



Base Metal Province of Yukon

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ABSTRACT

The material presented in this paper will be subject to modification as new data become available, but it is presented in the hope that it will inspire more intensive mineral exploration and geologic studies of what appears to be one of Canada's richest mineral provinces.

A metallogenic province 400 by 150 miles in extent, lying mostly northeast of Tintina trench, encompasses most of the base metal deposits of Yukon, as well as deposits of other metals. Its main features are northwesterly trending arcuate fold belts, with several orogenic axes, which include most of the metamorphosed rocks, granitic intrusives and mineralization; and which are modified by regional uplifts, northwest-striking fault trenches, and lesser transverse folding and faulting.

The main base metal occurrences and their regional controls are summarized briefly. Most of the replacement-type deposits are localized in late Proterozoic to early Paleozoic rocks, particularly Lower Cambrian — probably because these are the most physically and chemically favourable hosts encountered in an appropriate temperature and pressure environment; perhaps because of early age of deposition. Most of the deposits also occur near heat sources or intrusives with associated structural uplift, which has, moreover, served to expose the older rocks. They also tend to occur near known or suspected regional fault trenches, such as Tintina, Macmillan and Hess, al-

though this relationship may be fortuitous. In detail, they may be localized in fold axes, flat-lying beds or other appropriate structural traps. Vein-type deposits are fracture-controlled and localized by dilational localities, the competence of wall rocks and "damming" effects.

In the Anvil district, large stratiform iron-zinc-lead replacement deposits lie parallel to gently plunging flexures in phyllite in a zone parallel to the Tintina trench, along the southwest flank of the arch-like Anvil batholith. About 80 million tons of massive sulphide ore probably existed before erosion of the Faro orebody, the Vangorda deposit could have been of similar magnitude before erosion and much more tonnage probably remains to be discovered in the district. The Anvil deposits may differ from others found to date in Yukon, but resemble the Sullivan orebody of southeastern British Columbia in their large size, localization in essentially non-limy pelitic to arenaceous host rocks of Proterozoic or early Paleozoic age and proximity to the Rocky Mountain - Tintina trench system. These features suggest an origin from primordial subcrustal sources.

More major ore deposits, not only of lead, zinc and copper but probably of other metals as well, will no doubt be found in similar environments in Yukon or Alaska. Thus, the base metal province of Yukon offers challenging opportunities for prospecting, development, field studies and basic research.



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From 1953 to 1957, he served as manager of British Yukon Exploration, a subsidiary of White Pass and Yukon Railway Corporation, doing exploration work in the Yukon. From 1957 to 1967, as an independent consulting geological engineer, he worked in mineral exploration in Canada (mainly the Yukon) and South America, being particularly active in exploration syndicates and companies. He is currently president of Dynasty Explorations Limited and Atlas Exploration Limited, and vice-president of Anvil Mining Corporation Limited.

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REGIONAL SETTING

(Figure 1)

A METALLOGENIC PROVINCE 400 by 150 miles in extent, lying largely northeast of the Tintina trench, encompasses most of the known zinc-lead deposits of Yukon, as well as deposits of copper, tungsten, silver, gold, molybdenum, tin, antimony and iron. Physiographically, this province consists of the broad, dish-like northeast portion of Yukon Plateau, fringed in part by higher mountain ranges, interrupted by isolated mountain groups and incised by northwest-trending fault trenches.

Modified by continental flexure around the Pacific arc, the Cordillera here bulges anomalously northeastward. It consists of arcuate orogenic axes of metamorphosed rocks, granitic intrusives and mineral belts following the sweep of the mountain systems and locally modified by uplifts, northwest-striking fault trenches, lesser transverse folding, and northeast and north-south faulting.

Most of the rocks are Proterozoic and Paleozoic eugeosynclinal sedimentary and volcanic rocks, with local sections of Mesozoic sedimentary and volcanic rocks and minor Tertiary sediments of continental

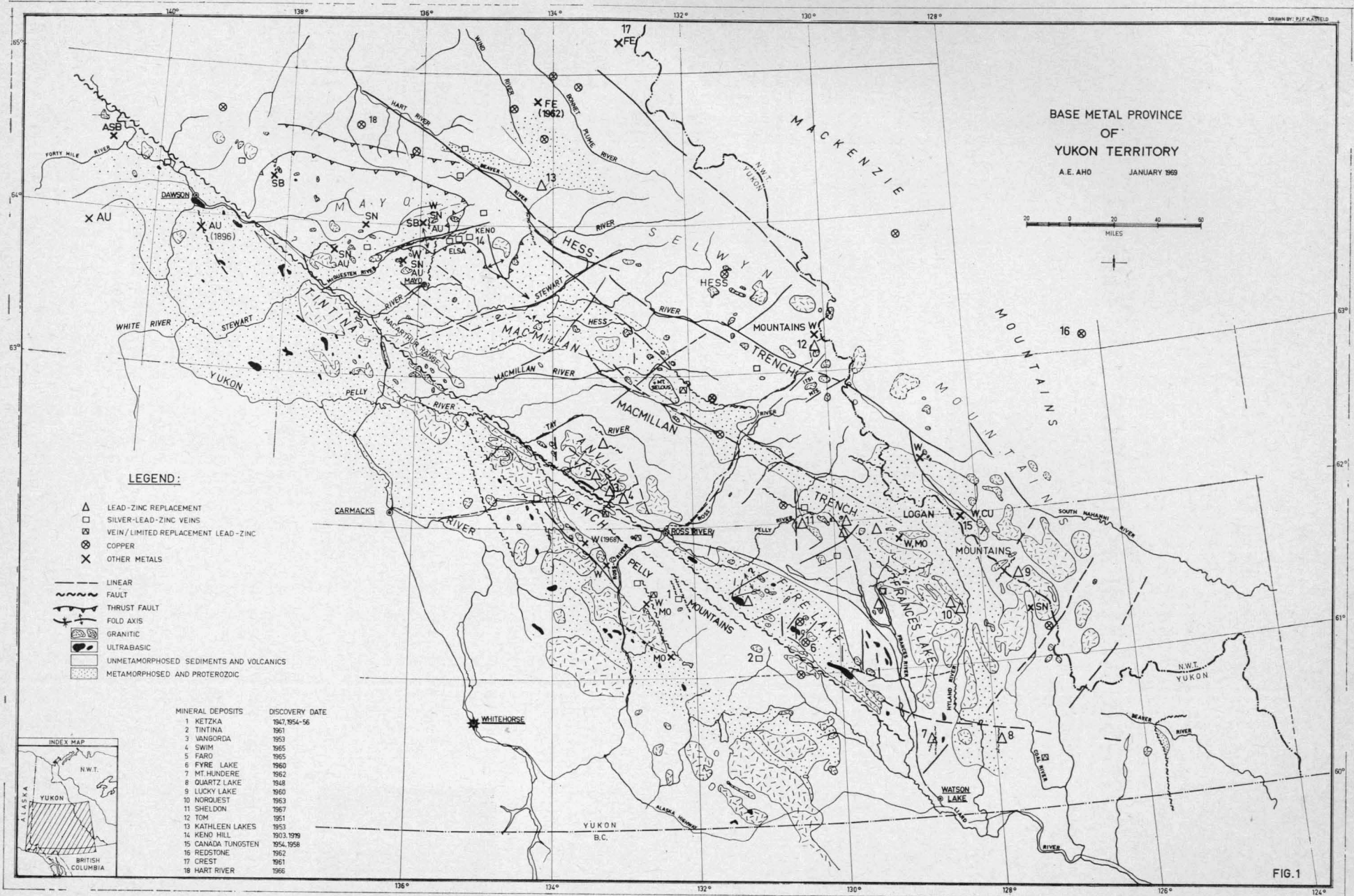


Figure 1.—Base Metal Province of Yukon.

origin. Volcanism has occurred at intervals from Proterozoic to Tertiary time. Deformation appears to have occurred in several periods ranging from late Proterozoic to early Tertiary, with regional metamorphism and intrusion being most widespread and intense in Mid-Upper Cretaceous and early Tertiary time.

The metamorphosed or older rocks, and most of the intrusives, appear to reflect four structurally high "backbones" or orogenic axes; the Pelly Mountains belt, the Anvil - Fyre Lake belt, the Macmillan - Frances Lake belt, and the Mayo - Selwyn Mountains belt. Except for the exposure of large areas of metamorphic and intrusive terrain in the Mayo and Logan Mountains areas, the intensity of metamorphism (or depth of erosion) in the three belts northeast of the Tintina trench appears to be progressively less to the northeast.

Age datings of granitic or metamorphic rocks have indicated ages of 96 million years in the Itsi Mountains, 80-90 million years in the Anvil batholith, 90-100 million years in the southeast Pelly Mountains, 75-85 million years at Mt. Selous and 85-100 million years at Keno Hill — all Mid-Upper Cretaceous. Older intrusives may be recognized, especially in the Pelly Mountains and Fyre Lake areas, but the main activity noted to date appears to be of this age.

The metallogenic province appears to be bounded in part on the southwest by the northwest-striking regional fault in the Tintina trench. It is cut by two other major but less continuous trench-like features, in part associated with the orogenic belts — the Macmillan and Hess trenches — which may also represent long-lived deep transgressive fault zones comparable to the Tintina fault. The Tintina and Hess trench systems are most prominent physiographically. Movements on the Tintina fault may range from early Paleozoic to late Tertiary in age; Paleocene rocks are preserved in both the Tintina and Macmillan trenches. Roddick (1967) has suggested a possible right lateral displacement of 220 to 260 miles on the Tintina fault, although Alaskan geologists suggest lesser displacements.

Several northeast to east-west cross flexures, linears or tear faults occur, notably in the McQuesten, Hess, Anvil, Ross River, Sheldon and Quartz Lake areas. The McQuesten anticline and its longitudinal faults, and other structures such as the northeast faults of the Sheldon area, appear to provide direct controls for vein-type mineralization.

Notable examples of north-south faults and linears are the major faults at Eldorado Creek, Mt. Haldane, Seagull Creek and Mt. Hundere and certain linears in the Anvil, southeast Pelly Mountains, and Sheldon and Logan Mountain areas. These may be tensional breaks related to regional right lateral movements on the Tintina and other trenches. They appear to have localized some mineralization in each of the areas noted.

MINERALIZATION

Most of the lead-zinc and copper, and especially the gold, tin, tungsten and molybdenum, occur near heat sources or intrusives along the orogenic axes or in structural uplifts which have also served to expose the older rocks. As in the geologically similar Kootenay arc, most of the replacement deposits are localized in rocks of late Proterozoic to Cambrian age. They also tend to occur near the main fault trenches, and some mineralization appears to be controlled by struc-

tures subsidiary to both the Tintina and Macmillan trenches.

Total metal content is greatest in the replacement-type zinc-lead deposits, which include those of the Anvil Range, Mt. Hundere, Quartz Lake (Macmillan), Lucky Lake, Norquest, Tom and lesser prospects. Of these, only the Faro deposit in the Anvil Range is proving economic at present, but other productive deposits will no doubt be developed.

Vein-type lead-zinc-silver deposits, including Keno Hill, Ketzka River, Tintina Silver, Mile 701 and numerous similar prospects, contain much less introduced metals, but the Keno Hill district has proved very productive thus far, having been Yukon's only consistent producer over several decades.

Copper is associated with many of the zinc-lead deposits as a lesser constituent, and also occurs in other prospects throughout the metallogenic province. However, except for Canada Tungsten, no economic deposits with copper as a principal constituent have yet been developed.

Other metals, such as tungsten, gold, molybdenum, tin, antimony and iron, occur in the region. Of these, only some gold placers and the Canada Tungsten deposit have so far proved economic.

Prospecting of this large base metal province is still in its infancy. Most discoveries have been made in recent years, as shown by the discovery dates on *Figure 1*, and the distribution of known deposits still shows a distinct relationship to access and intensity of prospecting. Mineral belts are therefore tentative, but, subject to modification as new discoveries and more geologic information become available, the province is provisionally divided into the following five metallogenic belts related to the orogenic axes.

- Pelly Mountains
- Anvil - Fyre Lake
- Macmillan - Frances Lake
- Mayo - Selwyn Mountains
- Mackenzie Mountains

The main known base metal deposits are now summarized briefly for each belt.

Pelly Mountains Belt

Several silver-lead districts in the Paleozoic rocks of the Pelly Mountains appear to be controlled by northwest fault zones parallel or nearly parallel to the Tintina trench — and by north-south faults at an angle to the trench — with Lower Cambrian limestone being the favoured host rock in the Ketzka, Tintina Silver and Mile 701 districts. A belt of tungsten and molybdenum prospects also occurs in skarns in Proterozoic to early Paleozoic rocks along the northeast contact of the batholithic core of Pelly Mountains. Only minor copper prospects have been found to date in the Pelly Mountains.

In the Ketzka district (1), high-ratio silver-lead veins are localized around a half-dome of Lower Cambrian rocks uplifted along northwest faults on the Ketzka river, and along possible lesser northeast faults. To the west, the north-south Seagull Creek fault and related structures may localize lower-ratio silver-lead veins and replacements. Replacement mineralization occurs in limy rocks of several ages, but favours Lower Cambrian limestone where it is present. Vein-type mineralization is controlled by competence in fracturing, dilational zones and damming by imperious argillite.

Other low-ratio silver-lead showings occur in folded Paleozoic rocks along the front range of the Pelly Mountains. They are possibly related to the St.-Cyr-type system of faults which parallels the Tintina trench for some 100 miles.

At the Tintina Silver Mines property (2), silver-lead deposits are localized as pods parallel to the bedding and as cross-cutting veins in Lower Cambrian limestone in an area of intense deformation near a granitic stock. As in the Ketza district, the main controls appear to be competence in fracturing, replacement of limestone and "damming" effects by argillite.

Anvil - Fyre Lake Belt

General

Two uplifted districts, with granitic intrusives, ultrabasic rocks and intense replacement-type base metal mineralization, occur in the Anvil - Fyre lake belt. This belt is believed to have considerable undiscovered potential, and other major base metal deposits may occur in similar environments elsewhere along the Tintina trench.

Paralleling the Tintina trench on the northeast, a zone of low topography extends intermittently through both districts. Most of the known prospects occur close to it. This zone may reflect some type of intermittent faulting or underlying structure buttressed between the Tintina fault and the intrusives or older rocks on the northeast. It is comparable to the St. Cyr system of faults and mineral occurrences paralleling the other side of the trench.

A. Anvil District

(i) *General Outline:* District structure consists broadly of a northwest-trending 20- by 40-mile doubly plunging arch-like uplift with the Anvil batholith as a core. Phyllites, volcanics, chert and argillite of Paleozoic age, dipping outward from it, are complicated by folding, faulting and irregularities in the intrusive contacts. This district is bounded by the Tintina trench and related faults on the southwest and by boundary faults and other formations on other sides. The full extent of the mineralized district is as yet undefined.

The main deposits occur as large stratiform iron-zinc-lead sulphide replacements of thinly laminated limy to pelitic and arenaceous phyllites of probable Lower Cambrian or Middle Cambrian age, and are localized in gently plunging flexures, parallel to the Tintina trench, along the southwest flank of the arch-like structure surrounding the Anvil batholith.

A comprehensive description of the geologic setting of the Vangorda (3), Swim (4) and Faro (5) deposits has been published by D. J. Tempelman-Kluit (1968 p. 49), as follows:

"... The Faro body occurs close to the contact between Units 2 and 3 (Lower and Middle Cambrian respectively), but the Vangorda and Swim deposits do not. There is no apparent relation of the deposits to a particular stratigraphic horizon within Unit 3 and the phyllitic host rocks near the deposits are the same as those elsewhere. The regional(?) metamorphic grade of the host rocks varies from moderate (biotite, andalusite) grade at Faro through intermediate (chlorite) grade at Vangorda to low (sericite) grade at Swim. Chloritic tuffaceous greenstone outcrops close to all three deposits, but is nowhere immediately against ore. Graphite is present in phyllites around all

three deposits, but it is far more important around the Swim body than near the Vangorda or Faro deposits . . .

"... The three deposits are mineralogically similar. Primary sulphides, in order of abundance, include pyrite, pyrrhotite, sphalerite, galena and minor chalcocopyrite. Tetrahedrite, bournonite and arsenopyrite have been identified as minor or trace constituents. Marcasite is the important secondary mineral; angle-site, geothite and gypsum occur sparingly. Quartz is the only important gangue mineral. In the Swim and Vangorda deposits, barite(?) also occurs. Sphalerite, galena, chalcocopyrite and tetrahedrite occur as inclusions in pyrite and interstitial to pyrite grains. The ores have a granular texture and probably average around 50 per cent sulphides. Proportions of the various sulphides are remarkably constant throughout individual deposits and between the deposits. Grain size of the sulphides varies within the deposits and from one deposit to another, but the average grain size in the Faro is distinctly coarser than that at Vangorda, which in turn is coarser than the Swim. Pyrite grains are generally coarser than those of other sulphides.

"Structures in the ore range from a faint regular banding, apparently conformable with the foliation of host rocks, in the Faro deposit, to faithful replacements of laminae involved in transposition structures in the Swim body The general shape of the deposits is tabular; the plane in which they lie conforms broadly to the crenulation foliation in the enclosing phyllitic strata and their long axes coincide with the intersection of this foliation and the bedding of the host rocks.

"An irregular envelope of bleached rocks, locally 100 or 200 feet thick, enriched in silica, alumina and perhaps soda and potash relative to iron and magnesia, occurs around all three deposits. No other alteration effects are evident . . ."

In addition to the massive sulphide deposits, minor prospects of copper, vein-type silver and lead, and gold also occur in this district.

(ii) *Vangorda:* On the Vangorda deposit, a total of 73 diamond drill holes have outlined a series of flat-lying overlapping lenses of massive to disseminated sulphides, 3,200 feet long, 490 feet wide and up to 150 feet thick, enclosed in a chlorite-sericite schist which in turn is underlain by graphitic schist. A total of 9.4 million tons averaging 3.16 per cent lead, 4.96 per cent zinc, 0.27 per cent copper, 1.76 oz/ton silver and 0.02 oz/ton gold, with an additional 12.6 million tons of low-grade to barren sulphides, is indicated. The upper portion of the deposit has been eroded away, and therefore it may have been originally considerably larger. Control of the deposit appears to be largely stratigraphic, with localization in a flat-lying fold or crumple paralleling the regional trends (Chris-holm, 1957) and a suggestion of termination against a fault in the vicinity of Vangorda creek.

(iii) *Swim:* On the Swim deposit, 30 diamond drill holes totalling about 14,500 feet delineated a 1,200-foot-long zone of two moderately dipping lenses of sulphides interconnected by a thinner lens and underlain by another layer of sulphides. The sulphides are localized in bleached phyllites, which in turn are enclosed by moderately dipping graphitic-chloritic phyllites. Approximately 5 million tons averaging about 9.5 per cent combined lead and zinc and 1.5 oz/ton silver, with minor copper and gold values, has been outlined.



The Pelly river, flowing within the Tintina trench.

(iv) *Faro*: The rocks around the Faro orebodies consist of limy and tuffaceous quartz-biotite-sericite schists or phyllites and minor greenstone, thought to be of Lower to Middle Cambrian age. These rocks have been largely hornfelsed and are intruded by granodiorite and quartz monzonite of the Anvil batholith, and by later diorite porphyry; they are mineralized by massive sulphides. Dykes of quartz porphyry or rhyolite, and basalt of Tertiary age, are localized by post-ore faults.

The metamorphic rocks have been strongly deformed and characteristically show gleitbrett structure, isoclinal drag folds, and northwest-trending lineation. The orebody occurs in a basin-like flexure parallel to this northwest trend.

The phyllites have been domed up by the granodiorite, which apparently dips underneath them. A local halo of thermal metamorphism, accompanied by calc silicates and biotite, extends outward from the granodiorite for a thickness of about 3,000 feet. The foliation in general dips about 15-30 degrees southeast, averaging about 20 degrees, and the orebodies are conformable with this foliation, terminating irregularly against a quartz diorite which is believed to be a border phase of the main granodiorite batholith. Lenses of altered diorite porphyry or quartz diorite occur in and near the orebody.

The orebodies show an alteration halo of sericite schist grading through quartz-sericite schist to more quartzose "metaquartzite" — about 30 to 100 feet thick on the hanging wall and 20 to 40 feet thick on the footwall side. They are surrounded by biotite-chlorite-quartz phyllite, which is locally slightly graphitic. Except for minor mineralization, there is little visible surface evidence of the existence of these massive sulphides.

Overlying the southeast section of No. 1 orebody, and exposed to the surface, is a remarkable breccia ranging from finely comminuted material up to house-sized blocks of foliated phyllite. It is completely in-

durated and thermally metamorphosed, with the development of interstitial calc silicates which are rarely accompanied by zinc-lead mineralization. The relationship of this brecciation, if any, to the mineralization can only be conjectured. Near the orebodies, similar brecciation occurs in three other minor localities, one of which also carries scattered mineralization.

In most of the ore, equant grains of pyrite are abundant. They may be altered in part to marcasite, or embayed and more rarely veined by sphalerite, chalcopryrite and galena; they contain small inclusions of sphalerite and rarely chalcopryrite. A finer grained interstitial groundmass consists of sphalerite, pyrrhotite, galena, chalcopryrite and marcasite. The sphalerite contains a few small inclusions of chalcopryrite or exsolution dots of pyrrhotite, and the chalcopryrite tends to be closely associated with it. A tentative paragenetic sequence suggested by Thompson (1965) is pyrite, pyrrhotite, sphalerite, chalcopryrite, galena and marcasite.

Minor mineral occurrences within, and in the general vicinity of, the orebodies consist of massive vein galena, magnetite and galena with a low silver content, chalcopryrite (with a 1/1 silver-copper ratio) disseminated in chlorite schist, scattered molybdenite in porphyry, scattered lead-zinc in skarn and reported magnetite-bornite float grading 10 oz/ton silver. The most unusual occurrence is a lensey galena vein in schist between No. 1 and No. 2 orebody. It contains some quartz, but is mainly coarse-grained galena enclosing coarse euhedral crystals of pink andalusite, with some arsenopyrite, minor chalcopryrite, pyrite and tetrahedrite(?), with values of up to 0.44 oz/ton gold, 103.2 oz/ton silver and 61 per cent lead.

The Faro orebodies consist of massive, banded and disseminated sulphides in two main deposits. Faro No. 1 orebody is about 4,700 feet long, up to 1,100 feet wide and up to 200 feet in thickness. It is overlain by an average of 56 feet of glacial overburden and by up to 300 feet of rock cover. Its deeper extent has not yet been fully delimited. The orebody is basin-like

in longitudinal section and is cut by two faults, with apparent vertical displacements of 160 feet and probably about 300 feet. Faro No. 2 orebody, 500 feet to the south, which is about 1,200 feet long, 1,000 feet wide and up to about 30 feet in thickness, lies under shallow overburden and is open to the southeast.

Eighty-nine vertical diamond drill holes, totalling 42,878 feet of drilling to depths of 300 to 800 feet, have outlined 63,472,940 tons of assured ore averaging 3.405 per cent lead, 5.721 per cent zinc and 1.196 oz/ton silver, assuming a cut-off grade of 5 per cent combined and a density factor of 8.5 cubic feet per ton. Of this tonnage, 58,313,605 tons are in No. 1 orebody, with 2,555,915 tons of additional possible ore, and 5,159,335 tons in No. 2 orebody, which contains an ad-

ditional 635,555 tons of possible ore. From present indications, if No. 2 orebody is a continuation of No. 1 with the intervening section and extensions eroded away, the total sulphide mass, including sections of submarginal grade, would have been at least 6,800 feet long, 1,000 feet wide and up to 200 feet thick — totalling in the order of 80 million tons — not considering any possible further depth extension.

Starting in the fall of 1969, open-pit mining and milling are scheduled to begin on the Faro deposit at a rate of 2 million tons per year of ore averaging 12.2 per cent combined for the first five years, and 3 million tons per year of ore averaging 9.3 per cent combined for the following twelve years. Test results indicate that the lead concentrate should assay about

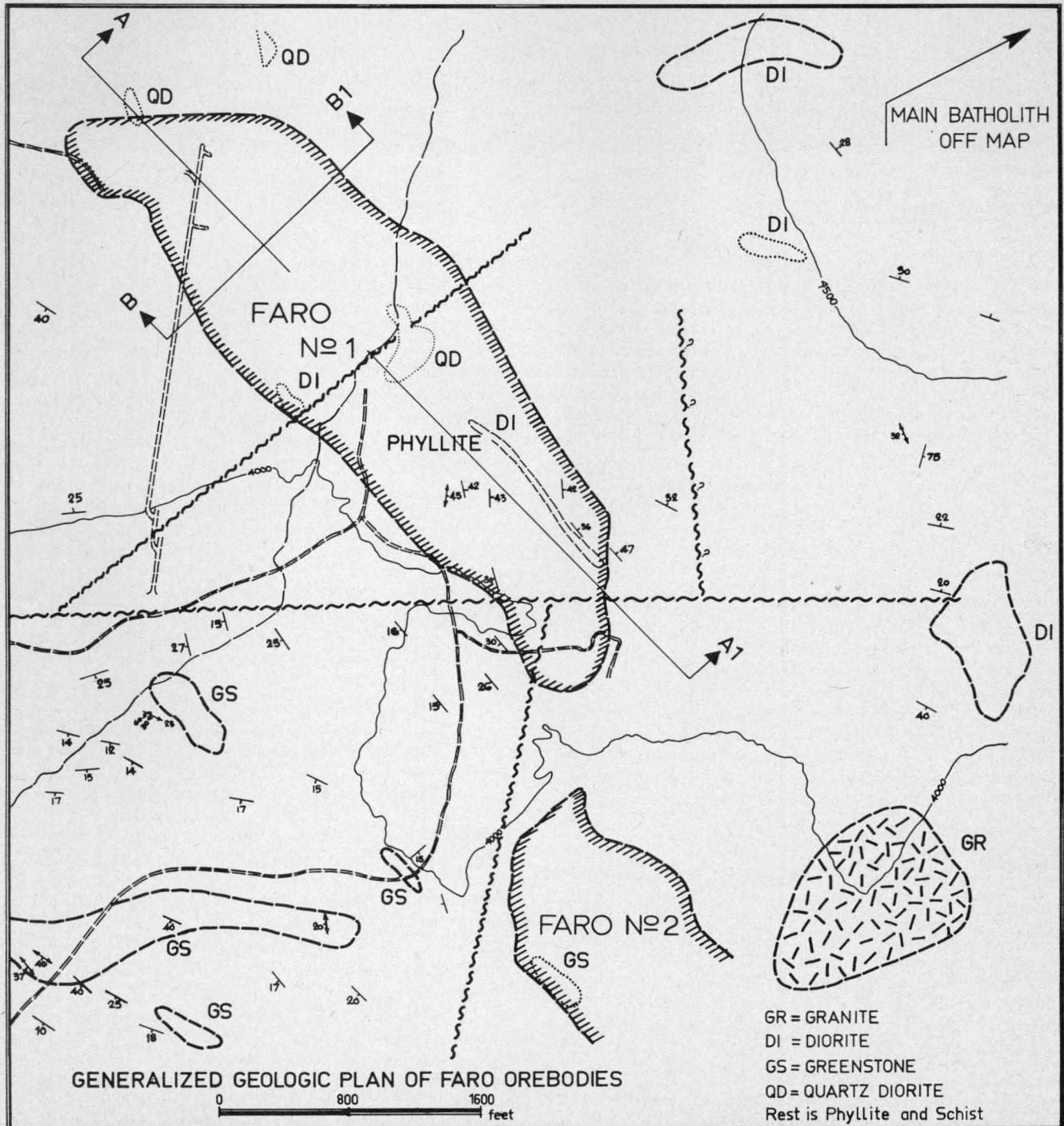
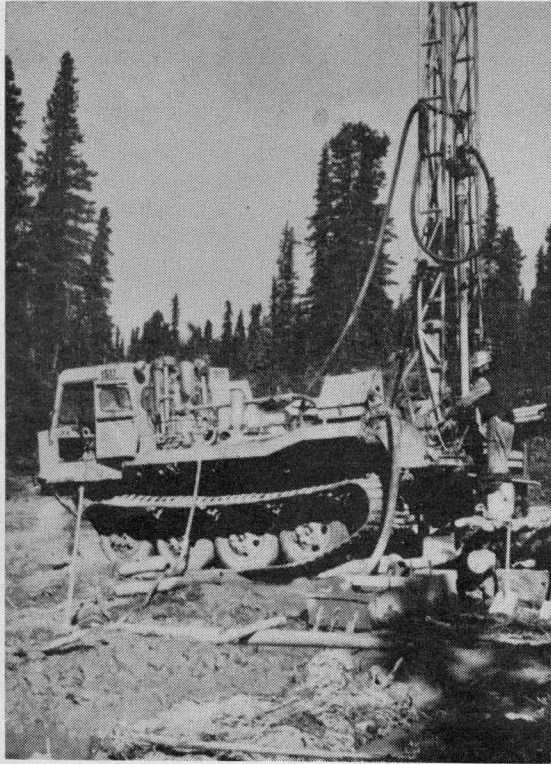


Figure 2(a).—Geological Plan of the Faro Orebodies.



Rotary drilling at Faro No. 4; July, 1965.

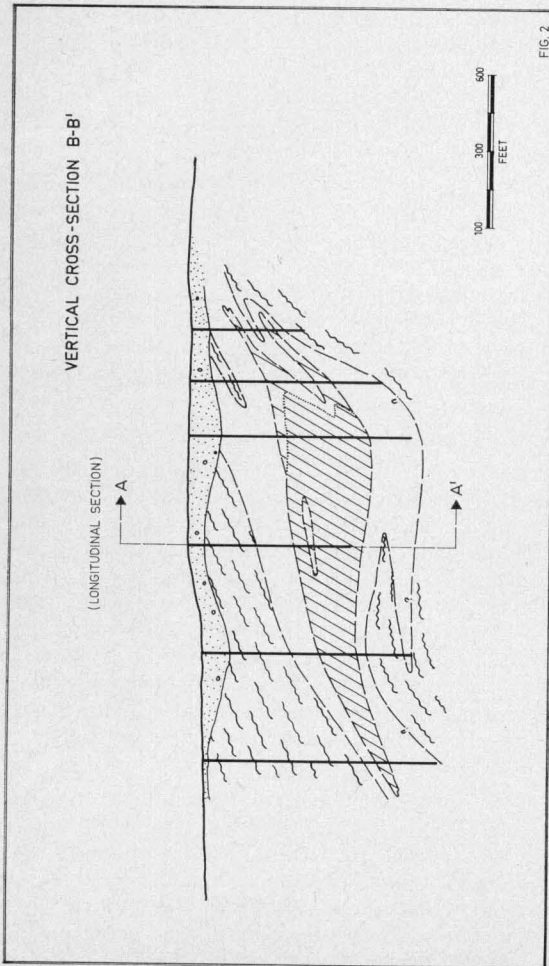
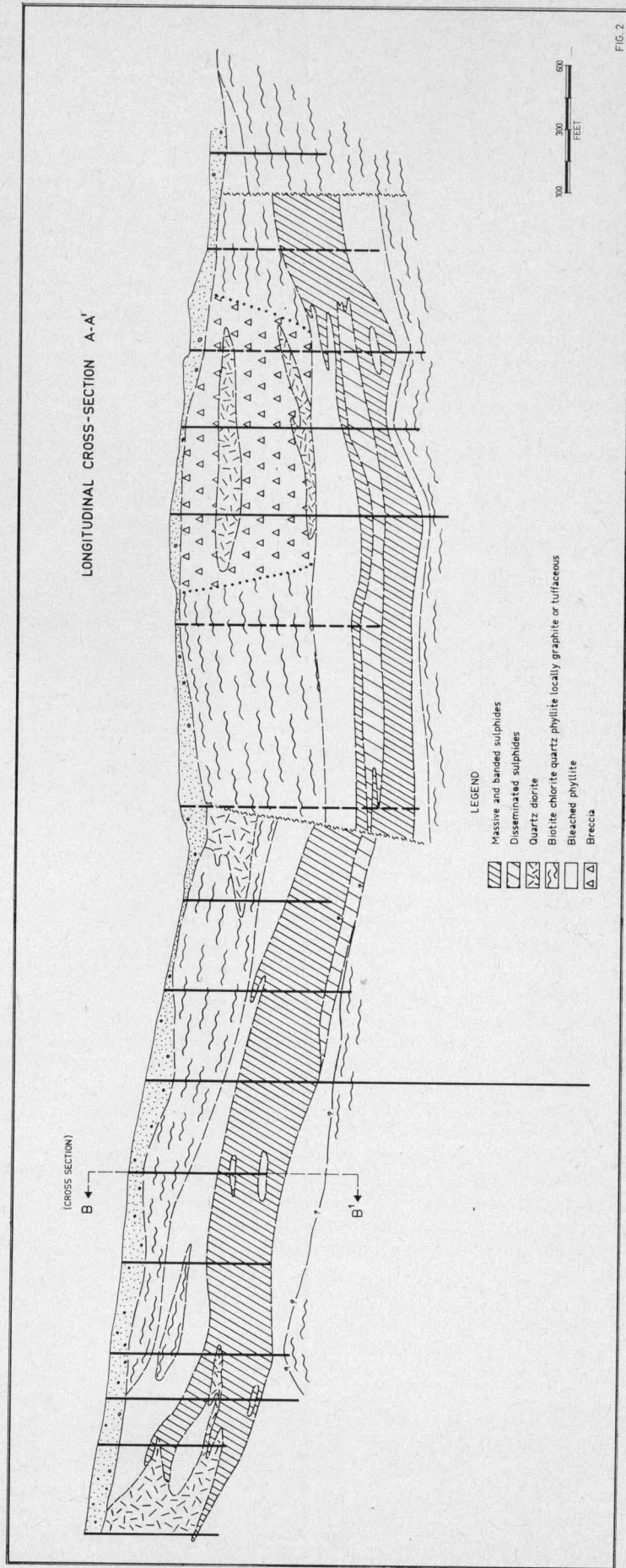


FIG. 2



LEGEND

- Massive and banded sulphides
- Disseminated sulphides
- Quartz diorite
- Biotite chlorite quartz phyllite locally graphitic or tuffaceous
- Bleached phyllite
- Breccia

FIG. 2

Figure 2(b).—Vertical and Longitudinal Sections of the Faro Orebodies.

69-70 per cent, with a recovery of 88-90 per cent of the lead and 75-80 per cent of the silver and that the zinc concentrate should assay about 53-54 per cent with a recovery of 85-88 per cent. The operation is planned to produce 128,400 dry short tons of lead concentrate and 240,200 dry short tons of zinc concentrate per year for eight years for a sales contract with Japanese buyers. Total cost of the project is about \$63 million.

(v) *Ore Controls*: Graphitic schist has been suggested casually as a source bed or localizing stratigraphic control. The Swim and Faro No. 2 deposits are localized, respectively, in and above graphitic schist and the Vangorda deposit occurs in chlorite-sericite schist above a graphitic schist member. A high-zinc geochemical background, where present in the district, does tend to favour graphitic sections. However, the Sea prospect and Faro No. 1 orebody have little or no associated graphitic material. Thus if there is any relationship, it would involve the mobilization of metals from graphitic schist source beds metamorphosed at depth.

Other controls may be northwest-trending folds or flexures, and possibly gentle north-south flexures. East-west faults and porphyry may be controls, but appear to be mainly post-ore. Northeast faults or fracture patterns, visible physiographically in many localities as prominent northeast linears, also appear to be largely post-ore, and are part of a typical late Tertiary physiographic pattern throughout much of the Tintina and Rocky Mountain trenches. Two such faults, mapped by Tempelman-Kluit, show an apparent left lateral displacement of several thousand feet, and two lesser faults of similar trend cut and vertically displace the Faro orebodies by about 160 feet and 300 feet.

Tempelman-Kluit (1968, p. 49) concludes:

"Local controls for emplacement of sulphides are as yet unknown. There is no evidence that graphite content of host rocks, proximity to granitic rocks and relationship to the Tintina fault or northeast-striking faults, cited elsewhere as possible controls, are significant."

The Faro orebodies appear to be localized by: (a) some unknown physical or chemical conditions which have led to a stratiform shape terminated laterally as well as vertically, and have given rise to typical replacement banding and other such structures; (b) a synclinal or basin-shaped flexure on the rocks, butting against an intrusive and trending roughly parallel or sub-parallel to fold axes in the area. No specific stratigraphic reason can be ascribed to their localization — the host rocks are simply quartz-mica phyllite with little or no significant graphite (except in No. 2 orebody) and no evidence of limy rocks or of any lens of

more permeable or reactive material. A favourable bed, if such existed, may have been completely destroyed by sulphide replacement or, alternatively, the ore may have been "injected" into the surrounding rocks along a plane of weakness.

Tempelman-Kluit (1968, p. 52) also suggests:

"In the writer's opinion, the deposits are early (i.e. Cambrian?) replacements of consolidated or unconsolidated quartz-rich parts of a tuffaceous Cambrian sediment. These sediments were later deformed, perhaps synchronously with regional (?) metamorphism in post-Cambrian pre-Devonian time. Volcanism may have played an important part in the original emplacement of the sulphides. During deformation and metamorphism of the host rocks, the sulphides were recrystallized and the alteration envelope formed. The Faro body was probably recrystallized for a second time during emplacement of the Anvil batholith."

His suggestion that the age of emplacement may be as early as Cambrian is apparently based partly on the type of occurrence and on the observation that the sulphides in the district have a structure that is identical to that of the surrounding rocks, including grain size variations in accordance with the metamorphic environment. However, a more geologically recent origin by emplacement soon after intrusion of the Anvil batholith could equally well explain the same characteristics.

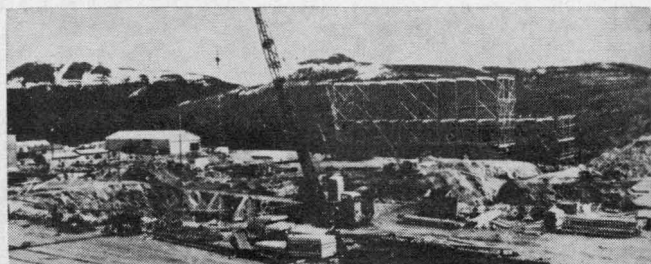
Whatever the age or origin of these deposits, they may be derived almost directly from primordial sub-crustal lead and they are more similar to the Sullivan deposit of southeastern B.C. than to the other known deposits in Yukon. Lead isotope studies should clarify this in the near future. The Anvil deposits show great mutual uniformity in character; they replace pelitic to arenaceous non-limy rocks and their size and other characteristics are similar to the Sullivan deposit, including regional localization near the Rocky Mountain - Tintina trench system.

Sections with a similar geologic environment elsewhere along the Tintina trench may be favourable for Anvil-type deposits. Moreover, if the Anvil deposits were deposited before the main trench displacement, and if large displacements did take place, then "equivalent" rocks on the opposite side of the trench might be considered favourable.

More detailed study and basic research on the Anvil deposits and their regional geology should help to clarify the above suggestions.

(vi) *Exploration*: Faro No. 2 orebody causes a strong 1,500-foot-long electromagnetic anomaly, but gives little or no associated magnetic anomaly. The main No. 1 orebody causes a magnetic anomaly of moderate intensity, about 4,000 feet long, but showed only weak electromagnetic response on the instruments used, mainly because of a deeper cover. It was detected as a low-intensity anomaly on detailed aeromagnetic surveys, but had no expression on later 1968 government aeromagnetic maps, whereas most of the other sulphide deposits or their immediate vicinities did give anomalies.

In the Faro area, geochemical anomalies totalling 8,000 feet in length, with zinc and lead values of up to several thousand parts per million and copper values of several hundred parts per million, appeared to reflect ground moraine and comminuted float with limited lateral or upward dispersion. Values are diluted or very erratic within a few hundred feet from their source, and sediments from the main streams nearby



Construction of the Anvil concentrator; June, 1968.

were not anomalous. Thus, if the orebodies had been masked with a greater thickness of overburden, the only indications might have been the separate and unrelated magnetic and electromagnetic anomalies and perhaps only spotty geochemical anomalies. These would have been classed as low-priority targets and probably would not yet have been explored.

However, a gravity survey showed No. 1 orebody as a "textbook" example of an oval-shaped anomaly, up to 1,500 feet by 2,500 feet or more in extent, with maximum relief of about 1.5 milligals, and early drill-hole data gave a fairly accurate estimate of 48.5 million tons of sulphides. Induced polarization also showed response over the orebodies.

From the above, it would appear that, although slower and more expensive, gravity and I.P. Methods might be the best methods of exploration in the Anvil district after regional targets had been narrowed down by airborne magnetic surveys and checked on the ground by geochemical and other methods. This may be the best approach for discovering this type of deposit, but the exploration is still dependent on the art of interpretation and decisions on the significance of anomalies. In this district, geochemical anomalies can be masked by overburden; magnetic anomalies can be caused by greenstone, volcanics, intrusives or accessory pyrrhotite in the phyllites; most EM response is caused by graphite or other conditions; many smaller gravity anomalies are caused by bedrock or overburden variations; and I.P. response can be caused by uneconomic sulphides and other conditions.

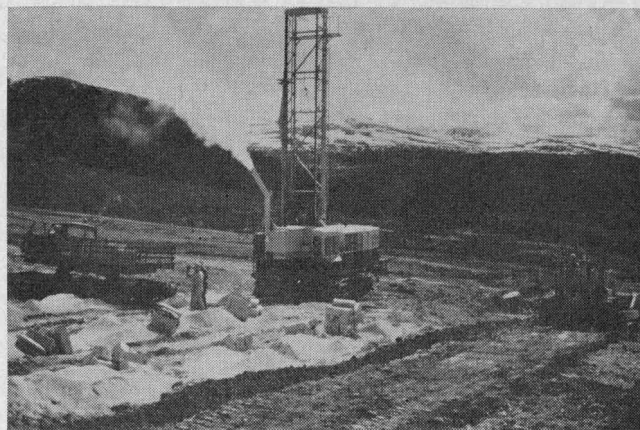
Careful structural and stratigraphic studies and other intensive geologic work along the Anvil phyllite belt should be very useful for intelligent guidance of further exploration.

B. Fyre Lake District

(Ref., private reports; R. Skinner, GSC paper 62-27, 1961, pp. 39-40).

Several deposits of replacement-type copper-zinc mineralization occur in the general Fyre Lake (6) - North Lakes area of the southeast Pelly Mountains in chloritic schists intruded by granitic and ultrabasic rocks and porphyry. Mineralization consists of disseminated pyrite, pyrrhotite, chalcopyrite and minor sphalerite and magnetite in nearly flat-lying quartz-mica and quartz-chlorite schists. One zone at Fyre lake, 400-1,200 feet long, 125-150 feet wide and up to 30 feet thick, grades roughly 0.5 per cent copper. These deposits are localized in gently dipping Precambrian schist, and may be related to a pattern of north-south and northeast faults, or to the northwest-trending zone of low topography parallel to the Tintina trench. Their geologic environment is similar to that of the Anvil district.

In the Grass Lakes area a few miles from the Tintina trench, low-grade disseminated lead-zinc mineralization (1.2 per cent combined) occurs as galena, sphalerite and minor pyrite in the foliation of a quartz-feldspar augen schist. The mineralized unit is about 100 feet thick, strikes N80°E and dips steeply, and is bounded on each side by graphitic schist and chlorite schist, all occurring on the south flank of a transverse east-west-trending dome of schist and gneiss. These rocks are thought to be of Proterozoic age, but their metamorphic age is about 100 million years, "probably representing consolidation of the metamorphic terrain during a plutonic episode." (J. O. Wheeler, GSC Paper 66-17, p. 33). Copper mineralization also occurs in the general area.



Drilling off bench at the Anvil open pit; June, 1968.

It is also interesting to note that placer gold occurs in some of the creeks and that some of the gneisses in the Fyre Lake district resemble those of the Klondike region, suggesting good placer possibilities, especially because the direction of old channels is mainly transverse to the schistosity and the direction of glaciation. Nickel occurs in ultrabasic rocks near the Hoole river.

Macmillan - Frances Lake Belt

(i) General:

Lead-zinc and copper deposits of vein, shear zone and skarny replacement types, some with a substantial silver content, occur along this belt which swings westward into the McArthur Range in the Mayo area. Such prospects occur in the Mt. Selous, Dragon Lake, Sheldon - Traffic Mountain, Frances Lake, Norquest and Mt. Hundere areas. To date, large portions of this belt have been only sparsely prospected and should yield other discoveries. Occurrences of copper, and in some cases molybdenum and tungsten, associated with fractured porphyries along this belt suggest that it might also contain important deposits of porphyry copper type. In addition, high-grade silver deposits similar to those of the Mayo district may be found.

(ii) Mt. Selous:

In the Mt. Selous-Dragon Lake area, several prospects of vein, shear zone and skarny replacement lead-zinc-copper mineralization occur in Proterozoic rocks near granitic intrusives, apparently controlled by fracturing, replacement of limy beds and thermal environment.

(iii) Sheldon:

(Ref. Atlas Explorations private reports).

Mineralization in the Sheldon area in general appears to be controlled by west-northwest fault and porphyry zones, north-south fault zones and northeast tear faults. Part of the general pattern consists of the McEvoy system of northeast faults and linears on the north side of the Logan Mountain regional bulge. Vertical uplift appears to be associated with some of the granitic and porphyry intrusives. Uplifted Cambrian rocks bordering intrusives near McEvoy lake seem to be favourable hosts for mineralization.

Mineralization consists mainly of skarn-type pyrometamorphic lead-zinc-copper prospects, with associated pyrrhotite, in Proterozoic to early Paleozoic rocks adjacent to intrusives. In addition, vein-type lead-zinc-silver-copper prospects, some grading to copper, and others with high silver-lead ratios, occur in the area.

At Fortin lake, zinc mineralization occurs in a northwesterly trending and moderately folded succession of low-grade metasedimentary rocks of Proterozoic to Devonian-Mississippian age, cut by numerous faults and intruded by a granitic stock lying to the southeast. The mineralization consists of fine- to medium-grained sphalerite, pyrite, minor galena and lesser chalcopyrite, widely scattered through sections of slightly silicified, altered and fractured dolomitic phyllites of probable Silurian or Devonian-Mississippian age in a possible synform structure cut by west-northwest and northeast faults. The area is largely covered by overburden. The mineralization is not detectable by geographical methods, but gives extensive geochemical anomalies. In 1968, 6,231 feet of drilling encountered local sections, up to 15 feet thick, grading 3 to 5 per cent zinc.

(iv) Norquest:

(Ref. L. H. Green, GSC paper 65-19, pp. 45-46).

The showings lie within the Logan Mountains Proterozoic arch in a northwest-trending belt of paragneiss believed to be formed by the metamorphism of quartz-pebble quartzite, shale and phyllite of late Proterozoic to Cambrian age. The contacts between schist and paragneiss are partly engulfed by nearby granitic rocks, mainly biotite granodiorite, which occur as cross-cutting stocks, dykes and sills or as lit-par-lit injections parallel to the foliation.

Epidote- and clinopyroxene-rich bands representing limy sections in the paragneiss or schist, with local pockets of marble still remaining, contain up to 10 per cent sulphides as pyrrhotite, pyrite, dark sphalerite, galena and chalcopyrite.

In the Fir Tree showing, the epidote band is about 40 feet thick and is traceable for 1,300 feet. Striking north and dipping 30 degrees east parallel to banding in the gneiss, it is enclosed in quartz-feldspar-biotite-chlorite gneiss.

In the Black Jack showing, 4 miles to the south, a number of similar epidote-rich bands contain sphalerite. The largest is 15 feet thick, has been traced for 1,400 feet, strikes east, dips about 30 degrees north and is enclosed by quartz-feldspar-biotite gneiss. Granitic rock occurs as scattered cross-cutting dykes and sills up to 10 feet thick.

The control for mineralization appears to be similar to that at Lucky Lake, described below, and the host rocks are also believed to be metamorphosed equivalents of the same general age group.

(v) Lucky Lake (9):

(Ref. R. E. Gordon Davis, private report).

Mineralization occurs in skarn zones in hornfelsic limy sedimentary rocks, considered to be Lower Cambrian, which have been intruded by sills and irregular bodies of feldspar porphyry on the northwest margin of a batholith of medium-grained to coarse-grained hornblende granodiorite. The sedimentary rocks strike northeast parallel to the granite contact and transverse to the regional trend, and dip steeply northwest away from the granite. Skarn zones a few hundred feet long and up to 40 to 50 feet thick occur in limy beds, commonly along intrusive contacts.

Mineralization consists of actinolite, epidote, garnet, calcite, diopside, chlorite, and lead, zinc and iron sulphides in variable concentrations. Generally, the grade is a few per cent lead and zinc with about one ounce per ton silver, but in limited localities it is up to 15 per cent combined lead and zinc.

The structure appears to consist mainly of steeply northwest-dipping hornfelsic limy sediments, which dip away from the intrusive contact, and two sets of joints — one at right angles to the beds and dipping vertically and the other parallel to the beds and dipping steeply southeast. These two sets of joints appear to have largely controlled the intrusion of porphyry into the mineralized section. In addition, right-handed north-northwest faults dipping nearly vertical further complicate the structure.

The controls for mineralization appear to be (i) appropriate impure limy beds of probable Lower Cambrian age, (ii) the transverse northeast trend of the intrusive contact and of the sediments dipping away from it, and (iii) a close association with intrusion and porphyry.

(vi) Mt. Hundere:

(Ref. A. E. Aho, J. W. Staniford private reports).

The Mt. Hundere deposits occur as high-temperature lead-zinc replacements in Lower Cambrian limestone within a dome-like uplift 6 miles long and 4 miles wide. This uplift is in part bounded and cut by faults and lies between the Stewart Lake east-west system of lineaments and the Tom Lake - Green River northeast system, which may possibly be related to conjugate tear faults or fractures at the southern margin of the Logan Mountains bulge, similar to those of its northern margin at McEvoy lake.

Mineralization consists mainly of quartz, sphalerite and galena in coarsely crystalline aggregates accompanied by diopside, lime garnet, hedenbergite, wollastonite and later epidote, but with remarkably little iron sulphide. Two deposits occur as a replacement of impure margins of white crystalline Lower Cambrian archeocyathid-bearing limestone, and are localized in gently plunging folds close to a north-south fault and a north-northeast quartz-fluorite-bearing fault.

Intrusive rocks in the area are limited to several small diorite sills on the north end of the uplift and several small quartz-feldspar microporphyry dykes.

Controls for mineralization appear to be (i) the chemically and physically favourable impure contact facies of Lower Cambrian limestone, (ii) a structural trap formed by gently or moderately dipping beds or fold axes and (iii) a proximity to faults which served as channelways for high-temperature mineralization.

(vii) Quartz Lake (8):

(Ref. L. H. Green, GSC Paper 66-31, pp. 72-74, H. Gabrielse, personal communication).

The Macmillan deposit near Quartz lake occurs in a limestone member in the upper part of a thick grit unit which is thought to be of latest Proterozoic to possibly early Cambrian age, and is bounded by Upper Cambrian rocks. It is localized on the east limb of a fairly open, north-plunging anticline modified by a small syncline and sliced by a thrust fault which strikes northerly and dips about 20 degrees east. Immediately to the north are east-west linears, part of the Stewart Lake system.

Mineralization consists of pyrite, fine-grained galena, sphalerite, ankerite, minor jamesonite and tetrahedrite, and traces of pyrrhotite and arsenopyrite, localized as replacements of finely laminated dark grey limestone in the hanging wall of the thrust fault. The rocks are only slightly metamorphosed and only minor silicification, pyritization and bleaching accompany the mineralization.

Diamond drilling of eighty-three holes, totalling 19,571 feet, has outlined a mineralized north-striking lens containing about 1¼ million tons assaying about 5 per cent lead, 10 per cent zinc, and 1.8 oz/ton silver.

Controls for mineralization may be (i) the favourable Proterozoic to Lower Cambrian (?) limestone, (ii) a structural trap formed by folds, gently dipping strata and the thrust fault and (iii) proximity to faults.

Mayo - Selwyn Mountains Belt

(i) General:

Mineralization in this belt consists of vein-type silver-lead-zinc and antimony deposits in the Mayo district, and more widely distributed shear-zone and replacement-type zinc-lead deposits, some copper deposits and tungsten-molybdenum-tin-gold deposits closely associated with granitic stocks along an extensive arc from McQuesten to Coal river.

Most of the mineralization appears to be related to the intrusive arc of granitic stocks, but it may also be related to the closely associated Hess trench system extending intermittently from the Hart river to the Nahanni drainage as a series of *en-echelon* linears, which probably reflect faults.

(ii) Mayo District:

(Ref. A. E. Aho, 1964).

The Mayo district, which has produced about \$300 million worth of silver, lead, zinc and cadmium from vein deposits and about \$3 million from placer gold, is associated with a N70°E anticlinal and intrusive belt intersected by a major southeast-plunging anticlinal fold.

The silver-lead-zinc-cadmium ores (United Keno Hill Mines has been the main producer) are localized in northeast-striking, southeast-dipping vein-fault zones in competent quartzite or greenstone and form part of a conjugate fracture pattern with northwest cross faults and east-west longitudinal faults, mainly near the regional fold intersection. This is a pattern typically related to anticlinal doming or uplift. The ore is localized in dilational open-space fillings in quartzite and greenstone at or near vein-fault intersections, near cross faults or under schist cappings, and attains its best widths near vein junctions and in cymoid loop structures. The host rocks, formerly believed to be Proterozoic in age, are now considered to be Jura-Cretaceous, overthrust by Proterozoic rocks.

Gold, tin and tungsten prospects also occur along the N70°E McQuesten anticlinal and intrusive belt, and are closely associated with a double row of granitic stocks. Significant amounts of placer gold have been produced from Clear, Hight, Haggart and several lesser creeks. Vein-type silver-lead-antimony prospects also occur in this belt. Silver-lead-antimony occurrences also appear to be associated with a row of synclinal stocks extending parallel to the Tintina trench from the south fork of Klondike river to Fifteenmile river in the Dawson area.

Widespread mineral deposition and the associated geologic environment strongly suggest much greater mineral potential for the Mayo district, although the character of the district makes it difficult and costly to explore and develop. The occurrence of considerable placer cassiterite in many of the creeks of the Mayo district suggests possibilities for economic tin deposits, especially because the geologic environment



The first Anvil open pit; June, 1968.

of Proterozoic rocks, intrusives, associated tourmaline and silver-lead mineralization resembles that of the Bolivian tin fields, and most of the world's tin is derived from the circumpacific regions.

(iii) Hart and Beaver Rivers:

In the vicinity of the Hart river, several shear-zone replacement deposits of copper, with minor zinc and lead, occur in late Proterozoic rocks. The Hart River Mines deposit (14), found by "grass roots" prospecting in 1966, is reported to be a zone of stratiform sulphide dissemination 700 feet long and up to 60 feet thick in late Proterozoic black argillite resting on a diorite footwall and grading up to 1.5 to 2.0 per cent copper, several per cent zinc, minor lead and 1.5 oz/ton silver. The deposit has been explored, mainly down dip, with twenty-eight drill holes, and an underground program is planned in 1969 to block out tonnage and grade.

At Beaver river, several deposits of lead and zinc occur as replacements of favourable limy beds, probably by vein-type mineralization of similar origin to that of Keno Hill. At Kathleen Lakes (13), mineralization occurs as a replacement of brecciated dolomite and limestone of Proterozoic to Lower Cambrian age, bounded on the top by ferruginous carbonate and shale and on the bottom by shale. These rocks have been folded into a southeast-plunging syncline, with the east limb dipping about 40 degrees south and the southwest limb about 20 degrees northeast. Brecciation occurs around the apex of the fold and is cemented with calcite, followed by replacement with galena, sphalerite, minor pyrite and manganiferous siderite.

(iv) Macmillan Pass:

(Ref. L. H. Green, GSC paper 65-19, pp. 47-48, and private information).

On the Hudson Bay Tom claims, mineralization consists of very fine grained pyrite, sphalerite and galena with associated barite and quartz in a light grey, thinly banded altered dolomitic carbonate bed which varies gradually from a few feet to 200 feet thick. Exposures of this bed are poor, but it has been traced for about 3,600 feet along strike by diamond drilling. Other similar, but thinner, beds occur in the slates in this vicinity.

The rocks in the area consist mainly of a section of black cherty slate, lesser chert-grain grit and fine chert-pebble conglomerate of Ordovician-Silurian age comprising part of a thick and regionally widespread section. Two miles south of the area is a granitic stock about 2 miles in diameter. Near the deposit, the

bedding appears to strike northwesterly and dip steeply southwest; however, few outcrops show reliable bedding attitudes.

Work up to the fall of 1953 consisted of thirty-nine diamond drill holes, totalling 17,834 feet, which outlined about 8 million tons averaging about 5 per cent zinc, 0.8 per cent lead and 0.2 oz/ton silver, with open possibilities. Renewed work in 1967 and 1968 outlined another smaller but higher grade body, about 1000 feet long and up to 50 feet thick, occurring as a replacement of limy beds in argillite.

(v) Canada Tungsten:

The deposit which is being mined consists of a tungsten-bearing pyrrhotite skarn, originally carrying about 1.1 million tons grading 2.5 per cent WO_3 and 0.45 per cent copper, localized in Lower Cambrian limestone. It occurs on the lower flat limb of an overturned syncline near a small granitic body along a septum of Cambrian rocks between Proterozoic rocks. Other similar prospects occur in the area.

Mackenzie Mountains Belt

The Ogilvie, Wernecke and Mackenzie mountains form an extensive mineral belt of Rocky Mountain-type geology and mineralization. The belt includes copper and iron deposits of both epigenetic and syngenetic types, the most notable of which is the Crest deposit, which contains 40 billion tons of sedimentary iron ore grading 40 per cent Fe. Copper most commonly occurs in shear zones in late Proterozoic rocks as chalcopyrite and lesser bornite and tetrahedrite with quartz and siderite gangue, and also tends to be associated with syenodiorite plugs. Lead and zinc have been found as lesser constituents or in smaller prospects. Further exploration of this relatively remote fringe of Yukon's base metal province may prove up other significant deposits. Possibilities also exist for the discovery of extensive syngenetic copper deposits.

CONTROLS FOR MINERALIZATION

As illustrated in part by the examples given, the controls for zinc, lead and associated mineralization appear to consist of some combination of the following:

- (1) Localization in late Proterozoic or early Paleozoic rocks, commonly Lower Cambrian. This is the most striking characteristic of nearly all the significant deposits in this metallogenic province as well as in northern British Columbia, except on the Hudson's Bay Tom property and in some lesser prospects. The Anvil deposits are localized in rocks of this general age, seemingly without regard for lithology, and the majority of the others tend to favour limestone or limy sections.

The writer does not attempt to interpret the origin of the deposits, but merely notes that both vein and replacement types tend to favour Lower Cambrian rocks, perhaps because these rocks are physically and chemically favourable and are usually the first ones to be encountered in a temperature and pressure environment appropriate for mineralization. Intense pre-mineral deformation may be a requisite, as in many other Cordilleran mineral deposits.

- (2) Close relation to vertical tectonics, in many cases caused by intrusives of Upper Cretaceous or early Tertiary age, and to heat sources related to intrusion or uplift. As in many cases elsewhere in

the Cordillera, most of the deposits in Yukon are associated with uplift by tectonic or intrusive action which in many cases has served to expose the older rocks in which the deposits are localized. Examples are Tintina Silver, Hundere, Quartz Lake and others. These controls are as widespread as that of the Cambrian rocks and are probably more basic, as they also apply elsewhere in the world.

In addition, the mineralogic types of deposits appear to be related to the degree that depth of erosion has exposed thermal environments imposed by intrusives or metamorphism in each belt.

- (3) Occurrence near regional fault trenches or linears. Although this relationship may be a projection of theory or wishful thinking, there does appear to be a tendency for deposits to occur in general proximity or parallel to the regional fault trenches. The major Sullivan and Anvil orebodies, and many of the other deposits in Yukon, occur close to such trenches. Faulting certainly localizes many deposits, especially the vein types, and north-south faults may be important tensional channelways resulting from a tendency for right lateral movements on the main northwest faults.
- (4) Transverse disturbed belts, folds or rows of stocks, possibly reflecting basement trends or otherwise anomalous structures; or structural intersections, as in the Mayo and Hess areas.
- (5) Localization in gently dipping beds, fold axes, crumples or stratigraphic traps. (Common type of control).
- (6) Structural intersections, dilational localities and damming effects in fracture systems. (Control for vein-type deposits.)

REGIONAL EXPLORATION

In the sparsely explored parts of this large mineral province, basic mineral exploration is still best done by searching for limonite zones, intrusives, alteration and other signs of mineralization by means of aircraft, and ground checking them by prospecting and reconnaissance geochemistry. In some cases, strong geochemical anomalies are found with no visible associated limonite, but transported limonite or rust-cemented overburden does occur with most of the significant deposits discovered to date.

Only a few of the limonite areas carry high zinc and copper values, but what comprises a significant geochemical anomaly in relation to transported limonites still remains to be determined by orientation surveys and exploration experience. If high lead values are also found in connection with a geochemical anomaly, then it is more apt to be of economic interest; a wider range of mineralization and variables, and a nearby source, are indicated. Soils in the Yukon tend to be immature in the glaciated areas and at higher elevations, so dispersion may be limited.

Once a promising area has been established by means of geochemistry and conventional prospecting and has been checked by detailed work, the character of any evident mineralization should be considered as to whether it is susceptible to discovery by airborne geophysical methods. However, because the surrounding rocks often give a higher response than the mineralization, the type of environment of the mineralization as well as its individual detectability should be determined before any widespread airborne survey is planned.

Preliminary reconnaissance should thus consist of conventional prospecting, geologic reconnaissance and geochemistry, followed by airborne methods such as magnetic and possibly electro-magnetic surveys where applicable. However, deposits such as Mt. Hundere as well as many others would not be susceptible to discovery by any indirect methods except geochemistry, and therefore airborne surveys would be useless except for geologic information.

Detailed follow-up work depends on whatever methods appear applicable to the type of mineralization indicated. The favourable geology and known deposits, the discovery dates, the increase in discovery rates in recent years, and the relationship of discovery locations to access and intensity of prospecting are all suggestive of further virgin prospecting. The exploration seasons are short and somewhat costly, but this region offers one of the best exploration potentials for base metals and associated minerals in Canada.

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Conference on Man in Cold Water

**McGill University,
Montreal, Que.,
May 12 and 13, 1969**

THE UNIQUE PROBLEMS and exciting economic opportunities provided by the cold and ice-covered waters to be found in and around Canada are to be explored in a two-day conference promoted by the Canadian marine, scientific, academic and manufacturing community.

Co-sponsored by McGill University and the Federal Department of Industry, Trade and Commerce,

the conference will be held at McGill University in Montreal on May 12 and 13. Canadians who are interested in or already participating in marine activities are welcome to attend.

Emphasis will be placed on manned under-water activities and the major subject areas to be featured are: exploration, development, and conservation of resources; transportation, communication and navigation; research in the life and physical sciences; new concepts in technology and techniques; and policy and organization for future underwater ac-

tivities and facilities in Canada.

A distinguished line of speakers, representing industry, government, academic and research organizations, will outline the myriad facets of Canada's environmental waters and the ice that locks them. Following each technical session, open forums will provide the audience with an opportunity for participation in stimulating discussion with a panel of assembled experts.

A banquet on the night of May 12 will be addressed by a government official on the subject of "Oceanology" in Canada.

O.D.M. Plans Geological Field Program for 1969

THE HONOURABLE ALLAN F. LAWRENCE, Ontario Minister of Mines, has announced that the Geological Branch of the Ontario Department of Mines expects to undertake twenty field projects in various parts of the province in 1969. Twelve of these projects will be in northwestern Ontario, thirteen in northeastern Ontario and four in southern Ontario. They will be led by twenty-six members of the department staff and by one additional qualified geologist who has been retained for the work. Ninety-seven graduate and undergraduate

students, most of them from Canadian universities, will be engaged as assistants. All field work in northwestern and northeastern Ontario is under the direction of DR. E. G. PYE, the Department's chief geologist; the four projects in southern Ontario are under the direction of DR. D. F. HEWITT, chief, industrial minerals section.

Among the projects to be undertaken is a helicopter-supported reconnaissance survey of 16,000 square miles in the Shabuskwiah — Fort Hope region of northwestern Ontario. Two other projects will have

partial helicopter support.

In addition to geological surveys, the Department plans to undertake geochemical sampling programs in the Maple Mountain and Jamieson township areas, and a detailed magnetometer survey in Godfrey and Turnbull townships near Timmins. The magnetometer survey will be essentially a control survey to permit the compilation of all available ground magnetic data, so as to produce a detailed vertical intensity isomagnetic contour map for correlation with the known geology.