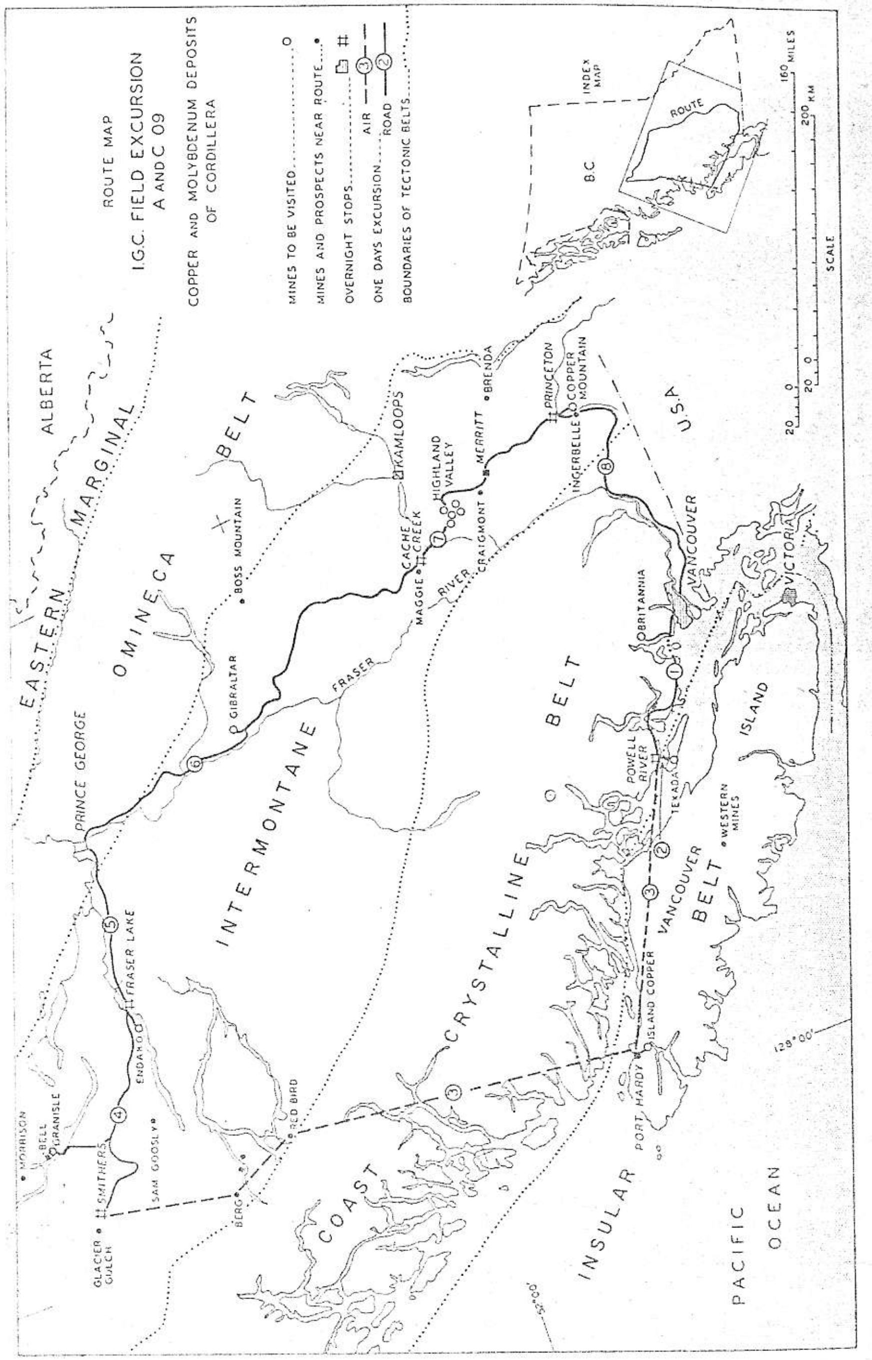

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XXIV INTERNATIONAL GEOLOGICAL CONGRESS
Montreal, Quebec
1972

Excursion A09 - C09

COPPER AND MOLYBDENUM DEPOSITS OF THE WESTERN CORDILLERA

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pegmatitic dykes are common as is a spatial relationship between faults and ore. Mineralization is confined to regular vein sets, and alteration is slight except in envelopes to veins [Endako, Brenda]. Gibraltar is difficult to classify because it occurs in regionally metamorphosed intrusions, but it may belong to this subclass.

Porphyry deposits of the diorite-syenite clan mostly belong to the complex subclass. They differ from calc-alkaline deposits by having virtually no associated molybdenum or tungsten, by having fracture stockworks free of quartz, by particularly strong potassic alteration leading to fenitization of included or adjacent volcanic rocks, by breccia fillings characterized by coarse biotite rather than quartz or tourmaline. The one example on our excursion is Copper Mountain.

D. *Route*

The excursion will start on Day 1 at the University of British Columbia and proceed by bus through Vancouver and up the scenic fiord of Howe Sound to visit the Britannia mine. Following this we will retrace our route to Horseshoe Bay, take the ferry across the Sound to Langdale, and drive along the Sunshine Coast to a second ferry across Jervis Inlet to Powell River. On Day 2 we will take another ferry to Texada Island and visit the Texada mine at Gillies Bay, returning to Powell River in the evening. On Day 3 we will proceed by air to Port Hardy and visit the nearby Island Copper mine, and then fly north obliquely across the spectacular Coast Mountains, viewing en route the Red Bird and Berg prospects from the air. We will spend the night at the attractive town of Smithers which in recent years has been the centre for mineral exploration in central British Columbia. Day 4, we will drive by bus east from the mountains to Topley then north to Babine Lake where we will visit the Granisle mine, returning to Topley then eastward again to Fraser Lake to stop for the night. Day 5, we will visit the Endako mine and then travel east to the minimetropolis of Prince George for the night. Day 6, we will drive south down the Fraser River to McLeese Lake, visit the Gibraltar mine, and then continue south across the Interior Plateau to stay at Cache Creek, a main highway junction in semi-arid surroundings. Day 7, we will drive from the arid valley of the Thompson River up to the wooded Highland Valley and there visit several of the five mines — Alwin, Bethlehem, Valley Copper, Lornex, and Highmont. We then drive south through the rolling upland cattle country past the Craigmont mine to stay at Princeton. Day 8 we will visit Copper Mountain, the first porphyry deposit to be mined in British Columbia. We will then continue through Manning Park in the northern Cascade Mountains to the town of Hope at the south end of Fraser Canyon, then across the Fraser Delta to Vancouver.

III. GEOLOGY OF THE DEPOSITS

DAY 1

BRITANNIA — By A. Sutherland Brown

LOCATION — Lat. 49° 36.6′ — Long. 123° 08.5′ — Britannia Beach, on east side of Howe Sound, 64 km by road north of Vancouver.

OWNERSHIP — Anaconda American Brass Limited.

Britannia is a massive sulphide deposit which has a record of nearly continuous production since 1905. In that time well over a billion pounds of copper and over a quarter of a billion pounds of zinc have been produced, making it the most productive copper mine in British Columbia. Current production is about 600,000 tons per year with a grade of copper about 1.35 per cent and zinc about 0.06 per cent containing significant gold, silver, and cadmium.

In spite of the long period of production and geological study, many features are subject to other interpretations than the one presented here.

Regional Setting

The Britannia mine occurs in a pendant of mainly volcanic rocks intruded by several plutons of the Coast Plutonic Complex (*see* Fig. 1). The stratified sequence (Gambier Group) is dominated by pyroclastic rocks of andesitic to dacitic character which are intercalated near the top and overlain by dark marine shales and silstones. A separate but lithologically similar pendant 10 km south of Britannia contains Albian ammonites. Potassium-argon analysis on the Squamish Batholith that intrudes the Britannia pendant on the north gives an apparent age 92± 4 million years. Formation of the ore deposits and later intrusion of a dacite dyke swarm predate the intrusion of this pluton. The volcanic pile north of the Britannia mine is tilted southward about 20° as a monoclinal panel. This monocline is tran-

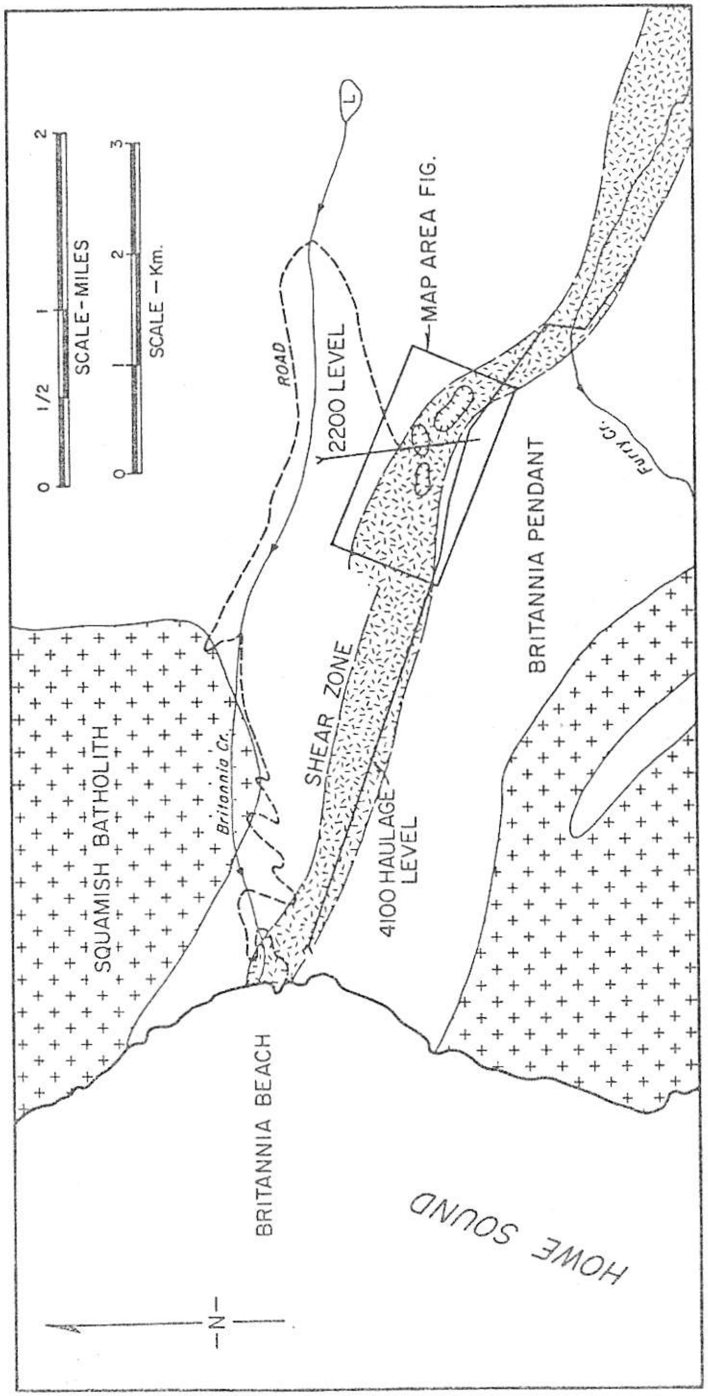


Fig. 1. Geological Setting of Britannia Mine.

sected to the south by a northwesterly trending belt of intense deformation, 400 to 800 metres wide, that has been called the Britannia Shear Zone. The orebodies of the Britannia mine occur within this deformed belt. Ten major orebodies of varying size extend along this lineal belt for 4 km. They are developed by an extensive system of access workings with a main haulage level (4100) extending eastward from a portal near Britannia Beach (*see* Fig. 1). The most recently developed orebody (040) is the closest to the portal, about 2.5 km.

Local Geology

Stratigraphy

The geology of a central part of the shear zone in which most of the orebodies outcrop is shown on Figure 2. The stratified sequence consists of a pyroclastic unit overlain after a zone of interfingering and intercalation by a shale-siltstone unit.

The apparent local stratigraphic section is:

	Metres	Feet
Top		
Black argillite, siltstone, etc.	150±	500±
Intercalated grey and green argillite	0 - 15	0 - 50
Mixed crystal tuff and black argillite	3 - 7.5	10 - 25
Plagioclase crystal tuff	7.5 - 15	25 - 50
Dacitic pyroclastic flows with minor argillitic interbeds	120+	400+
Base		

The dacitic pyroclastic rocks are composed dominantly of lapilli-sized clasts, most of which are charged with chalky white plagioclase phenocrysts. They are light green compact rocks with a primary foliation imparted by many wispy or lenticular clasts. They are intercalated with plagioclase crystal tuffs, especially toward the top where these intergrade with green and black argillite beds to form a distinctive marker assemblage. Most characteristic of this assemblage are interbedded crystal tuff and black argillite that may be regularly bedded, convoluted, or disaggregated by soft rock deformation.

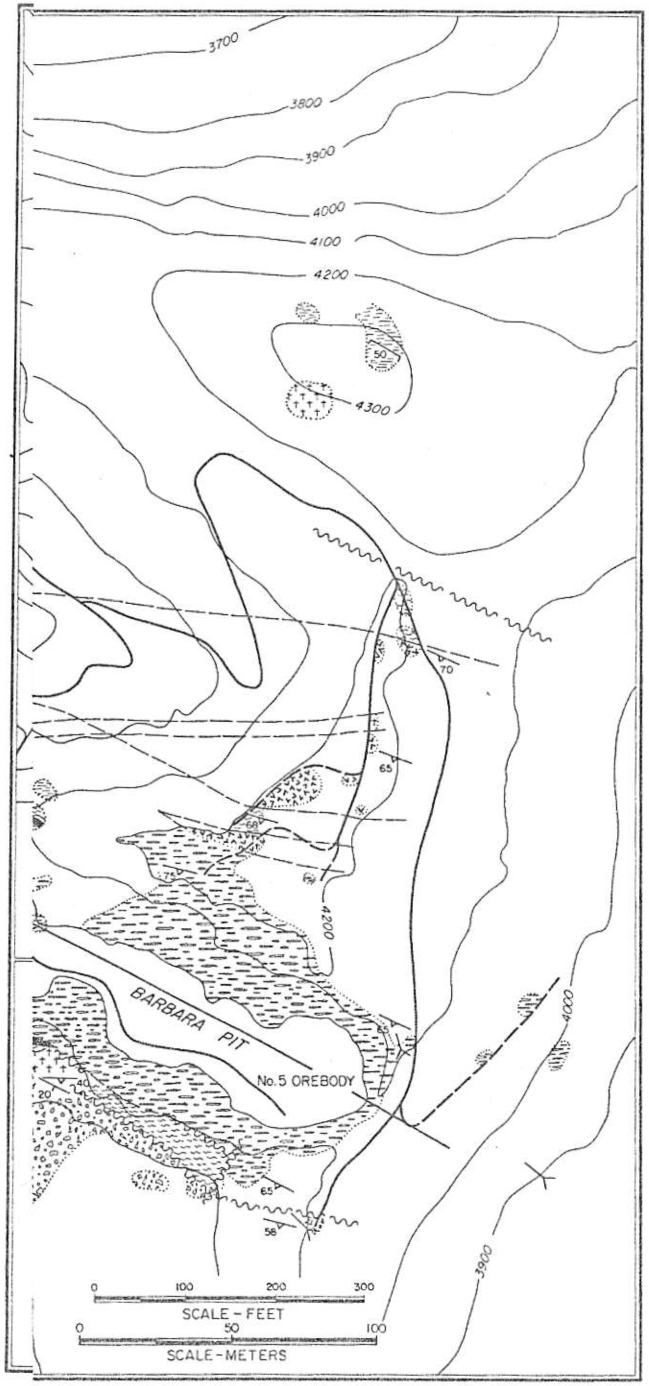
Overlying the marker beds is a sequence of black argillite and siltstone with minor intercalations of dark to light-coloured greywacke and minor tuff. The black argillite and siltstone are relatively featureless, poorly bedded, but commonly cleaved. Intercalations of greywacke may show graded bedding, shale sharpstones, and minor slump structures.

Intruding the stratified sequence are two major dyke sequences and a group of small late basic dykes. The early dyke intrusions are composed of dark grey-green andesites that commonly have a slightly mottled texture that reflects a fragmental nature. They may also contain abundant quartz and chlorite amygdules. The andesite bodies have complex field relationships, some are intrusive thin lineal dykes whereas others form large wedge-shaped bodies of ambiguous relations. Even though formed of fragmental andesites some seemingly are intrusive whereas others may be local pyroclastic flow domes. The second group of dykes are porphyritic dacites that are massive grey-green rocks with about 15 per cent plagioclase phenocrysts 1 to 2 mm long. Some have a flow-foliation indicated by fluxion arrangement of phenocrysts and small inclusions, and uneven distribution of phenocrysts. Some are only microporphyritic but in general they have a characteristic appearance and texture. Small late dykes are common but volumetrically insignificant and include lamprophyre, basalt, and andesite.

Structure

As mentioned, the strata of the Britannia pendant north of the Shear Zone are tilted southward about 20° in a gently warped monoclinal panel. This uniform dip is abruptly transformed at the Britannia Shear Zone where these rocks are highly deformed in a fault-bounded anticline and subsidiary syncline within the map-area (*see* Fig. 2). The anticlinal nose is quite clearly shown on the west slope of Jane Basin where it plunges westward at 22°. The marker beds of crystal tuff and argillite can be traced around the nose and on either limb beyond the marginal faults. Within the shear zone the rocks are transformed into schists which can only be correlated with the rocks outside with difficulty and with the aid of the marker beds. The crystal-rich dacitic pyroclastic rocks are metamorphosed to chlorite-mottled schists virtually devoid of feldspar crystals. The argillites are commonly changed to sericite schists and the andesites in varying degree to chlorite schists. The porphyritic dacite dykes, however, remain massive, so it is concluded that they were emplaced late in the deformation process.

Within the Shear Zone bedding can rarely be identified, however, near the southern margin minor folds in green schistose argillites that appear to be equivalent to those of



Copper Beach Estates — 4 wheel drive vehicles Morris Neill 896-2221 representative on site Coopers & Lybrand Price Waterhouse Coopers — receiver

ywacke may show graded or slump structures.

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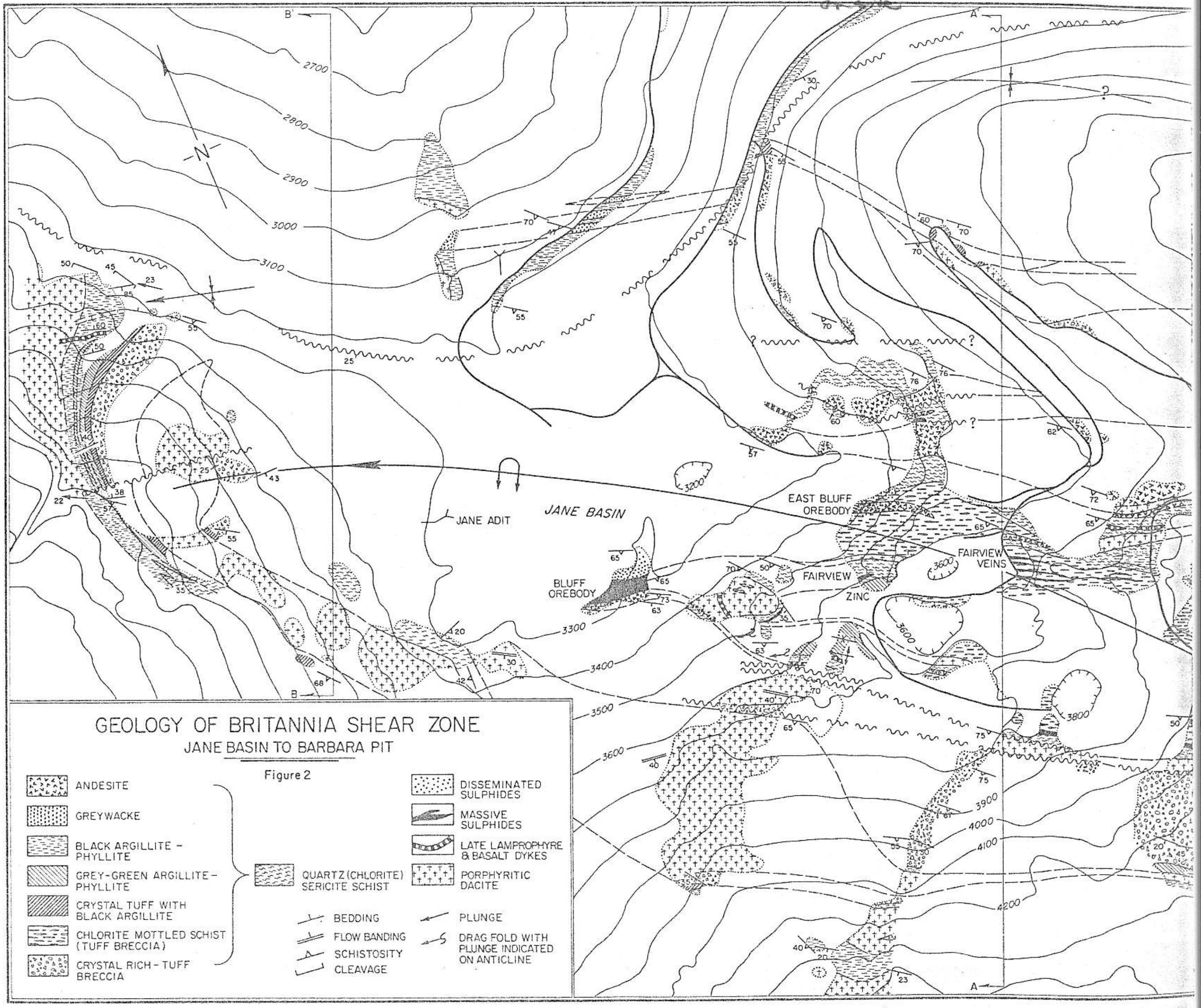
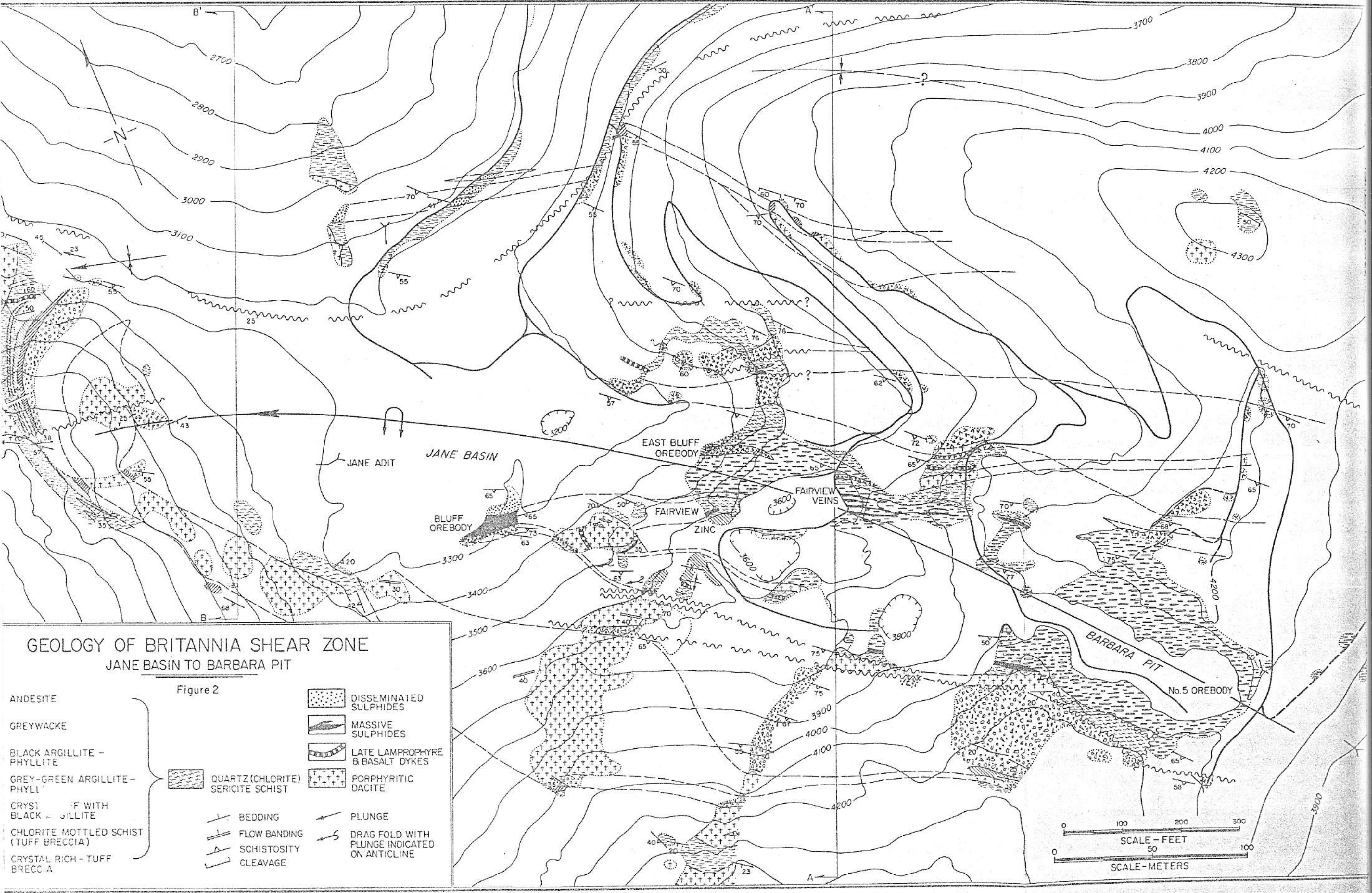


GEOLOGY OF BRITANNIA SHEAR ZONE

JANE BASIN TO BARBARA PIT

Figure 2



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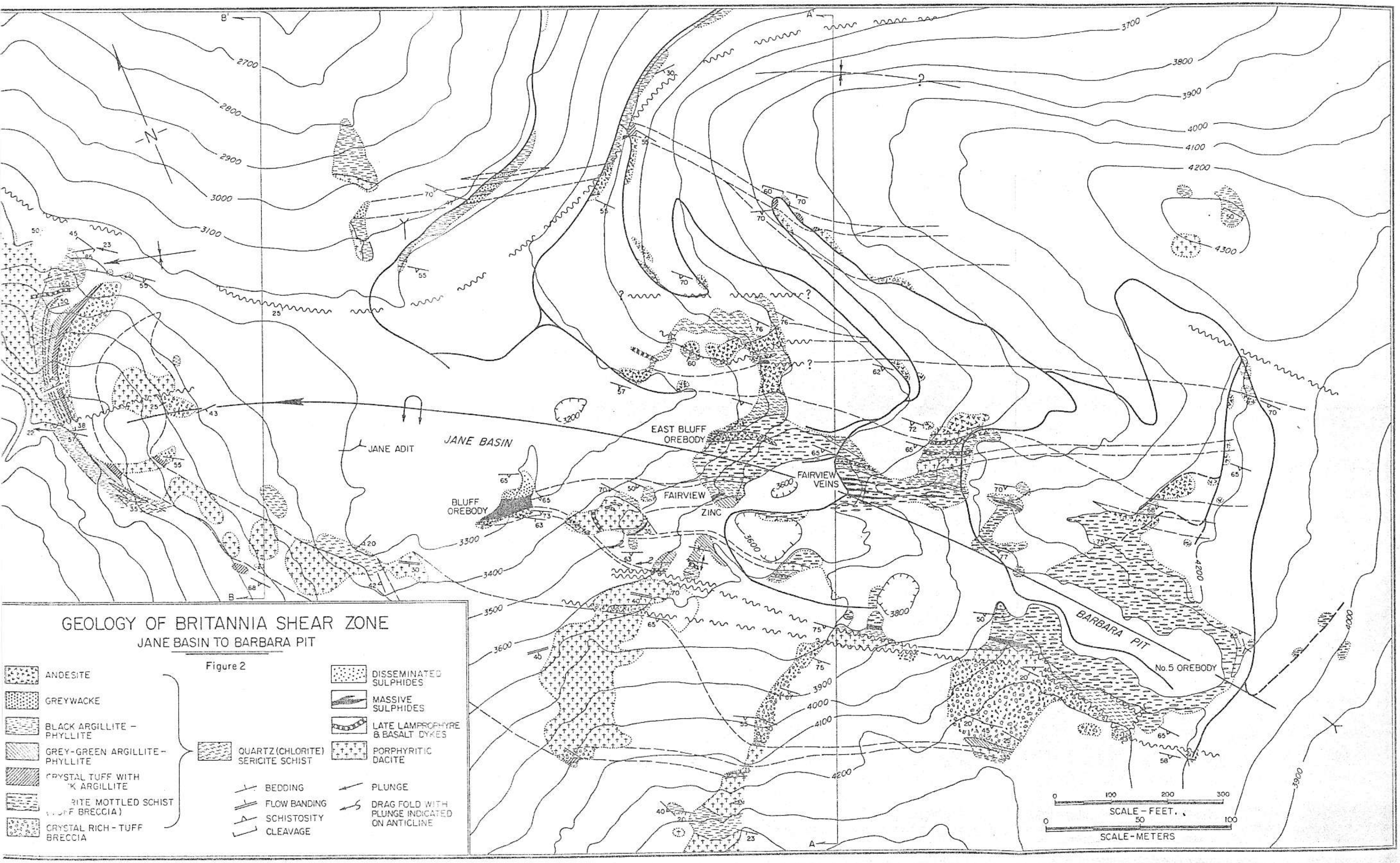

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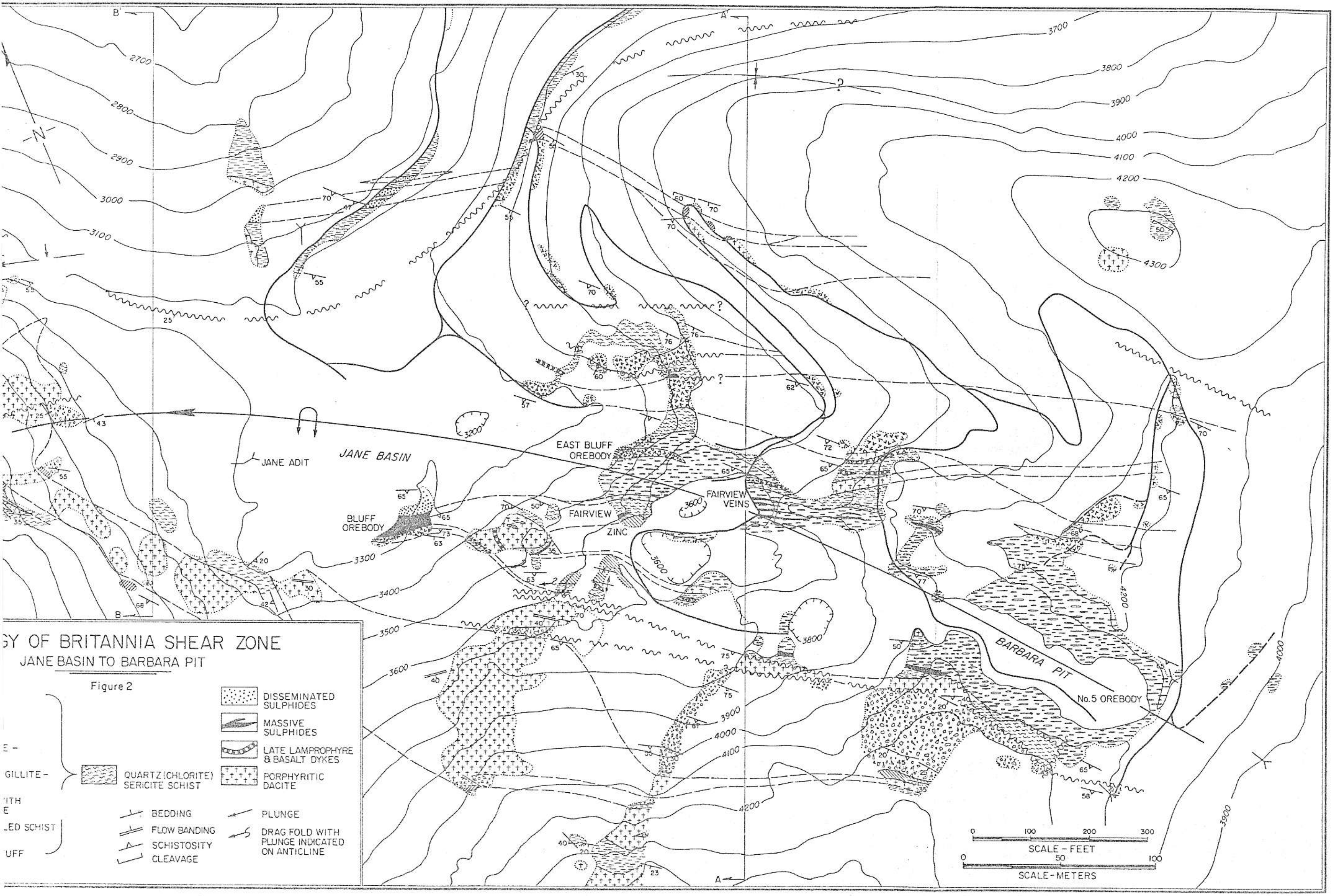

GY OF BRITANNIA SHEAR ZONE

JANE BASIN TO BARBARA PIT

Figure 2

the marker sequence, show that the anticlinal hinge lies to the north. It cannot however be identified in the schistose core of most of the area despite the fact the marker beds can be traced across the west slopes of the basin. A faulted portion of the subsidiary syncline is evident also on these slopes.

The bounding faults of the Shear Zone do not appear to be continuous throughgoing faults but rather an *en echelon* sequence. This is suggested underground and can be inferred from the map (Fig. 2). The hangingwall fault(s) dip southward at about 70°. Faults exposed near the footwall of the Shear Zone dip from 60° to vertical.

Metamorphism and Alteration

All the rocks except the late basic dykes have been subjected to a low grade of regional dynamothermal metamorphism of greenschist facies. The rocks within the Shear Zone have in addition been subjected to intense dynamic metamorphism involving granulation, flattening, and recrystallization. Superimposed on this is a more local intense hydrothermal metamorphism.

Surrounding the sulphide orebodies the host rocks, commonly chlorite-mottled schist or andesitic schist, are affected by an outward-grading alteration. Around and between the massive sulphide lenses remnant rocks are composed almost entirely of quartz, pyrite, muscovite, and minor chlorite, with textures indicative of the original chlorite-mottled schist, etc. Outward from the sulphide bodies the intensity of the silicification decreases gradationally and its mode changes from complete replacement to ramifying fine veinlets within 300 metres or less. In a parallel way pyrite also decreases but muscovite-sericite, chlorite, and clinozoisite increase to proportions characteristic of the Shear Zone remote from sulphide bodies. Anhydrite, gypsum, and erratically distributed barite are found in discrete veins and disseminations in a zone roughly coincident with that of intense silicification.

Sulphide Mineralization

The sulphide orebodies of Britannia are highly heterogeneous mixtures of sulphides, remnant altered host rocks, and discrete veins. The parts that are predominantly sulphides have a charactertistic braided appearance that results from the juxtaposition of lenticles of varying mineralogy separated by schistose mica bands and intersected by discrete quartz-sulphide and sulphide veins.

The main mineralogy of orebodies is simple and fairly constant. Pyrite is by far the most abundant mineral with less chalcopyrite and sphalerite and minor erratically distributed galena, tennantite, or tetrahedrite. The main nonmetallic minerals include quartz and muscovite (chlorite)?, anhydrite, and siderite.

The main massive orebodies called Bluff, East Bluff, No. 5, No. 8, and 040, all show a marked zonal structure (see Figs. 3 and 4) in which one or more high-grade chalcopyrite cores are enveloped successively by a lower grade zone and overlapping pyrite and siliceous zones. The plan of the 040 orebody on 4950-level shows this well, although it is less regular than some of the other orebodies. Zinc-rich ore tends to occur in the upper central parts of massive bodies and as almost separate sheet-like masses like the Fairview zinc-vein. In section the main orebodies have a crude lens shape oriented within the schistosity and are commonly connected to a steeply plunging root which may or may not be of ore grade (*see* Fig. 3). The long dimension of the Bluff ore lenses plunge about 45° to the west. The plunge increases in the western and eastern orebodies. It is of interest that although the individual orebodies plunge steeper than the crest of the anticlinal structure, the overall top of the ore zone plunges about the same as the latter and is crudely coincident with the base of the argillite sequence.

The other orebodies such as the Fairview, Empress, and Victoria are stringer lodes and veins composed of thin sheet-like masses of chalcopyrite and pyrite with some quartz that appear generally parallel with the schistosity but actually, in plan, cut across the schistosity at a small angle. The tops of these orebodies are eroded so that one can only guess whether they too might have had an upper limit at the argillites.

Some of the grey-green argillites within the Shear Zone and above the massive orebodies contain significant quantities of pyrite with traces of chalcopyrite. Sulphide-rich layers are intercalated with the phyllitic argillites and may also occur as laminae that are in effect composed chiefly of nodules of almost solid pyrite that may resemble sharpstones, or in some cases worm-tubes. The sulphide nodules normally have an incomplete zone of quartz near their outer rim. Planes of schistosity and fracture in the argillite may also be coated with fine pyrite.

In summary, the Britannia massive sulphide deposit has similarities to the siliceous, pyritic, replacement and stockwork (keiko) ore of the Kuroko deposits of Japan.

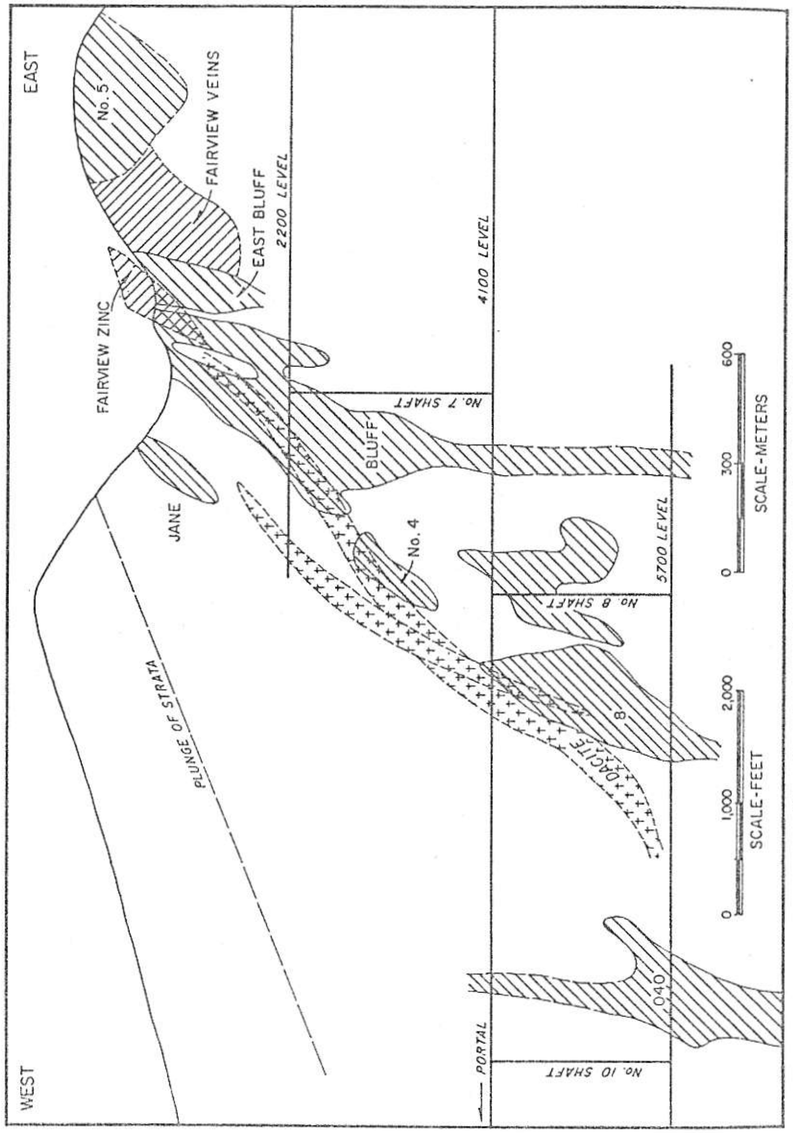

Fig. 3. Longitudinal Section Britannia Mine.

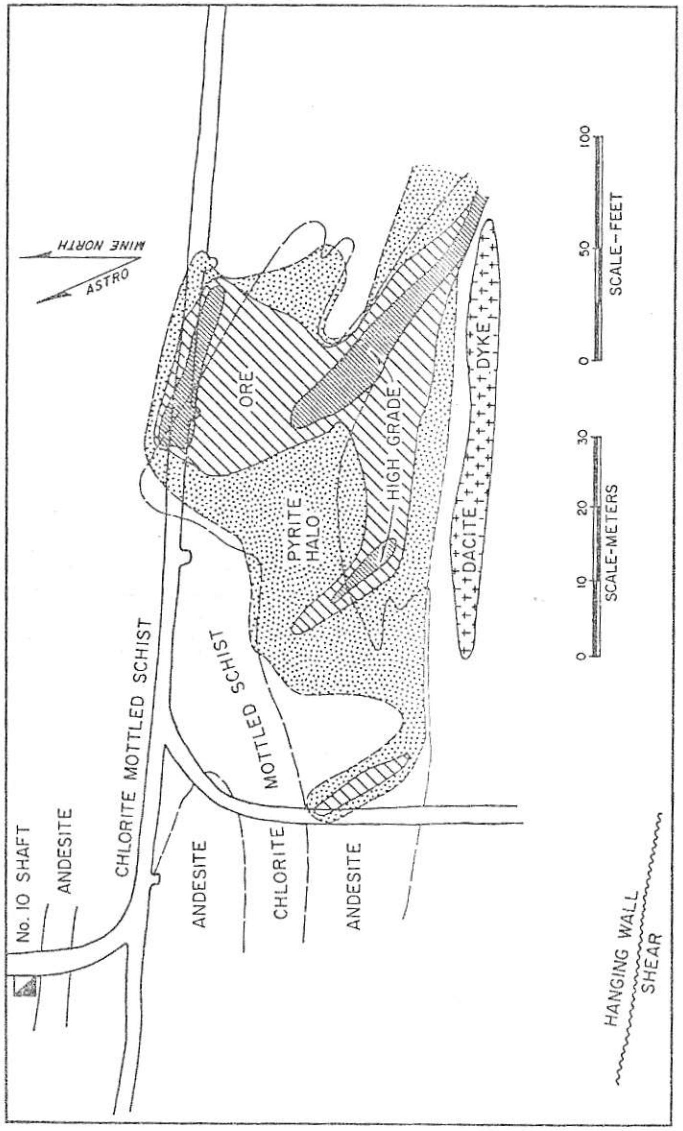

Fig. 4. Plan of 040 Orebody, 4950 level, Britannia Mine.

DAY 2

TEXADA: By A. Sutherland Brown.

LOCATION: Lat. 49° 43′ — Long. 124° 34′ — Gillies Bay on the west coast of Texada Island.

OWNERSHIP: Texada Mines Ltd. (a subsidiary of Kaiser Aluminum & Chemical Corp.).

Texada is a copper-iron skarn deposit typical in most respects of the class as developed in the Insular Belt. It has the longest history of production of this group of deposits with very minor production at intervals from 1885 and steady production since 1952. From this year to the end of 1970, 16.5 million tons have been mined yielding approximately 8.8 million tons of iron concentrate grading about 65 per cent iron with 16,500 tons of copper, 20,000 ounces of gold, and 450,000 ounces of silver.

Production from 1952 until 1964 was from four separate open pits (*see* Fig. 5) and since then entirely from underground. Originally access underground was by a shaft and four main levels at 200-foot (61 metres) intervals shown on Figure 7, but trackless mining now utilizes surface trucks with a new system of inclined large diameter tunnels.

Regional Setting

Texada Island, although close to the mainland coast, is formed of the typical Insular Belt stratigraphy, hence is underlain mostly by the very thick Triassic oceanic basalt (Karmutsen Formation, 4,500 metres). This is overlain by a massive Upper Triassic limestone (Quatsino Formation, 600 metres) which outcrops in a belt extending from the Texada mine northward to the northeast point of the island. A number of small plutons have intruded the stratified section. One emplaced at the southern termination of the limestone belt (Gillies stock) is mainly responsible for both the structure and metasomatism of the basalt and limestone, near their common boundaries. It has a potassium-argon age of 120 million years (Lower Cretaceous).

The stratified rocks of Texada Island generally occur in tilted panels or gentle folds cut by block faults. The limestone belt appears to be synclinal with some minor sharp folds near intrusive plutons and faults.

Local Geology

The Karmutsen basalts of northwestern Texada Island are well pillowed but in the vicinity of the Gillies stock are

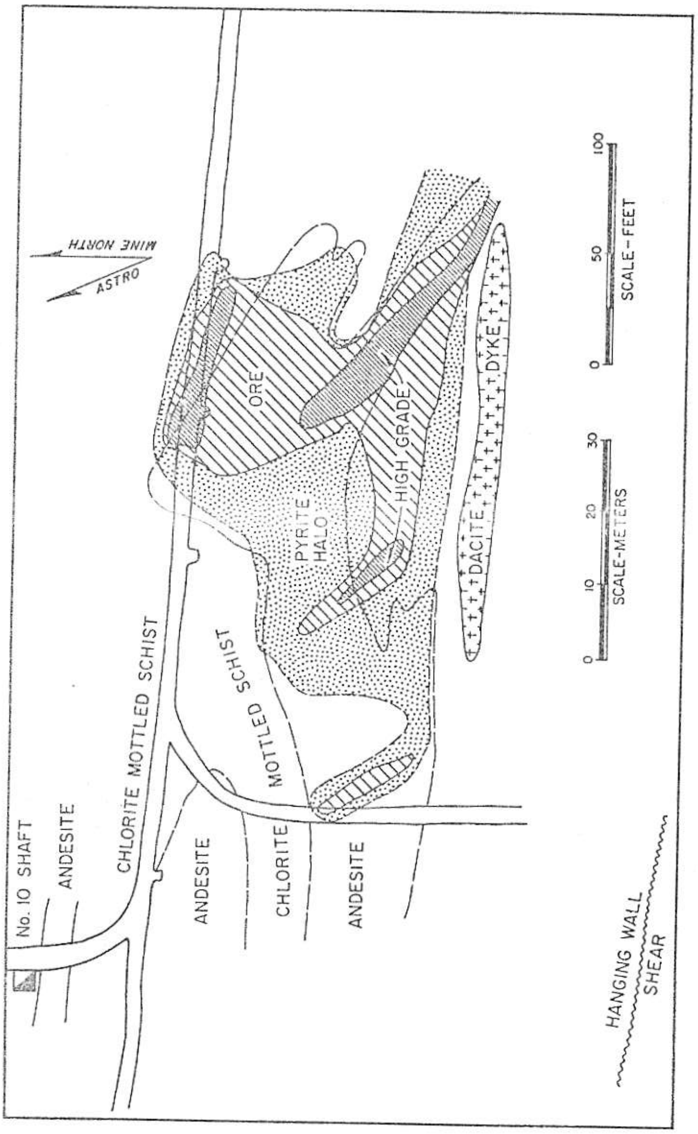

Fig. 4. Plan of 040 Orebody, 4950 level, Britannia Mine.

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