are illustrative of the structural and alteration complexities in the immediate vicinity of the Hemlo deposit; and a visit with the Hemlo Gold staff to examine core and specimens from the Golden Giant Mine. The section along Highway 17 is presented in an east-to-west direction because this allows the field trip participants to start with the least strained and/or altered rocks and work towards an increasing number of geological conundrums.

Two figures are repeatedly referenced in the text. Figure 14 shows the regional geology of the Hemlo-Heron Bay area, along with some of the accompanying field stops, and is located on the

inside front cover. Figure 19 shows the local geology of the Hemlo deposit, along with most field stops, and is located on the inside back cover.

It will become evident over the course of the tour that many of the rocks, particularly those in the Hemlo area, have undergone considerable deformation and, locally, alteration, which have developed heterogeneously. It is acknowledged, therefore, that these factors, coupled with the effects of metamorphism, render lithologic terms, used to denote primary rock types, quite interpretive in many cases. The terms used in this field guide are based on the examination of many rocks in the area and their applicability may not be readily apparent in any one outcrop. In many cases, there is no consensus, among geologists, of the interpretation of protolith, structural features, metamorphic and/or alteration features, and relative timing of the various related events, including in some cases, intrusive relationships (see Muir 1993 for a more detailed discussion).

Another point to note is that the present configuration of the units, for instance as viewed along the highway for this trip, represents a highly modified crustal section. The rocks have undergone various stages of folding, transposition, attenuation, shearing (*i.e.*, largely ductile), and faulting (*i.e.*, largely brittle). The units shown in Figure 19, for example, actually represent an assemblage of lithotectonic components, only some of which preserve reasonably original stratigraphic segments. In the more highly strained parts of this greenstone belt, the original stratigraphy is a matter of notable conjecture, and hence, no formal stratigraphic nomenclature has been applied.

A simplified interpretation of the structural history used for this field guide is based on Muir and Elliott (1987) and given below. Structural measurements are presented in this guide using the right-hand rule (*i.e.*, strike given such that dip direction is to the right).

S_0 refers to bedding, generally with primary sedimentary features. S_1 refers to a compositional layering similar to bedding but which lacks sufficient criteria to be termed S_0 with confidence. S_0 and/or S_1 are locally folded (F_1), apparently on a small scale. These features are overprinted by an S_2 fabric which forms the axial planar cleavage to F_2 folds, which appear to reflect a regional folding event.

The S_2 fabric occurs as a penetrative foliation, or a spaced cleavage, and/or a differentiated layering which locally shows evidence of more than one stage of development. The F_2 folds are open to tight (locally presently isoclinal), and commonly display S-shaped asymmetry in the Hemlo deposit vicinity. The folds plunge moderately towards the northwest in the western part of the Hemlo area, and moderately toward the northeast in the eastern part of the area. A number of equivocal explanations for this configuration could be invoked.

The above structures are overprinted by a widely developed, generally micaceous, S_3 fabric which is axial planar to F_3 folds. The F_3 folds have Z-shaped asymmetry and, although locally steeply plunging, generally plunge moderately to the northeast. The S_3 fabric ranges from weakly developed (common), to possibly predominant in high-strain zones. The fabric locally is present as a crenulation cleavage, particularly within and near F_3 folds and boudin necks. It appears to be associated with a period of dextral shear, in which case, where the high strain zones occur, the S_3 fabric is interpreted to consist of a system of components corresponding with s-c-c' fabrics in shear zones, here denoted as S_{3s} , S_{3c} , and $S_{3c'}$. Some of the crenulation fabrics, and accompanying F_3 folds, appear to be superposed on shear fabrics, possibly as a result of progressive deformation. If not specified, the term S_3 fabric refers to the flattening fabric of the developing shear system (*i.e.*, S_{3s}).

Locally there are kink folds, some in conjugate pairs, which are termed F_4 folds. In some cases, the sense of movement on the conjugate kinks suggests an east-west directed shortening. Only rarely is there even a vague hint of north-south oriented pressure shadows; no north-striking foliation has been observed. In other cases, conjugate brittle fractures indicate a north-south directed shortening. Relatively late, layer-parallel, brittle breccias, ultracataclasites, and/or pseudotachylite occur in most units in the vicinity of the Hemlo deposit. These features rarely provide any sense of movement, but where determinable, the sense is dextral. However, because these features appear relatively fresh, and rarely display any fabric, they may be considerably later (Proterozoic?) than would be features formed by a progressive transition from ductile to brittle dextral deformation.

Designations for planar fabrics of undetermined chronology are alphabetically subscripted (e.g., S_a , S_b). Dips are, almost everywhere, in a northerly direction except for isolated cases of the S_3 crenulation fabric.

HERON BAY AREA SEGMENT

Figure 14 (inside front cover) depicts the generalized geology of the Hemlo-Heron Bay part of the greenstone belt and indicates the approximate location of the field stops. Note, a "*" indicates field stops intended for the 3-day overview field trip.

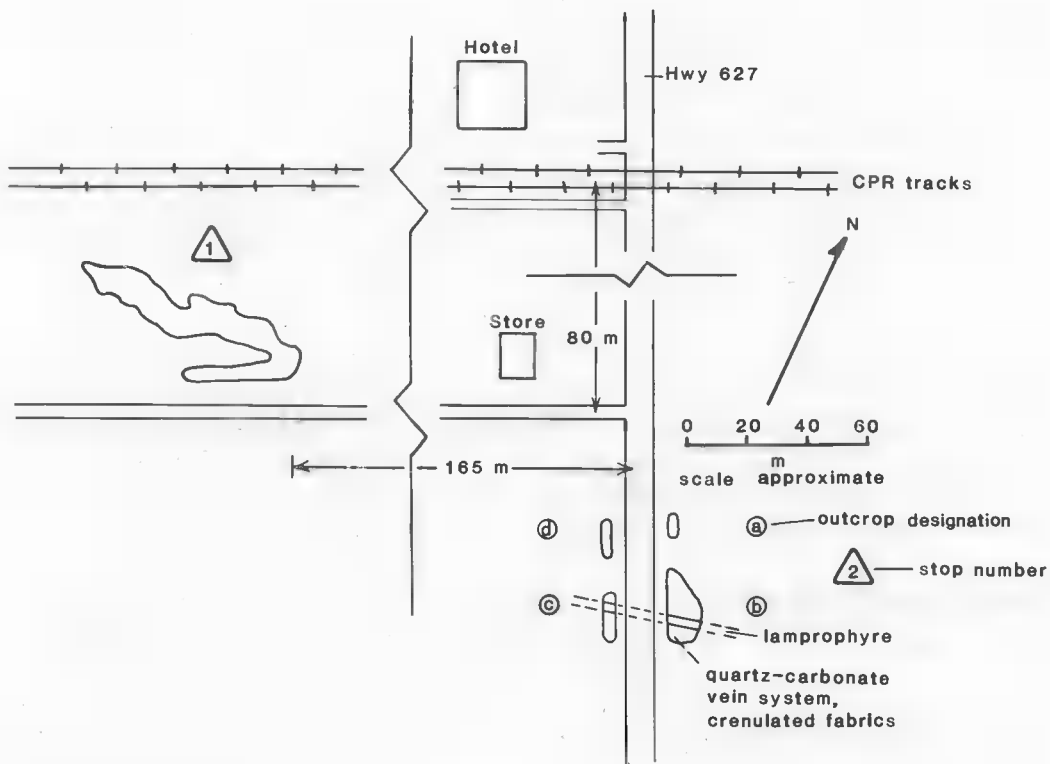


Figure 15. Stops 1, 2: Simplified sketch map of the Heron Bay area stops. Outcrop at Stop 1 is lapilli-tuff, and pyroclastic breccia (see Figure 16). Outcrops "a" to "d" of Stop 2 are lapilli-tuff and lapilli-stone.

• **Stop 1: PEEKONGAY PROPERTY** (Figures 14, 15 & 16)

Permission for access to the property is required. Information on whom to contact should be obtained from the Resident Geologist's Office, Thunder Bay (see address on title page).

Location: 165 m west of Highway 627 on the gravel road just south of the Lecours sporting goods store, about 80 m south of the CP railway tracks at the town of Heron Bay. Climb over the hill at the north side of the road to a cleared off outcrop area. A description of the Peekongay property in general is given in the section "Part 4: Peekongay property" in this field guide. The outcrop for Stop 1 (Figure 16) is the site of the 2 shafts of the Heron Bay Mine (see "Main Zone Mineralization", Part 4).

This outcrop area consists of heterolithic, intermediate (to felsic), quartz-feldspar-phyrlic, lapilli-tuff and pyroclastic breccia (by fragment size). Variations in the size and abundance of fragments in the outcrop can be seen, particularly from north to south, but no bedding is clearly defined. Some fragments are blocks up to 50 cm long. The majority of fragments are more felsic than the matrix. Some fragments consist mainly of chlorite and feldspar phenocrysts. The

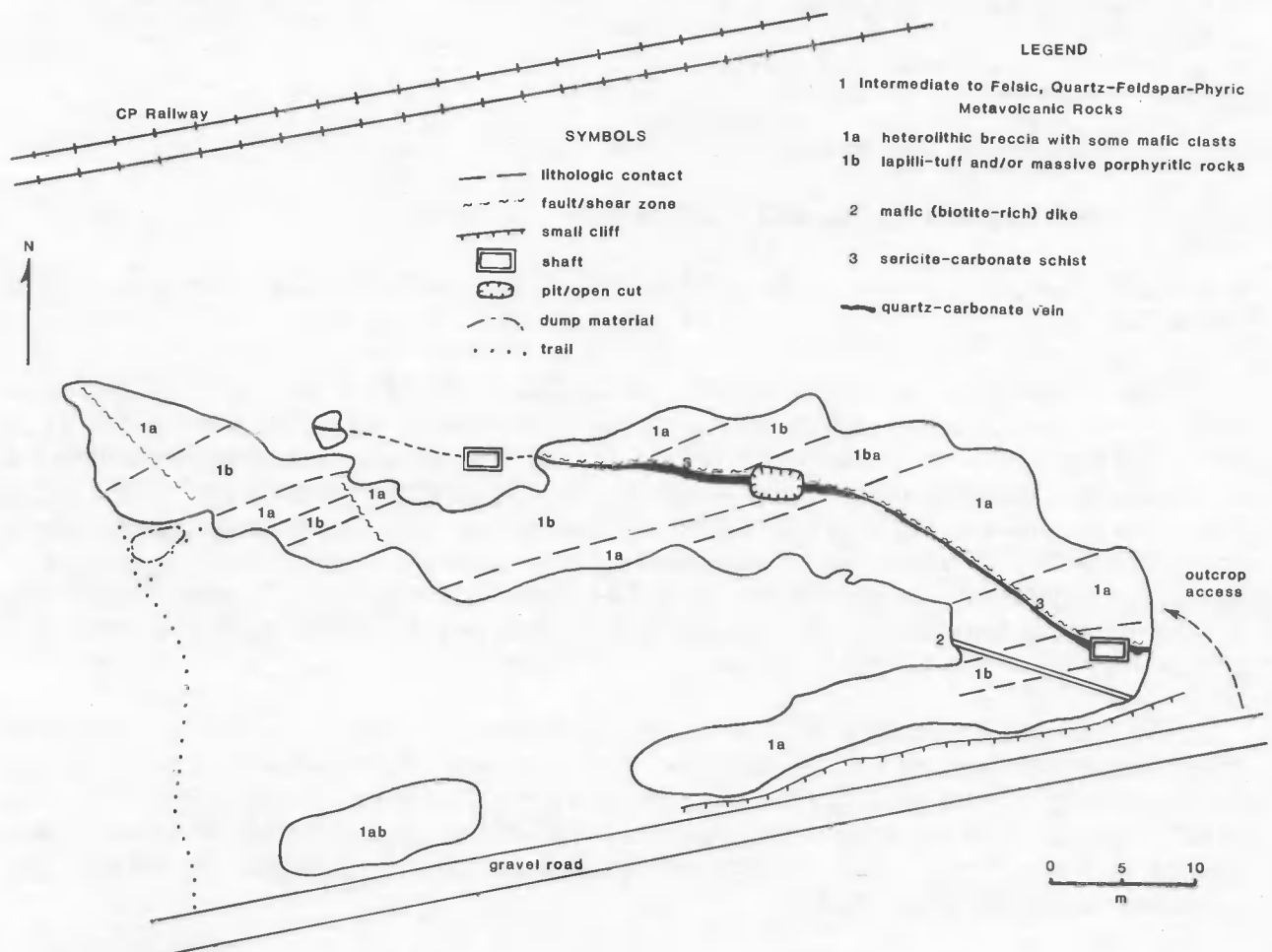


Figure 16. Stop 1: Detailed sketch map of an outcrop on the Peekongay property at the old Heron Bay Mine. Outcrop consists of calc-alkalic, intermediate composition, quartz-feldspar-porphyrific, pyroclastic deposits with local carbonatization and a mineralized quartz-carbonate vein system. (Geology by B.R. Schnieders, MNDM, 1990).

fragments are elongated and plunge moderately to the west. Sericite±chlorite are present in various amounts in the matrix and fragments. Two to three planar fabrics are present and although the rock has a "sheared" appearance, kinematic indicators are insufficiently developed to allow deduction of sense of movement, if any. A sample taken from this outcrop for U-Pb zircon geochronology gave an age of 2695 ± 2 Ma (Corfu and Muir 1989a).

The rocks show pervasive, disseminated carbonatization as well as quartz-carbonate veins which are deformed about 2 planar fabrics, S_a and S_b . A conspicuous 0.3 to 2 m thick, sinuous carbonate + quartz vein system cuts across the outcrop, striking from 275° to 300° , oblique to the predominant planar fabrics in the outcrop. The vein system locally consists of up to 70% carbonate. Sulphide minerals present include pyrite, chalcopyrite, galena, sphalerite, and molybdenite. The wall rocks to the vein system appear bleached. Quartz + tourmaline veinlets which are slightly deformed are locally present, as are quartz + carbonate±chlorite±tourmaline(?) veinlets.

Structural Summary:

Overall flattening of fragments; S_a 250/44

Subordinate fabrics (not everywhere found):

S_b 256/66 (forms diamonds/lozenges with above)

S_c 225/45

S_d 280/87 (crenulates the above 2 to 3 fabrics)

Lineations: elongation L_o 275/23
 mineral L_m 290/35 (tourmaline)
 crenulation L_c 252/30, 266/07, 275/23

Stop 2: HERON BAY PYROCLASTIC ROCKS (Figures 14 & 15)

Location: Set of outcrops on Highway 627, 110 m south of the CP railway tracks at the town of Heron Bay.

These outcrops are typical of Heron Bay pyroclastic rocks and consist of lapilli-tuff and lapillistone. The rocks are calc-alkalic dacite (intermediate) in composition, although rhyolite breccias are locally found. Overall, the fragments are subrounded to subangular, heterolithic in texture and composition, commonly more felsic than the matrix, and quartz-feldspar phyric. Some of the fragments are more mafic than the matrix and include intermediate, feldspar- ±quartz-phyric rocks, and mafic, aphyric rocks. Bluish quartz phenocrysts are locally common. The matrix consists of feldspar, quartz, sericite, ±chlorite. The upper parts of outcrops "b" and "c" reveal that the degree of fragment elongation is greater than the degree of flattening. Elongation lineations plunge moderately to shallowly to the west.

The outcrops, particularly "b" and "c", display evidence of irregularly developed, disseminated carbonatization, as well as deformed, light-brown-weathering, quartz-carbonate veins. Pyrite cubes up to 5 mm across (commonly 3 mm) are present in the country rock. Within this zone of carbonatized rocks, the more mafic fragments, which contain chlorite±biotite, may have quartz phenocrysts and pyrite cubes. These outcrops are intruded by a foliated (Archean?), carbonatized, biotite lamprophyre dike.

The south face of outcrop "b" shows folded, quartz-carbonate veins and schistose planes with 2 and possibly 3 sets of crenulation lineations. The south end of outcrop "c" shows a planar fabric in the matrix that is oriented differently compared to the fabrics in the fragments. There are also a few, west-plunging, minor folds with "S" asymmetry.

Structural Summary:

Outcrop "b":

Predominant fabric ~270/87 (undulating)

Crenulation lineations:

 L_{c1} 090/00±07 L_{c2} ~088/67 (overprints L_{c1}). L_{c1} consists of short, small-amplitude, small-scale, anastomosing crenulations. L_{c2} is predominant.

Outcrop "c":

General flattening of fragments 240/50

Fabrics in fragments (anastomosing):

predominant 245/? and subordinate 258/?

Fabric in matrix: 268/?

Elongation lineation (fragments): L_0 280/30

Minor "S" fold: axial plane 275/75; axis 290/44

Quartz-tourmaline veinlet 240/60

Stop 3: THOLEIITIC PILLOWED FLOWS (Figure 14)

Location: Go 4.2 km north on Highway 627, from the railway crossing at Heron Bay, to an outcrop on the west side where a power line crosses the highway. This is a minor stop and is intended to illustrate that some segments of this part of the belt are relatively undeformed compared to rocks in the Hemlo deposit vicinity. Discrete zones of significant strain, up to several metres thick within mafic pillowed flows for example, are well exposed on the shoreline of Lake Superior at Pulpwood Harbour in Pukaskwa National Park to the south. However, in the vicinity of the Hemlo deposit, significant strain is essentially pervasive.

Several small outcrops constitute this stop. The more northerly ones consist of a "massive", medium- to fine-grained, mafic, tholeiitic flow. One outcrop displays what appears to be a dike with highly irregular orientation. The main outcrop consists of mafic, tholeiitic pillows and a "massive" section, possibly part of the same flow. Although the pillows are somewhat flattened, they have well-defined shapes preserved and indicate that the top direction is toward the south. The most southerly outcrop exposes a section that displays possible flow banding and what appears to be a flow top breccia or pillow breccia. Minor quartz±carbonate veins are present, particularly in the main outcrop.

Structural Summary: S_p ~100/75 "flattening" of pillows V 190/25 quartz-carbonate vein*** Stop 4: NORTHERN EAGLE PROPERTY (Figures 14 & 17)**

Permission for access to the property is required. Information on whom to contact should be obtained from the Resident Geologist's Office, Thunder Bay (see address on title page).

Location: Return north to Highway 17 and head 6.3 km east on Highway 17 to the Black River bridge, then continue 900 m beyond the east end of the bridge. (This point can be more accurately located by noting a gravel road, that heads south from the highway about 650 m from the bridge, then continuing 320 m beyond it, to a point 30 m past the Beaver Tourist Centre sign.) Take the diamond drill road, which is on the north side of Highway 17 at this point, and follow it, essentially north, for about 230 m to a power line. [Note: As of 1993, a new subsidiary powerline now crosses the highway here and has rendered delineation of the drill road difficult. However, the drill road intersects the east side of the powerline right-of-way near the highway.] Cross the power line (slight jog to the west across a small creek) and continue on the same drill road, again essentially north, to a small hill. Go

Figure 17. (*Opposite page, legend below*)
Stop 3: Northern Eagle property. Detailed sketch map of the main barite showing. Upper part of figure represents the west half of the stripped area. Lower part represents the east half. Point "A" in each part of figure represents the same geographic location. Identification of minerals and alteration is based on field observations and interpretation. (Geology by T.L. Muir, OGS, 1990).

LEGEND: STOP 4

Mafic Metavolcanics(?)

- 1 biotite+amphibole schist (mafic), subgneissic

Metamudstone

- 2a black
 2b dark gray
 2c medium gray, sandstone
 2d medium-light gray

Altered Rocks Derived from Mudstone

- 3a sericite±biotite (laminated, cleaved)
 3b sericite±biotite+pyrite (laminated, cleaved)
 3c feldspar+sericite schist
 3d feldspar+sericite+green mica+pyrite schist

Altered Rocks of Undetermined Protolith

Schistose

- 4a sericitized, feldspathized
 4b sericitized, pyrite
 4c sericitized, green mica, pyrite
 4d sericitized, silicified
 4e sericitized, silicified, barite

Granular

- 5a feldspathized+silicified±barite
 5b feldspathized+pyrite (commonly in seams)±barite
 5c silicified±feldspathized+pyrite
 5d barite-rich±silicified±feldspathized±pyrite

Dikes

- 6 feldspar porphyry

quartz vein

up and over the hill on an old grid line to a clearing, about 360 m from the power line. The road and grid line are flagged and recut for this trip.

For the most part, the Northern Eagle property structurally overlies south-dipping mafic metavolcanic and metasedimentary rocks. In the stripped area, exposures have been created over a strike length of about 100 m and a width of up to 12 m (Figure 17). The showing is now considerably overgrown and oxidized in parts. In 1995, significant additional stripping was undertaken to the north, adjacent to the original stripping. This new exposure has not been mapped by the author. As presently exposed, the outcrops consist of argillite, which locally has been moderately to intensely altered and deformed, massive to laminated barite and sulphide minerals, sericite schists, minor mafic schists, and feldspar porphyritic dikes. In earlier reports, these rocks collectively have been interpreted to be barite±sulphide-bearing cherts and quartzites, as well as graphitic argillite, siltstone, arkose, quartz + sericite±carbonate±limonite schists, "massive" barite, and quartz-feldspar porphyries (MNDM assessment files, Thunder Bay; Glendon 1985).

The western part of the stripped area consists of black to dark grey argillite, and white-weathering rocks, consisting of feldspar, quartz, sericite, and green mica, which are interpreted to be altered argillite because of the similar cleavage developed in both rocks and the intimate spatial association between light and dark coloured rocks. Xenoliths of the green-mica-bearing schists are present in the feldspar porphyry dikes. This suggests that the alteration preceded intrusion, because black argillite is locally present as the host rock to the dikes, and it is considered unlikely that alteration could have pervasively altered the dike (and xenolith) and not the immediately adjacent country rock. The porphyritic dikes are similar to dikes at Hemlo that are inferred to have intruded at 2687 ± 3 Ma (Corfu and Muir 1989a).

If the alteration exposed at the Northern Eagle property was contemporaneous with the mineralization of the Hemlo deposit, and if the porphyry dikes at this stop are coeval with those at the deposit, then a minimum age of mineralization is 2687 ± 3 Ma.

The majority of the remainder of the exposures in the east part of the stripped area are interpreted to be highly altered rocks derived from an equivocal protolith. However, several outcrops along the north side and east end reveal grey and dark grey argillitic metasiltstones which locally can be seen to grade relatively abruptly into white to buff schists. An isoclinal fold can be seen near the east end of the stripped area. The main fabric here is axial planar to the fold and is parallel to weakly defined layering in the siltstone. Transposition and differentiation of the layering appears to have locally taken place. As such, the layering present in these outcrops should not be assumed to be bedding. In this area, several discordancies of fabrics and layering can be seen suggesting faulting has taken place.

There are 4 trenches across the width of the exposed area. These trenches reveal a variety of schists and "massive" rocks which are heavily weathered. The rocks are considerably deformed and appear to have resulted, based on field identification (*i.e.*, no laboratory confirmation) from feldspathization, silicification, sericitization, and pyritization, which in places is reminiscent of alteration at the Hemlo deposit (*e.g.*, Stop 33A) and/or the Barren Sulphide Zone (Sucker Zone) (Stop 14). The schists range considerably in their content of green mica, barite, feldspar, quartz, sericite, and pyrite. The green mica here is somewhat different in colour than that of the Hemlo deposit and thus may contain different types or relative abundances of trace elements. The green mica at this stop is largely present in flattened lenses and along cleavage planes. Pyrite is the common sulphide. The barite occurs in zones of various concentrations and is commonly equigranular and fine grained. Gliddon (1985) interprets it to have been recrystallized. Barium occurs in trenches 1 to 3 in amounts in excess of 20% (Cavey 1984). Some of the barite-rich zones are variably laminated parallel to the predominant fabric. The origin of the barite is contentious. It appears here to be spatially associated with shear zones (Gliddon 1985) and alteration, and lies within isoclinally folded and tectonically disrupted argillite.

Assay results from these trenches returned values of ≤ 0.005 oz of Au/short ton, up to 32.76% Ba in zones containing barite, and up to 1000 ppm As (MNDM assessment files office, Thunder Bay). Gold values up to 0.12 oz. per ton have been reported (*Northern Miner*, November 23, 1983, p.23), but were not noted in the assessment files.

Structural Summary:

- West end: Fabrics at 090/80, and 077/83 in argillite
 - Foliated dike oriented at 265/56 with internally deformed quartz veins
- Central: Fabrics at 082/77 and 072/77 in green mica schist
- East end: Layering and axial plane of west-closing isoclinal fold at 084/71
 - Fabric overprinting fold at 095/77
 - Faint cleavage at 077/79

HEMLO AREA SEGMENT: HIGHWAY 17

Figure 18 displays the location of field stops numbered 5 to 31 inclusive. Figure 19 (inside back cover) and Figure 20 illustrate the lithologic units and major structural components in more detail. Figure 21 shows the "cultural" features and projected ore for the Hemlo deposit and vicinity, and includes locations for Stops 7 through 26. Figure 22 depicts a projected longitudinal view of the main ore zone of the Hemlo deposit at the same scale as in Figure 21. Note, an asterisk (*) indicates field stops intended for the 3-day overview field trip.

Stop 5: INTERIOR OF CEDAR LAKE PLUTON (Figures 14 and 18)

Location: Highway 17, about 1.1 km east of the Highway 614 turnoff (to Manitouwadge), or if one is coming from the east, it is about 3.7 km west of Wabikoba Creek which enters Cedar Lake. The stop is at the west end of a long roadcut on both sides of the highway. The following description is based on the westernmost 75 m of the roadcut on the north-northwest side.

The majority of the Cedar Lake Pluton consists of very weakly to moderately foliated, medium-grained, microcline-megacrystic, hornblende-biotite granodiorite that contains ubiquitous mafic/ultramafic(?) xenoliths. This main phase has been intruded by a number of subordinate, fine-grained, more mafic phases. The megacrystic phase at Stop 5 has been dated at 2688 ± 3 Ma (Corfu and Muir 1989a). The effects of hematization and epidotization are locally present, and may be extensive. There is some evidence that this type of alteration may be associated with fault zones. Other exposures of this phase, such as on Highway 614 to Manitouwadge, display a wider variety of xenoliths and dikes, including aplite and pegmatite.

The microcline megacrysts range from medium to coarse grained, up to 2.5 cm long, and contain fine-grained crystals of hornblende, quartz, plagioclase, and possibly biotite. Crude zoning is apparent in some megacrysts. The xenoliths range from about 5 mm to 30 cm long, and are most commonly about 2 to 4 cm long. Most of them appear to be fine-to medium-grained amphibolite, although some appear to have little or no salic minerals and are hence presently ultramafic. The xenoliths are generally aligned parallel or subparallel to the foliation in the granodiorite, where the latter can be discerned. The orientation of the foliation is similar to that of S_3 in the country rocks and is interpreted to be most likely related to D_3 .

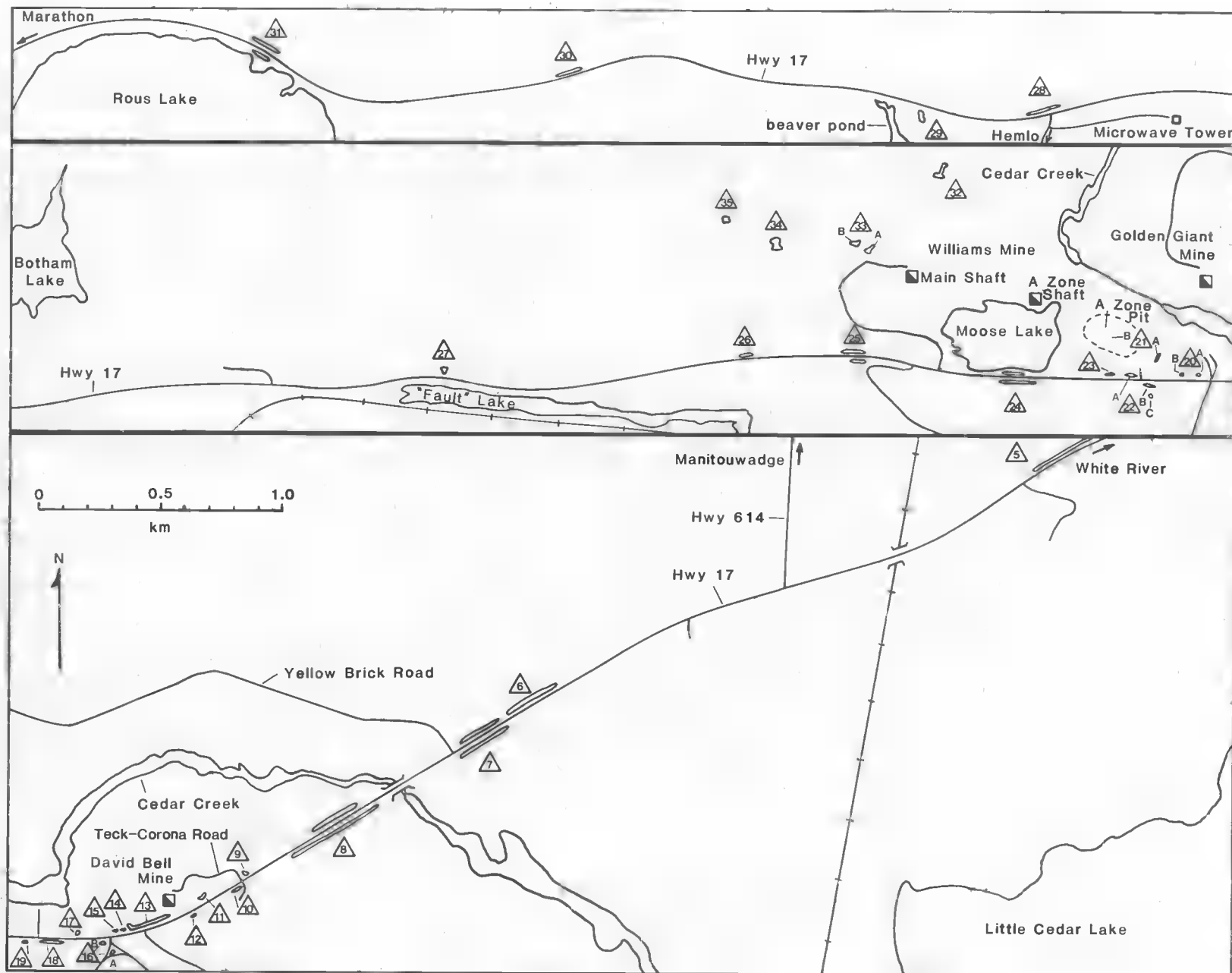
The megacrystic granodiorite at this stop has been intruded by a few intermediate dikes, likely of Archean age, and a Proterozoic biotite lamprophyre dike. The Archean dikes are sheared, with an apparent dextral sense. This relationship and the presence of an " S_3 -oriented" fabric within the pluton suggests that at least some of the D_3 strain postdated intrusion and crystallization (*i.e.*, 2688 Ma).

Structural Summary:

S_0 ranges from 260/70 to 275/60; alignment of mafic minerals in granodiorite
 S_d 302° sheared intermediate dike; fabric subparallel to dike margins
 S_a 281° in dike; biotite/hornblende; back rotated
 S_b 327° in dike; deflects S_a
 D 145/70 lamprophyre dike

*Stop 6: WEST CONTACT OF CEDAR LAKE PLUTON (Figures 14, 18 & 23)

Location: Go about 1.1 km west-southwest of the Highway 614 turnoff (to Manitouwadge) on Highway 17, to the contact of the Cedar Lake Pluton near the east end of a long roadcut beginning on the northwest side of the highway. The last highway exposure (in this direction) of microcline-megacrystic granodiorite lies about 300 m east-northeast of here.



The contact phase of the Cedar Lake Pluton is fine- to medium-grained, biotite-hornblende granodiorite which is massive except for a weak foliation within several metres of the contact. This phase is not exposed elsewhere on roads or railways and its extent in the bush is unknown, as is its relationship with the main megacrystic phase(s) (see Stop 5). The granodiorite at Stop 6 has been dated at 2687 ± 3 Ma (Corfu and Muir 1989a).

The granodiorite is intruded by many aplite dikes, up to 40 cm thick, and some pegmatitic dikes, up to 10 cm thick. Some of the dikes are composite aplite/pegmatite. Although either type may crosscut the other, more often than not, pegmatitic dikes crosscut aplite dikes. The dikes terminate against the schist, although some display ductile deformation within the contact granodiorite (Photo 1). This may indicate that extensions of the dikes into the country rocks have been sheared off. The dikes display a range in strike but tend to have preferred orientations as approximated below.

Dike orientations:

5 m from contact	290/64, 305/52
10 m from contact	$260 \pm 5^\circ$, $290 \pm 5^\circ$, $330 \pm 5^\circ$
65 m from contact	$250 \pm 5^\circ$, $270 \pm 5^\circ$

The country rocks within about 9 m of the contact consist of crenulated mafic schist containing several aplitic and granodioritic dikelets and stringers which display refolded folds and are locally dismembered. Refolded folds in aplitic dikelets adjacent to granitoid bodies in the area have been noted elsewhere (*e.g.*, Cedar Creek Stock, Pukaskwa Batholithic Complex). Although it may be inferred that these are F_2 folds refolded by F_3 (which is associated with the crenulation fabric), this poses problems based on the inferred timing of intrusion relative to regional folding (see Stop 11). It may be more likely that, during intrusion, differential ductile movement between relatively softened, contact-metamorphosed country rocks and the intruding granitoid magma, led to marginal-restricted zones of progressive deformation that did not produce analogous structures farther away from the plutons.

To the west of the crenulated mafic schists, for about 15 m, the country rocks consist of a mixture of mafic, biotite-hornblende schist (either of sedimentary or igneous origin), pyritiferous argillitic rocks, and some metawacke, all of which have been intruded by a few aplitic dikelets and quartz veins. Within this schist, a granodioritic dike intruded by quartz veins contains minor molybdenite, although most of this has been "excavated" by moly-thirsty "geotourists".

For approximately the next 150 m, the country rocks consist mostly of various sets of metawackes and metasiltstones which have been intruded by swarms of dikes. These sets are crudely defined based on differences in layering thickness, composition, and grain size. Several sets consist of feldspathic metasandstones and, in at least one case, possibly quartzite. A few gossans occur in some of the feldspathic metawackes. There are several isoclinal folds which have developed locally. A few of these appear to be intrafolial. In the first outcrop to the west of the "Yellow Brick Road" highway sign, the S_2 fabric is clockwise with respect to layering, as it is at Stops 6 (west end) and 7 (west end).

Figure 18. (opposite page) Three-component strip map of the Highway 17 section of field stops numbered 5 to 31 inclusive, for the Hemlo area. The uppermost strip represents the west third; the lowermost strip represents the east third. East and west boundaries defining connected strips are mutually adjoining (*i.e.*, no overlap). Only the outcrops for field stops described in this road log are shown.

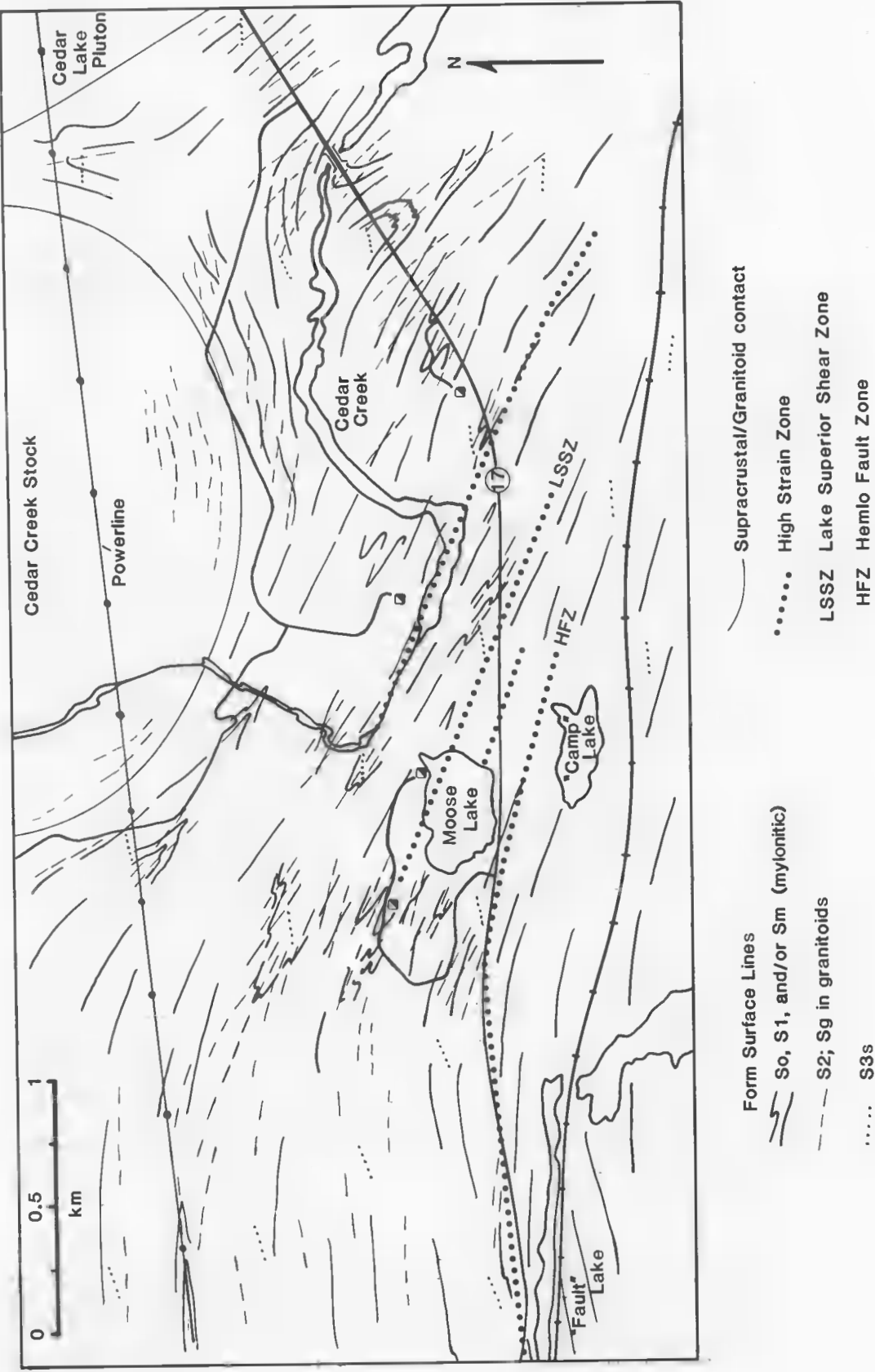


Figure 20. Form-surface map of the Hemlo deposit area showing generalized traces of different generations of fabrics. (Modified after Muir and Elliott, 1987).

The dikes within the above-mentioned sets comprise a wide variety of foliated granitoid dikes as well as some mafic dikes that display boudinage. The granitoid dikes consist mostly of weakly foliated granodiorite, which is similar in grain size and composition to the marginal phase of the Cedar Lake Pluton, and some plagioclase-porphyritic dikes. The granitoid dikes have been intruded by fine-grained, intermediate-composition dikes. The relationship between the granitoid dikes and the mafic dikes (Archean) is not established. A small diabase dike (Proterozoic) has intruded the country rocks.

Structural Summary:

S₁ 330/66 84 m from the contact
 S predominant 318/52 mafic schist
 S₃ crenulation 296/57
 L_c 104/26 crenulation lineation

Stop 7: METASEDIMENTARY ROCKS AND GRANODIORITE SHEET (Figures 14, 18, 19 & 23)

Location: Stop 7 is essentially a continuation (for another 200 m) of the roadcut for Stop 6. For the most part, the features described here are on the southeast side of the highway. The stop begins about 65 m west of the "Yellow Brick Road" highway sign. The more important features of this roadcut are at the east-northeast end, say, for the first 80 m (see Figure 23).

In the northeast end of this outcrop is a thick, composite sheet of foliated, medium-grained, plagioclase-porphyritic, amphibole-biotite granodiorite, and foliated, finer-grained, biotite-amphibole granodiorite, both of which were intruded by aplitic dikes and subsequently by quartz veins. The finer-grained granodiorite occurs as "layers" or sheets, parallel to the foliation. The relationship between the two phases is not well established but circumstantial evidence suggests that the finer-grained phase is younger. Aplitic dikelets in the country rocks are folded about the foliation. The dikelets have also been sinistrally offset in a number of places. The porphyritic phase has been dated at 2687 ± 3 Ma (Corfu and Muir 1989a).

Across the highway at the structurally lower contact of this sheet, apophyses of the porphyritic granodiorite are folded about a less steeply dipping, S₂-like foliation, with attendant attenuation and boudinage which has taken place in two dimensions (features on horizontal section are no longer visible). This relationship could suggest that the intrusions predated, or were synchronous with, the D₂ event. However, the overall deformation of the S₂ fabric near the granitoid bodies in the Hemlo area suggests that the intrusions post-dated most, if not all, the D₂ deformation (see Figure 20).

The units of metasedimentary rock west of the granodioritic sheet consist of a variety of metawacke with minor amounts of metasiltstone. Different units collectively display a range of biotite/amphibole ratios from biotite predominant to amphibole predominant. As exposed in the roadcut, the metasedimentary rocks can be crudely subdivided into several sets, based on composition, grain-size, and layering thickness and definition.

Metasedimentary units west of the sheet (for about 120 m), display layering that tends to become wispy. Here, the S₂ cleavage is not distinct from layering, which suggests: transposition of layering has taken place; or the intersection of S₁ and S₂ is essentially horizontal. Vertical faces locally show an S₂-like cleavage that strikes parallel to the layering and dips less steeply to the northeast. This would suggest that the F₂ fold axes are essentially horizontal here. Subhorizontally plunging folds in some mafic dikes are visible in the roadcut face. Insufficient information is available to define the character of the range in orientation of F₂ axes from horizontal at Stop 7, to northeast plunging at Stop 8, to northwest plunging at Stop 33B.

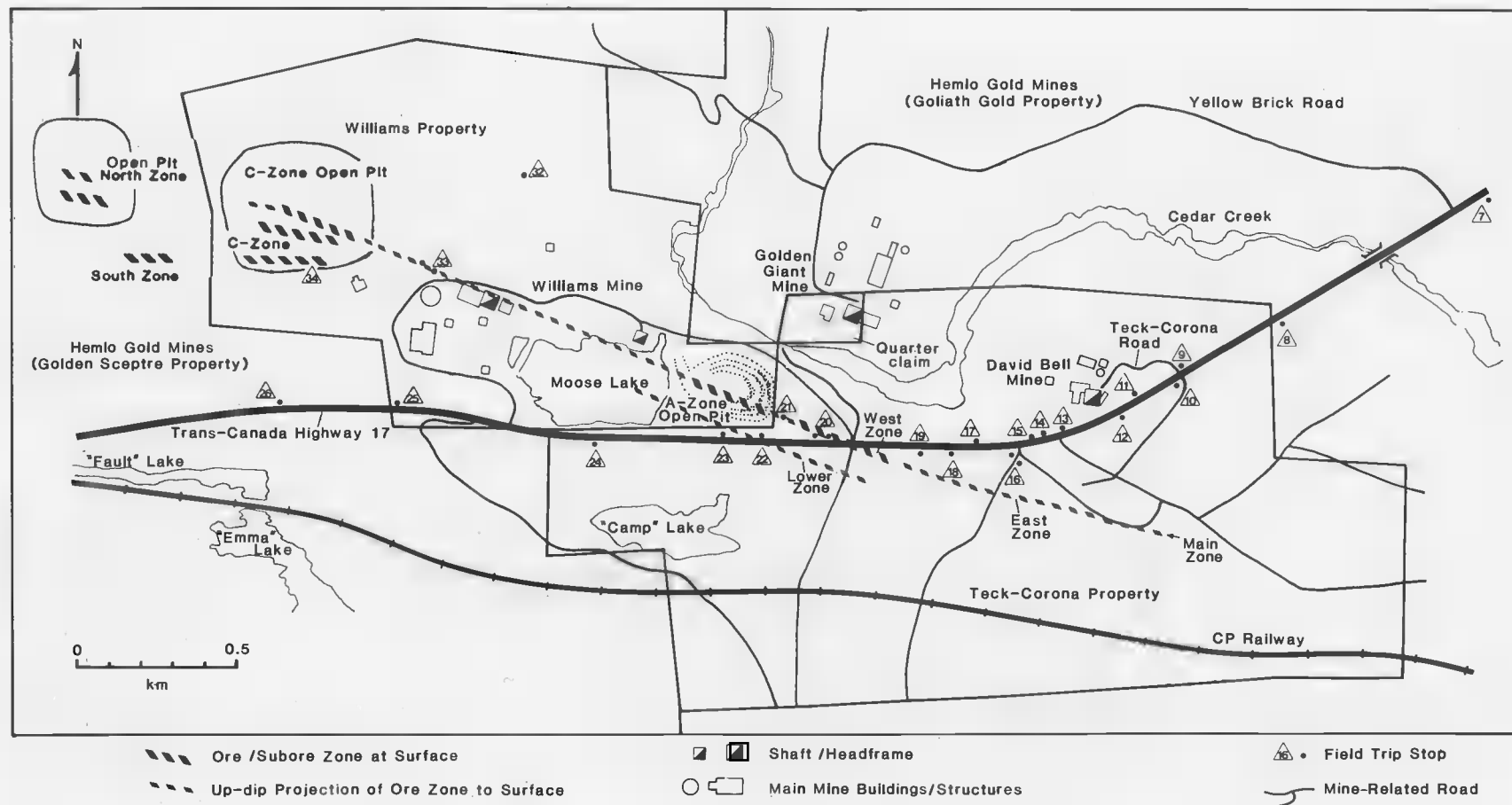


Figure 21. Main cultural features of the Hemlo camp, and up-dip ore projection of the Hemlo deposit. Locations of field stop numbers 7 to 26, and 32 to 35 are shown for reference. Same scale as Figure 22. (Modified after Smyk *et al.* 1990).

The last 50 m or so of the roadcut indicate that the S_2 cleavage is clockwise with respect to layering, the same relationship as with the "Jake" unit (see Stop 8) which is on the southwest limb of a southeast-closing F_2 fold. This suggests that a northwest fold closure may be present within the vicinity of Cedar Creek where there is essentially no exposure.

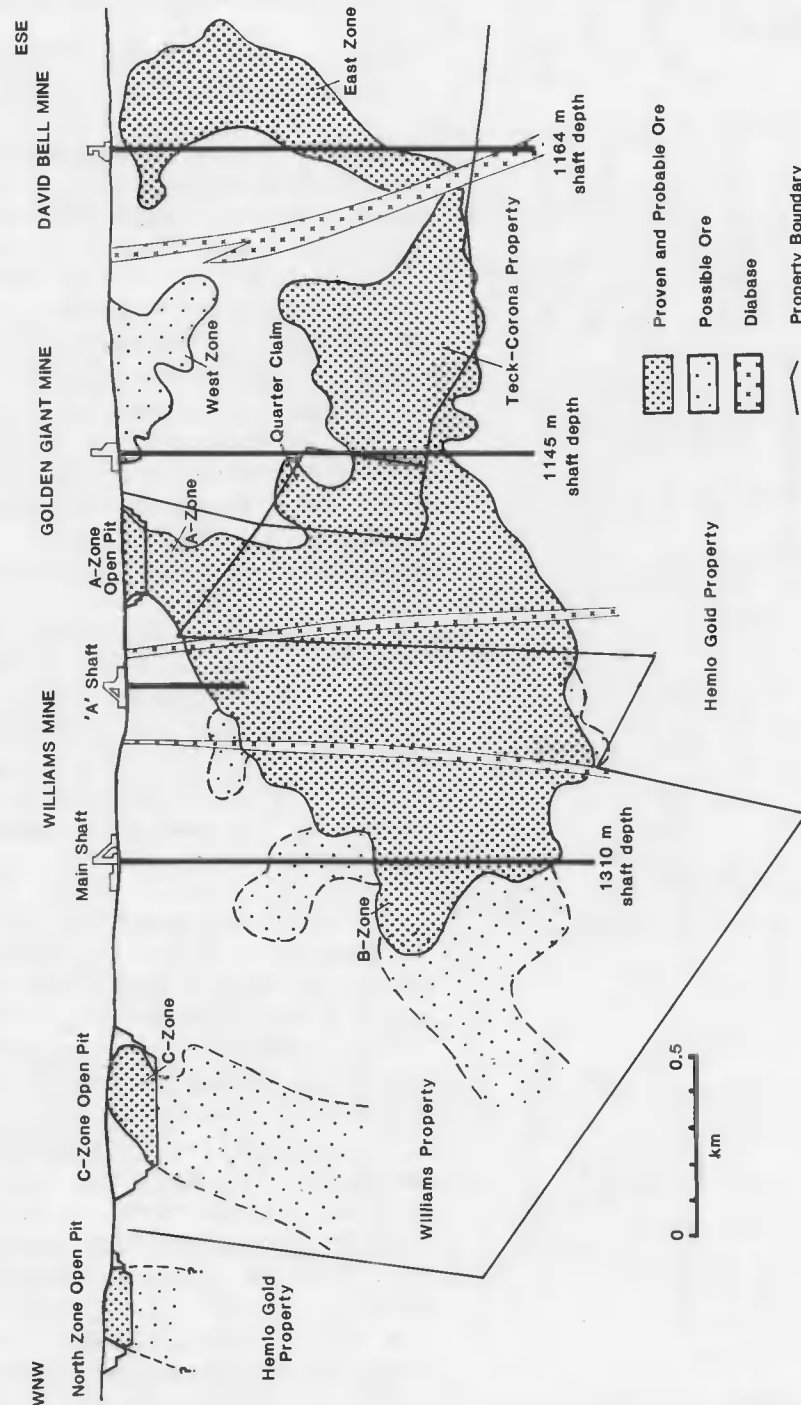
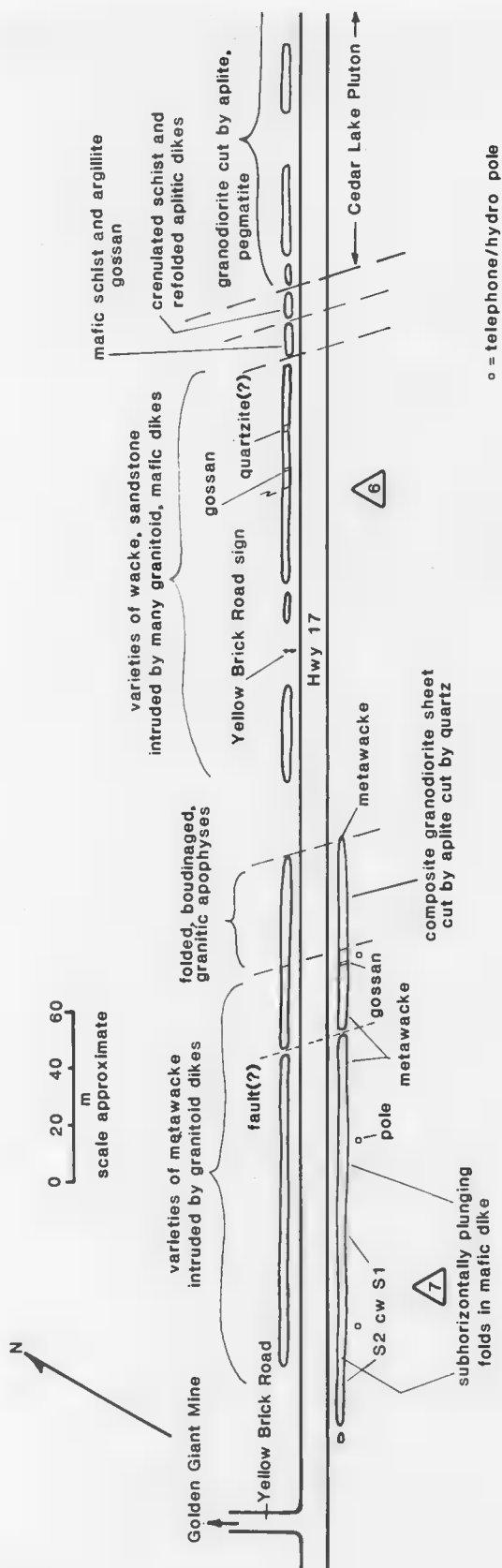


Figure 22. Longitudinal section of the Hemlo orebody projected onto a vertical plane. Property boundaries projected onto the orebody plane before final projection. Same scale as Figure 21. (Modified after *Canadian Mining Journal*, February 1990, p.28, 29).

**Structural Summary:**

S_0/S_1 323/62 away from contact with granitoids

S_2 336/? toward west end of roadcut

S_1/S_2 310/49 near granitoids

$S_3?$ 297/? alignment of amphibole

S_g 305/? in granitoid sheet

Range of sinistral faults in aplitic dikelets in sheet: 285° to 320°

*** Stop 8: CEDAR CREEK FOLD** in metawacke/metasilstone turbidites (Figures 18, 19 & 24)

Location: Go 650 m west-southwest on Highway 17 from the Yellow Brick Road (Golden Giant Mine) turnoff at the west end of Stop 7 to a point at the first large roadcut east of Cedar Creek. The set of exposures on the south side of the highway, at this roadcut, extends for about 400 m. The starting point for this stop is on the south side, at a northeast-facing rock face with the word "Jake" plastered on it (loathsome as it is to acknowledge rock defacing of any kind, let alone outcrop painting), assuming that highway maintenance personnel have not painted over it in an attempt to deface the defacement. This starting point is about 120 m east of a "0 m" reference point at the west end of this set of outcrops.

The main features of interest lie on both sides of the highway, between this point and 75 m further along the highway to the east-northeast (i.e., at about 195 m). In this part of the roadcut, a section through a medium- to large-scale, southeast-closing F_2 fold is unusually well exposed as a result of original highway construction, despite recent highway "improvements".

The outcrops along this part of the highway show a variety of turbiditic deposits composed mostly of medium grey metawacke and meta-siltstone. Light and dark grey varieties are locally present. Some crenulated mafic metawackes are exposed at 2 places, at about 55 m and 300 m (see Figure 24) and are inferred to be folded about the Cedar Creek fold axis which is located at about 163 m. These mafic metawackes also contain minor conglomeratic components consisting of wacke and sub-porphyrific granitic clasts in a mafic matrix. Locally there are unidentified retrograded porphyroblasts (andalusite?), particularly just to the west of the eastern, mafic schist unit. A few micaceous gossans occur on both sides of the axial plane. It is not clear whether any of the gossans can be matched across the axial plane as folded units.

Figure 23. Stops 6, 7: Simplified sketch map of the west contact of the Cedar Lake Pluton (Stop 6) and adjacent metasedimentary rocks (largely metawacke) and granitoid sheet (Stop 7).

The "Jake" unit (see Figure 24) is a reference turbidite for this stop in terms of primary features, and is to be compared to the "anti-Jake" unit (at about 193 m). The "Jake" unit (Photo 2) is interpreted to be a turbidite unit in the following context. The structurally lower half of the unit is fine grained, light weathering, and quartzo-feldspathic. The structurally upper half is coarser grained, darker weathering, biotite- ± amphibole-bearing, and has a set of laminations defined by mafic minerals in its uppermost part. The darker half is considered to be the upper, more silty part of the turbidite deposit which, through metamorphic recrystallization, has become coarser grained than the lower quartzofeldspathic part. A traverse along this section of the exposure to the "anti-Jake" unit (this unit is not likely the same bed as the "Jake" unit, but is an unmarked reference unit for comparison) reveals bedding deformed about the fold axis, with preservation of the turbidite features in reverse on the northeast limb. That is, the laminations are on the structurally lower part of the unit, which is interpreted to indicate overturned bedding.

Within the nose of the F_2 fold, the layering thickness is greatly exaggerated, pseudoflame structures have developed from incipient transposition of layering, and recrystallization is more pronounced. A foliated, boudinaged, plagioclase-porphyritic dike (at about 170 m) is near and parallel to the axial plane. The strike of the foliation appears to be parallel to S_2 . An uncommon, relatively fresh, medium-grained, mafic dike which is chemically equivalent to calc-alkalic andesite has intruded the mafic metawacke of the northeast limb (at about 296 m). Possible graded bedding at 405 m (end of exposure on the southeast side) suggests tops are to the southwest, as with the "anti-Jake" unit.

Stereonet construction of the fold indicates it is reclined with a northeast-trending, moderately plunging axis and a northwest-striking axial plane. Structural facing is toward the northwest. Exposures along the highway to the southwest and northeast of Cedar Creek (about 335 m from the fold axis along the highway) suggest that a northwest-closing fold may be present, which would produce an overall S-shaped pair of folds. The axial planar cleavage, S_2 , strikes at about 310° , roughly parallel to the contact with the Cedar Lake Pluton to the northeast (Stop 6), and oriented 40° clockwise relative to Stop 13.

Another fabric is weakly developed throughout the folded strata and is interpreted to be S_3 . Measurements of strike span over 50° which suggests that: more than one deformation feature was measured; or more than one component of the D_3 products was measured (e.g., S_{3s} , S_{3c} , etc.); or deformation subsequent to the so-called D_3 event (separate or progressive) has occurred. Crenulation schistosity measured in the mafic schist (i.e., mafic metawacke) show a range in orientations which is consistent with that of other outcrops (e.g., Stops 25, 26, and 29).

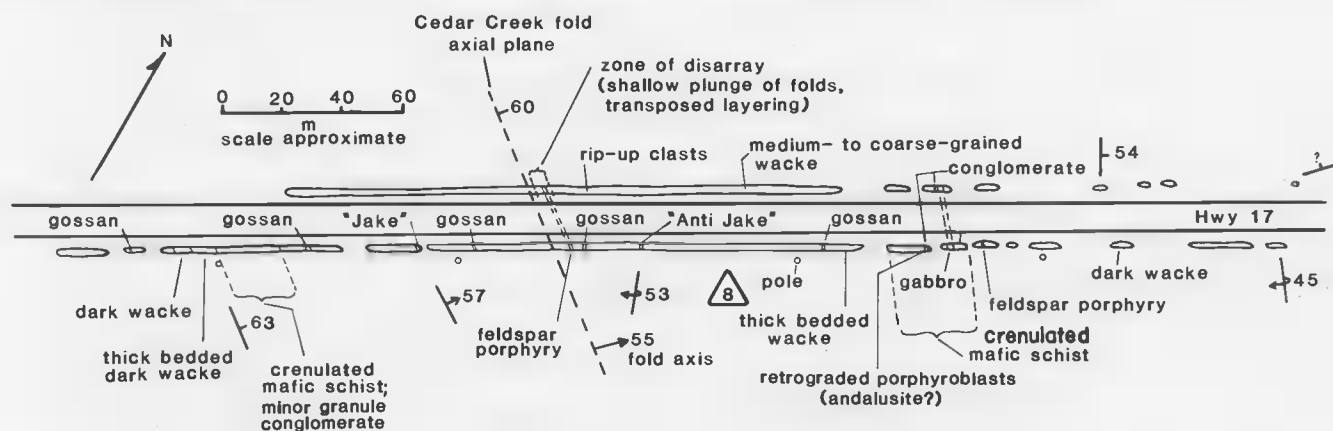


Figure 24. Stop 8: Simplified sketch map of turbiditic metawacke and siltstone units of the Cedar Creek fold (F_2).

After completing the section from "Jake" to "anti-Jake", cross the highway and walk back through this different section of the fold. The "beds", not all of which show sufficient primary features for top indications, overall reveal the layering to be overturned, as would be expected from an uncomplicated fold, which this may not be (see next paragraph). Semi-aligned rip-up clasts can be seen at a point to the northeast of the fold axis (see Figure 24). Here, the S_2 fabric strikes at 296° , (S_0/S_1 at 344°). A sampling of clasts indicates alignment ranges from 291° to 309° , suggesting the clasts did not completely rotate into the S_2 plane.

Opposite a point about 25 m east of a hydro pole (see Figure 24), is a zone of structural complexity, about 5 m northeast of the fold axis, that has no unequivocal explanation, particularly after recent blasting removed some of the devilish structural inconsistencies in the fold. Here, some of the layering ranges from pseudoflake features to notable transposition and wispy development of differentiated layering parallel to S_2 . What is no longer evident is that there is a section of the units here that displayed shallow, northwest-plunging folds, best defined by the laminations at the overturned(?) top of one of the beds. The actual nose of the main fold, exposed on this side of the highway, appears to be relatively uncomplicated.

Structural Summary: southeast side of highway (see Figure 24; distance reference from west end of exposures)

Feature	Measurement	Distance (m)
S_0/S_1	306/63	50
S_2	315/63	50
S_2 axial plane	308/60	163
crudely fans from 296° to 320° and crudely dips more steeply (5° to 10°) on southwest limb		
F_2 axis	045/55	163
S_0/S_1	332/55	210
S_2	312/53	210
S_3 overall; biotite, faint (crudely fanned?)	264° to 316°	120 to 265
(crudely fanned?)		
S_3 crenulation, biotite	260/85 to 280/72	53 and 298
(range is present in each outcrop of mafic metasedimentary rocks)		
L_c crenulation (various)	$\sim 070/67$	53
	$\sim 073/63$	298
L_b boudin	$\sim 087/70$ in porphyritic dike	

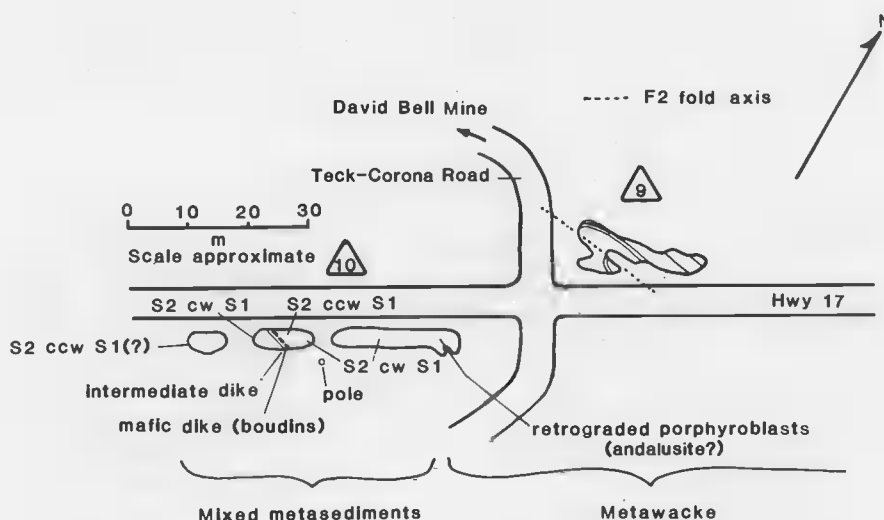


Figure 25. Stops 9, 10 Simplified sketch map of F_2 -folded metawacke (Stop 9) and F_2 -folded, mixed metasedimentary rocks (Stop 10) at the Teck-Corona Road turnoff.

Stop 9: FOLDED METAWARE (Figures 18, 19 & 25)

Location: Northeast corner of the Teck Corona Road turnoff (to the David Bell Mine) on Highway 17, about 370 m west-southwest of the "Jake" unit. Note: this outcrop is now "landscaped" (*i.e.*, largely covered over).

With the exception of the east end of the easternmost outcrop at Stop 10, this outcrop represents the last exposure, as one heads westward on Highway 17, of a relatively thick set of grey wacke/siltstone units, which are interpreted to be turbidites. This set of units extends, in terms of highway exposure, from here almost to the Cedar Lake Pluton, about 1.3 km along the highway.

The outcrop at Stop 9 consists of biotite±amphibole metawacke and metasiltstone. Some of the metawacke is relatively feldspathic. An F_2 fold is partly exposed and displays good examples of a variety of S_2 characteristics.

The range in the strike of S_2 cleavage is approximately the same as the range in strike of layering on the limbs of the fold. This relationship has been shown for other F_2 folds as well, for example, the fold at Stop 13, and commonly results in a local range of S_2 of 10° to 12° within the same structure. Locally, the S_2 fabric at this stop has been deformed near the fold nose, possibly by D_3 .

The S_2 fabric appears to have developed in two stages in the locality of Stop 9. The first, S_{2a} , appears to be a vein-like cleavage with development of quartz + feldspar ± amphibole which is presently at a relatively high angle to the axis of the fold. The second, S_{2b} , is represented by a spaced, hairline thick cleavage, and by biotite and wispy compositional layering which is essentially the typical axial planar cleavage (see Muir and Elliott 1987 for more details).

Pseudoclasts have locally developed in some layers in the nose of the fold as a result of compositional changes of the rock along the S_2 cleavage and transposition of the layering. Retrograded porphyroblasts, possibly initially medium- to coarse-grained andalusite, are present at the west and east ends of this stop. A set of narrow quartz veins with associated saussuritization(?) of feldspar is locally present.

Structural Summary:

Note: complexities in the southwest corner of the outcrop suggest that the fold may be deformed and/or not completely intact.

	<i>Southwest limb</i>	<i>Northeast limb</i>
S_0/S_1	297/56	286/56
S_{2a}	280/61	298/61
S_{2b}	286/52	292/61
S_3	272/?	273/63
QV	262/74 set of quartz veins associated with "bleaching"	

*** Stop 10: FOLDED, MIXED METASEDIMENTARY ROCKS (Figures 18, 19 & 25)**

Location: Southwest corner of the Teck Corona Road turnoff on Highway 17.

There are 3 outcrops to this stop. Most of the exposure here consists of variably rusty weathering, feldspathic and biotitic, locally garnet-bearing metawackes with a variety of many amphibole-rich interlayers. The present layering is generally <5 cm thick, but tectonic modification is evident. The eastern end of these exposures consists of light grey metawacke with some amphibole-rich layers. Retrograded porphyroblasts, possibly initially medium- to coarse-grained andalusite, are present within some layers. The porphyroblasts are aligned within the S_3 and L_{3f} (fold axis) structures; a relationship which has been established elsewhere (Muir and Elliott 1987,

Muir 1988), more than 1 km from the Hemlo deposit. This suggests that a relatively large-scale (regional?) metamorphic event was contemporaneous with the dextral shear event.

Vestiges of the S_2 cleavage can be seen locally. Both counterclockwise and clockwise orientations relative to layering can be seen (see Figure 25), but no fold closures are discernible. However, the presence of at least 3 folds was corroborative from previous exposures across the highway (presently "pleasingly" landscaped with grass). Some of the S_2 fabric has taken the form of a spaced cleavage commonly filled with thin quartz seams. Examples of this style of cleavage are better displayed at Stop 9.

A mafic dike with backrotated boudins can be seen adjacent to an intermediate dike exhibiting no boudinage. An example of layer-parallel brecciation is present in the middle exposure and locally is discordant (at 265°) to the layering.

As a matter of not-insignificant note for the "ditch-pigs" among you, a few, small outcrops in the highway ditch, within 50 m west of the westernmost outcrop of this stop, successively reveal the presence of: dark grey, amphibole-bearing metawacke; garnet + staurolite + aluminosilicate(?) porphyroblastic, schistose metasedimentary rocks; and a felsic quartz-feldspar-porphyrific sericite schist. These units structurally overlie the metaconglomerate/metawacke unit of Stop 11, but because of lack of exposure, are not well delineated within the tectono-stratigraphic section beyond this locality.

Structural Summary:

S_0/S_1	290/50	
S_2	305/53	alignment of amphibole; spaced, quartz-filled cleavage
S_3	272/65	alignment of micas, locally amphibole

* Stop 11: METACONGLOMERATE, METAWACKE (Figures 18 & 19)

Location: About 130 m west-southwest on Highway 17 from Stop 10 to a set of outcrops on the northwest side (the main outcrop is easily visible).

The set of 3 outcrops at this stop reveal several units of metaconglomerate and metawacke that form a relatively distinctive unit up to about 70 m thick (on surface). The main, western-most outcrop consists of 2 metaconglomerate units, one with predominantly cobble- and boulder-sized clasts, the other with predominantly pebble-sized clasts, separated by a medium- to coarse-grained metawacke with an entrained zone of pebble- to cobble-sized clasts (Photo 3). Any possible grading is equivocal because, at least in part, the units are too deformed.

The clasts comprise various proportions of feldspar-porphyrific rocks, biotite±amphibole schist, feldspathic rocks, and wacke. The porphyritic clasts, with plagioclase phenocrysts up to 8 mm long, are not identical to the many feldspar-porphyrific dikes in the Hemlo area which tend to have smaller and more uniformly sized phenocrysts. A small proportion of some of the coarser-grained crystals are presently K-feldspar. This feature has not been noted elsewhere in plagioclase-porphyrific dikes of this area, and some microscopic evidence suggests that this may be a product of metasomatism. These crystals appear to occur as phenocrysts in some clasts, and/or phenoclasts in the matrix. The matrix consists of biotite, quartz, and feldspars. Rare, small, quartz crystals can be found as phenoclasts in the matrix and as phenocrysts in some fragments; virtually none are seen in the feldspar-porphyrific clasts.

The adjacent outcrop to the east consists of a thick subunit of coarse-grained metawacke, and metaconglomerate. The third outcrop consists of several thinner subunits of granule to pebble,

polymictic metaconglomerate and medium- to coarse-grained metawacke, all of which are notably more amphibole rich than in the other 2 outcrops. In these thinner subunits of metaconglomerate, some of the clasts are mafic in composition; felsic clasts are generally either fine-grained and homogeneous, or feldspar-phyric. In all outcrops at this stop, magnetite is locally noticeable in the matrix and in some clasts.

Some of the subunits here are reminiscent of amphibole-rich conglomerate/wacke units north of the North Zone on the Golden Sceptre property, and near Botham Lake (see Figure 18 for location of the lake). However, there is insufficient information to relate the two units, stratigraphically or structurally.

The metaconglomerates and metawackes of the unit at Stop 11 are moderately to strongly deformed. On the relatively horizontal outcrop surface, the clasts appear "flattened" with aspect ratios of about 2:1 to 5:1 (locally greater). There is a slightly sinuous shape to many of the clasts as a result of the development of an anastomosing pattern in the matrix and the micaceous clasts. This pattern is interpreted to be the result, at least in part, of the overprinting of D_3 on D_2 . The clasts are aligned slightly clockwise to the crude layering; the alignment is interpreted to be parallel to S_2 and is consistent with this unit being on the northeast limb of the large fold on the Williams property (see Figure 19). The unit can be traced, for the most part, into the fold nose.

The S_2 fabric at Stop 11 is about 20° clockwise relative to that at Stop 13. This represents part of the "swing" in orientation of S_2 from about 305/60 at Stop 8, to about 270/65 at Stop 13 (see Figure 20), and is possibly a result of deformation from the intrusion, or presence, of the Pukaskwa Gneissic Complex (2719 $\pm$ 6/-4 Ma and 2688 $\pm$ 3 Ma) to the southwest, the Cedar Lake Pluton (2687 $\pm$ 3 Ma) to the east-northeast, the Cedar Creek Stock (2684 $\pm$ 4/-3 Ma) to the north (ages from Corfu and Muir 1989a), and/or the D_3 event.

A fine-grained, foliated, amphibole-bearing, felsic dike has intruded the boulder metaconglomerate (westernmost outcrop), and is locally deformed, along with the clasts, into a small, open, F_3 fold. The presence of amphibole in the matrix of the metasedimentary rocks, in some clasts, and in the dike may be inferred to indicate that some type of alteration has been superposed on the rocks, or, alternatively, it reflects metamorphism of compositionally distinct metasedimentary rocks with local effects on the dike.

Structural Summary:

S_0/S_1	287/53	
S_2	291/74	clast alignment and biotite fabric
S_a	282/50	flattened side of aligned clast, parallel to fabric in that clast
$S_{3c}?$	300/?	weak; part of "anastomosing" system
$S_{3s}?$	250/?	axial plane of small F_3 fold
L_{F3}	065/45	axis of above fold
L_e	005/47	elongation of clasts (from south side of highway)

• Stop 12: FELDSPATHIC VOLCANICLASTIC METASEDIMENTARY ROCKS ("ARKOSE") (Figures 18 & 19)

Location: Go 50 m west-southwest on Highway 17 from Stop 11 to an outcrop on the south side. There are 3 relatively small outcrops at this stop.

This unit is somewhat similar to that of Stop 15 except that the layering is thinner, ranging from 3 to 15 cm, and the quartz crystals (phenoclasts?) are generally fewer and finer grained (<1 mm). The outcrop weathers rusty brown from oxidation of fine-grained pyrite. The matrix is fine-grained, white, and appears to have been feldspathized and sericitized to some degree. Very minor green

mica is present. A grab sample from this outcrop returned an assay value of 7 ppb Au (Schnieders *et al.* 1988). A pebble conglomeratic unit is visible at the east end of the easternmost outcrop and possibly is part of the unit seen at Stop 11. A felsic dike is locally discordant to the layering.

The feldspathic volcanoclastic metasedimentary rocks of this stop have been interpreted to be the equivalent of the unit at Stop 15, folded about the large fold axis centred on the Williams property (Kuhns 1988). In any case, the rocks at Stop 12 do not have the same adjacent units at both locations. If this unit is on the northeast limb of the large fold, the S_2 fabric, if present, should be clockwise to layering. Fabric S_b is in such an orientation but is not clearly an S_2 fabric. It is still possible that the S_b fabric may be related to D_3 .

Structural Summary:

S_0/S_1 290/56

S_a 275/63 sericite

S_b 299/? sericite

•Stop 13: FOLDED, PORPHYROBLASTIC, METASEDIMENTARY ROCKS (Figures 18, 19, 26 & 27)

Location: Go 100 m west-southwest on Highway 17 to a roadcut, on the north side, that begins with an outcrop on which there is a survey tripod and pin. The roadcut consists of almost continuous exposure for the next 200 m, but is divided into 3 stops for lithological (if not logical) reasons. Stop 13 extends for about the first 150 m to a hydraulically cleaned area. The rocks range from straight-layered metapelites and metawackes, at the eastern end, to open-folded metapelites and metawackes, to sheared and tightly folded metapelites at the western end. Figure 27 shows a detailed sketch map of the west half of this stop.

The west end of Stop 13 is "on strike" from the axial plane of the relatively large, tight, north-northwest-plunging, west-closing fold best exposed on the Williams property (see Figure 19) and thus might be expected to display an overall "M" or "W" configuration. Complicated features in the outcrop suggest that a simple folding event is inadequate to explain all of the features. Hugon (1986) described a progressive, ductile, dextral shear event for the Hemlo area. Muir and Elliott

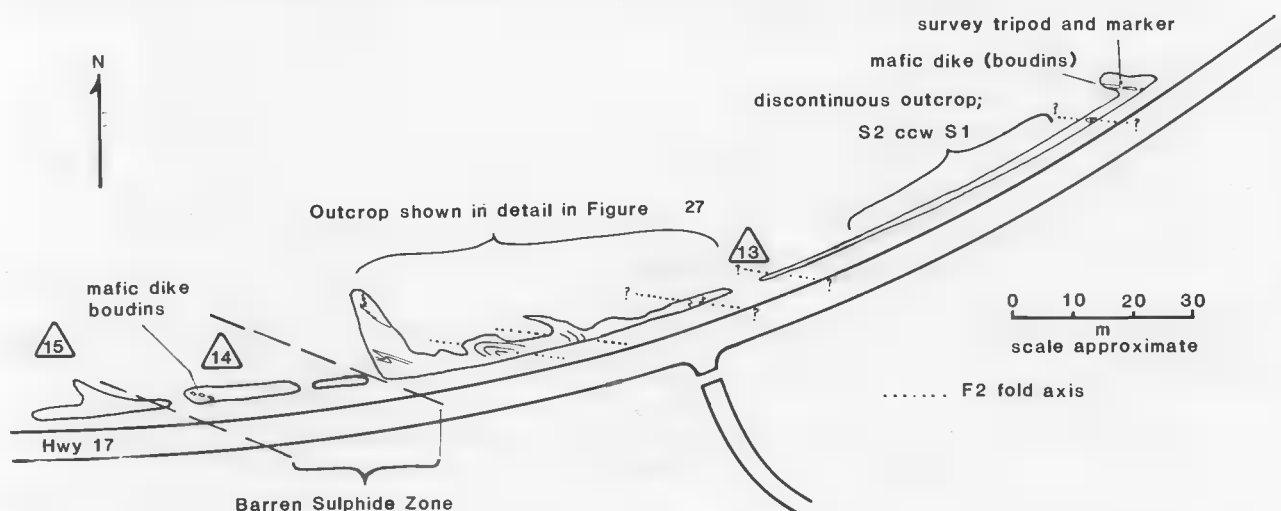


Figure 26. Stops 13, 14, 15: Simplified sketch map of folded and sheared metapelitic rocks (Stop 13), sheared and altered rocks of the Barren Sulphide Zone (Stop 14), and feldspathic metavolcanoclastic rocks (Stop 15).

(1987) proposed that F_2 generation folds may have been produced during a sinistral event, followed by a dextral event which produced F_3 folds.

The layering is generally well defined in much of this section of exposures, and appears, largely, to reflect original compositional differences between beds of siltstone, wacke, and the precursors to the amphibole-rich layers. The amphibole-rich layers in the east end of the stop display reaction rims involving some type of bleaching process. The outcrop depicted in Figure 27 displays a zone in which the amphibole-rich layers appear to be unaltered, followed to the west by increasingly altered amphibole-rich layers which are completely bleached at the west end.

The layering is presently enhanced by the development of porphyroblasts which occur in a variety of combinations and are controlled to some extent by bedding/layering composition. Porphyroblasts identified are garnet, staurolite, anthophyllite/gedrite, cummingtonite, sillimanite, retrograded cordierite, retrograded kyanite(?), and possibly chloritoid, in a variable matrix consisting of biotite, muscovite, quartz, and feldspar (Muir 1982b; Patterson 1984; Burke *et al.* 1986). Anthophyllite/gedrite or cummingtonite are present in individual layers (based on a limited thin section study) and are locally variably lineated. Staurolite tends to be non-preferentially oriented. Cross-twinning crystals are locally present. Some garnet porphyroblasts, in oriented thin sections, display open Z-shaped patterns in inclusion trails (Hugon 1986). However, S-shaped patterns in inclusion trails in some garnet porphyroblasts (oriented thin section) have been recently noted, from the author's study, in garnet-staurolite metapelitic rocks along Highway 17, about 1 km west of Stop 27. The regional significance of the asymmetry of inclusion trails, therefore, is not readily assessable.

The open folds in the west part of Stop 13 are interpreted to be F_2 generation folds based on their style. The retrograded cordierite occurs as lenses, most visible on weathered surfaces, which are constrained to specific layers and lie parallel to what is interpreted to be the axial planar cleavage (*i.e.*, S_2) of these folds. Locally, there are a few lenses of fresh, unrecrystallized cordierite that appear to be boudins and are not apparently related to the retrograded lenses. The metapelitic rocks in the western part of the outcrop, shown in Figure 27, are similar to those in Stop 17 in terms of types of porphyroblasts (garnet, staurolite, sillimanite), folds, and the S_3 fabric overprint.

The easternmost 30 m or so of Stop 13 display equivocal evidence for the limb/layering relationship in terms of the large fold centred on the Williams property. This stems largely from the significantly well-developed S_3 cleavage here and the lack of retrograded cordierite porphyroblasts. Within the next 50 m or so, up to the east end of the outcrop depicted in Figure 27, there are retrograded cordierite lenses which are aligned counter-clockwise to the layering. The relationship of the retrograded porphyroblasts to layering in the east part of the outcrop indicates that many of the rocks in the east part of this pelitic unit are, in a relative sense, on the north limb of an east-closing fold. This appears to be contrary to what would be expected if the axial plane of the large fold on the Williams property extended through the centre of a thickened, repeated unit of pelitic metasedimentary rocks in the nose of the fold. Further study is required to resolve this problem.

A partly preserved, west-northwest-closing, northeast-plunging fold is well exposed at the west end of Stop 13 (Figure 27). Based on the style of the fold and the development of axial planar cleavage, this structure is interpreted to be an F_2 fold. The axial plane is slightly convex to the northeast, ranging from 270° to 275° . The plunge of the fold, is similar to that of the Cedar Creek fold (Stop 8), but is contrary to the plunge of F_2 folds to the west-northwest of this stop, including the large fold on the Williams property, which are generally north-northwest plunging. Generally,

F_3 fold axes plunge to the northeast. Interestingly, a minor fold in a rootless section of an altered amphibole-rich layer plunges to the northwest, next to a northeast-plunging fold in contiguous layering. Note also that the axial plane orientation of S_2 , at 270° to 275° , is uncharacteristically more west-striking (*i.e.*, counterclockwise) than is the case for much of the Hemlo area, north of Highway 17, from Stop 6 to Stop 24 (Figure 20).

The southern limb of the fold in this outcrop is partly disrupted, in part along ill-defined faults which display apparent dextral and sinistral displacements. Some layers within the folded metasedimentary rocks display aligned lenses which have been interpreted to be retrograded cordierite porphyroblasts. The lenses, which are not readily visible on fresh surfaces, lie parallel to what is interpreted to be the axial planar cleavage (*i.e.*, S_2) of the fold. Proceeding eastward, there is a poorly exposed east-closing fold that can be detected from changes in the orientation of layering and from minor, or parasitic, fold asymmetry. Recent blasting has removed much of the previously exposed parts of this fold.

The western end of the outcrop at Stop 13 is variably schistose, and altered (feldspathized, sericitized). Some of that alteration includes pyritization, leading to a rusty weathering surface that tends to obscure some features. The schistose, altered rocks of the Barren Sulphide Zone, immediately to the west, may have been derived, at least partly, from these pelitic rocks. Locally, boudins or "rafts" of what are interpreted to be altered amphibole-rich layers are "adrift" in the schistose matrix, attesting to the anisotropic tectonic disruption of layering.

The metasedimentary rocks have been intruded by a plagioclase-porphyritic granodioritic dike, a boudinaged mafic dike with internally deformed layering, and a thin diabase dike in the west end of Stop 13. The feldspar porphyritic dike uncharacteristically contains garnet crystals. This type of porphyritic dike in the Hemlo area typically did not incorporate xenoliths of country rock during intrusion, so intrusive contamination is not considered important. The question remains whether the dike underwent alteration involving relative aluminum enrichment, in which case a relative timing for the alteration may be inferred (*i.e.*, postdating about 2687 Ma: see Corfu and Muir 1989a), or whether the dike intruded aluminous, altered metasedimentary rocks and was subsequently metamorphosed, which would put a minimum age for alteration at about 2687 Ma. It should not be automatically assumed that this alteration is related to the gold mineralization. The above problem is similar to that outlined for the dikes at the Williams A Zone pit (Stop 21B), and at the Northern Eagle property (Stop 4).

The superposition of alteration and complex deformation on the rocks, particularly those in the west half of the outcrop, has resulted in the recording of a "microcosm" of events which have affected the rocks in the Hemlo area as well. For instance, there is evidence for a number of fabrics within the rocks of the west-northwest-closing fold (Figure 27). Deflection, backrotation, and sinuous and anastomosing sericitic and biotitic schistositys present a confusing picture. It appears, (with a requisite degree of simplification and interpretation!), that the F_2 folds, with the axial planar S_2 cleavage, have been overprinted by a dextral shear event which has led to the development of s-c-c' fabrics. The orientation of these shear fabrics relative to layering is variable, depending mostly on the orientation of layering within the F_2 structures. The generalized fabric orientations and relationships are presented below.

Structural Summary:

S_0/S_1 variable within folds; ~ 290° away from detectable folds
 S_2 variable within folds; generally ~ $270/67$, fans from 265° to 275° ;
 biotite, alignment of retrograded cordierite lenses
 S_{3c} 292/54 locally sinuous, deflects S_2 ; biotite
 $S_{3c'}$ 318/46 locally sinuous and spaced, deflects S_2 and S_{3c} ; biotite

S_{3a}	260/?	locally backrotated by S_{3c} (?), locally anastomosing with S_2 ; biotite
L_{F2}	~043/49	general F_2 fold axes
L_{F2}	~320/49	isolated F_2 (?) fold axis
L_{st}	~312/00	stretch and/or crenulation (?) lineation, variable, depends on reference schistosity, may be shallowly east- or west-plunging

• Stop 14: BARREN SULPHIDE ZONE (Figures 18, 19 & 26)

Location: Immediately adjacent to the west end of Stop 13 (Figure 26) and comprises a few noticeably rusty weathering section of outcrops totalling about 30 m along the highway.

This rusty weathering Barren Sulphide Zone (BSZ), also known "affectionately" as the "Sucker Zone", does not have clearly defined contacts because it appears to "grade" into the adjacent "units" in terms of fabric development and composition. The BSZ appears, though, to be about 15 m thick here based on the most intensely altered and sheared rocks.

The BSZ consists of sericitized, feldspathized, and pyritized schist which has an equivocal protolith(s). It is in ill-defined (because of exposure) contact with the aluminous, well-layered metasedimentary rocks to the east (Stop 13), and the quartz-crystal-bearing feldspathic volcanoclastic metasedimentary rocks to the west (Stop 15). The oxidation on weathered surfaces is severe, and it is not possible to positively recognize features of the adjacent units within the BSZ, assuming the BSZ was derived from either or both of these units. Towards the structurally lower "contact" there is what appears to be quartz-crystal-bearing rock bounded by sericitic schists. Elsewhere in the exposures, rare quartz crystals can be seen which suggests the protolith is the feldspathic volcanoclastic metasedimentary rock of Stop 15. The BSZ is described, from diamond drill core specimens, as consisting of 10 to 20 cm of massive pyrrhotite/pyrite, and 10% disseminated sulphides extending 10 m into the hanging wall and footwall units (Quartermain 1985). Grab samples from the highway exposure returned Au values of <0.01, 0.02, and 0.51 ounces per ton (Patterson 1986), and 11 ppb (Schnieders *et al.* 1988).

The schist displays lozenges, some up to 1 m by 0.3 m in plan view, with apparently backrotated fabrics as well as sinuous, deflected, and anastomosing fabrics. These fabrics could, given their relative relationships, be representative of s-c and possibly c' fabrics of a dextral shear system, although this is not completely clear.

A relatively fresh-appearing, competent, multiply boudinaged, mafic dike occurs in the west part of the BSZ outcrop. The dike is comparable in composition to tholeiitic basalt but has elevated Ni and Cr contents relative to most mafic dikes in the area having similar, major element compositions.

Structural Summary:

S predominant (S_{3c} ?)	284/59 sericite, deflects S_b ; also crude compositional layering
S_a (S_2 ?)	272/66 sericite
S_b (S_{3s} ?)	254/58 sericite, backrotated within lozenge
Axial plane of F_3	246/66 folds foliation, almost chevron style

• Stop 15: FELDSPATHIC VOLCANICLASTIC METASEDIMENTARY ROCKS ("ARKOSE") (Figures 18, 19 & 26)

Location: This stop, immediately adjacent to Stop 14, accounts for the westernmost 25 m, approximately, of the section of exposures for Stops 13 to 15.

The outcrops consist of slightly rusty weathering, layered, feldspathic, quartz-crystal-bearing (phenoclast?, phenocryst?) rocks. The layering is poorly to moderately defined by grain size and mineral abundance, ranges from about 4 to 20 cm thick, and displays no other primary sedimentary features. The quartz crystals appear moderately strained and range from 0.5 to 4 mm across; most crystals are about 1 mm across. The matrix consists largely of feldspar and sericite.

The rock has an almost chalky white to grey appearance towards the Barren Sulphide Zone (*i.e.*, to the east). This, coupled with the presence of irregularly disseminated pyrite, small lenses of green mica less than 3 mm long, and moderate amounts of microcline along some bedding/cleavage planes, indicates this unit has undergone alteration similar to that of the Hemlo deposit. The rocks appear to "grade" into the Barren Sulphide Zone unit at the structurally upper contact. The feldspathic volcanoclastic rocks are structurally underlain, based on highway exposure, by quartz-feldspar-porphyrific, felsic metavolcanic, fragmental rocks to which they may be related as reworked equivalents.

As mentioned for Stop 12, Kuhns (1988) has interpreted the unit exposed at Stop 15 to be the folded equivalent of the unit exposed at Stop 12. Figure 19 suggests this may be the case. However, it should be noted that the unit at these locations is bounded by different rock types at its structurally upper and lower contacts, facing directions are not determinable, and structural complexities are present that may require an alternative interpretation.

Structural Summary:

S_0/S_1 294/58 generally, locally deflected to 302°

S_a and S_b : sericite 277° and 286° (possibly S_2 and S_{3a} , respectively, but indeterminable); forms small lozenges

S_d : possibly S_{3c} 302°; note similarity to deflected S_0/S_1

*** Stop 16: FELSIC PYROCLASTIC ROCKS (Figures 18, 19 & 28)**

Location: Go 50 m further west on Highway 17, south side, to a tailings/haulage road turnoff to the south. This stop consists of 2 parts: Stop 16A lies to the southeast of the turnoff, and Stop 16B lies just to the west of the turnoff.

• Stop 16A: TECK-CORONA TRIANGLE (Figure 28)

Permission to visit this stop is required from the Teck-Corona Operating Corporation.

These hydraulically cleaned exposures show felsic, quartz-feldspar-porphyrific fragmental rocks (outcrop "a") structurally overlying feldspathic metasedimentary rocks (outcrops "b", "c", and "d"). The fragments in the pyroclastic(?) rocks are fairly monolithic and range from lapilli- to small block-size, and have aspect ratios ranging from about 3:1 up to 5:1. This unit is better represented in Stop 16B.

The southern 3 exposures comprise well-layered, feldspathic, metavolcanoclastic(?) rocks. Outcrop "b" consists of thickly layered, cleaved, and locally schistose rocks. The layering is disrupted by irregularly shaped, locally truncated bodies of "layer-parallel" breccia, and by numerous high- and low-angle faults accompanied by some block rotation. The metasedimentary rocks display irregular rusty weathering zones. Outcrop "c" consists of similar rocks except that here, layers relatively rich in amphibole are present. Locally there is a consistent asymmetrical distribution of amphibole across the thickness of the layers, with more abundant amphibole present on the structurally upper (*i.e.*, north) side. The high- and low-angle faults (relative to layering) found here collectively display apparent sinistral and dextral offsets. Some light-coloured pseudotachylite/ultracataclasite, possibly associated with the layer-parallel faulting, based on

other exposures, is present near the southwest end of the outcrop. Outcrop "d" shows a highly deformed mafic dike within feldspathic metasedimentary rocks.

The white-, and locally rusty, weathering character of these rocks suggests that they may have undergone some degree of alteration. This aspect needs to be studied in more detail.

Structural Summary:

Felsic porphyritic rocks

S_p 286/55 predominant, flattening(?) fabric

Feldspathic metasedimentary rocks

S_0/S_1 290/62

$S_{2?3?}$ 267/? minor alignment of amphibole

Displacements along generalized subvertical sets: 305°, 340°, 020°, 050°, 070°, (there is no apparent consistent sense of displacement with the orientation of a fault)

* Stop 16B: FELSIC PYROCLASTIC UNITS(Figure 28)

This exposure is one of the best for displaying the fragmental character of this unit. Here, one can see crudely layered, felsic, quartz-feldspar-phyrific, fragmental rocks interpreted to represent pyroclastic deposits.

The south part of the outcrop consists of lapilli-tuff which contains heterolithic fragments. Some fragments are more mafic than the matrix, and many are not porphyritic. Several layers of lithified tuff, or volcanoclastic sedimentary material, separate the lapilli-tuff from the structurally overlying pyroclastic breccia. The tuff is similar to what is interpreted to be volcanoclastic metasedimentary rocks to the north and northwest of the Hemlo deposit. The pyroclastic breccia (block and ash flow?) is almost monolithic: one ill-defined layer is defined by an abundance of block-size fragments.

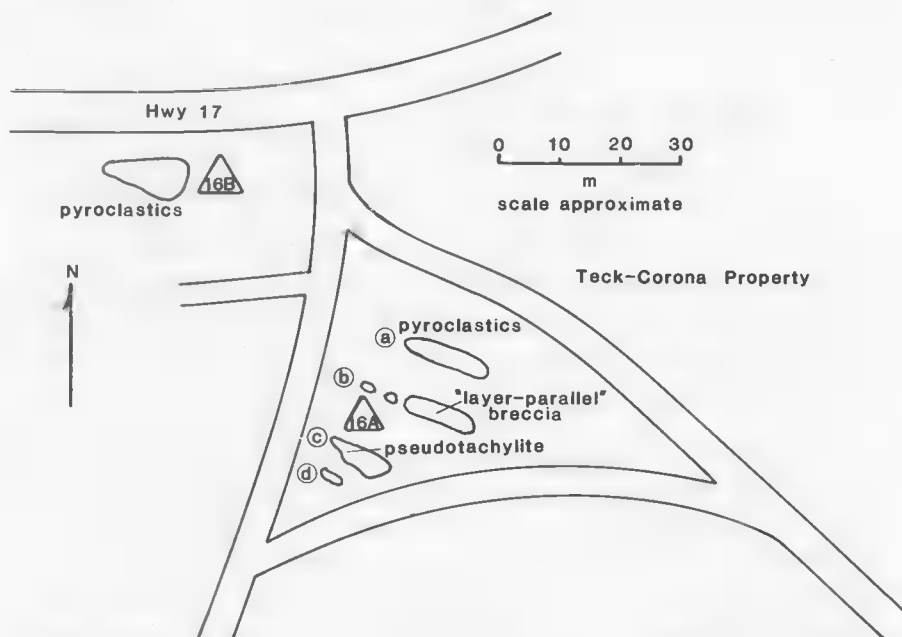


Figure 28. Stop 16: Simplified sketch map of quartz-feldspar-porphyritic fragmental rocks structurally overlying layered, feldspathic, metasedimentary rocks with layer-parallel breccias and pseudotachylite/ultracataclasite.

Both the fragments and matrix of the fragmental rocks contain quartz and feldspar phenocrysts. Most fragments are more felsic than the matrix which contains more biotite. The phenocrysts range from about 1 to 5 mm across.

The predominant fabric in this outcrop is the one in which the fragments are flattened. It is interpreted to be the S_2 axial planar cleavage and is here counter-clockwise to the layering. This is contrary to the S_1/S_2 relationship at Stop 24, so there may be an east-closing fold nose somewhere between these stops. The distribution of quartz-feldspar-phyrlic rocks (see Figure 28) supports the possibility of a tectonically disrupted fold closure southeast of Stop 13, which could be the "mate" to the large fold on the Williams property. If the structural and lithological interpretation is correct, the unit at Stop 16 represents the repeated unit which hosts the ore, although complexities make this interpretation equivocal. The unit is considerably thicker in the vicinity of this stop and exhibits a variety of lithological characteristics as well as heterogeneous strain and alteration from outcrop to outcrop (e.g., compare Stop 17 with Stop 16B).

As reported by Quartermain (1985) from the examination of diamond drill core, part of this unit contains an "ore clast", with visible gold, and "molybdenite-bearing fragments". The ramifications implicit in these interpretations highlight the necessity for explicit documentation of details regarding primary features, the timing of mineralization relative to deformation, and the stratigraphic and structural features thus produced.

Structural Summary:

S_0/S_1 295/46
 S_2 273/56 alignment of flattened fragments
 $S_{3a}(?)$ 252° sericite
 $S_{3c}(?)$ 285° deflects S_{3a}
 $L_2(L_0?)$ 352/42 also possible elongation lineation

* Stop 17: BILITHOLOGIC OUTCROP (Figures 18 & 19)

Location: Go 115 m west on Highway 17, north side, from the tailings/haulage turnoff at Stop 16. The outcrop consists of a felsic metavolcanic(?) unit, and a structurally overlying metasedimentary unit. The west end of the outcrop shows the felsic rock in contact with an approximately 30 m thick, subalkalic (i.e., common) diabase dike.

Felsic Metavolcanic Rock

The structurally lower part of this outcrop consists of altered, felsic, lenticular, quartz-"eye"-bearing rock. On fresh surfaces, the matrix is pale greenish yellow, possibly due to the presence of saussurite. The rock appears to be recrystallized and altered.

The lenses, which generally have aspect ratios in the order of 4:1 to 10:1 (Photo 4) are commonly pinkish and/or medium to dark grey in appearance. Some lenses are lighter-coloured than the matrix. The pink colouration extends along some cleavage planes, forms ill-defined and irregularly shaped but commonly lenticular zones, and forms rims around some of the darkish lenses (Photo 4). Staining indicates the pink colour is due, at least in part, to potassium feldspar. Some geologists have suggested that the pink colouration may be the result of contact metamorphism from the nearby diabase dike. The dark colour in some lenses is possibly due to chlorite and/or biotite. The darker colour is not evident on weathered surfaces. A deeper pinkish orange alteration also extends along relatively late fracture planes at high angles to the fabric. It has not been determined whether this is potassic or hematitic alteration.

The quartz "eyes" are variably flattened and range in aspect ratios from 1.5:1 to 4:1 in faces perpendicular to dip and dip direction. The "eyes" are heterogeneously distributed and are not readily apparent on fresh surfaces. Fine- to medium-grained feldspar phenocrysts are present throughout the matrix although they are best seen in cut surfaces. There are what appear to be feldspar crystals (phenocrysts?, porphyroblasts?) within the lenses.

Discontinuous laminae of quartz are locally present as stringers parallel to the predominant fabric. Quartz veins are buckled and/or dismembered. Several quartz-muscovite clots are present.

Although the rock is altered and deformed (possibly mylonitized), it is interpreted to have been, originally, a quartz-feldspar porphyritic fragmental (pyroclastic?) rock particularly given that the outcrop is on strike with the one at Stop 16B.

Porphyroblastic Metasedimentary Rock

The structurally upper part of this outcrop presently consists of finely laminated, aluminous metasedimentary rocks which are in sharp contact with the felsic metavolcanic rock described above. The layering, defined by variations in mineral content and grain size, shows no primary sedimentary features. Relict amphibole-rich layers which have undergone attenuation and boudinage are locally present. The layering presently defines an east-closing, almost isoclinal, F_2 fold, which subsequently has been overprinted and modified by the S_3 foliation (D_3). The south limb of this fold is much more attenuated as indicated by the thickness of the layering. There is some equivocal evidence for a west-closing fold to the south of this fold. A few late fractures associated with pink-orange alteration are present.

The porphyroblasts comprise garnet, staurolite, sillimanite, and possibly a fourth type represented by roughly equant, white-weathering mineral(s) which may be retrograded crystals. Garnet occurs as reddish brown, fine- to medium-grained, euhedral crystals which are distributed, in part, according to the composition of the layering. Staurolite crystals are fine- to coarse-grained, euhedral to subhedral, dark to medium brown, and locally have overgrown and preserved the modified metasedimentary layering. The entrained layering is straight within the crystals, suggesting static conditions during growth. Many of these crystals have subsequently undergone a clockwise rotation, on both limbs of the F_2 fold as indicated by the re-orientation of the layering. This suggests the effects of the dextral shear event post-dated porphyroblast growth, at least in part. Porphyroblasts which appear in long section on the outcrop show a weak tendency to be aligned parallel to the S_3 fabric.

Sillimanite occurs as fibrolite and appears, on the glaciated surface of this outcrop, as relatively dark, wispy, splaying, aligned, sigmoidal ("S") clusters of crystals. The fibrolite is commonly adjacent to, and locally is deformed around, staurolite porphyroblasts, particularly where the latter are at a high angle to the layering. The sigmoidal deflection of the clusters appears to be a D_3 feature and may represent an s-c fabric relationship in a dextral shear zone. These metasedimentary rocks are very similar to those at Stop 13, although they are not along strike from this outcrop.

Structural Summary:

Metasedimentary Rocks

S_1 282/58

S_3 273/?

Late fracture (pink-orange alteration) 356/90±

Metavolcanic Rocks

S predominant (mylonitic?) 292/51

*** Stop 18: FELDSPATHIC METASEDIMENTARY ROCKS** (Figures 18, 19 & 29)

Location: Go 160 m west on Highway 17, south side, from Stop 17, to a point just before a turnoff to the north. This unit is approximately on strike with the metasedimentary unit at Stop 16A.

This outcrop is not nearly as illustrative as it was before the recent blasting. It shows grey to light grey weathering, feldspathic metasedimentary rocks with some amphibole-rich layers and some minor garnet-bearing layers. The present layering is likely a result of a combination of primary compositional layering and subsequent, locally developed, tectono-metamorphic layering. At the east end of the outcrop some layers display repetitive, light/dark grey-graded couplets (dark part on the north side) (*cf.* Stop 16A). Some flattened, S-shaped folds in quartz veins with dismembered limbs are present. The flattening fabric ranges from parallel to slightly counter-clockwise to the layering.

Several low-angle, counter-clockwise (to layering), dextral faults are present and may be genetically related to several zones of layer-parallel breccias and pseudotachylite/ultracataclasite that are visible at this stop. The faults are locally parallel to layering along strike. The pseudotachylite, which locally contains spherical to elongate vesicular features (naturally at a precarious spot at the top edge of the roadcut), has possibly undergone ductile deformation in places. At the east end of the outcrop at road level, is a zone of breccia in which blocks of metasedimentary rocks appear to have undergone clockwise rotation with infilling by more finely brecciated host rock. This may represent a variety of the layer-parallel breccias that have resulted from dextral sense displacement. There are also sets of numerous, relatively late, brittle faults which are at a high angle to layering.

On the fresh roadcut face, the metasedimentary rocks appear to be purplish grey and pale greenish grey. However, the greenish grey colour is spatially associated with the sets of fractures mentioned above, and appears to be some type of alteration involving bleaching of the rock. Locally, up to 80% of the rock is similarly bleached. This raises questions about how much of the rocks, here and elsewhere, are altered, and what form of alteration has taken place. Some hematitic alteration is present, along with quartz and chlorite, on some fractures. Other fractures contain epidote + calcite ± amphibole. The metasedimentary rocks are intruded by a schistose dike, not readily apparent on horizontal surfaces, that has undergone significant pinching and boudinage.

The metasedimentary rocks at this stop should be compared to those at Stop 24, structurally underlying the deposit, which some geologists think are part of the same unit.

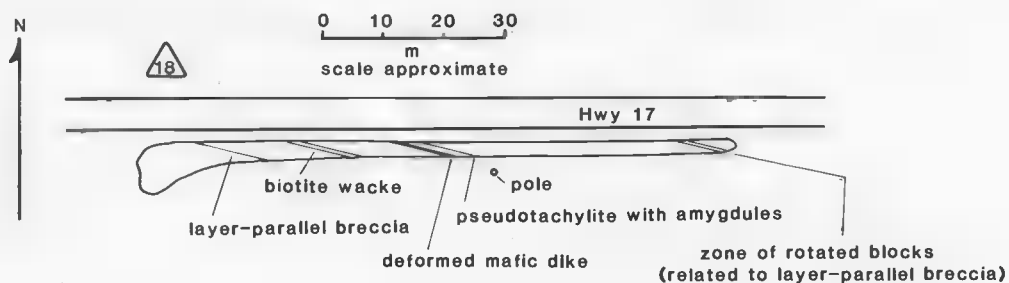


Figure 29. Stop 18: Simplified sketch map of feldspathic metasedimentary rocks with brecciated zones and pseudotachylite/ultracataclasite.

Structural Summary:

S_0/S_1	297/55±5	overall
S_0/S_1	285/?	layering adjacent to zone of aligned blocks (see description above)
Alignment of blocks	303° to 320°	(long axis)
Low-angle, faults	265/80	dextral, brittle-ductile; D_3
High-angle faults	358/85	dextral
	328/90±	sinistral; offsets a low-angle, D_3 -related fault
	010/90±	sense not determined
L_s (slickenside)	~297/05±	

•Stop 19: "HANGING WALL" METASEDIMENTARY ROCKS (Figures 18 & 19)

Location: Go 50 m further west on Highway 17, south side, from the west end of Stop 18 (which is opposite a turnoff to the north).

This is the first relatively large outcrop to the east of the Main Mineralized Zone (Stop 20A), and best represents the "hanging wall" unit as exposed along the highway. The metasedimentary rocks display indistinct, possibly transposed layers, defined mostly by various proportions of feldspar, quartz, and biotite, as well as some amphibole-rich layers. There are also zones consisting of numerous amphibole-rich knots or lenses. A few veinlets associated with tourmaline and bleaching of the country rock are present. There are several layer-parallel, fine-grained gossans which are locally ill-defined.

In this outcrop, there are several, weakly defined, angular discordancies between sets of layered rocks and between angular relationships of cleavage with respect to layering. These features may be examples of juxtaposed faulted blocks, or, possibly 3 or so ill-defined, tight, F_2 folds, or a combination of both features. F_2 folds have been observed in the hanging wall rocks at the Williams A Zone pit, and north of the highway along the effluent/haulage road between Stops 19 and 20.

The metasedimentary rocks exposed at this stop should be compared to those at Stop 22 which form, with respect to highway exposure, the footwall rocks to the main part of the Quartz-Feldspar-Porphyritic Complex (Stop 20).

Structural Summary:

North part of outcrop:

S (predominant) 295/60

South part of outcrop:

Range of S_0/S_1 layering 282° to 297°

Range of possible S_2 cleavage 292° to 282°

•Stop 20: QUARTZ-FELDSPAR-PORPHYRITIC COMPLEX AND MAIN MINERALIZED ZONE (Figures 18, 19, 30 & 31)

Location: Go 235 m further west on Highway 17 from Stop 19, to a low-lying outcrop (Stop 20A), north side, about 55 m west of an effluent/haulage road.

•Stop 20A: MAIN MINERALIZED ZONE (Figure 30)

This outcrop, which used to be larger before being completely buried, then partly recovered, is part of the rootless, mineralized, West Zone of the Teck-Corona property (see Figure 22). The West Zone presently is not economical to mine, in part because of its location beneath Highway 17.

The outcrop consists of rusty weathering, schistose, locally lenticular, heterogeneously sericitized and pyritized quartz-feldspar porphyritic rock which displays tourmaline, some relatively large green mica lenses, and wisps of very fine-grained molybdenite. The green mica in the Hemlo camp has been determined to be vanadian muscovite (Harris 1986b, 1989). Grab samples from this outcrop returned values of 0.16 ounce Au per ton (0.05% MoS₂) (Patterson 1984), 6.35 and 24.35 ppm Au, and 550 ppm Mo (Schnieders *et al.* 1988). Channel samples from this outcrop by Hemlo Gold Mines Inc., assayed up to 9.0 ppm Au across 1.14m (J. Londry, geologist, Hemlo Gold Mines Inc., personal communication 1994).

Despite considerable recent oxidation, one can still see a variety of lenses defined by differences in grain size, texture (e.g., porphyritic/non-porphyritic, schistose/"massive"), and composition (e.g., sericite/biotite) (Photo 5). Some of the lenses consist of quartz which may indicate that some quartz veins have been completely dismembered. Considerable variation in texture and grain size also can be seen between fabric-parallel, non-lens-bearing "zones", some of which are not pyritized.

There is no consensus as to the protolith of the unit. Some geologists interpret the rock to be a mylonite, and others a deformed, possibly mylonitized pyroclastic/volcaniclastic fragmental. The unit appears texturally similar to sericitized "fragmental" rocks in the mines and in the Teck-Corona trench (Stop 21A). Felsic, monolithic and heterolithic, quartz-feldspar-phyrlic pyroclastic/volcaniclastic rocks can be seen elsewhere in the area, (e.g., Stop 16B, and outcrops on the Williams property and Golden Sceptre property (Hemlo Gold Mines Inc.)). Because of the internal complexities in this unit (particularly to the west-northwest), such as "massive" and fragmental porphyritic rocks, Muir (1985) coined the term "Quartz-Feldspar Porphyritic Complex" for the essentially contiguous quartz-feldspar-phyrlic rocks, of which this unit appears to be part.

A small outcrop, about 7 m east of the east end of the main outcrop at Stop 20A, shows a 2 m thick, apparently unaltered, medium-grained, subporphyritic (plagioclase) granodiorite dike which has intruded the sericitized, pyritized, porphyritic rocks. The dike has muscovite poikiloblasts.

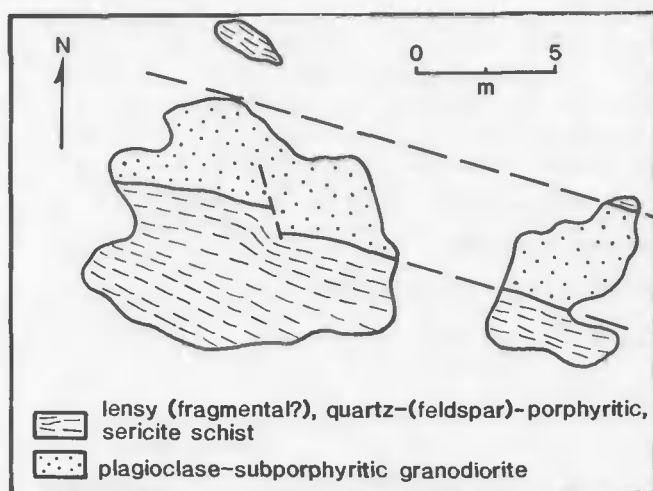


Figure 30. Stop 20A: Detailed sketch map of the West Zone (See Figures 21 & 22) (Teck-Corona property) as originally exposed along Highway 17. Present outcrop outline differs. (Modified after Patterson 1984).

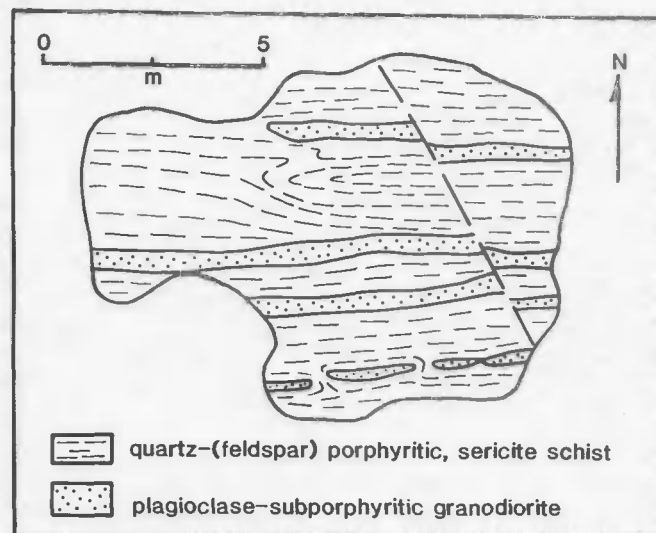


Figure 31. Stop 20B: Detailed sketch map of part of the Quartz-Feldspar-Porphyritic Complex, structurally underlying the West Zone (See Figures 21 & 22), as originally exposed along Highway 17. Present outcrop outline differs. (Modified after Patterson 1984).

Structural Summary:

S (predominant) (S_{3c} ?) 288/~70
 S (subordinate) (S_{3a} ?) 263/? deflected by above S (predominant)
 S (subordinate) (S_{3c} ?) 297/? backrotates S (predominant)
 S_3 ? (late overprint?) 250/74 crenulation in F_3 fold
 Axial plane boundary 011/? sinistral sense kink

***Stop 20B: "MASSIVE" QUARTZ-FELDSPAR PORPHYRY (Figure 31)**

Location: Go 55 m to the west of Stop 20a, north side.

This low-lying outcrop structurally underlies the main mineralized zone, seen in Stop 20A, and consists of white-weathering, felsic, foliated, green-mica-bearing, quartz-feldspar porphyry which is intruded by several feldspar porphyritic dikes. The quartz-feldspar-porphyritic rock may have been a subvolcanic intrusion or part of a massive flow. Some of the dikes display boudinage with D_3 -related features (*i.e.*, S_3 , F_3) evident in the necks. The dikes are foliated with sericite±chlorite, and contain non-preferentially-oriented muscovite poikiloblasts. Small-scale, conjugate(?), sinistral and dextral kinks (F_4 ?) are present.

Structural summary:

Predominant fabric 286/70
 Subordinate fabric anastomosing with above 275/74
 Weakly developed fabric defects(?) above 304°
 Trace of sinistral kink band boundary 037°
 Trace of dextral kink band boundary 002°

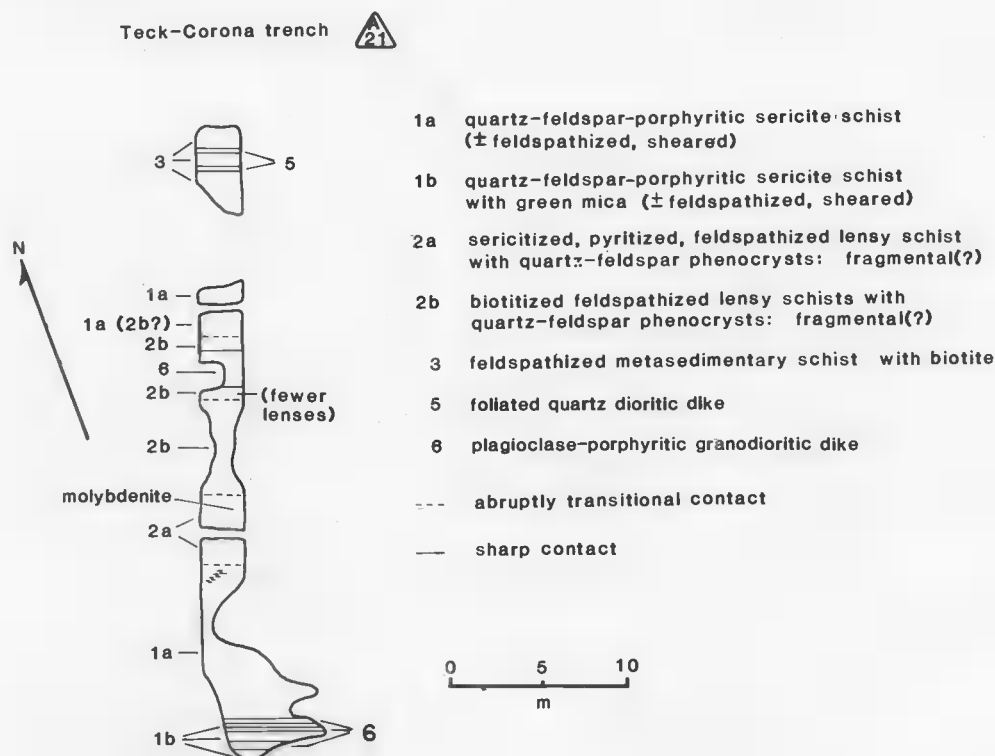


Figure 32. Stop 21A: Detailed sketch map of the westernmost Teck-Corona trench showing the non-economic, on-strike equivalent of the Williams A Zone. (Geology by T.L. Muir, OGS 1987).

• **Stop 21: TECK-CORONA TRENCH and WILLIAMS A ZONE PIT SITE** (Figures 18, 19, 21, 22, 32 & 33)

Location: Go 165 m west from Stop 20B to a short turnoff to the north used for access to the A Zone exhaust turbines.

• **Stop 21A: TECK-CORONA TRENCH** (Figure 32)

Permission to visit this site is required from Teck-Corona Operating Corporation.

Location: Enter the bush (to the north), from the highway right-of-way, on a cut line about 25 m east of the short turnoff road. Follow the line/trail for about 40 m to a 35 m long stripped "trench" which is roughly on strike with the Williams Mine A Zone.

The southern end of the stripped zone consists of foliated, sericitic, felsic, quartz-feldspar porphyry which locally contains green mica lenses. Structurally overlying this is a mineralized, rusty, highly schistose (sheared?), lensey, sericitic rock with quartz eyes, pyrite, and sparse, very fine-grained molybdenite. A grab sample from the mineralized part of this trench returned a value of 2.27 ppm Au and 105 ppm Mo (Schnieders *et al.* 1988).

There is no agreement as to whether the lenses are in whole or in part primary, but this rock appears to be the sericitized equivalent of the structurally overlying, schistose, biotitized rock which contains heterolithic lenses. Both rocks have been altered and are referred to generally in mine terminology as "fragmentals", although the term is used non-genetically by some geologists. To the north, the rocks in the trench consist of schistose, quartz-eye-bearing, biotite + sericite schists, structurally overlain by what may be somewhat feldspathized and sericitized metasedimentary rocks. The rocks have been intruded by plagioclase-porphyritic granodioritic dikes and fine-grained, "quartz dioritic" dikes.

Structural Summary:

North end of stripping

S₁ (mylonitic?) 295/57

S₃? (forms lozenges with above fabric) 284/70

South end of stripping (all fabrics defined by sericite)

S (predominant) 291/64

S (subordinate) 281/64 forms lozenges with above fabric

S (subordinate) 304/57 seems to deflect either or both of the above two fabrics

* **Stop 21B: WILLIAMS A ZONE PIT** (Figures 22 & 33)

Permission to visit this site is required from Williams Operating Corporation.

Location: Return to just south of the south end of the stripping where a flagged shortcut takes one westerly to the A Zone pit area, or, return to the highway right-of-way and approach the fenced-off open pit area from the short turnoff road. This is a "view stop" which is best achieved by walking north along the outside of the east end of the fenced-off area for about 50 m to a knoll. Hidden just in the bush on the way in is what appears to be one of the original small pits created in the 1940s.

The west end of the open pit shows a rusty zone which crudely marks the uneconomic, on-strike extent of the A Zone of the Williams Mine. Footwall rocks to the ore zone are variably altered and schistose, felsic, quartz-feldspar porphyry. The hanging wall rocks consist of tight to isoclinally folded and transposed metawacke and metasiltstone with amphibole-rich layers. Staurolite and

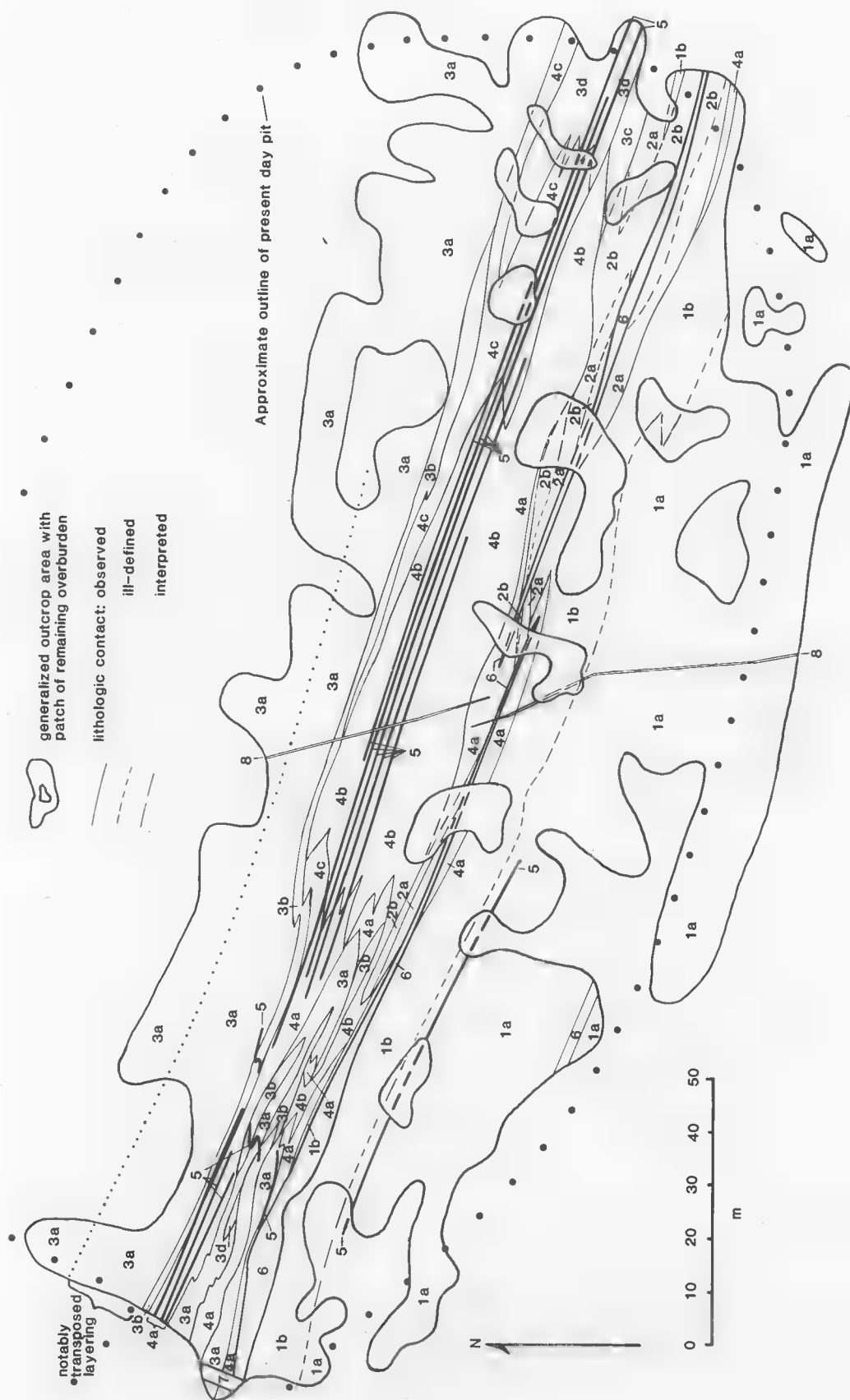


Figure 33. Stop 21B: Generalized sketch map of detailed surface geology of the Williams A Zone prior to excavation for the open pit. (Modified after mapping by T.L. Muir 1985; Muir *et al.* 1988).

kyanite are present in these hanging wall rocks in a zone up to about 50 m thick (Walford, Stephens *et al.* 1986). The biotitized/sericitized "fragmental" unit appeared, on surface, to pinch out to the west, about midway into what is now the open pit area (Figure 33). The ore, as exposed on surface (Photo 6), was interpreted to be derived, for the most part, from feldspathized and pyritized metasedimentary rocks (Unit 4, Figure 33). At surface, it was up to 35 m thick and "H" shaped (Walford, Weicker *et al.* 1986) with tails to the east and west.

Open pit operations, which began in August, 1985 and ended July 1986, resulted in the extraction of 3.8 million tons of rock, including 0.8 million tons of ore grading 5.13 ppm Au (A. Guthrie, Williams Operating Corp., written communication 1992). Pit dimensions are approximately 275 m by 170 m (top), 150 m by 25 m (bottom), and 70 m deep (Resident Geologist Files, MNM, Thunder Bay).

Plagioclase-porphyritic and quartz dioritic dikes appear to have intruded the A Zone ore (Photo 7) (Corfu and Muir 1989a). Kuhns (1988) also interpreted feldspar porphyry and intermediate composition "sills" to have intruded the Golden Giant orebody. The dikes within the A Zone (and elsewhere in the Hemlo area) typically contain muscovite poikiloblasts and are anomalous in Au, Ba, Hg, and Sb. If they actually intruded an existing ore, then a minimum age for the mineralization can be inferred to be about 2680 Ma, based on U-Pb dates from Corfu and Muir (1989a). The dikes likely have undergone subsequent metamorphism which would account for the poikiloblasts. Whether or not the dikes assimilated mineralized material or "absorbed" the metals during metamorphism is unclear. Native gold is locally found along fractures within an essentially unaltered, plagioclase porphyritic dike that has intruded the David Bell Mine orebody (Paul Bankes, Teck Exploration Limited, personal communication, 1987), suggesting that some remobilization has occurred.

LEGEND: STOP 21B

Metavolcanic? / Metasubvolcanic? Rocks

- 1a felsic, variably schistose: quartz-feldspar porphyritic, sericite±microcline
- 1b intermediate, variably schistose: quartz-feldspar porphyritic, biotite±sericite±microcline

Fragmental? Rocks - volcanic? volcanoclastic?

- 2a biotitized, feldspathized, lensy rock
- 2b sericitized, feldspathized, lensy rock (with green mica lenses)

Metasedimentary Rocks

- 3a wacke, feldspathic arenite±siltstone±amphibole-rich layers
- 3b schistose wacke, feldspathic arenite±siltstone
- 3c feldspathized to schistose metasediments
- 3d feldspathized metasediments

Schists and Granofels of Undetermined Origin (possibly metasedimentary)

- 4a sericite±biotite schist±mineralization
- 4b intensely feldspathized rocks±mineralization
- 4c feldspathized to schistose rocks

Dikes

- 5 intermediate, foliated, quartz dioritic
- 6 plagioclase-porphyritic granodiorite
- intrusive contact
- 7 diabase
- intrusive contact
- 8 magnetite-biotite lamprophyre (Proterozoic)

Most ore comprises subunits 4a and 4b

From this open pit operation, and given the character of the rocks in the nearby Teck-Corona trench, one can appreciate the potentially narrow "windows" (Figure 22) of exploration for ore bodies of this type, even though this is a large deposit. One can also appreciate the relative quietness of the highway after leaving this stop.

Structural Summary:

S ₀ /S ₁	292±5/64±4	hanging wall
S ₂	305/62	hanging wall
S _{3s} ?	270/65±5	schistose ore; felsic metavolcanic rock
S _{3c} ?	295/60±5	schistose ore, felsic metavolcanic rock
F ₃	060/60, 100/43	schistose ore
L _m	307/33	tourmaline mineral lineation
L _s	107/07	slickenside

*** Stop 22: MAGNETITE-LAYER-BEARING METAWACKE (Figures 18, 19 & 34)**

Location: This stop is beside and opposite the A Zone pit turnoff referred to for the Stop 21 location.

• Stop 22A: MAGNETITE-BEARING METAWACKE AND PORPHYRY DIKES (Figure 34)

The beleaguered outcrop, on the north side, immediately to the west of the turnoff, is all that remains of a larger predecessor. The rocks are mostly transposed, foliated metawacke with magnetite ± amphibole-rich layers (Photo 8). The metawacke appears to contain muscovite poikiloblasts. It has been intruded by two types of plagioclase-porphyritic dikes, both of which have magnetite crystals within many of the phenocrysts suggesting this is a secondary (metamorphic?) phenomenon. The structurally upper dike is more typical of feldspar porphyry dikes in the Hemlo area (although a wide variety of textures and grain sizes exists among dikes) and contains numerous, medium-grained, plagioclase phenocrysts. The structurally lower dike, now visible only in the blasted face, contains fewer, and medium- to coarse-grained, plagioclase phenocrysts. It is colloquially known as "popcorn" porphyry.

Structural Summary:

S₁, S₂(?) 290/62

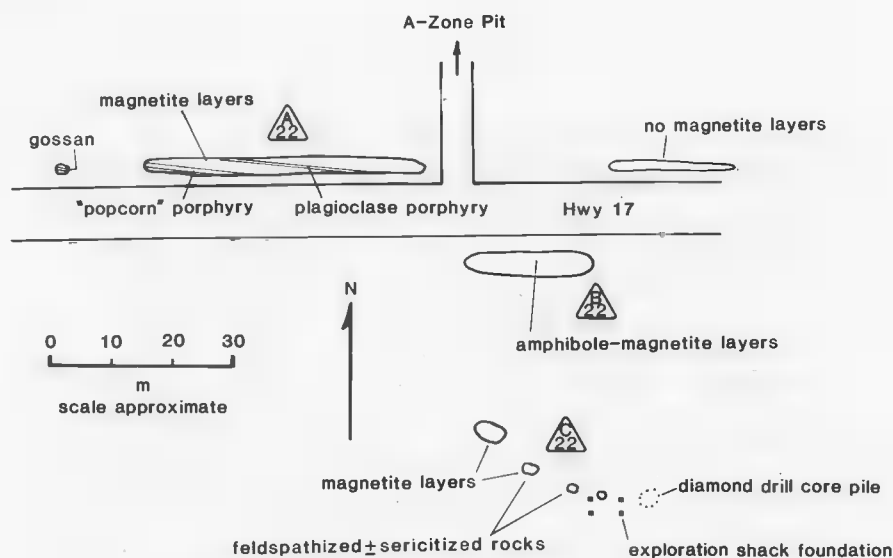


Figure 34. Stop 22: Simplified sketch map of transposed metawacke with magnetite-amphibole layers and localized alteration.

Stop 22B: METAWACKE WITH MAGNETITE-AMPHIBOLE-RICH LAYERS (Figure 34)

Almost immediately south of the turnoff is an outcrop of foliated but "massive"-appearing metawacke which has magnetite + amphibole-rich layers and is locally garnet rich. The layering appears to be transposed to some degree. Some of the amphibole-magnetite-rich layers are disrupted. There are discordancies between blocks or wedges with respect to layering and fabrics. Some of the layering may be tightly folded with "S" asymmetry. The rock is intruded by foliated, boudinaged, plagioclase-porphyritic dikes containing muscovite poikiloblasts.

Structural summary:

S₁, S₂(?) 289/68

Stop 22C: ALTERED MAGNETITE-BEARING METAWACKE (Figure 34)

The northernmost outcrop of this part of the stop lies 27 m south of the west end of Stop 22B and consists of metawacke with poorly defined magnetite layers. A second outcrop lies 8 m to the southeast and consists of variably schistose, sericitized and locally pyritized rocks intruded by felsic dikes. Several years ago one could see magnetite layers within feldspathic white-weathering rock, suggesting the rock is altered magnetite-bearing metawacke (see Stop 23 which is approximately on strike from this outcrop). Presently the outcrops in this area are being reclaimed by lichen. A trail to the southeast of here leads to two more sericitic outcrops as well as the foundation to a drill core shack and an unruly pile of drill core. This was the campsite of the Lake Superior Mining Corporation from the late 1940s.

Structural Summary:

S₁ 284/74; S₂? 294/?; S₃ 066/88 (weak crenulation)

• Stop 23: LOWER MINERALIZED ZONE (Figures 18, 19, 35 & 36)

Location: Go 110 m further west on Highway 17, north side, from the A Zone pit turnoff, past a small, previously unexposed, rusty weathering, schistose, alteration zone, to a rusty weathering, hydraulically cleaned outcrop (Figure 35). The small alteration zone returned a value from a grab sample of 43 ppb Au (M. Smyk, MNM, personal communication, 1990).

The outcrop at Stop 23 is the surface expression of a zone of mineralization that structurally underlies the main ore body, and is ore grade at about a depth of 900 m. Surface grab samples returned values of 0.02 and 0.31 ounces Au per ton (Patterson 1986). The outcrop consists of

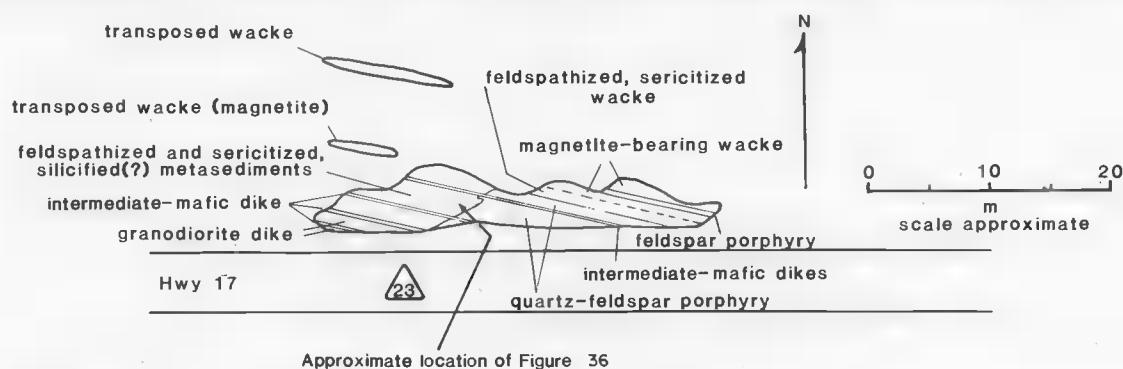


Figure 35. Stop 23: Simplified sketch map of the surface equivalent of the Lower Mineralized Zone quartz-feldspar porphyry, and the adjacent, locally altered, metasedimentary rocks structurally underlying magnetite-bearing metawacke.

altered, schistose, quartz-feldspar porphyry, (structurally lower part of the outcrop), which is in sharp contact with intensely altered rocks that possibly are derived from the structurally overlying metawacke.

The porphyry, which shows no recognizable features indicative of a volcanic origin, is white weathering, except for local, bright orange, surface staining. It consists of feldspar (some of which is microcline), quartz, and sericite, with pyrite, tourmaline, and sparse green mica. Locally, the tourmaline is euhedral and up to several millimetres long. Barite has recently been noted in cross-cutting veinlets and layer-parallel seams (B.R. Schnieders, personal communication 1994).

The feldspathized/sericitized rocks adjacent to the porphyry are about 40 cm thick and are distinguishable largely because of the lack of quartz eyes, finer grain size, and more abundant sericite. Layering is defined by grain size differences and variations in the abundance of sericite. Locally there are fragment-like feldspathic lenses which may have resulted from disrupted layering or alteration "veins". There are also numerous, small, white porphyroblasts which appear to be retrograded. The origin of the rock is equivocal.

Tracing the contact between the 2 rock types on the outcrop indicates that it is only locally straight: it appears to change abruptly because the porphyry is not present at the west end of the outcrop. Where the contact is straight and parallel to the predominant fabric, the layering is conformable. However, at the west end, the layering and some of the numerous quartz veins found here are folded and disrupted (Figure 36) and possibly transposed, suggesting the contact has been folded and is left stepping. Several fine-grained, foliated, boudinaged, intermediate, biotite-bearing dikes appear to be unaffected by this folding, suggesting the folding is of the F_2 generation. The southwest end of the outcrop shows a fine-grained, biotite granodiorite dike with fine- to coarse-grained muscovite poikiloblasts.

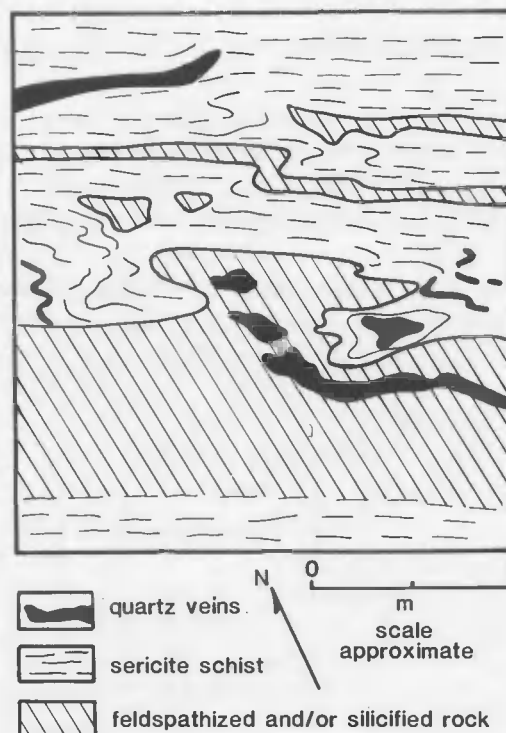


Figure 36. Stop 23: Detailed sketch map of part of the outcrop shown in Figure 35, as originally exposed along Highway 17. Location of the sketch map site, indicated in Figure 35, is approximate. (Modified after Patterson 1984).

The altered rocks adjacent to the porphyry display a fairly abrupt "contact" with the structurally overlying metawacke. The metawacke displays wispy to ill-defined layering which is possibly the result of transposition. Within the metawacke are transposed layers rich in magnetite and amphibole. Two outcrops to the north of the roadcut are part of this magnetite-bearing metawacke unit, which has already been seen at Stop 22. The magnetite-bearing metawacke is intruded by feldspar porphyry dikes.

Structural Summary:

Predominant cleavage (sericite) 280/68
 Subordinate fabric (sericite) (S_3 ?) 269/65
 S_3 ? fabric (sericite) in boudin neck 242/78 (late overprint?; see Stop 20A)

*** Stop 24: FELDSPATHIC METASEDIMENTARY ROCKS (Figures 18 and 37)**

Location: Continue west on Highway 17, south side, for about 410 m to a roadcut with outcrop on both sides of the highway, south of Moose Lake. The features of the unit at Stop 24 should be compared to those at Stop 18, which some geologists interpret as the same unit. It should be kept in mind that the highway exposures do not provide a continuous section through the deposit "stratigraphy", and that changes in rock types are evident along strike and down dip. The immediate hanging wall and footwall rocks to the Hemlo deposit are not exposed along the highway.

South Side of Highway 17

The east end of the roadcut shows a fine- to medium-grained plagioclase-pyroxene-phyrlic diabase dike. This is the same dike that lies near the boundary between the Williams property and the Golden Giant property (see Figure 22). Country rocks adjacent to the dike show notable epidote and pink (hematized?) feldspar.

The remainder of the outcrop consists mostly of relatively feldspathic metasedimentary rocks which show some cleavage-parallel alteration that is better displayed at the next stop. Compared to Stop 25, the rocks here display more pronounced layering which, although notably tectonic in origin, is interpreted to at least partly reflect modified primary compositional layering, as it is similar to less tectonized rocks elsewhere. The layering is defined, in part, by grain size variations and the abundance of amphibole and/or feldspar. Some of the layers appear to be examples (modified?) of amphibole-rich layers common in other metasedimentary units. For the most part, the S_2

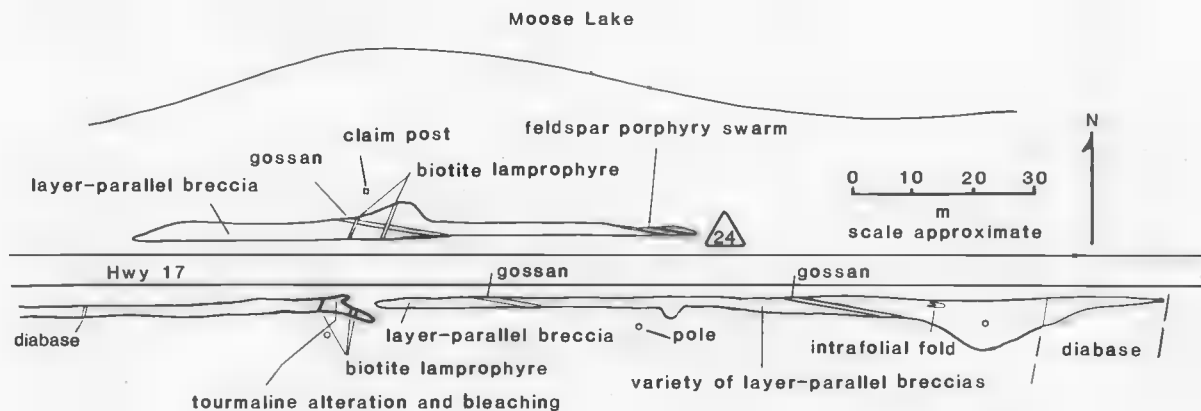


Figure 37. Stop 24: Simplified sketch map of "footwall", mylonitic(?), feldspathic, metasedimentary rocks and layer-parallel breccias.

cleavage, where identifiable, is oriented counterclockwise to layering. Intrafolial folds are present near the east end of the outcrop and near the eastern gossan and may reflect an F_1 folding event.

There are two gossans in this outcrop which are sufficiently oxidized on surface to hinder determination of the "protolith". The western gossan, about 1 m thick, appears to be composed of metasedimentary rocks similar to the bounding layers. The eastern gossan, about 3 m thick, appears to consist of rocks with more biotite and feldspar (alteration?) than the bounding metasedimentary rocks, and has along its northern boundary a narrow (<20 cm), somewhat heterolithic, lensey unit which may have been a volcanoclastic/conglomeratic rock initially. Some of the lenses/fragments are feldspar phyrlic. This zone may be the eastern extension of the Highway Zone (Patterson 1986) (see Stop 27). A grab sample from this gossan returned a value of 0.01 ounces Au per ton (Patterson 1986).

The roadcut face reveals clots of calcite + pyrite + tourmaline, quartz + pyrite, and pink/orange feldspar + fluorite. Subhorizontal to shallowly west-plunging slickensides are also present.

The outcrop at Stop 24 displays layer-parallel breccias. Collectively, in the Hemlo deposit area, layer-parallel breccias are relatively late, given that there is rare evidence of ductile deformation in most cases and generally no overprinting fabric. The brecciation has affected all Archean rock types (except possibly diabase). Overall, in this part of the greenstone belt, the breccias occur from the mafic metavolcanic rocks near the Pukaskwa Gneissic Complex, about 2 km to the south, to the metawacke units about 3 km to the north (Golden Giant Mine tailings site). The breccias are most common and volumetrically important in relatively competent feldspathic rocks such as this outcrop. Layer- and fabric-parallel fault gouges within sericitic rocks, spatially associated with the Hemlo deposit, are likely equivalent examples of this brecciation. Light grey to black pseudotachylite, with or without internal layering, is spatially and apparently genetically associated with the breccias in the more feldspathic rocks. The sense of movement on the fault planes is generally not determinable, but locally shows a dextral component of displacement. Some of the breccias terminate abruptly along strike and become thin seams which may or may not contain pseudotachylite/ultracataclasite. The brecciation could be associated with a continuation of the dextral shearing noted in other stops, resulting from a change from predominantly ductile to predominantly brittle processes, or it could be a manifestation of Proterozoic crustal movement, or both. Examples of these breccias that show at least 3 stages of brecciation have been noted locally.

There are about 4 "types" of layer-parallel breccias exposed in one part of the outcrop at Stop 24:

- (A) an uncommon semi-ductile type, with aligned layering in fragments and blocks at about 075° — the boundaries of the breccia are ill-defined;
- (B) the most common type, with angular, unoriented fragments in a matrix similar in colour to the host rock — generally has sharp boundaries to the breccia zone with one side commonly straight and the other slightly to very irregular in form — possibly affects (*i.e.*, postdates), type A;
- (C) tabular zone with angular, unoriented, various-sized fragments of country rock in a light-brown-weathering, relatively high proportion of matrix. A thin section of this breccia shows that prehnite constitutes a significant portion of the matrix;
- (D) an *in-situ* shattering of the country rocks with a recessively weathering matrix — predominant fracturing at 342°.

North Side of Highway 17

The units are much the same as for outcrops on the south side. Several previously interesting features did not survive recent blasting.

Some features to note:

- some amphibole-bearing layers contain small quantities of garnet;
- collectively, both the slightly discordant faults and the layer-parallel breccias cut across layering structurally up and down;
- a very-fine-grained, white matrix of a layer-parallel breccia body (type C?) south of the claim post (Figure 37). Locally forms up to 50% of the breccia;
- a swarm of feldspar porphyry dikes occurs at the east end of the outcrop as did some epidote-bearing pseudotachylite/ultracataclasite (before recent blasting);
- there are some sinistral and dextral kinks (F_4) in the layering;
- northerly striking, Proterozoic, biotite + pyroxene(?) lamprophyre dikes occur in the western third of the outcrop; one has a central "core" consisting of a 3 cm thick calcite vein.

Structural Summary:

S_1	285 to 293/62±2
S_2 ? cleavage (local)	298/56
S_3 ? fabric (sericite)	272/63
L_1 ? (intersection)	345/53 (muscovite elongation?)
L_1 ? (intersection)	078/49
L_1 (slickenside)	103/08 to 283/08

*** Stop 25: HEMLO FAULT ZONE (Figures 18, 19 & 38)**

Location: Go 600 m further west on Highway 17, north side, from the claim post shown in Figure 37, to a set of small outcrops on both sides of the highway, about 60 m west of the Williams Mine tailings/effluent overpass. These outcrops also show many of the same features as at Stop 26 but have suffered less from the ravages of recent blasting.

This is one of several sets of outcrops that depict the Hemlo fault zone, which the highway roughly parallels for a few kilometres. The Hemlo fault zone is characterized, in this area, by strongly deformed rocks which comprise mafic, magnesian schists at or near the contact between gneissic amphibolite and gneissic feldspathic rocks. The layering in these rocks is interpreted to be, in part, mylonitic (Photo 9). The amphibolite is part of the mafic unit of Stops 26 and 28 and has a whole rock composition comparable to high-iron tholeiitic basalt. No primary volcanic features have been observed. Multiplexed veinlets of quartz, feldspar, epidote, and calcite are common in the amphibolite. The gneissic feldspathic rocks are felsic in composition and locally contain phenoclasts(?) of quartz, similar to volcanoclastic metasedimentary rocks in the area.

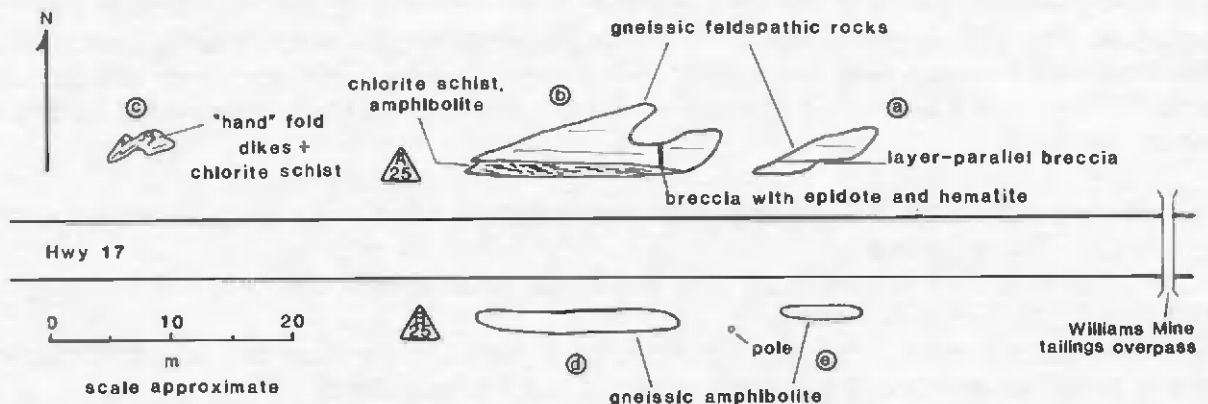


Figure 38. Stop 25: Simplified sketch map of lithologic units and structures of the Hemlo fault zone, including the "hand" fold.

• **Stop 25A: NORTH SIDE OF HIGHWAY 17 (Figure 38)**

Outcrop "a"

Feldspathic laminated rock showing:

- (1) tectono-metamorphic features such as symmetrical, pale pink (hematite?, potassic feldspar?) and sericitic alteration along cleavage planes as well as bleached rims along planes defined by chlorite (similar to that seen locally at Stop 24);
- (2) west-closing fold in layering;
- (3) quartz necks in boudins (traces of necks on surface are 0.80 ± 5), and rolls (075/50) in undulating, locally garnet-bearing layers;
- (4) fine-grained, intermediate dike;
- (5) zone of layer-parallel, cataclastic breccia (not well exposed because of recent blasting). The exposure used to show that the country rocks and the intermediate dike were brecciated. (See Stop 24 for discussion of layer-parallel breccias.)

Outcrop "b"

This outcrop displays the contact between gneissic feldspathic rocks and gneissic amphibolite containing chlorite + amphibole schist. The feldspathic rocks form part of a unit that structurally overlies the amphibolite unit for at least several kilometres. To the east (e.g., Stop 24), the rocks of this package display layering that is better defined and somewhat resembles less tectonized feldspathic metasedimentary rocks. To the west, opposite "Fault" Lake (Figure 18), the corresponding feldspathic rocks (*i.e.*, structurally above the amphibolite unit) are quartz-feldspar phyric and contain lapilli-size lenses suggesting a fragmental protolith. The feldspathic rock package may comprise more than one primary unit derived from pyroclastic and/or volcanoclastic deposits that have been heterogeneously transposed.

In outcrop 25b, the thinly layered feldspathic rocks have a tectono-metamorphic layering/cleavage which is interpreted to be, in part, mylonitic. Many of the cleavage planes have an associated symmetrical alteration which itself produces a small-scale tectono-metamorphic layering, considered here to be superposed on flattened and transposed primary layering. The layers are locally display pinching and boudinage, which has resulted in apparent intrafolial folds in some places. The layers are also locally discordant as a result of slightly oblique dextral faults. Isolated, small, flattened quartz crystals (phenoclasts?) are sparsely distributed. Elsewhere, quartz occurs as flattened(?) thin seams, particularly within ill-defined zones.

The mafic schists are phyllonites and may have been derived from the amphibolite unit exposed on the south side of the highway and/or from relatively magnesian-rich dikes in the fault zone (see Stop 26). As with Stop 26, deflection, backrotation, and crenulation of more than one fabric appears to have developed in response to ductile shearing. Irregular zones and clusters or pods consisting of coarse-grained tourmaline and a fine-grained unidentified white mineral can locally be found.

At least two types of dikes are presently contained within the schists: both types show boudinage. The types are:

- (1) an altered, chloritized granitoid dike which has undergone boudinage and has irregularly distributed pink/hematitic alteration;
- (2) a foliated mafic dike containing numerous mafic xenoliths (possibly akin to the lamprophyre dike of Stop 29), and having a folded and crenulated, internal fabric.

Towards the east end of this outcrop within the feldspathic rock, is a 10 cm thick, brittle fault breccia (oriented at 345/74), which displays at least two stages of brecciation (*i.e.*, breccia within

breccia). The country rocks have undergone hematization and epidotization within and adjacent to this zone. The breccia does not appear (in part due to exposure limitations) to have affected the phyllonite. However, with the exception of relatively late strike slip movement on earlier faults, as is suggested in the Hemlo area by offset diabase dikes and subhorizontal slickensides, the fault breccia is considered to post-date ductile deformation because of the undeformed, angular, fragments it contains.

Outcrop "c"

This is a small outcrop, about 25 m west of outcrop 25b, which shows schistose and gneissic amphibolite intruded by granitoid dikes, all of which have been notably folded. The main fold, the "hand fold", is atypical in that the "fingers", defined by several folds in a granitoid dike, display multiple orientations of a crenulation cleavage defined by the schists (Photo 10). Crenulation cleavage in the Hemlo area is ascribed to D_3 , and although it displays various orientations in any one outcrop ($\pm 20^\circ$ for example), it generally strikes east-northeast to east-southeast. However, in this case, the strike of the cleavage spans a range of about 125° from north to southeast. Although not fully understood, this fold could be an aberration within the fault zone because of the overall orientation of the layering and dikes. It is possibly a result of a relatively large-scale crumpling of layers adjacent to a detachment. Chevron-like folding of the schistose layering, and isolated boudins of dikes attest to considerable shortening and extension in different directions. Isolated "knots" of medium- to coarse-grained tourmaline are locally present.

Structural Summary:

Layering 280/60 (tectono-metamorphic in feldspathic rock)
 S_{3c} 265/83 chlorite; various orientations
 $S_{3c'}$ 300/85 chlorite; various orientations
 S_3 205/78, 225/77, 240/87, 247/53, 297/51 crenulation fabric with corresponding:
 L_c 242/52, 282/70, 022/43, 015/40, 043/39 crenulation lineations
 L_s 281/06 slickenside lineation

Stop 25B: SOUTH SIDE OF HIGHWAY 17 (Figure 38)

Outcrops "d" and "e"

The gneissic amphibolite is considered to be derived from highly deformed mafic metavolcanic rocks because it can be traced as part of a "wedge" of mafic rocks into the pillowed mafic rocks described at Stop 28. However, there are no unequivocal (let alone equivocal?) volcanic features at this outcrop. The amphibolite consists of plagioclase, hornblende, and lesser amounts of biotite. The layers are poorly to moderately defined by variations in the abundance of these three main mineral constituents. Well-defined micaceous layers, comparable to those displayed at the "hand fold" outcrop (25c), were present near outcrop 25e before recent blasting. It is not known whether these layers are largely primary (e.g., interflow sediments) and/or tectonic in origin.

The outcrop contains numerous veins consisting of either quartz or quartz + epidote $\pm$ feldspar. The veins have been buckled, dismembered, and/or transposed depending on their orientation and time of emplacement relative to the complex tectonic history. Various veins are folded with "S" or "Z" asymmetry: locally refolded folds are present.

Two fabrics in the amphibolite, one parallel to the layering and one axial planar to the folds, can be locally discerned. Close inspection of the fabrics reveals a third fabric which appears to crenulate the other two.

Structural Summary:

Layering $\sim 290 \pm 5/81$ (with internal foliated biotite)
 Fabric $\sim 276/85$ biotite
 S_3 fabric $\sim 260 \pm 5/85(\pm)$ biotite, crenulating fabric

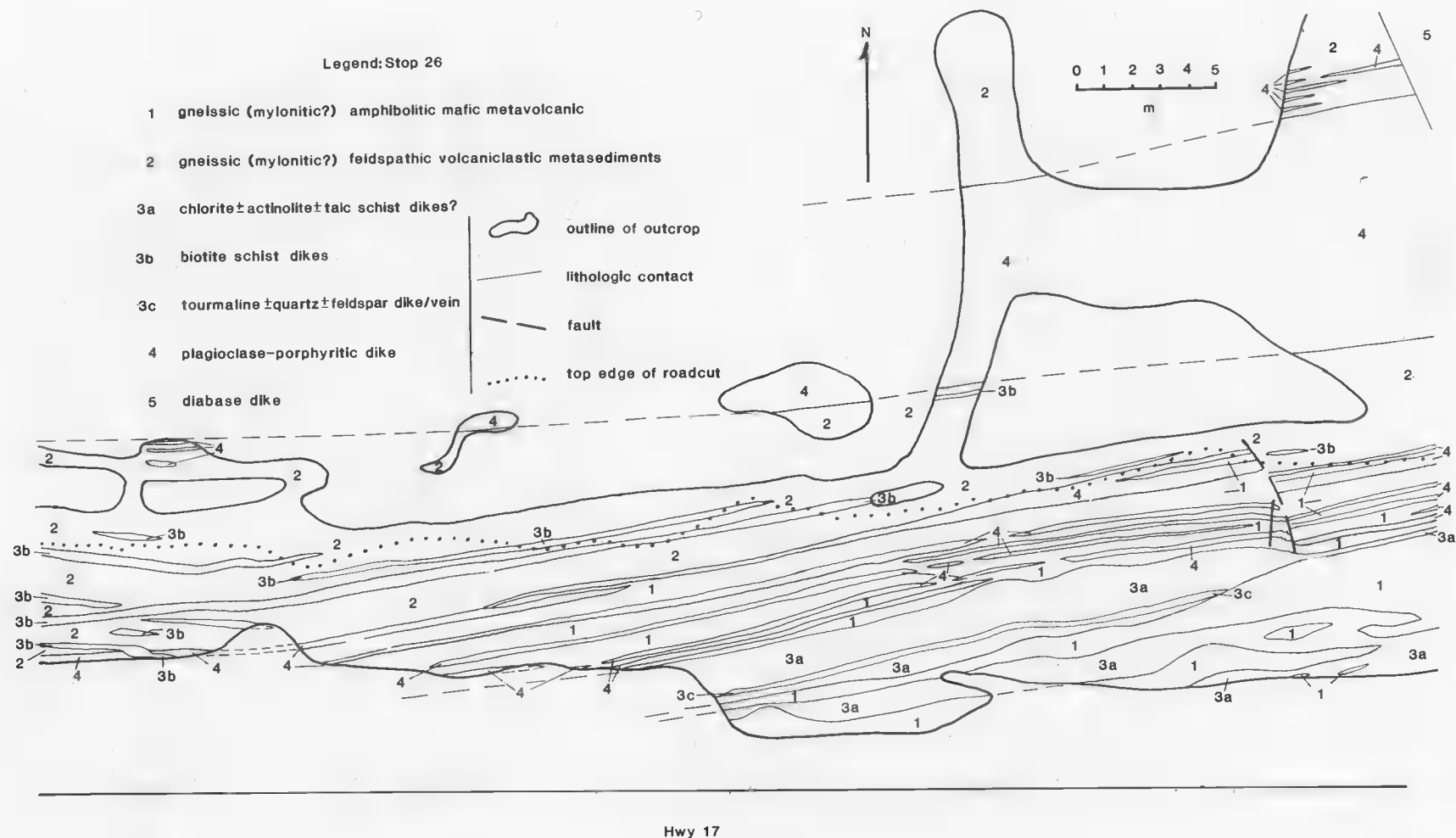


Figure 39. Stop 26: Detailed sketch map of the Hemlo fault zone and the contact between feldspathic, mylonitic(?), gneissic, metasedimentary rocks, and mylonitic(?), gneissic amphibolite with schists derived from sheared magnesium-rich dikes. (Modified after Smart 1988).

Stop 26: HEMLO FAULT (Smart's outcrop) (Figures 18, 19 & 39)

Location: Go about 370 m to the west on Highway 17, north side, to a steep, 7 m high roadcut. The outcrop has been studied in detail (Smart 1988) although the exposed face has been considerably modified by subsequent blasting. The outcrop shows the contact between gneissic feldspathic rocks and structurally underlying, gneissic, amphibolitic rocks, both of which are similar to corresponding units described for Stop 25. Refer to Stop 25 for a more detailed description of these 2 rock types. At Stop 26, a pyritiferous gossan lies within the feldspathic rocks at or near the contact with the amphibolite. Mafic schists of distinct composition lie within the gneissic amphibolite.

The mafic schists comprise chlorite±tremolite/actinolite and chlorite + talc±tremolite/actinolite phyllonites, all of which contain sufficient magnetite to attract a hand magnet to some degree. These schists commonly contain undeformed, medium-grained, pyrite cubes (common in similar schistose rocks as far away as the Lake Superior shoreline near Heron Bay). The schists are interpreted to have been derived largely from lineated/foliated, fine- to medium-grained actinolite-rich dikes, as can be seen 1.0 km to the west on the north side of the highway at the contact between amphibolite and feldspathic rocks. These dikes are highly deformed within the fault zone. They have a composition comparable to picritic basalt (based on Irvine and Baragar 1971) or komatiitic basalt (based on Jensen 1976) and contain considerably more MgO, Ni, and Cr than the tholeiitic basalts and amphibolite (see Muir 1982b). Locally, some of the chloritic schists which have a somewhat different colour, appear to have been derived from the gneissic amphibolite.

The gneissic feldspathic rocks have been intruded by: mafic dikes which may have been isoclinally folded and are now biotite schists; and numerous plagioclase-porphyritic dikes that are slightly discordant to the gneissosity and display boudinage. Some of the porphyritic dikes display fracture and cleavage controlled hematization, and some show subhedral muscovite poikiloblasts. A fine-grained, feldspathic, dike-like body, containing crystals and clumps of crystals of medium- to very coarse-grained tourmaline, occurs within chlorite + actinolite schist. Coarse-grained tourmaline also occurs as clusters or pods in the schists.

The phyllonites have a variety of fabrics, within and between lozenges, that display deflected (*i.e.*, curved), backrotated, and crenulated fabrics which are interpreted to be a result of D₃ deformation (see also Muir and Elliott 1987). Many of the fabrics appear to be consistent with ductile dextral shear (see Hugon 1986) in that they display s-c-c'-like configurations. However, the following points should be made:

- (1) The temporal and geometric relationships of fabrics are locally complex and equivocal, with some overprinting by another set of crenulation fabrics, possibly due to progressive flattening/shearing.
- (2) Extension by boudinage, shortening by folding, and undulations in the layers and dikes, has occurred in 3 dimensions, resulting in highly variable orientations of lozenges, fabrics, and minor fold axes.
- (3) The structural history of this area suggests that the D₂ event produced regional folds, with "S" asymmetry, that may have resulted from a component of sinistral shear.

Therefore, a simple history of movement along this zone of structural discontinuity should not be assumed. A diabase dike has intruded all rock types at the east end of this outcrop.

Structural Summary:

(most measured structures, overall, are quite variable within the outcrop; "typical" orientations are listed below)

Layering	~263/63	gneissic
L _m	~312/42	mineral lineation of hornblende and locally tourmaline
D	~265/60	orientation of porphyritic dikes
S _{3c}	~259/60	chlorite
S _{3c'}	~283/59	chlorite (deflects S _{3c})
S ₃	~243/64	crenulates above planar fabrics (later overprint?)
L _{3c}	~053/37	crenulation lineation
L _{st} ?	~290/17	possible stretch lineation

*** Stop 27: HIGHWAY ZONE** (Figures 18 & 40)

Location: Proceed 1.3 km west on Highway 17, north side, to a point 175 m to the west of the Highway sign indicating "Cigar Lake". The highway sign is incorrect, but there is no widely accepted name for the lake lying immediately to the south of the highway at this location. This guide uses the term "Fault" Lake because of a similar earlier reference in the assessment records and because it is geologically appropriate. (Officially recognized names for other lakes in the area named Cigar Lake and Rule Lake (also occasionally applied to "Fault" Lake) already exist.) At Stop 27, a hydraulically cleaned outcrop extends up the hill, to the north, within the cleared highway right-of-way.

This exposure is particularly useful for at least two reasons. It is one of the best exposures of what is locally known as the Highway Zone, and it demonstrates some of the structural complexities that complicate stratigraphic reconstruction and interpretation. The Highway Zone is essentially a deformed, and possibly altered, erratically auriferous unit of felsic, quartz-feldspar-phyrlic, fragmental rocks which are interpreted to be volcanic in origin. It is traceable for about 2 km but its character along strike does change from place to place. The style of deformation in the outcrop, including numerous discordancies in the layering and/or fabrics, illustrates that folding, ductile shearing, and brittle faulting have produced, on this mesoscopic scale, a tectono-stratigraphic section rather than a preserved, primary, stratigraphic section. Detailed mapping, overall, suggests this style of deformation is represented on a much larger scale as well.

The southern half of the outcrop consists of: a zone of slightly rusty weathering, schistose, garnetiferous, biotite-quartz-feldspar-bearing metasedimentary rocks which display thinly laminated, tectono-metamorphically modified primary layering; and a zone of feldspathic meta-sedimentary rocks which display highly cleaved, more widely spaced, tectono-metamorphic layering. The layering, which may be mylonitic, at least in part, reveals sharp, tight, and in some cases rootless, S-shaped folds with later, locally developed, Z-shaped folds.

The central part of this outcrop consists of what appear to be wedges or lozenges of fragmental units which are juxtaposed and apparently interleaved with medium to coarse-grained wacke. The fragmental rocks can be subdivided, at least locally, on the basis of type, size, and abundance of the fragments. The structurally lowest fragmental unit is pyritiferous, rusty weathering, quartz-feldspar phyrlic, and relatively monolithic, although a variety of fragments is present overall (Photo 11). Some of the fragments have been converted into 2 or more smaller lenses by the development of a sericitic cleavage through them. Some lenses consist entirely of quartz which may indicate that some quartz veins have been completely dismembered. The structurally uppermost unit is distinctive for its chloritic±biotitic fragments, many of which display 2 or more "tails". Grab samples from the pyritiferous unit returned Au values of <0.01 ounces per ton (Patterson 1986), and 164 ppb (M. Smyk, MNM, personal communication, 1990).

At the north end of the outcrop, the fragmental units presently lie adjacent to layered, feldspathic, volcanoclastic metasedimentary rocks which display vestiges of F_2 , S-shaped folds overprinted by narrow, planar zones of F_3 , Z-shaped folds. Relatively small lenses of a tectonically disrupted unit of schistose, garnetiferous metabasite, illustrate the disruption of layering in the northern third of the outcrop (e.g., Unit 1e in Figure 40).

Although a few straight quartz veins are present in the outcrop, most secondary quartz occurs as knots or deformed veins. The deformed veins range from continuous and buckled, to highly dismembered. Brittle faults, which overprint the ductile deformation fabrics, are mostly dextral by apparent sense of displacement.

The country rocks are intruded by foliated, medium grey, fine-grained dikes, one of which shows tightly folded internal layering, and by a late Archean diabase dike which has locally intruded parallel to the layering.

Pyritiferous, schistose, high-strain zones are exposed in 2 other places to the west of this outcrop. They may be the equivalent of the Highway Zone but each has somewhat different lithologic characteristics. One gossan, in a rock cut about 350 m to the west of Stop 27, returned an assay value of 337 ppb Au, and the other gossan, near a turnoff to the north (shown on Figure 18), about 700 m west of Stop 27, returned an assay value of 2 ppm Au and 6 ppm Ag (M. Smyk, MNDM, personal communication, 1990). Previous assay results, from the latter gossan, of 0.32 ounces Au per ton and 0.43 ounces Ag per ton were reported by Muir (1982b), and values of <0.01, 0.01, and 0.04 ounces Au per ton were reported by Patterson (1986). This gossan is in contact, on the north side, with a locally highly strained and hematized, plagioclase-porphyritic felsic body that has been intruded by less deformed, essentially foliation-parallel, plagioclase-porphyritic felsic dikes.

Structural Summary:

Feldspathic metasedimentary rocks (south part of stop):

- Mylonitic layering 270/64
- Possible S_2 fabric 279/74
- Possible S_3 fabric 253/74

Metasedimentary schists:

- Mylonitic layering 275-290/60

Sericitic, quartz-feldspar-phyrlic fragmental rock:

- Crude layering (S_0/S_1 ?) 270°
- S_2 fabric (alignment of fragments) 283°
- Sericitic fabric 252±5°

Volcanoclastic metasedimentary rocks (north part):

- S_0/S_1 layering 270/61
- S_2 cleavage (axial planar to S-folds)
 - 280/67 in feldspathic schist
 - 295/67 in adjacent feldspathic wacke
- S_3 fabric 255/61 in feldspathic schist
- Axial planar (to F_3 Z-folds) S_3 245° to 255°
- Dextral brittle-ductile faults 230°, 310°, 340°

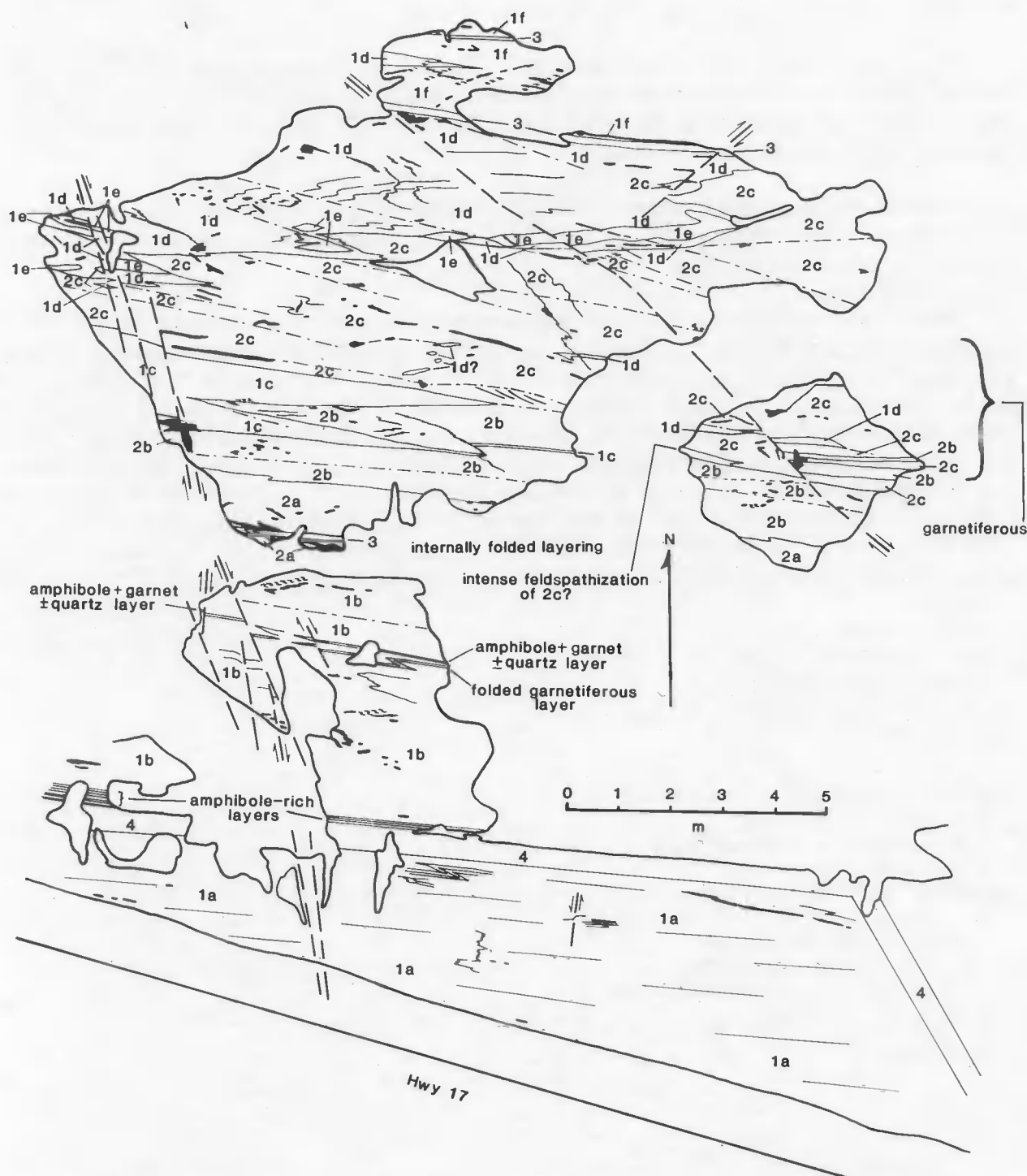


Figure 40. (legend on opposite page) Stop 27: Detailed sketch map of the Highway Zone: folded and faulted, auriferous, felsic, quartz-feldspar-phyric pyroclastic rocks sandwiched between variably strained metasedimentary rocks. (Geology by T.L. Muir, OGS, 1990).

*** Stop 28: HEMLO TURNOFF MAFIC PILLOWS** (Figures 18 & 41)

Location: Continue west on Highway 17, north side, for 2.6 km to an unmarked gravel road turnoff, to the south, at the west end of a westbound passing lane (this road leads to the old site of Hemlo).

The outcrops at this stop display pillowed and non-pillowed, high-iron tholeiitic basalt flows. They are part of a large, tectonic(?) "wedge" of mafic rocks that are 250 m thick here and thin to the east to less than 50 m. The stratigraphic relationship of this "wedge" to a thick pillowed unit, lying

LEGEND: STOP 27

Volcaniclastic Metasediments

- 1a feldspathic wacke:
highly strained, mylonitic(?), transposed, cleaved
- 1b garnet-biotite-feldspar wacke/siltstone:
highly strained, mylonitic(?), transposed, laminated
- 1c garnetiferous wacke, transposed
- 1d feldspathic siltstone:
generally with preserved S_0S_1 layering
- 1e metawacke: garnet-feldspar-biotite schist
- 1f feldspathic, feldspathized(?) arenite

Quartz-Feldspar-Porphyrific, Felsic Pyroclastic Units

- 2a crystal tuff(?)
- 2b relatively monolithic lapilli-tuff, lapilli-stone, tuff:
pyritiferous, sericitic, altered(?)
- 2c heterolithic lapilli-tuff, lapilli-stone:
with chloritic and sericitic lenses

Dikes

- 3 fine-grained, intermediate

Intrusive Contact

- 4 diabase



outline of outcrop with internal patch of overburden



lithologic contact: may also be tectonic discontinuity



layering



apparent tectonic discontinuity



predominant cleavage



bounded zone of F3 "Z"-shaped folds



quartz veins, veinlets

to the north and west-northwest at Botham Lake (and extending intact to the Coldwell alkalic complex, 27 km to the west), is unclear. The exposures at this stop allow one to view the vestiges of some primary features which, beyond about 1750 m to the east, are no longer preserved, even though the mafic unit can be traced for well over 10 km further. The unit appears to be geometrically and geographically controlled, for the most part, by the Hemlo fault zone.

Opposite the turnoff, on the north side of the highway, are garnetiferous and non-garnetiferous, moderately strained basalt pillows with aspect ratios of at least 5:1. The strike of ill-defined units is about 270°, slightly oblique to the highway. Fine- to coarse-grained garnet, present in both the selvages and pillow cores, is most abundant here. Overall, garnet is heterogeneously distributed throughout the remainder of the outcrop to the west where there are non-pillowed (*i.e.*, massive) units as well. Prior to recent blasting, features reminiscent of highly strained flow top breccias, and possibly interflow sediments, were present.

Variolitic pillows are present on the south side of the highway to the west of the turnoff. To the east of the turnoff (not shown on Figure 40), on the south side of the highway, there are variolitic and non-variolitic pillowed units. At least 2, 25 cm thick, interflow units of rusty-weathering, pyritic, medium- to very dark grey metasiltstone are present at about 95 m and 155 m from the turnoff.

The flows have been intruded by at least three different types of foliated, fabric-parallel dikes: intermediate, plagioclase-porphyritic; schistose mafic; and fine-grained intermediate. A recently revealed carbonatitic/alkalic dike, oriented at 355/77, occurs at the first (heading east) oxidized, interflow, metasiltstone unit. The dike appears to be associated with fracturing/faulting and some form of alkalic(?) alteration.

Structural Summary:

Predominant and flattening fabric 266/70

Subordinate, locally present fabric 276/72

* Stop 29: HOMESTAKE PROPERTY F₃ Z-SHAPED FOLD (Figures 18 & 42)

Permission for access to the property is required. Information on whom to contact should be obtained from the Resident Geologist's Office, Thunder Bay (see address on title page).

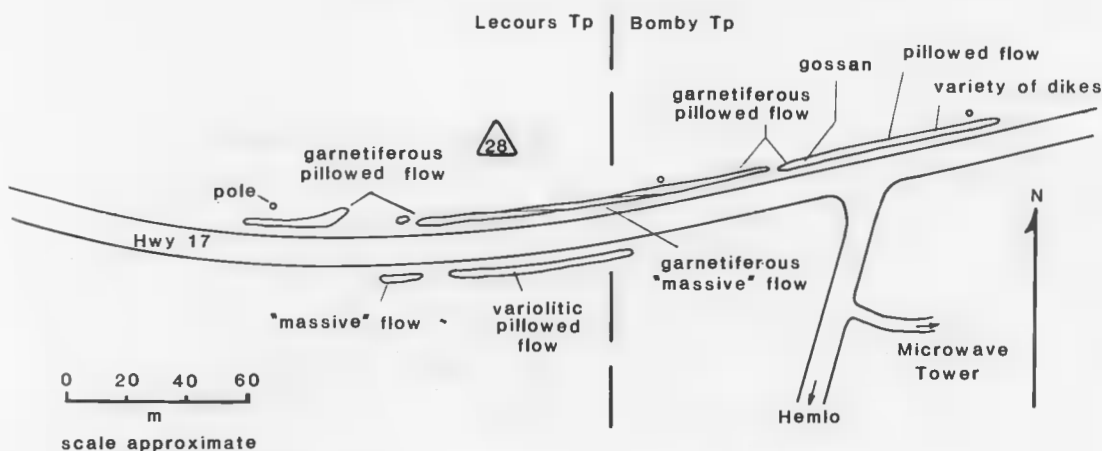


Figure 41. Stop 28: Simplified sketch map of varieties of pillowed and "massive" mafic flows which are locally garnetiferous or variolitic.

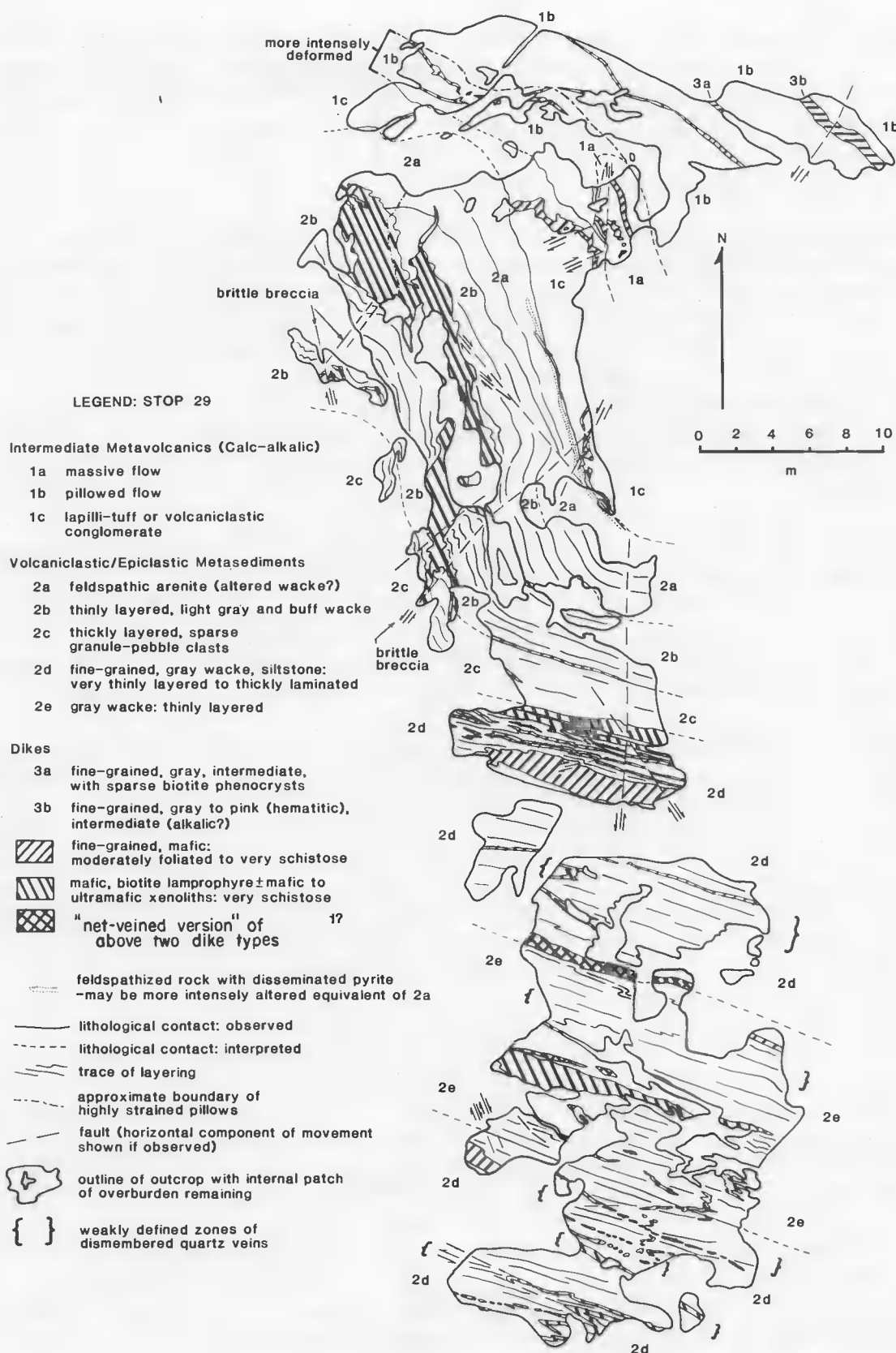


Figure 42. Stop 29: Geology of an unusually large, Z-shaped, F_3 fold with high-alumina basalt pillows, F_2 -folded metasedimentary rocks, numerous Archean lamprophyre and gabbro dikes, and local, minor "Hemlo style" (?) alteration (Homestake property). (Geology by T.L. Muir, OGS, 1990).

Location: Continue for 525 m west on Highway 17, south side, from the Hemlo turnoff, to a 4 m high roadcut. Climb the outcrop to the hydraulically cleared area which extends for about 70 m south from the roadcut. This stripping was undertaken by Esso Minerals Limited prior to acquisition of the property by Homestake Explorations Limited. Exposed here is one of the largest F_3 generation, Z-shaped folds presently observed in the Hemlo area. The F_3 fold has resulted in rotation of the layering from about 285° to 330° .

The north end of the outcrop consists of pillowed flows. The pillows are feldspar phyric and are presently alkalic in composition. Locally, amygdaloidal/vesicular textures can be seen. The pillows contain fine- to medium-grained hornblende crystals. The selvages are relatively thick, biotite rich, and locally pyritiferous. The pillows are found nowhere else in the area (except for the adjacent roadcut about 70 m to the west). This has led to suggestions that these rocks represent altered tholeiitic pillows (MNDM assessment files, Thunder Bay). However, the significant differences between the two "types" of pillows, in terms of selvages and cores (*cf.* Stop 28), and the presence of small, feldspar phenocrysts, suggests the pillowed unit at Stop 29 was not tholeiitic originally. Chemically, the pillows are relatively sodic (from spilitization?) and more akin to high alumina basalt.

The pillowed unit displays an abrupt change, towards the south, from slightly deformed pillows to moderately and highly strained equivalents, within the northern part of the fold. It is not clear whether the considerable strain is a result of the D_3 folding or whether a zone of heterogeneous, high strain formed prior to the F_3 fold. The highly strained pillows pass into (relationship unclear) a volcanic breccia or volcanoclastic unit. The fragments in this unit are variably strained, feldspar phyric, and appear to be similar in composition to the pillows (pillow breccia?).

Adjacent to this fragmental unit are "units" of light grey- to white-weathering metasedimentary rocks and medium grey metasedimentary rocks. Although the two "units" overall are distinct from one another, detailed examination shows that some of the colour differences are locally independent of layering. This suggests that at least some of the feldspathic character of the lighter weathering unit may be due to feldspathization, a type of alteration common in the Hemlo deposit. Locally at, and slightly discordant to, the contact between the fragmental unit and the feldspathic metasedimentary rocks is a bleached, rusty weathering, tabular zone that appears to have been folded (F_3) and is very similar in appearance to some of the alteration in the Hemlo deposit area. A grab sample from this zone returned an assay value of 103 ppb Au and 100 ppm Mo (M. Smyk, MNDM, personal communication, 1990).

The remainder of the outcrop consists predominantly of varieties of variably deformed metawacke and metasiltstone locally containing sparse garnet±magnetite octahedra±retrograded, yellowish porphyroblasts which were possibly staurolite. In the south half of the outcrop, preserved F_2 folds with S-asymmetry can be seen amongst F_3 , locally chevron-like, Z-shaped folds. In one case, an individual layer displays a F_2 , S-shaped fold adjacent to a F_3 , Z-shaped fold.

Strain was heterogeneous as indicated by the layering which ranges from well defined and continuous, to wispy and discontinuous, suggestive of transposition. Transposition is also suggested by the considerable disruption and dismemberment of quartz veins and dikes constrained to crudely defined zones which are subparallel to layering (see Figure 42).

Several foliated dikes have intruded the metavolcanic and metasedimentary rocks and all of them have been affected by the F_3 folding. A relatively thick dike, and several narrower subsidiary dikes, of Archean, mafic, biotite lamprophyre show diverse textures and, to a lesser extent,

mineralogy. They locally contain mafic to ultramafic xenoliths which are locally concentrated in zones. The matrix of these dikes is similar to that of intrusion breccia (diatreme) bodies on the Golden Sceptre and Williams properties. Conflicting relationships are present, but it appears that these dikes have been followed by numerous, thin, gabbroic dikes which have behaved more competently during subsequent deformation.

The gabbroic dikes locally display considerable variation in response to strain (*e.g.*, buckling and regularly spaced, backrotated boudins), depending on orientation relative to shortening or extension. A locally developed brecciation involving fragmentation of the main lamprophyre dike and adjacent metawacke, and having a chloritic matrix, can be seen in the north part of the outcrop. The matrix is foliated.

Relatively late, sinistral and dextral, brittle faults have produced minor offsets of layering. Some earlier(?) ductile sinistral sense movement is indicated by hooked tails on disrupted dikes.

Structural Summary:

S_0/S_1 from 285° (local strike) to 340° (on short limb of large F_3 fold)

S_2 fabric $\sim 305^\circ$

S_3 fabric ranges from strike of 230° to 280° , and dip of $85^\circ N$ to $85^\circ S$ (rarely $65^\circ S$) depending on position within F_3 fold

F_3 axis: various 068/72, 105/47

L_c crenulation: various 096/62, 110/34, 265/60

L_b boudinage 080/20

Zones of transposition 285° to 290°

Backrotated boudins of mafic dike: 285° (within layering that strikes at 295°)

General trend of late breccias 225° and 355°

Late dextral faults 315° , 330° , 345°

Late sinistral faults 180° , 210° , 225°

Stop 30: CONTACT OF HERON BAY PLUTON (Figures 18 and 43)

Location: Proceed 1.5 km further west on Highway 17, north side, to a 7 m high roadcut opposite an area cleared of trees on the south side.

This outcrop shows:

(A) plagioclase-porphyritic granodiorite which appears to represent the marginal rock of the Heron Bay Pluton and is similar in many ways to some of the plagioclase-porphyritic dikes found in the supracrustal rocks in the area. The granodiorite is intruded by pink aplite/pegmatite dikes and white quartz veins;

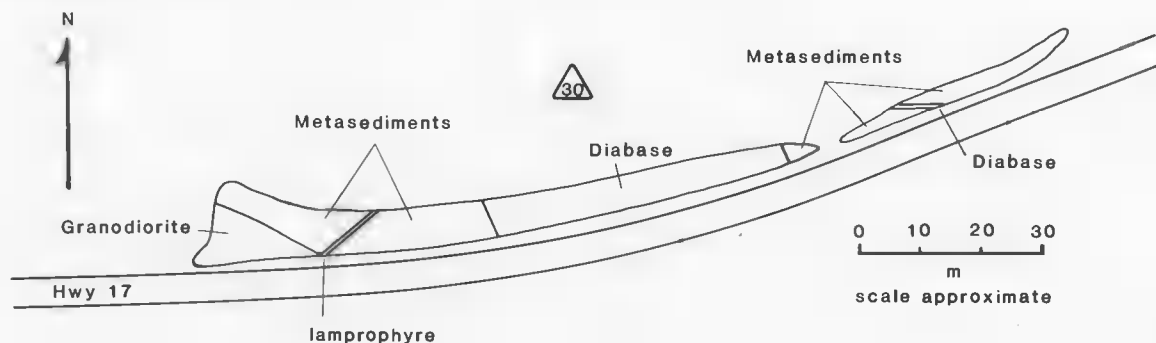


Figure 43. Stop 30: Simplified sketch map of the geology at the east contact of the Heron Bay Pluton.

(B) deformed (*e.g.*, folds, boudins), medium to dark grey, biotite-hornblende-bearing metawacke which locally contains garnet (east side of diabase dike);

(C) quartz-feldspar-muscovite veins, in the metawacke, which display boudinage (sub-horizontal necks). The top surface of the outcrop used to show that boudinage had occurred in the horizontal and vertical planes;

(D) a medium- to fine-grained, plagioclase-porphyritic diabase dike;

(E) a Proterozoic, massive, pyroxene(?) - magnetite lamprophyre dike likely associated with Lake Superior rifting.

Stop 31: HERON BAY PLUTON (Figure 18)

Location: Continue east on Highway 17 for 1.3 km from Stop 30, to a roadcut (both sides) about 180 m west of the "Rouse Lake" highway sign. The correct name of the lake is Rous Lake. The outcrop is opposite a large clump of trees between the highway and the lake.

These outcrops are typical of the inner part of the Heron Bay Pluton, as exposed along the highway, although different phases, such as microcline-megacrystic, are present further within the pluton. At this roadcut, massive biotite-hornblende granodiorite is intruded by aplite and pegmatitic dikes. The granodiorite locally contains sparse mafic xenoliths. An extremely faint fabric appears to strike from 300° to 330°.

The dikes commonly strike at 030°, 050°, and 070° and dip steeply to the southeast. The latter two orientations tend to be predominant. A few quartz-rich veins which cut the dikes are oriented at 260-280/40 and display a fabric which is possibly mylonitic.

Samples for U-Pb geochronology, taken here and farther within the pluton, gave a combined age of 2688±5 Ma for the granodiorite (Corfu and Muir 1989a).

END OF HIGHWAY 17 ROAD TRIP

Note: Those choosing to do the entire field trip from east to west should proceed to Stop 4, about 13.2 km to the west (of Stop 31) on Highway 17, to a point on the north side, about 900 m east of the Black River bridge.

HEMLO DEPOSIT SEGMENT: WILLIAMS PROPERTY VISIT

This part of the trip will be supervised by Williams Operating Corporation staff. Hard hats and safety glasses must be worn by everybody while on the property.

This is an instrumental part of the Hemlo trip because of the exposures available on the property. However, at the time of writing and up to the time of the field trip, no guarantees can be made as to which exposures will be "available". In case some of the exposures are "unavailable", brief descriptions of the potential stops are presented here, with examples of detailed sketch maps showing the salient features. Because the geological history is complex, a summary of what will be presented is given for each stop, not a detailed presentation of the development of the interpretation. Matters of contention can best be debated on the spot. Previous field guides covering similar and additional aspects of the mine and property were presented in Valliant *et al.* (1985) and Walford, Weicker, and Guthrie (1986). [Note: Stop 33A outcrop has all but vanished; Stop 35 outcrop has been destroyed.]

Stop 32: "BACK 40s" OUTCROPS (Figures 18 & 44)

Location: The Back 40s outcrops lie about 450 m northeast of the Heritage outcrops (Stop 33). They have miraculously avoided burial for some time now. The outcrops have been chosen (aside from the fact that they are the only ones left in this area), because they show a number of features that epitomize the structural history of the area, and they are relatively far away from the ore zone with its attendant high strain and substantial alteration.

The southernmost and largest of this set of exposures consists of a variety of metasedimentary rocks derived from volcanoclastic(?) feldspathic arenite, wacke, siltstone, and possibly conglomerate. There are also numerous amphibole-rich layers. The northernmost outcrop consists of turbiditic wackes, some containing rip-up clasts.

These exposures lie on the northeast limb of a tight, large-amplitude, northwest-closing, north-northwest-plunging fold, centred on the Williams property (Figure 19). The S_2 cleavage, which is prominent in this outcrop, is thus oriented clockwise with respect to the layering. Several layers, including one comparable to volcanoclastic conglomerate, suggest that the units are overturned at this location, assuming normal grading.

Structural features that are important are as follows:

F_1 sheath fold or interference fold

F_1 isoclinal in an unusual, layer-parallel zone of conglomeratic(?) rocks

F_2 S-shaped, parasitic folds with north-northwest plunges

S_2 stripy cleavage developed within some layers, and S_2 fabric and clast alignment in others

F_3 related folds in boudin necks

S_3 fabric occurs: in F_3 folds and boudin necks as a crenulation cleavage; in sericitic layers; and as pressure shadows around garnet porphyroblasts.

Two zones of structural discontinuity occur in the Back 40s outcrops, one at the south end of the southernmost exposure (Photo 12), the other near the north end of the northernmost exposure. The southern zone has been interpreted to be folded about the F_2 axis and thus predates that fold generation. Its origin is not well understood because it displays features, some of which can be interpreted in a primary sense (*e.g.*, soft sediment slump structures), and others in a tectonic sense (*e.g.*, low-angle-to-layering faulting or thrust faulting). Both processes may have occurred. The northern zone is associated with varieties of metasiltstone and amphibole-rich layers displaying discordant layering, disrupted folds, layer-parallel breccias and sinistral faults. The

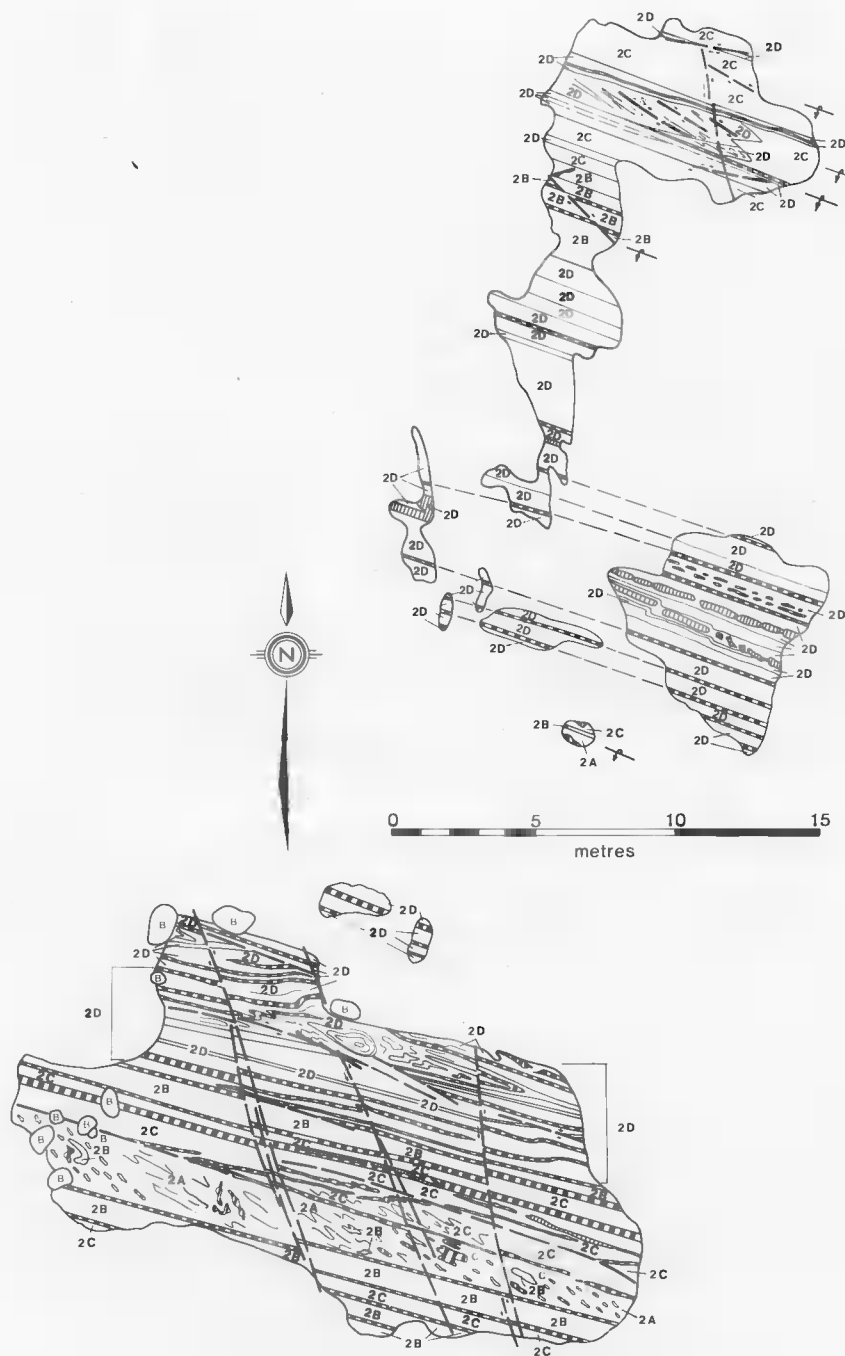


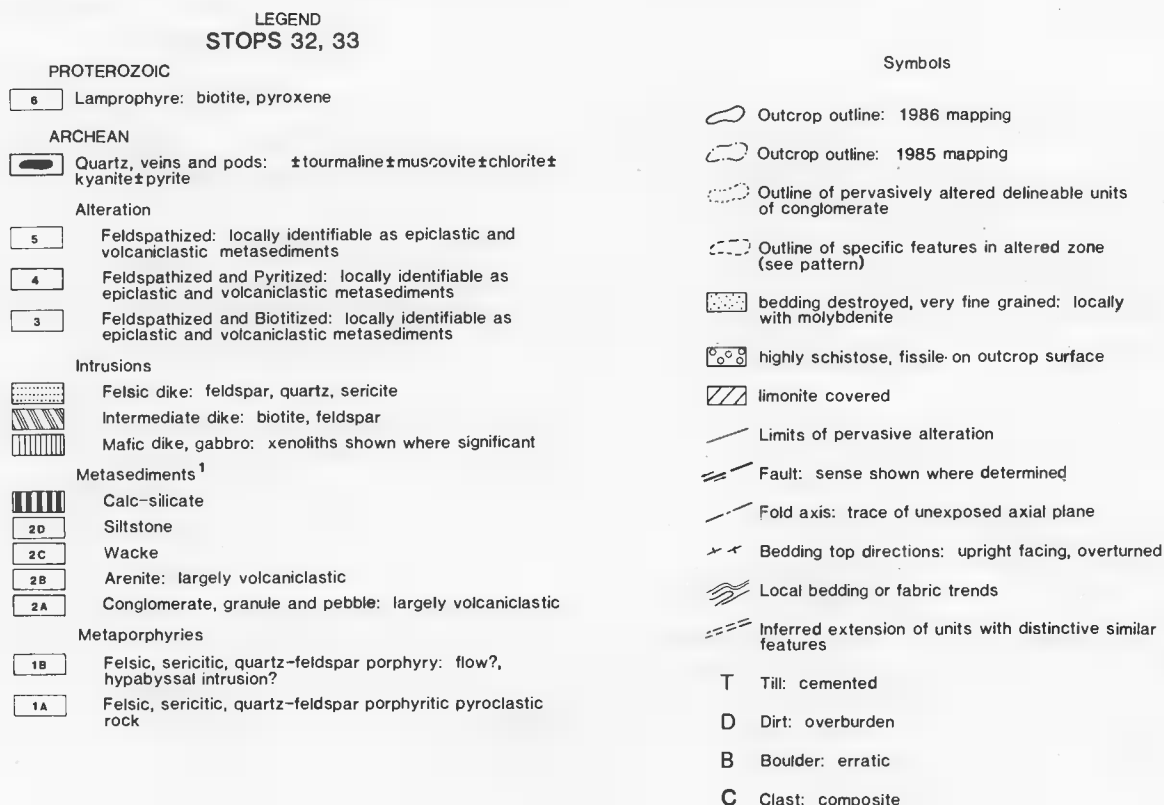
Figure 44. (legend on opposite page) **Stop 32:** Detailed sketch map of the Back 40s outcrop (Williams property), showing a variety of lithologic units and structures that reflect the events of D_1 to D_3 . Legend and scale same as for Figures 45 and 46. (After Muir 1986).

zone passes, along strike, across what appears to be a folded contact, into thick-layered, rip-up-clast-bearing metawackes which do not seem to show similar deformation features. (See Muir and Elliott (1987) for more details.)

Fine-to medium-grained garnet porphyroblasts are common within many of the lithologic units of the southern 30 m of exposures, including the amphibole-rich layers. The occurrence here of garnet in amphibole-rich layers, which elsewhere is uncommon, may be a result of alteration prior to metamorphism. Outcrops in the central part of the outcrop area contain garnet and staurolite porphyroblasts. The latter appear to be of two generations. The earlier(?) generation is aligned parallel to the S_2 fabric, and is partly retrograded to staurolite, quartz, feldspar, and muscovite. The later generation tends to be subhedral and non-retrograded.

Another example of alteration, at least on a more local scale, involves an incipient to well-developed, stripey, differentiated layering, and locally a development of "lenses", along the S_2 cleavage in silty and arenaceous layers. Here, the textural and mineralogical composition of the non-primary layers and lenses so produced, presently resembles the range of compositions among silty and arenaceous layers. Hence, some or all of the interpreted feldspathic arenite may actually be a result of alteration of wacke and possibly siltstone. This underscores the difficulty in distinguishing between originally feldspathic rocks and feldspathized rocks, particularly if the latter were initially feldspathic.

Two gabbro dikes intrude the central part of these exposures. One dike is layer-parallel and displays boudinage with quartz fillings in the necks. The other dike is slightly discordant and, although otherwise similar in appearance and composition, displays back-rotated boudins with quartz + tourmaline neck fillings and locally associated bleaching of the country rocks. In the southern part of the main outcrop, there is a slightly discordant gabbro dikelet which is somewhat similar to the adjacent amphibole-rich layers.



Structural Summary:

South part of stripped outcrops

S_0/S_1	290/75	general orientation in outcrop
S_0/S_1	292/63	north limb of a F_1 isocline
S_0/S_1	288/60	south limb of same F_1 isocline
S_2	312-316/82	range of S_2 overprinting above F_1 isocline
S_3	275/73	commonly sericitic
	252/63	pressure shadows about garnet porphyroblasts: (possibly a later development of S_3 (?))
L_{F1}	321/67	isocline fold axis
L_{Fn}	290/47	one hinge of sheath fold/interference fold
L_{F2}	311/77	parasitic F_2 fold axis

North part of stripped outcrops

S_0/S_1	289/72	tops to south(?): grading and distribution of amphibole
S_2	301/83	
S_3	260/73	

*** Stop 33: HERITAGE OUTCROPS** (Figures 18, 45 & 46)

These exposures are considerably worse for wear than a few years ago. The urge for parking lots to reproduce and grow is "clearly" illustrated here. Many of the features in the east outcrop are no longer visible, relative to Figure 45.

Stop 33A: HERITAGE EAST OUTCROP (Figure 45)

Location: About 40 m to the west of the security building.

The Heritage East exposure used to show part of what might be considered the mineralized, updip equivalent of the Williams Mine B Zone (Figure 22; Photo 13), although it may not be connected to it. In some aspects, this mineralized section is similar to the A Zone section, based on surface exposures. The internally folded (F_2 ?), footwall, sericitized and microclinized, quartz-feldspar porphyry is structurally overlain by an 18 m thick zone of considerably folded, transposed, and altered, metavolcaniclastic deposits of wacke and granule and pebble conglomerate.

The alteration is interpreted to include feldspathization (microclinization), sericitization, pyritization, and possibly local silicification, with anomalous gold and locally visible, very fine-grained molybdenite. Numerous, deformed quartz veins lie in a central zone of feldspathized and biotitized volcaniclastic metasedimentary rocks, which are structurally overlain by feldspathized, sericitized, and pyritized metasedimentary rocks. The zone of altered rocks is in sharp, faulted contact with the hanging wall volcaniclastic metasedimentary rocks which are locally partly altered and isoclinally folded. Initially, the exposure showed 4 folds, with alternating east and west closures (the folds must now be examined at Stop 33B).

The hanging wall rocks to the zone of alteration and mineralization were intruded by a xenolith-rich (net-veined?) gabbroic dike, and subsequently by a swarm of granitoid dikes. The quartz-feldspar porphyritic footwall unit was intruded by dikes of intermediate composition.

Structural Summary:

S_1	293/74	volcaniclastic metasediments
S_2	287/75	stripy cleavage
S_{3s} ?	265/70	altered rock in mineralized zone
S_{3c} ?	275/63	altered rock in mineralized zone
S_{3c} ?	320/76	altered rock in mineralized zone
L_m	323/55	tourmaline lineation
L_o	348/51	elongation of clasts in volcaniclastic conglomerate

L_c	047/76	crenulation (sericite) lineation
L_m	081/34	retrograded feldspar(?) porphyroblasts
F_3	077-128/50	fold axes
D	291/80	feldspar porphyry dike (from swarm)
V_q	090±5°	generalized quartz vein orientation (steep dipping)

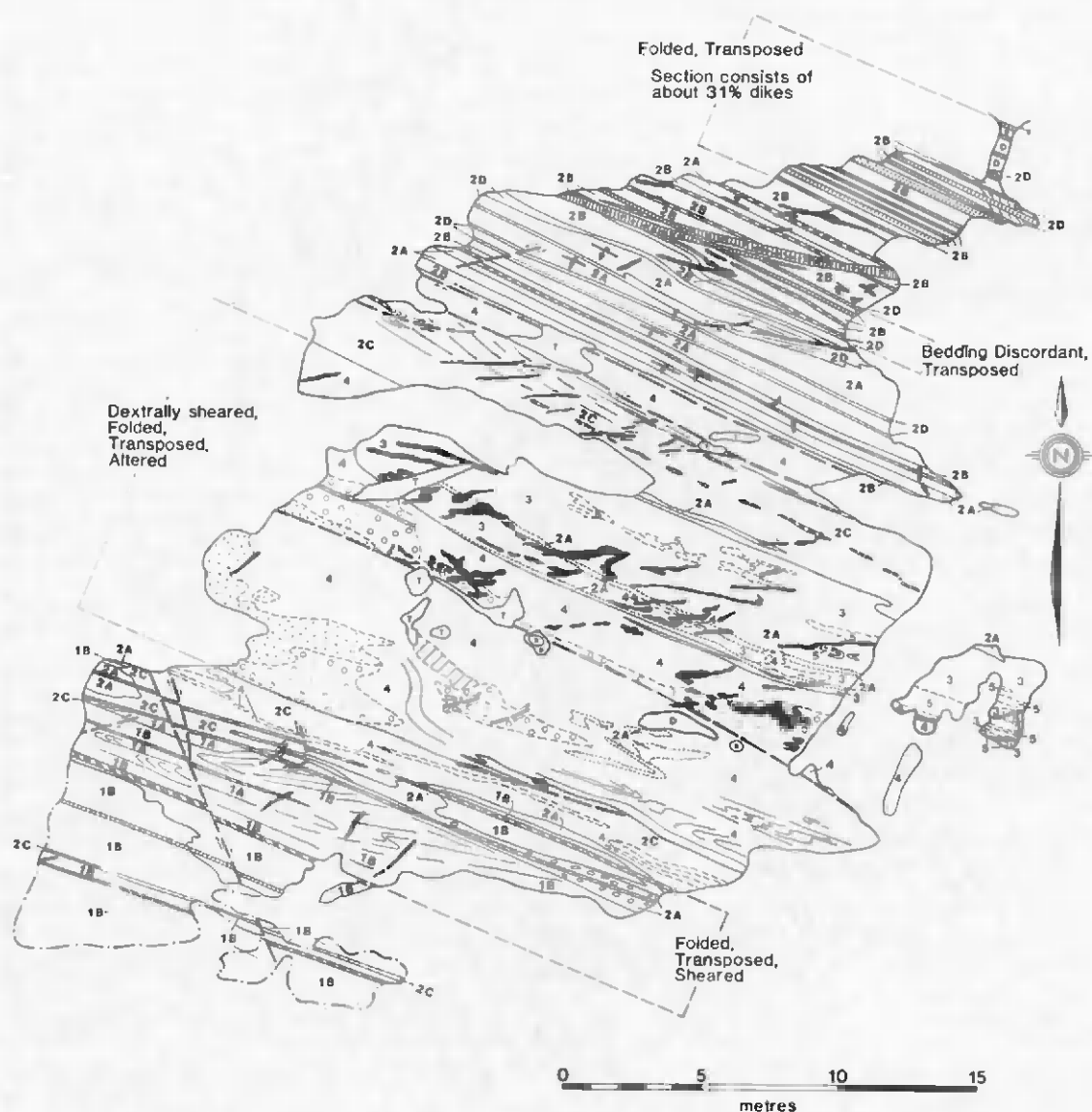


Figure 45. Stop 33A: Detailed sketch map of the Heritage East outcrop (Williams property), showing highly transposed and altered/mineralized, metavolcaniclastic/meta-epiclastic rocks (possibly equivalent to the Williams Mine B Zone) between footwall quartz-feldspar porphyry, and hanging wall metavolcaniclastic/meta-epiclastic rocks. Legend and scale same as for Figures 44 and 46. (After Muir 1986).

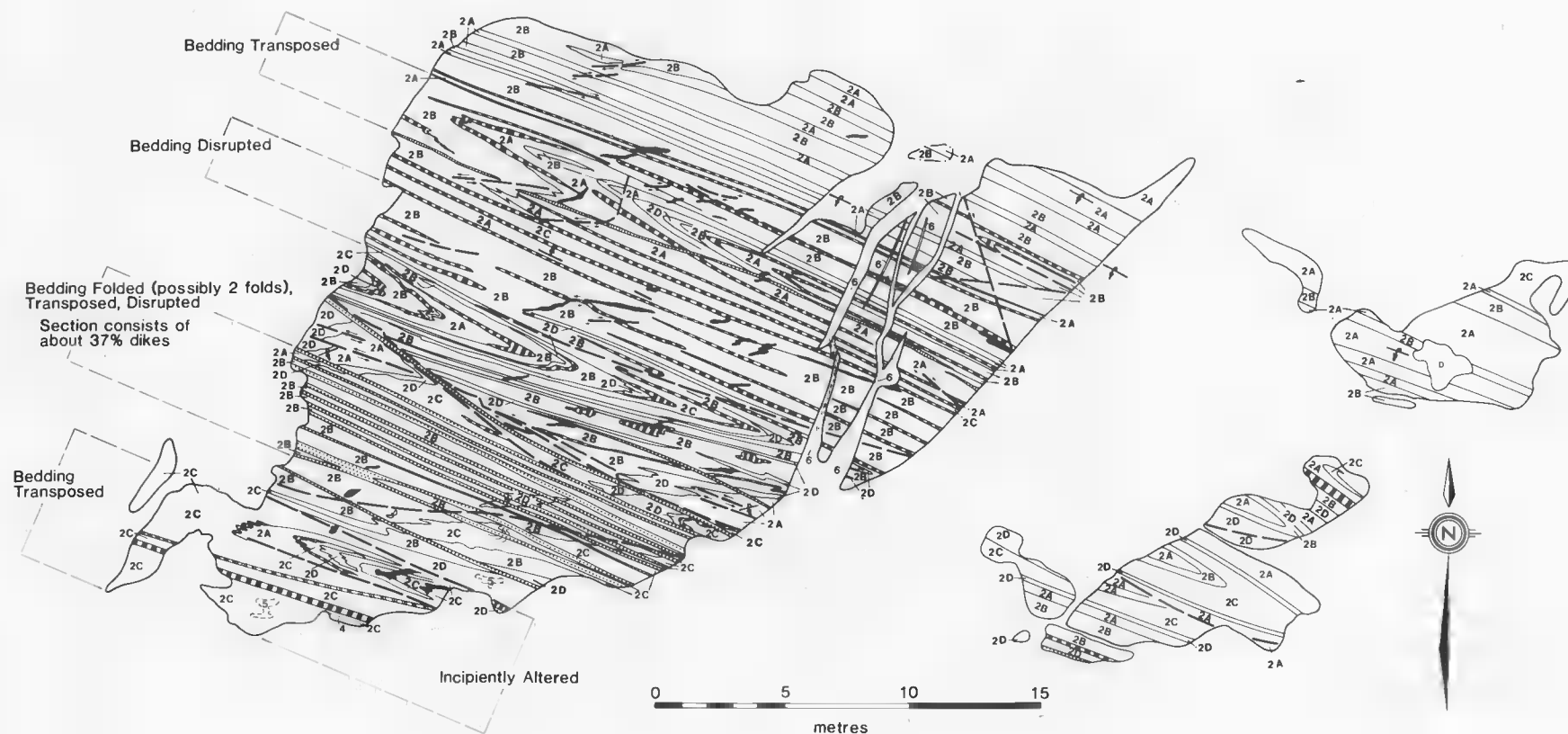


Figure 46. Stop 33B: Detailed sketch map of the Heritage West outcrop (Williams property), showing disrupted and tightly F_2 -folded, mixed, hanging wall metavolcaniclastic/meta-epiclastic rocks, as well as a swarm of granitoid dikes. Legend and scale same as for Figures 44 and 45. (After Muir 1986).

Stop 33B: HERITAGE WEST OUTCROP (Figure 46)

Location: About 50 m to the west-northwest of the Heritage East outcrop.

This outcrop shows the hanging wall metasedimentary rocks which are composed of folded metavolcaniclastic wacke, pebble conglomerate, and siltstone, with numerous amphibole-rich layers. Some layers within the northernmost fold are garnet and/or staurolite bearing. The rocks have been intruded by a swarm of granitoid dikes (the same swarm no longer visible in the Heritage East outcrop). The granitoid dikes postdate F_2 folding and display muscovite poikiloblasts.

Three, tight, F_2 -generation folds are well exposed in this outcrop. These folds are associated with a well-developed, axial planar, S_2 cleavage with local attendant transposition and disruption of layering, particularly in the noses of the folds where horsetail structures are locally developed (Photo 14). The variations of layers of different composition, in response to the strain, is particularly interesting.

Locally, in the nose of the northernmost fold, staurolite occurs within grey weathering rock. This rock represents the remnant part of the metasedimentary unit that has been unaffected by alteration (bleaching) along multiple, fairly closely spaced S_2 cleavage planes. Interpretation is equivocal regarding the timing of the formation of the staurolite crystals relative to the development of cleavage/alteration.

Dextral displacement subparallel to the limbs is demonstrable. Smaller-scale, sinistral displacement of the layering is also present. Some of the conglomeratic units show asymmetric distribution of lenses within layers which reverses about the fold axes and is interpreted to represent grading of clasts. If the grading was normal, the northeast limbs are overturned which is consistent with evidence, albeit equivocal, for the large, F_2 fold (see Stop 32), and implies a structural facing to the east-southeast. However, this is not consistent with the F_2 fold at Stop 8.

A zone of incipient alteration is present in the south end of this exposure. Quartz + tourmaline alteration, and quartz + muscovite + kyanite knots are present here but also occur locally in other parts of the Heritage outcrops.

A north-northeast-striking, Proterozoic, bifurcating, biotite + pyroxene lamprophyre dike is present in parts of recessively weathering fractures in the east part of the outcrop.

Structural Summary:

S_1	293/66 to 303/73	north limb, E-closing F_2 fold
	279/73 to 282/81	south limb, E-closing F_2 fold
S_2	287/78	generalized due to variations throughout outcrop
S_3	257/66	
F_2	316/62	
V_q	090 $\pm$ 5°	generalized quartz vein orientation (steeply dipping)

• Stop 34: EAST C ZONE OUTCROP (Figures 18 & 47)

Location: About 400 m west of the Heritage outcrops.

This outcrop consists of variably feldspathized (microclinized and albitized?), sericitized, and silicified quartz-feldspar-porphyrific rocks which have been locally pyritized and mineralized with gold and locally visible, very fine-grained molybdenite. Figure 47 depicts the visually approximated distribution of the various types of alteration and mineralization. The quartz-feldspar-porphyrific rocks have no unequivocal major primary features preserved, such as unit layering.

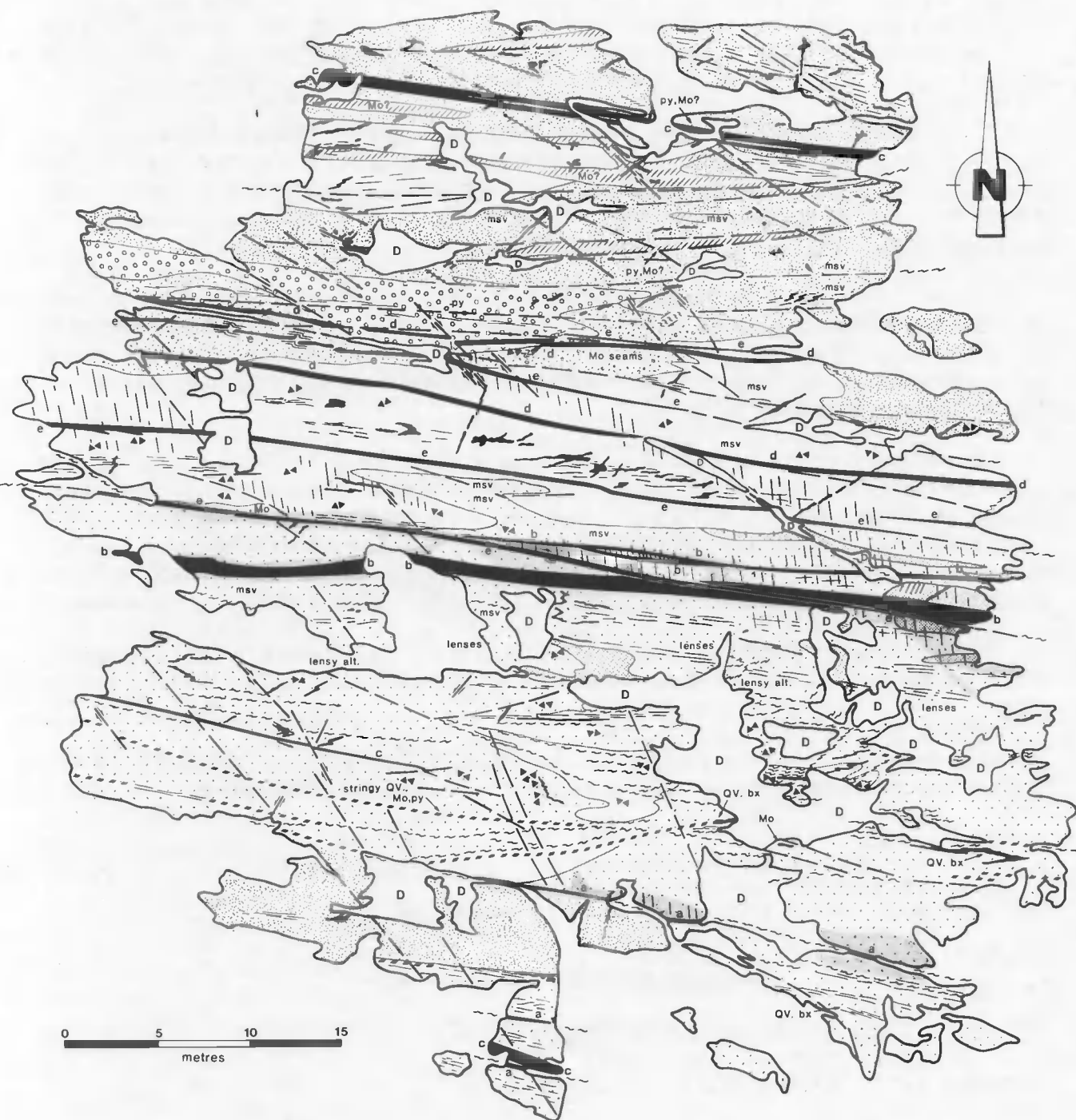
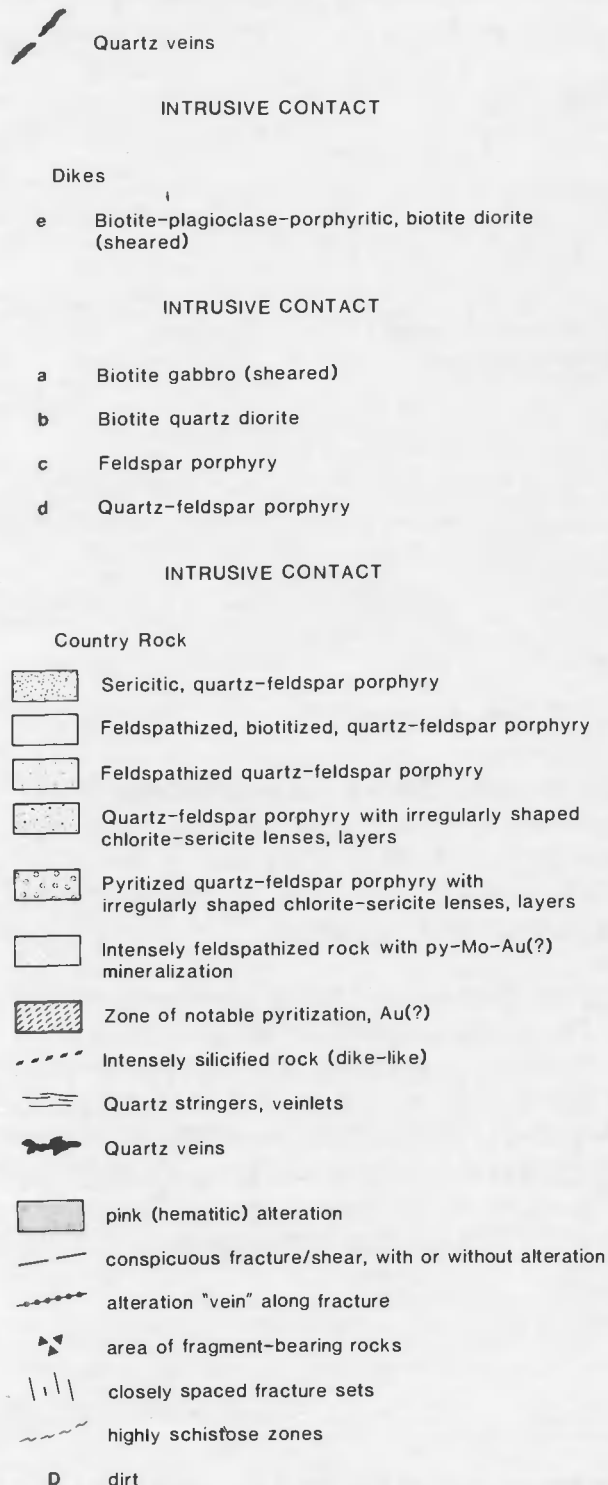


Figure 47. (*legend on opposite page*) **Stop 34:** Detailed sketch map of part of the C Zone, east end (Williams property), showing variably altered and mineralized quartz-feldspar-porphyritic rocks (lapilli-tuff?) intruded by several dikes of various compositions. (After Muir 1988).

LEGEND: STOP 34



However, many parts of the outcrop display numerous lapilli-sized lenses considered to be possible pyroclasts (Figure 47; Photo 15). Many of the small lapilli-size fragments are barely discernible because of the alteration. There is also a section of the outcrop reminiscent of a coarse fragmental unit. This exposure is on strike from, and about 400 m to the east of, a quartz-feldspar porphyritic rock dated at 2772 Ma (Corfu and Muir 1989a).

There are several dikes in this outcrop which collectively have a variety of compositions and textures. The dikes strike parallel to the main fabric, which is at about 275° to 280°, and are also foliated. Some of the dikes display muscovite poikiloblasts. A few of the dikes are spatially associated with a hematitic alteration which, in at least one case, appears to have affected the dike and thus postdates it. Two of the dikes consist of quartz-feldspar porphyry and are roughly on strike from, and about 400 m to the east of, a quartz-feldspar porphyritic dike that was dated at either 2684 Ma or 2695 Ma (geochronological problems not resolvable; Corfu and Muir 1989a). Note that the more felsic dikes, in particular, appear to have intruded the altered, pyritized, and mineralized(?) country rocks. It is not clear whether the dikes could have undergone the same alteration history as the country rocks, but reacted to it differently because of chemical and rheological properties. The same problem has been addressed for Stops 13 and 21.

A few of the dikes have undergone boudinage. F_3 folds with axial planar S_3 crenulation cleavage occupy many of the necks. The more mafic dikes display the effects of ductile, dextral shear.

Non-primary quartz is abundant in the exposure as a whole. It occurs as: dike-like zones of silicification; irregularly shaped zones associated with intense feldspathization and very fine-grained molybdenite; zones of numerous, thin stringers parallel to the main fabric (Photo 16); local areas of brecciated country rock with a quartz matrix (Photo 16); and two or more generations of quartz veins, some of which show considerable shortening due to buckling.

A northwest-striking set of dextral sense faults is present as is a set of northwest-striking vein-like alteration zones. These veins appear to have involved intense, fracture-controlled feldspathization, possibly albitization (*i.e.*, not microcline) which overprinted the sericitization. In irregularly defined, but specific zones, there is an almost north-striking set of closely spaced fractures. There are also relatively late northeast-striking, sinistral and dextral faults.

Structural Summary:

S _a	270°	various fabrics - sericite
S _b	282°	sericite
S _d	290/70	sericite (locally within AV 320°)
S ₃	264/82	sericite; crenulation fabric
S ₃ ?	258/80	sericite
F ₃	~074/51	crenulation fold axis
AV	262°, 279°, 292°, 320°	vein-like alteration
C _E	260°, 311/70	relatively early fracture sets (with or without displacement)
C _L	004/77, 210/61	relatively late fracture set (with or without displacement)

Fabrics within mafic dike:

S _{3a}	273/70	chlorite
S _{3c}	284/69	chlorite
S _{3c'}	308/75	chlorite
L _s	102/10	slickenside
V _q	000°, 020°, 060°, 090°	generalized quartz vein orientation (steeply dipping)
L _g	236°	glacial striation

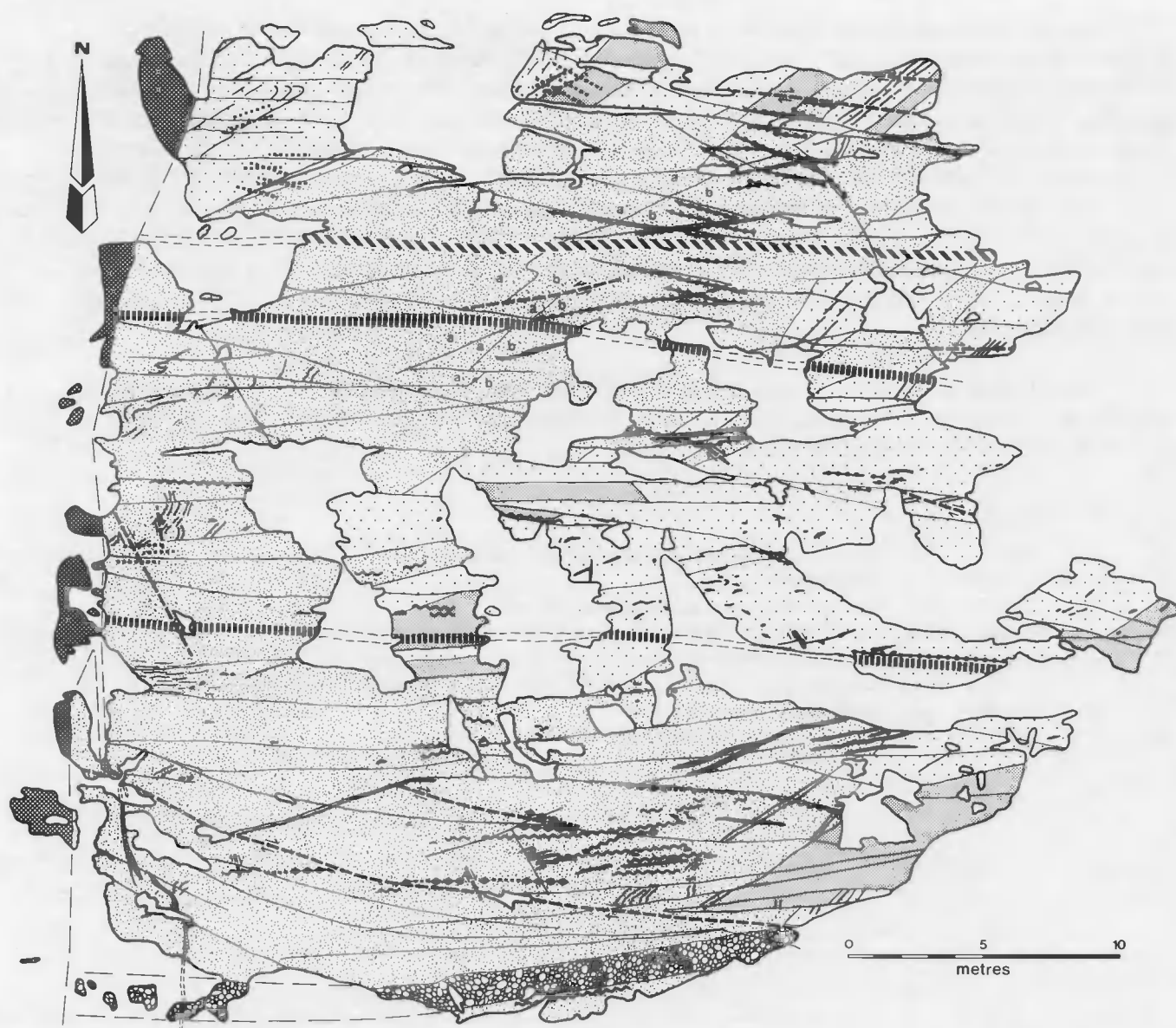
Stop 35: WEST C ZONE OUTCROP (Figures 18 and 48)

Location: About 200 m west-northwest of the East C Zone outcrop.

This outcrop consists of metamorphosed and notably altered: quartz-feldspar-phyric, heterolithic fragmental rocks, many of which have the characteristics of lapilli-tuff, lapilli-stone, and tuff (Photo 17); volcanoclastic(?) granule and pebble conglomerate; and wacke. A few of the contacts between subunits of lapilli-stone and lapilli-tuff are well defined, sharp, and folded. Some of the quartz-feldspar-phyric rocks may be intrusive (subvolcanic?) porphyry.

Remnant layering in the country rocks (Photo 18), where identifiable, commonly strikes northeast and displays S-shaped asymmetric folds. The predominant fabric, which is considered to be S₂, is clockwise to the layering. This indicates that there is either another fold axis south of the major northwest-closing fold centred on the Williams property (Figure 19), or that tectonic juxtaposition of segments of the upper crust have resulted in this configuration. There are also numerous displacements of layering, up to a few metres apparent magnitude, along the predominant fabric, which has resulted in a very blocky configuration of rock types in places. There are a few north-northwest and west-northwest-striking, dextral faults and east-northeast-striking, sinistral faults.

Figure 48. (opposite page) Stop 35: Detailed sketch map of part of the C Zone, west end (Williams property), showing variably altered, folded, faulted, and discordant blocks of metapyroclastic rocks and metavolcanoclastic/metasedimentary rocks intruded by several dikes of various compositions. Vein-like and fault- or shear-controlled alteration/mineralization overprints earlier pervasive alteration/mineralization. (After Muir 1989).



- Overburden
- DIKES, VEINS
- Diabase
- INTRUSIVE CONTACT
- Quartz veins, stringers, knots
- Biotite gabbro
- Plagioclase porphyry
- Granodiorite
- INTRUSIVE CONTACT
- Fragmental rocks (pyroclastic, volcanoclastic)
- a coarse
- b medium to fine
- Granule to pebble conglomerate
- Wacke

SYMBOLS

ALTERATION (vein-like)

- Feldspathization (and/or silicification?)
- ◆◆◆ Silicification, molybdenite
- ~~~~~ Feldspathization, pyrite (± Au?)
- ◆◆◆ Iron carbonate

FAULTS (ductile and/or brittle)

- Sense of displacement known
- Planar schistose zones —sense unknown

BEDDING

- Internal bedding
- Unit contact

Pervasive alteration is in the form of feldspathization and biotitization. Some of the layering appears to be selectively feldspathized. Vein-like alteration is in the form of feldspathization (albitization?), carbonatization, pyritization, and silicification. Molybdenite is locally associated with the vein-like feldspathization±silicification. The "veins" are collectively oriented with preferred strikes of about 250°, 270°, and 290°, which have been locally dextrally offset. Sizeable quartz veins are uncommon but there are numerous quartz knots. A few of these knots show adjacent, incipient bleaching of the country rock with associated development of coarse-grained muscovite in dilational zones. Gold mineralization is sporadic in grade and distribution but is most commonly associated with molybdenite and/or pyrite in this outcrop. About 100 m east-northeast of the West C Zone outcrop was a small exposure containing sugary textured barite, pyrite, and possibly molybdenite.

Three types of dikes, which are presently foliated, have intruded the country rocks and are parallel or subparallel to the predominant fabric. An unfoliated Archean diabase dike crosscuts all the rock types on the west side of the exposure.

Structural Summary:

S_0/S_1	250/72	
S_2	260/77	parallel to long dimension of fragments (horizontal surface)
S_3	050°, 080°	axial planar to F_3 folds
AV_f	270/55, 290/73	vein-like alteration; most are feldspar rich
AV_c	260/75, 280/75, 300/74	vein-like alteration; some are carbonate rich
C	265°-290°	planar schistose zones (with or without apparent displacement); some are associated with pyrite ± Au?, some with molybdenite ± silicification?
L_e	328/58	elongation lineation of fragments
V_q	070°	rare, relatively long quartz vein orientation

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PART 9: PHOTOGRAPHS

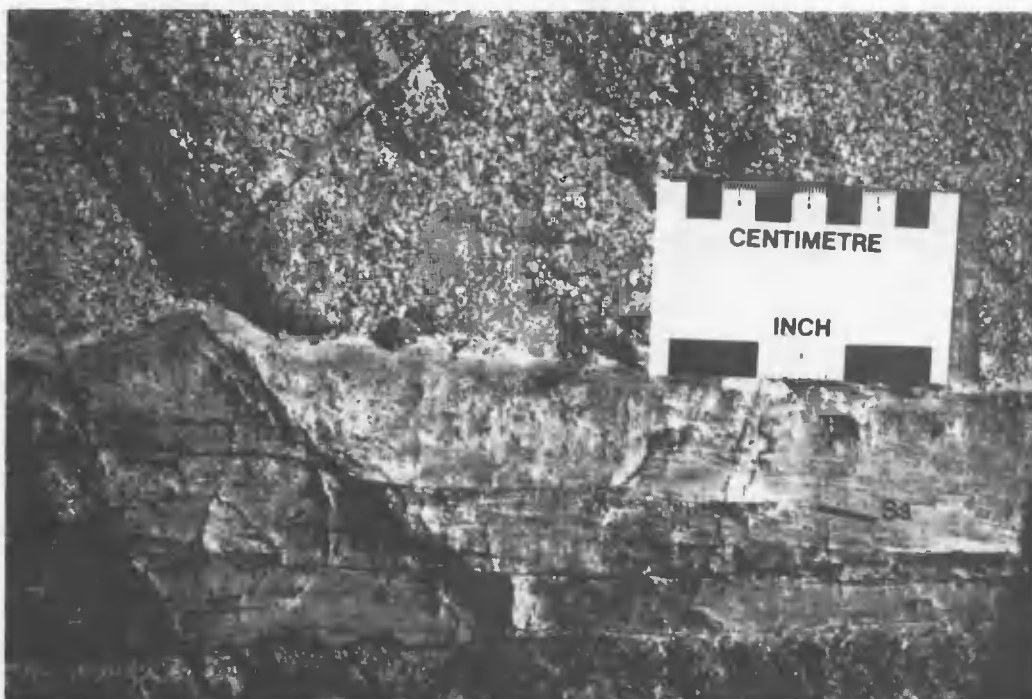


Photo 1: STOP 6 (Figures 18, 19, 23). Highly strained (mylonitized) aplite dike within virtually unstrained biotite granodiorite. Aplite locally displays ribbon quartz. Fabric is likely S_3 .

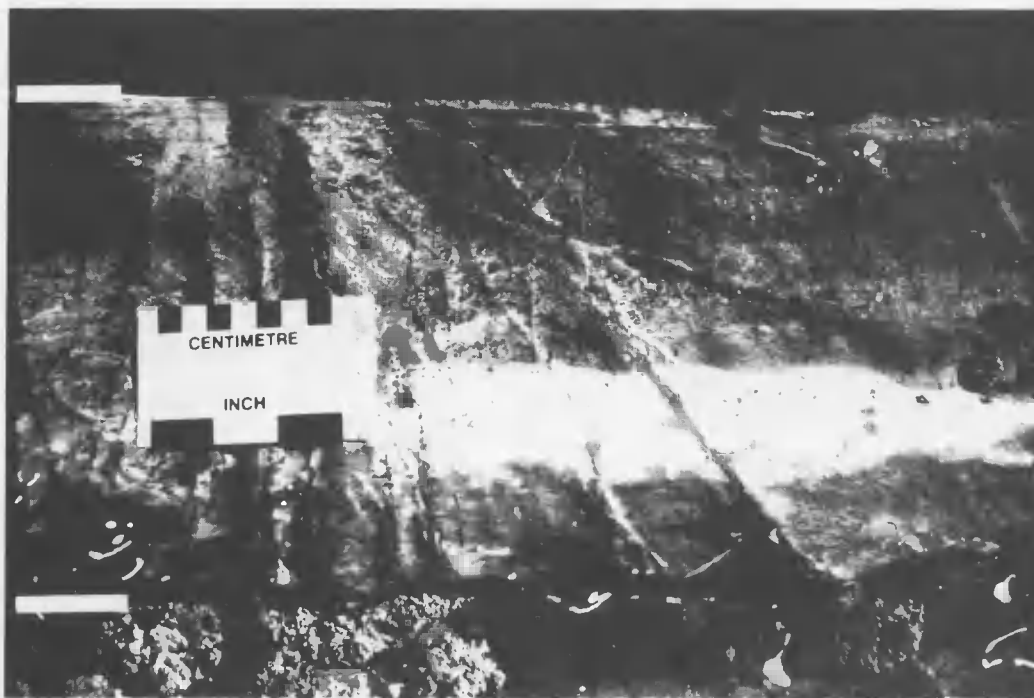


Photo 2: STOP 8 (Figures 18, 19, 21, 24). Turbidite (top and bottom outlined in part by white lines at left) consisting of a feldspathic arenite bottom part (lower part of photo), a feldspathic wacke middle part, and a laminated (not clearly visible in this photo) uppermost part. View toward northeast.



Photo 3: STOP 11 (Figures 18, 19, 21). Moderately strained conglomerate in two well-defined units (left and right sides of photo) and one ill-defined unit (near centre) entrained within feldspathic wacke (centre). Main structural features are indicated. Scale card outlined at centre is 9 cm long. View toward northwest.

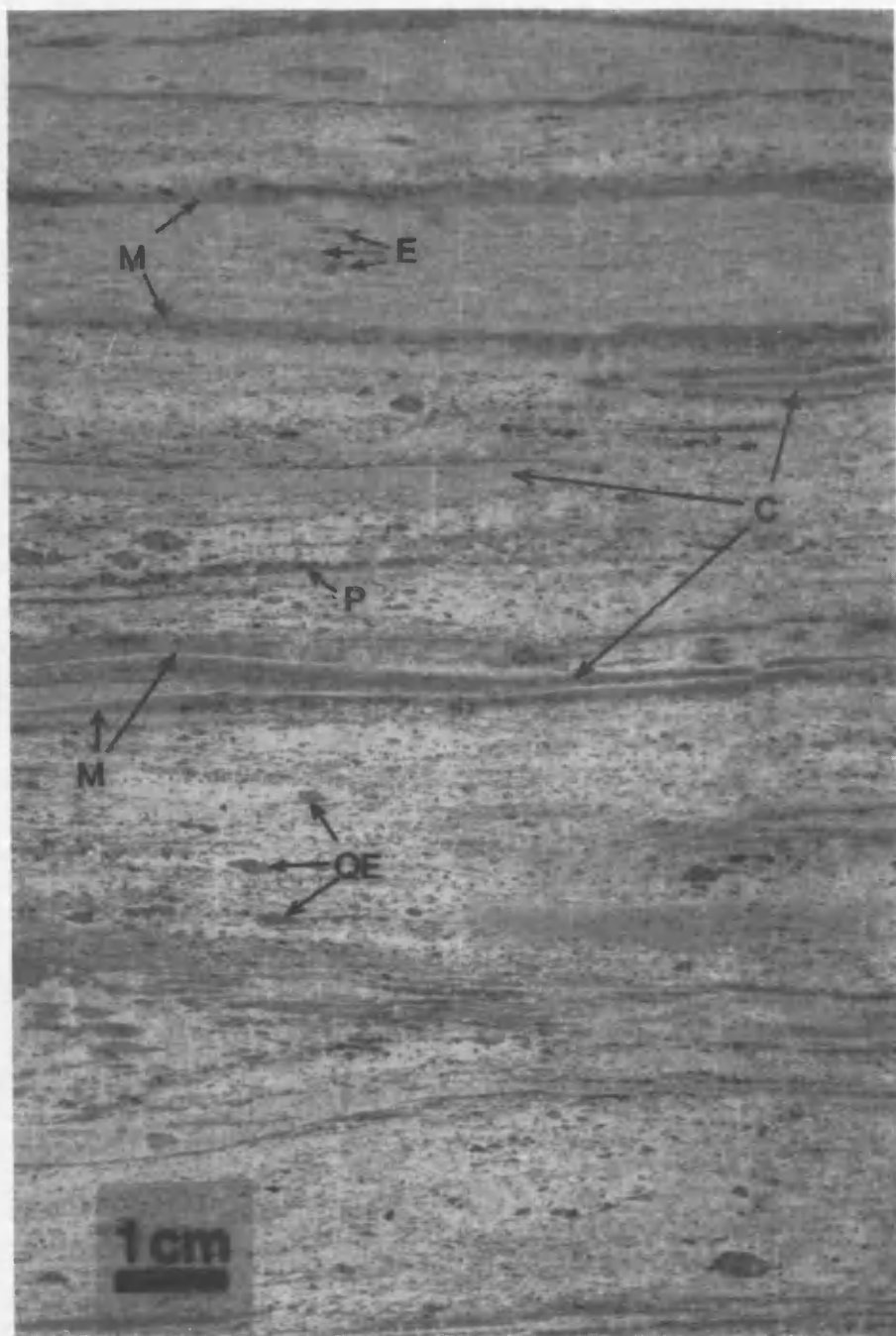


Photo 4: STOP 17 (Figures 18, 19, 21). Variably altered, highly strained, quartz-(feldspar)-phyric fragmental rock. Distribution of potassium feldspar, as evident from stained slab face, appears to have been partly controlled by the presence of fragments and cleavage planes. C = deformed clast. QE = quartz eye. M = microcline-rich zone. P = pyrite-rich zone. Some concentrations of potassium feldspar are oval and enigmatic (E).



Photo 5: (above) STOP 20A (Figures 18, 19, 21, 30). Highly strained, feldspathized and sericitized fragmental rock from the Main mineralized zone. Main structural features are indicated. This rock may be the feldspathized equivalent of a biotite-predominant conglomerate or biotite fragmental unit, spatially associated with the Hemlo deposit (see Muir 1993).

Photo 6: (opposite page, top) STOP 21B (Figures 18, 19, 21, 33). General view of the western half of the A Zone orebody, as seen before open pit mining. View toward west. Generalized descriptions of major units in the photo are, from left to right: **A** — footwall, partly microclinized, quartz-plagioclase porphyry; **B** — plagioclase-phyric dike; **C** — feldspathized metasedimentary rocks; **D** — structurally lower, rusty-weathering, microclinized, sericitized, and pyritized rocks (ore), likely derived from metasedimentary rocks; **E** — variably feldspathized and schistose wackes; **F** — structurally upper, rusty-weathering, feldspathized, sericitized, pyritized schists (ore), derived from metasedimentary rocks; **G** — hanging wall, mixed wacke, siltstone, and amphibole-rich layers

Photo 7: (opposite page, bottom) STOP 21B (Figures 18, 19, 21, 33). View of main part of orebody showing a dioritic dike swarm that intruded a mineralized pseudobreccia (ore). The pseudobreccia (PBX) is enhanced by differential weathering of highly altered and tectonized rocks. The lenses consist mostly of feldspathized rock and the matrix is largely granular pyrite with some biotite. Dikes are partly indicated by dashed lines at bottom of photo. Scale card outlined at centre left is 9 cm long. View toward east.



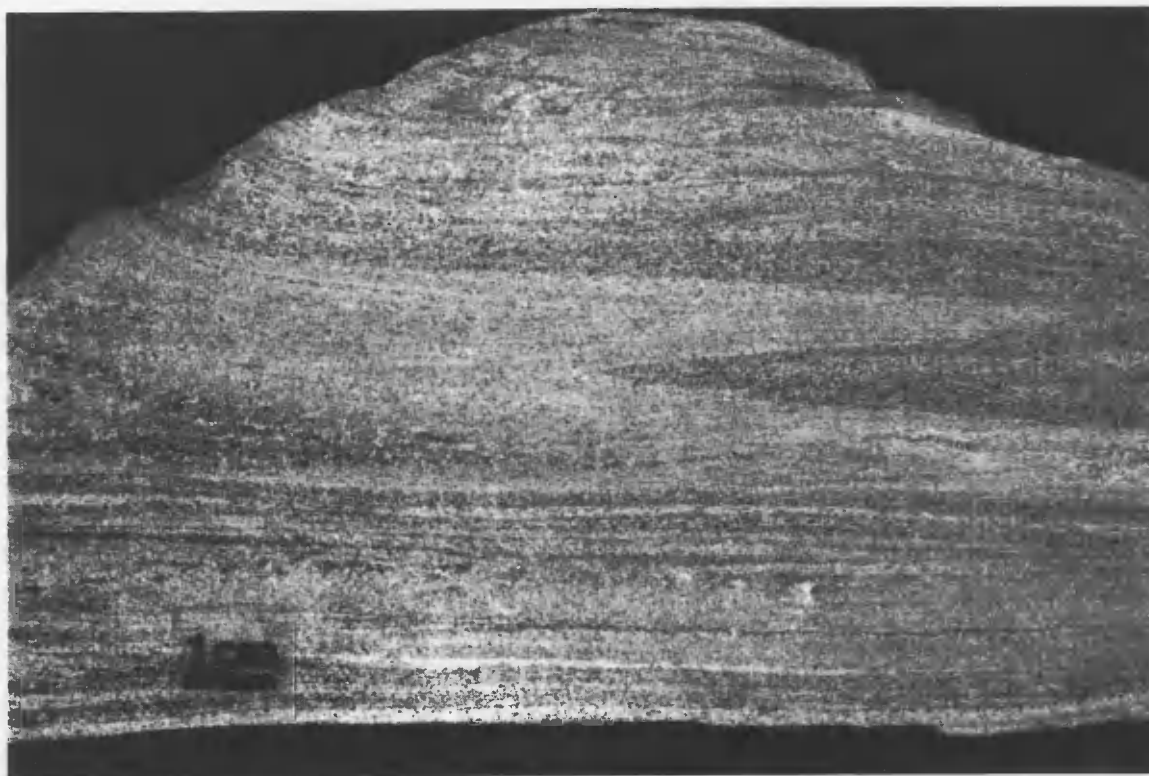


Photo 8: STOP 22A (Figures 18, 19, 21, 34). Subtle folding and transposition (enhanced by acid-etched, sawn hand specimen surface) in layered, magnetite-rich, feldspathic wacke, located between the Main mineralized zone, and the Lower mineralized zone.

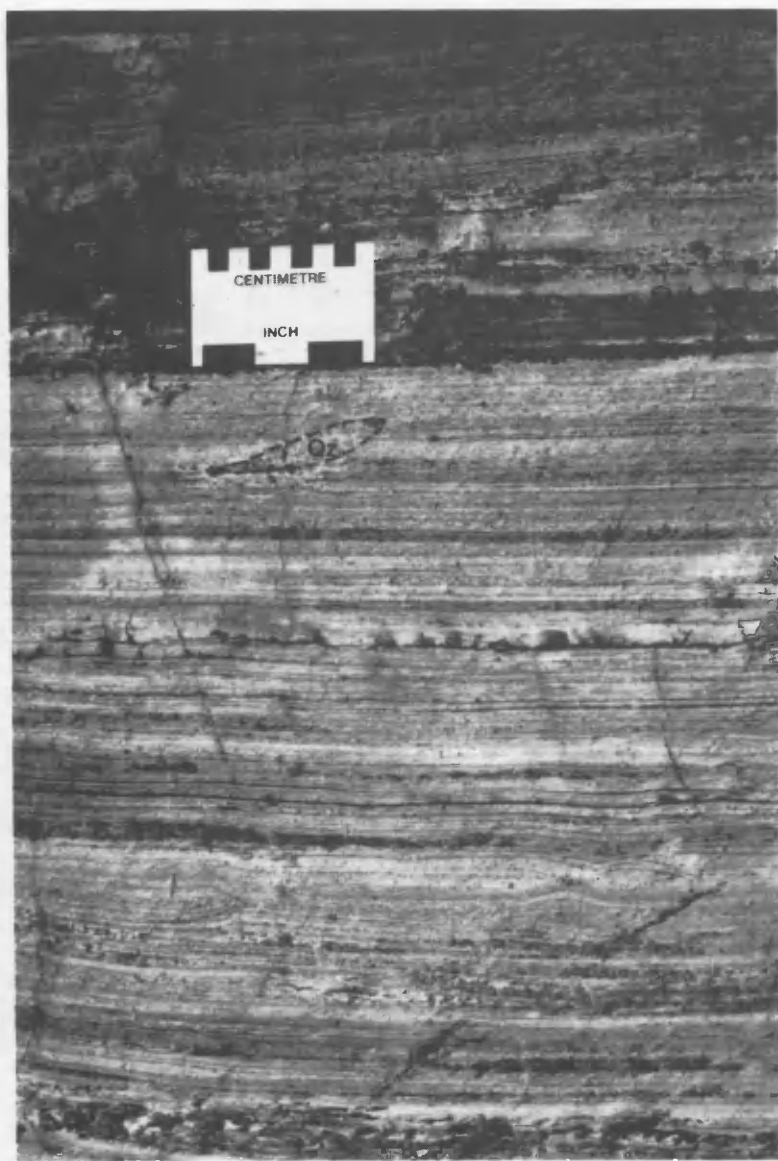


Photo 9: STOP 25A (Figures 18, 19, 21, 38). Gneissic feldspathic metasedimentary rocks displaying tectonometamorphic layering and layer-parallel spaced cleavage. Quartz gash infilling indicated (Qz). North toward top of photo.

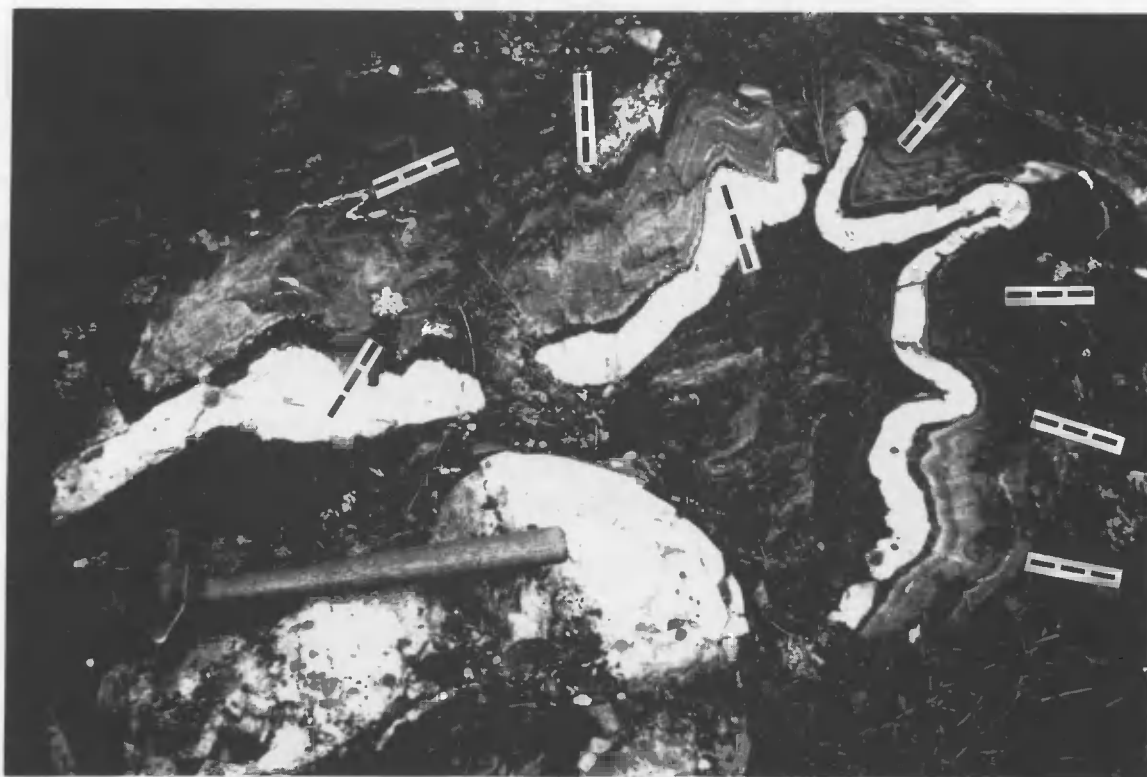


Photo 10: STOP 25A (Figures 18, 19, 21, 38). Polyclinally folded mafic schist, gneissic amphibolite, and subporphyritic granitic dikes within the Hemlo fault zone. S_3 crenulation cleavage collectively fans over a range of about 125° , as indicated by dashed lines. Folding may have resulted from a detachment along a plane with attendant crumpling or folding of units and existing fabrics. Hammer is 40 cm long. North toward top of photo.



Photo 11: STOP 27 (Figures 18, 40). Moderately to strongly deformed possibly altered, felsic, quartz-plagioclase-phyrlic lapillistone. Most fragments are similar in composition and texture. A few lenses are composed of quartz (Qz) and may represent accidental, fragmented quartz or tectonically dismembered quartz veins. North toward top of photo.



Photo 12: (above) STOP 32 (Figures 18, 19, 21, 44). Back 40s outcrop, south half. Zone of tectonic disruption, outlined by long-dashed lines can be traced around large-scale fold on Williams property (Figure 19), and is a D_1 or D_0 feature. Main structural features are indicated. Gabbroic dikelet outlined by short-dashed lines. View toward west.

Photo 13: (opposite page, top) STOP 33A (Figures 18, 19, 21, 45). Heritage east outcrop, south half. Outcrop almost entirely covered over now. View to east-southeast. Squiggly lines represent faults. Width of visible outcrop is about 15 m. Generalized descriptions of notable segments in the photo are, from right to left: **A** — footwall, partly microclinized and sericitized, quartz-plagioclase porphyritic rock, locally displaying fragments; **B** — variably feldspathized metasedimentary rocks; **C** — structurally lower gossan of transposed, microclinized and possibly silicified metasedimentary rocks, locally with molybdenite and ore-grade gold contents; **D** — zone similar to **C** except with more quartz veins; **E** — central zone of feldspathized (sodic?) and biotitized rocks with numerous deformed quartz veins; **F** — zone of variably and relatively weakly feldspathized metasedimentary rocks; **G** — structurally upper gossan of rusty weathering, feldspathized, metasedimentary rocks; **H** — hanging wall, variably and relatively less feldspathized and biotitized metasedimentary rocks

Photo 14: (opposite page, bottom) STOP 33B (Figures 18, 19, 21, 46). Heritage west outcrop. Nose of tight F_2 fold displaying “horsetail” structure and transposed layering. Darker layers are amphibole rich. Main structural features are indicated. Dismembered quartz vein outlined by dashed lines.



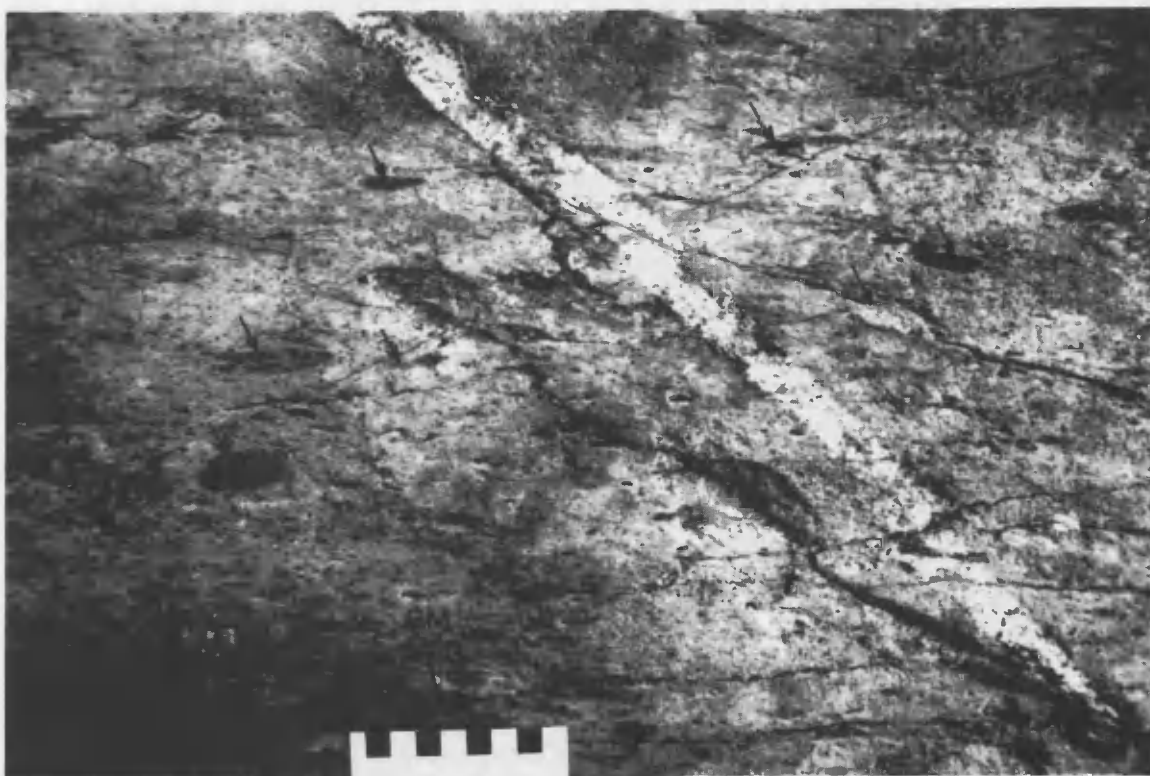


Photo 15: STOP 34 (Figures 18, 19, 21, 47). C Zone east outcrop. Pervasively feldspathized quartz-plagioclase-phyric rock (tuff/lapilli-tuff?). Arrows indicate some of the many, variably discernible fragments. Lens of green muscovite indicated (Gm). Scale in centimetres. North toward top of photo.



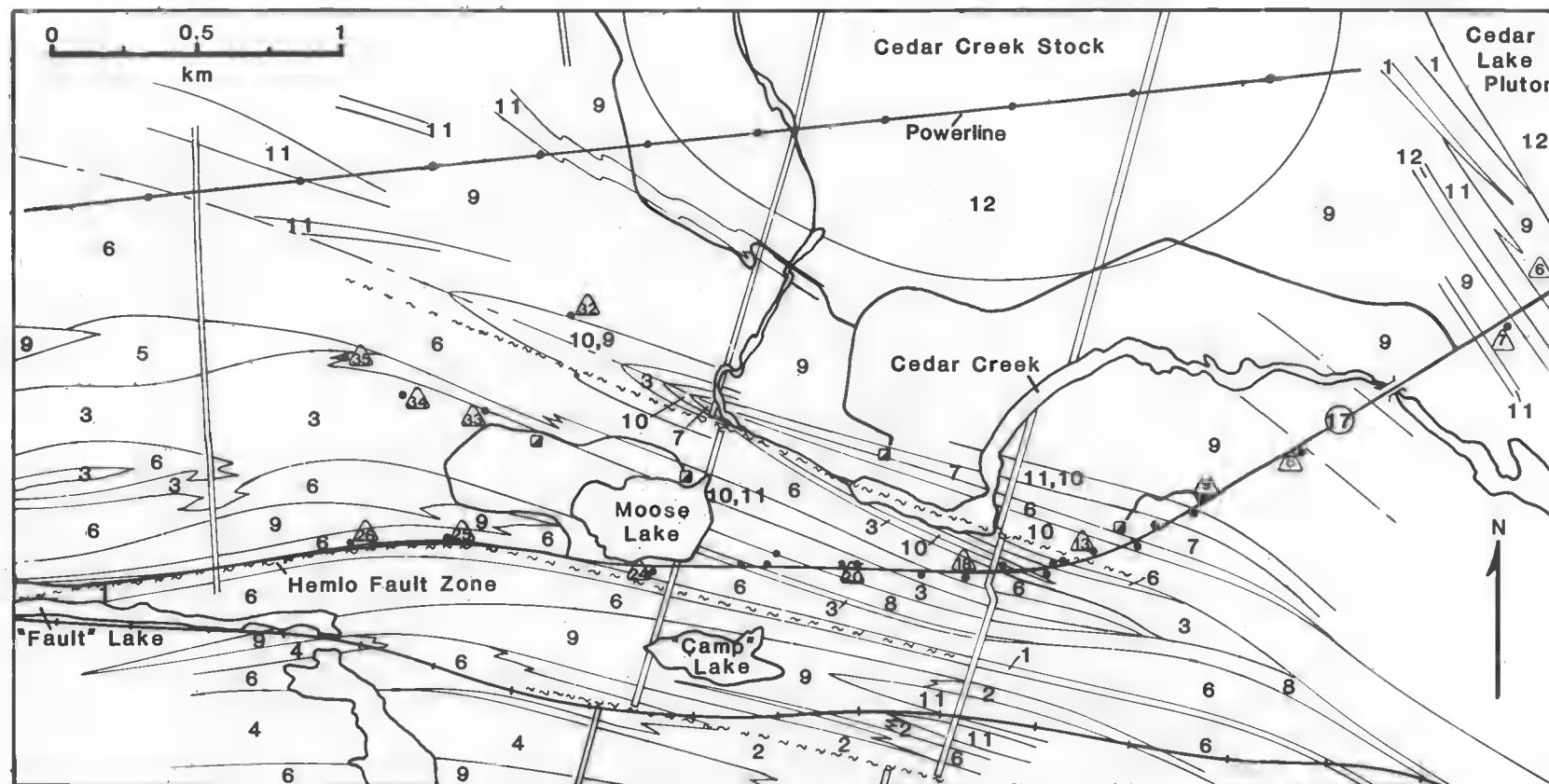
Photo 16: STOP 34 (Figures 18, 19, 21, 47). C Zone east outcrop. Feldspathized and possibly partly silicified quartz-plagioclase-phyrlic rock with numerous quartz stringers (QS) and breccia (QBX) consisting of angular country rock fragments within a quartz matrix. North toward top of photo.



Photo 17: STOP 35 (Figures 18, 19, 21, 48). C Zone west outcrop. Variably feldspathized and biotitized, heterolithic, quartz-plagioclase-phyric tuff-breccia. Strain is moderate but lower half of photo is a near-dip-face plane thereby masking the degree of flattening. View toward south. Scale card is 9 cm long.



Photo 18: STOP 35 (Figures 18, 19, 21, 48). C Zone west outcrop. Folded feldspathic wacke (outlined by dashed lines) separates units of quartz-plagioclase-phyric lapilli-tuff (top and bottom). Clasts are aligned parallel to S_2 . All units are feldspathized to some degree. North towards right of photo. Hammer (beside scale card) is 40 cm long.



- 1 Mafic Metavolcanics
- 2 Mixed Mafic-Felsic Gneissic Rocks
- 3 Felsic Quartz-Feldspar Metaporphyry and Metapyroclastics
- 4 Intermediate to Mafic, coarse Metavolcaniclastics
- 5 Intermediate, medium to coarse Metavolcaniclastics
- 6 Feldspathic Metavolcaniclastics

- 7 Metaconglomerate
- 8 Metawacke with Magnetite Layers
- 9 Metawacke/turbidite
- 10 Metasiltstone/Pelite
- 11 Meta-arkose
- 12 Granodiorite
- // Diabase

- Lithotectonic Contact
- - - Fold Axis
- ~ ~ ~ Fault/shear
- (4) Field Stop (Numbered)
- ▣ Headframe

Figure 19. Simplified geological map of the Hemlo deposit area, covering STOPS 7 to 26, and 32 to 35. Units shown represent litho-tectonic units: that is, each unit depicts a variety of similar rock types displaying simple to complex internal structures which, in some cases, appear to be independent of the adjacent units. (Geology by T.L. Muir, 1985-1990).