STRATIGRAPHY AND STRUCTURE IN THE ANYOX AREA (103P/5)

By D. J. Alldrick

INTRODUCTION

This report summarizes preliminary results of a mapping project in sedimentary strata of the Anyox pendant between May 27 and June 6, 1985. The objectives of the program are to:

(1) Study the sedimentary section for marker horizons that may outline present structure and for facies relationships that may indicate paleotopography in the underlying volcanic rocks.
(2) Compare the sulphide-bearing ore horizon chert to strata-bound, sulphide-bearing 'quartz veins' reported within the sedimentary strata.
(3) Sample chert and carbonate sedimentary rocks for fossil studies.

OTHER RESEARCH

The most recent report on the Anyox area is also the most comprehensive. R. J. Sharp completed a Master's thesis at the University of Alberta, Edmonton, in 1980. The research focused on three of the deposits in the area but the thesis also presents a major review of the regional geology and an extensive bibliography.

D. G. MacIntyre (this volume) compared petrochemistry of several Triassic volcanic sequences in the Insular Tectonic Belt. F. V. Kirkham, at the Geological Survey of Canada, is compiling lead isotope data for volcanogenic massive sulphide deposits throughout Canada. Both these studies include data or samples provided from Sharp's work.

STRATIGRAPHY

Schematic stratigraphic columns are illustrated on Figure 29-2, which also shows the stratigraphic position of five major mineral deposits.

VOLCANIC SEQUENCE

Sharp (1980) describes lithologies within the volcanic sequence as predominantly pillowed tholeiitic basaltic flows with subordinate fragmental and tuffaceous layers. The fragmental strata may include tectonic, explosion, pillow, flow top and fault scarp breccias, and volcaniclastic conglomerates. Tuffaceous strata are preserved as chloritic schists. Pelitic rocks are locally interbedded; these form the host rock strata at the Double Ed deposit.

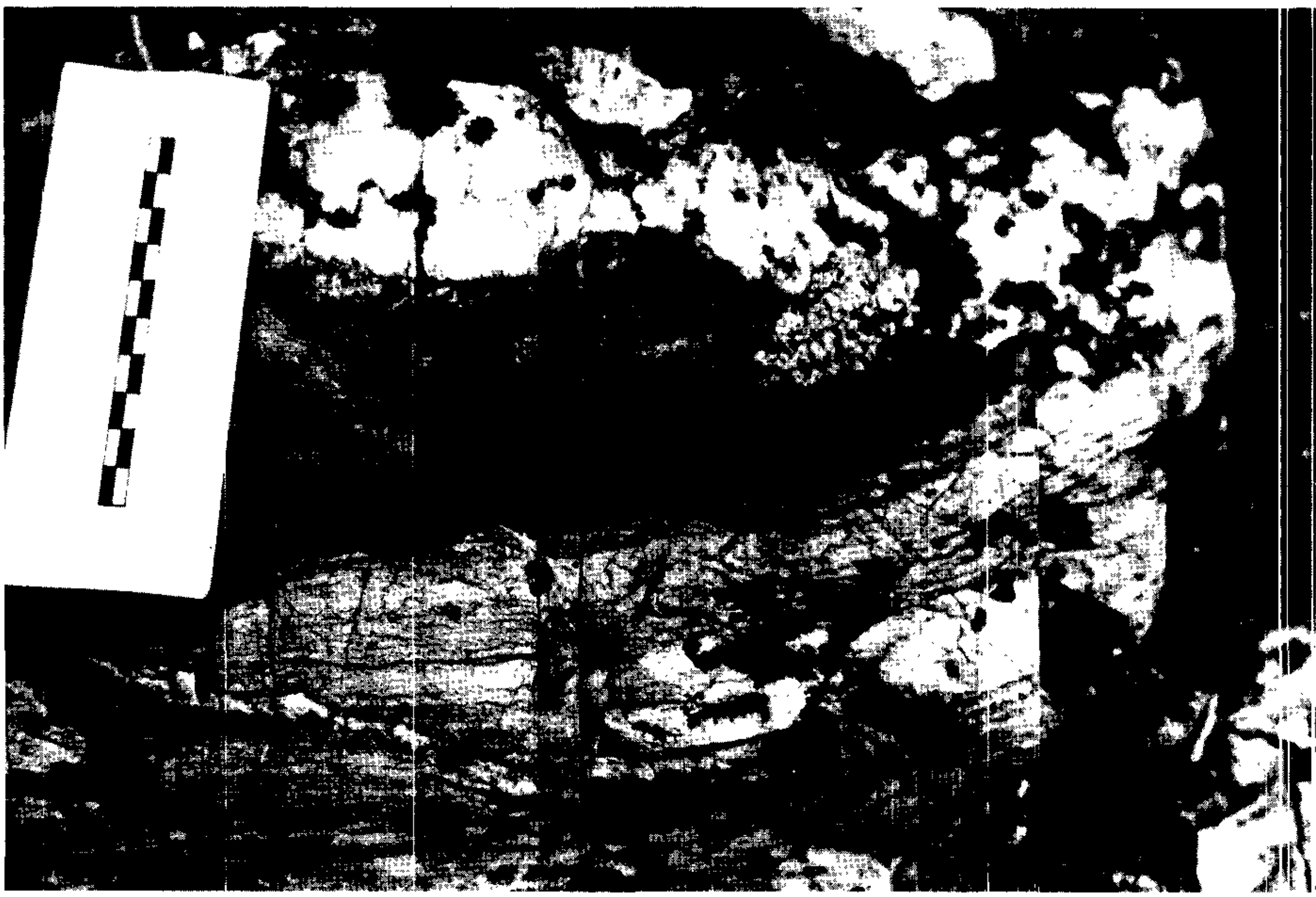
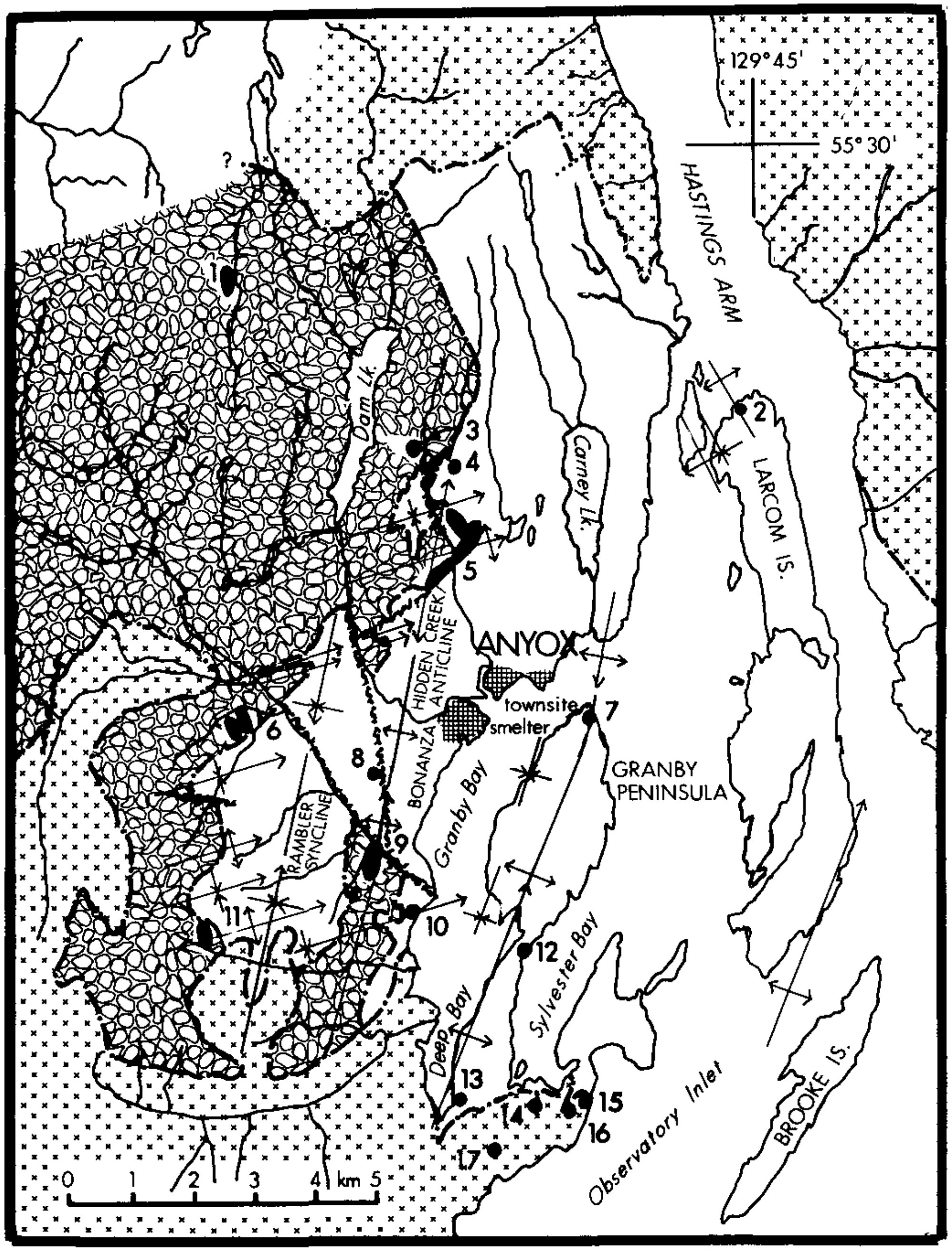


Plate 29-1. Bull quartz vein and foliated chert, 1.5 kilometres southwest of Hidden Creek mine. Scale bar 10 centimetres.

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1985, Paper 1986-1.



LEGEND

COAST RANGE BATHOLITH

SEDIMENTARY SEQUENCE

PILLOW BASALTS SEQUENCE

SYMBOLS

MINERAL OCCURRENCES		COMMODITIES	MINFILE NUMBERS
1	EDEN	Cu, Zn	103P-026
2	LARCOM ISLAND QUARTZ	Si	103P-227
3	DEADWOOD QUARTZ	Si	103P-243
4	QUARTZ	Si	
5	HIDDEN CREEK MINE	Cu, Zn, Pb, Co	103P-021
6	DOUBLE ED	Cu, Zn	103P-025
7	GRANBY POINT QUARTZ	Si, Au	103P-022
8	RAMBLER QUARTZ	Si	103P-226
9	BONANZA MINE	Cu, Zn, Pb	103P-023
10	BLACK BEAR	Si	
11	REDWING	Cu, Zn, Pb	103P-024
12	GOLDLEAF	Au, Si	103P-028
13	GOLSKEISH	Si, Au	103P-027
14	MOLLY MAY — WEST ZONE	Mo	103P-228
15	MOLLY MACK	Mo	103P-228
16	MOLLY MAY — EAST ZONE	Mo	103P-228
17	MOLLY MAY — SOUTH ZONE	Mo	103P-228

Figure 29-1. Geology of the eastern Anyox pendant (with compilation from Sharp, 1980 and Grove, 1983).

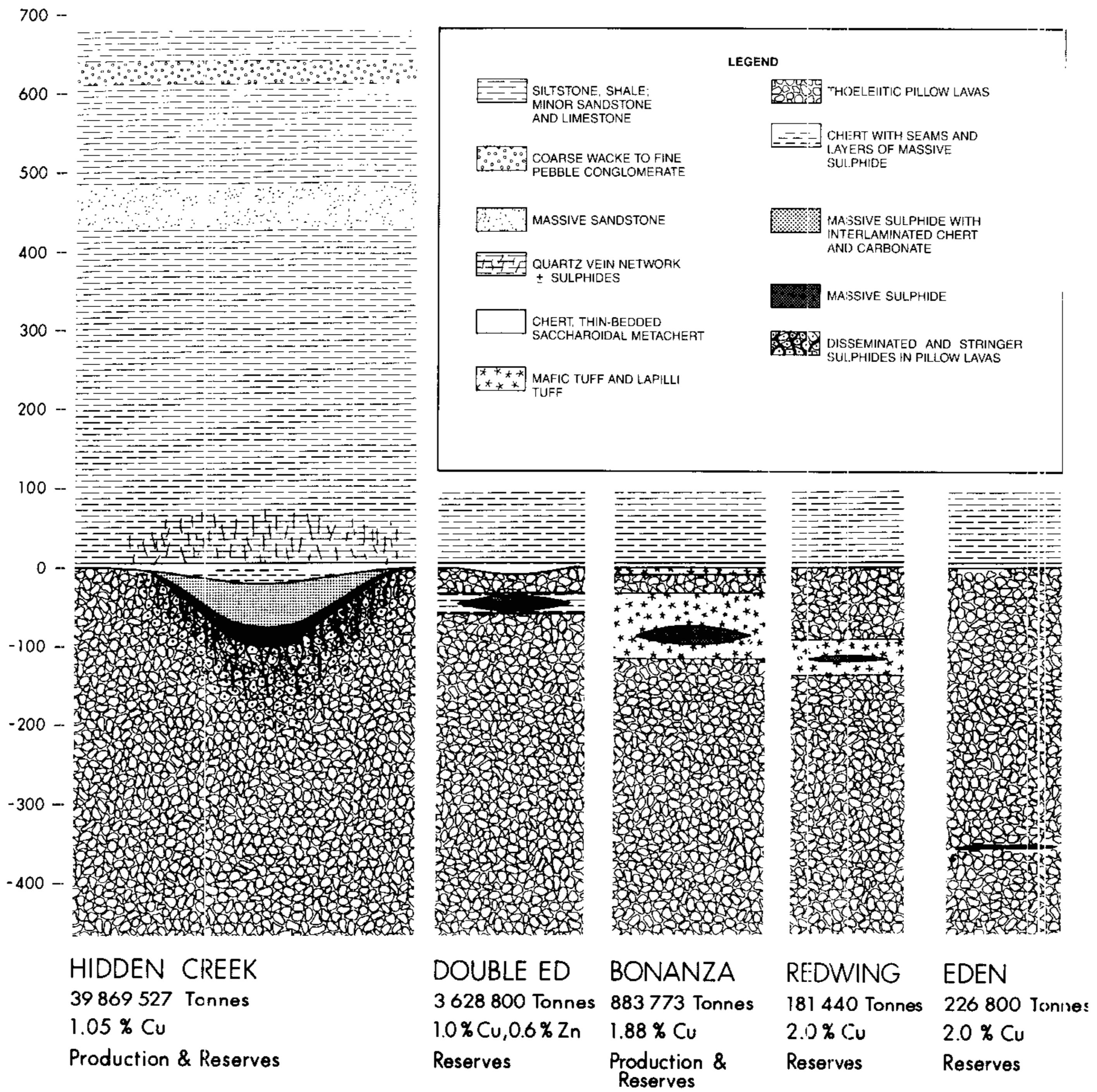


Figure 29-2. Schematic stratigraphic columns through five deposits (including compilation from Sharp, 1980).

ORE HORIZON CHERT

Chert is preserved as thin to thick-bedded, foliated, saccharoidal quartzite. The rock varies in colour from ivory to light grey depending on the amount of included tuffaceous material. Chert crops out along the volcanic-sedimentary contact throughout the Anyox pendant, although Sharp (1980) reports it is locally discontinuous. The chert may be interbedded with tuffaceous layers and the unit varies in thickness from a few tens of centimetres to over 1 metre. An abnormal thickness of chert is exposed in two areas; overlying the Double Ed deposit where the cherty strata thickens to 3 metres, and overlying and within the Hidden Creek deposit where the chert averages 30 metres in thickness and reaches 75 metres in one location where it is interlayered with massive sulphides and tuff (Sharp, 1980).

Chert is readily distinguished from massive, white bull quartz veins by its saccharoidal texture, prominent foliation, and pale grey to ivory colour (Plate 29-1). Further, chert is commonly interbedded with mafic tuffs and clastic sedimentary rocks.

SEDIMENTARY SEQUENCE

The hangingwall sedimentary strata comprise a flysch sequence of fine-grained, thin to medium-bedded shales and siltstones with minor carbonate and coarse clastic units. The formation is at least 700 metres thick. Its eastern limits were not examined in the study but no chert beds were identified within this sequence and no distinctive marker units were noted in the lower part of the formation.

Sharp (1980) documented thin, interbedded carbonaceous phyllite to graphitic schist layers in the basal 300 metres of the sedimentary sequence; he reports that discontinuous exposures of this rock type extend from the Hidden Creek mine to the Bonanza mine. Several thin, dark grey to black limestone beds are preserved within the immediate hangingwall of the ore deposits. Higher in the sedimentary sequence there are dark grey to black, thin-bedded to massive limestone beds, limestone lenses and nodules within grit beds, and calcite-cemented sandstones and grits. No macrofossils have been found in the Anyox pendant.

A thick section of massive sandstone beds exposed along the west shoreline of Granby Peninsula may correlate with a similar exposure reported by Bancroft (1918) east of Carney Lake. Coarse grits to fine pebble conglomerates crop out on the southwest end of Larcom Island and on the southeast end of Doben Island.

Sedimentary structures are well exposed in these strata. Graded beds are abundant; rounded, symmetric ripple marks were noted in two exposures; truncated crossbeds are well preserved in the pebble conglomerates at the southwest end of Larcom Island. Crossbed orientations indicate an eastward source for the clastic material.

The features of this flysch sequence suggest a deep water, reducing environment in which clastic sedimentation rates greatly exceeded those of chemical carbonate deposition. We found no diagnostic evidence to establish the tectonic setting.

STRUCTURE

There are numerous exposures of small-scale folds and axial plane cleavage in the sedimentary sequence and the ore horizon cherts, the volcanic sequence shows little evidence of deformation. Figure 29-1 illustrates the interpreted overall structure; the field data are plotted on a 1:25 000-scale topographic base map which is available for reference by contacting the author. Field evidence indicates two phases of deformation: a major F_1 event produced large-scale, north-northeast-trending open folds with steep west-dipping axial surfaces (Fig. 29-3); a later F_2 fold event produced smaller scale east-northeast-trending tight folds with near-vertical axial surfaces and local axial planar cleavage.

Phase 1 fold structures include the Rambler syncline and the Hidden Creek-Bonanza anticline (Figs. 29-1 and 29-3). The western anticlinal limb is flat to gently westward dipping; the eastern limb is vertical to steeply eastward dipping. This pattern also holds for other phase 1 anticlines. These early major folds have undulating fold axes, so the Rambler syncline, for example, is canoe shaped in longitudinal section. The Hidden Creek-Bonanza anticline is a saddle-shaped structure between the two orebodies, but forms a doubly plunging anticlinal dome at Hidden Creek mine.

Since limbs of early folds are either near-horizontal or near-vertical, they have been selectively eroded by recent glaciation. The flat-lying limbs, which are more resistant, underlie at least two major topographic features — Granby Peninsula and the ridge east of Rogers Creek, and Larcom Island.

Phase 2 folds are most easily recognized along the volcanic-sedimentary contact, and along the west side of Larcom Island (Fig. 29-1). These folds are tight with near-vertical, east-northeast-trending axial planar cleavage, and gently east-northeast-plunging axes. Topography and selective erosion have combined to influence the outcrop pattern of the contact trace so that some of these folds appear to be isoclinal (Fig. 29-1).

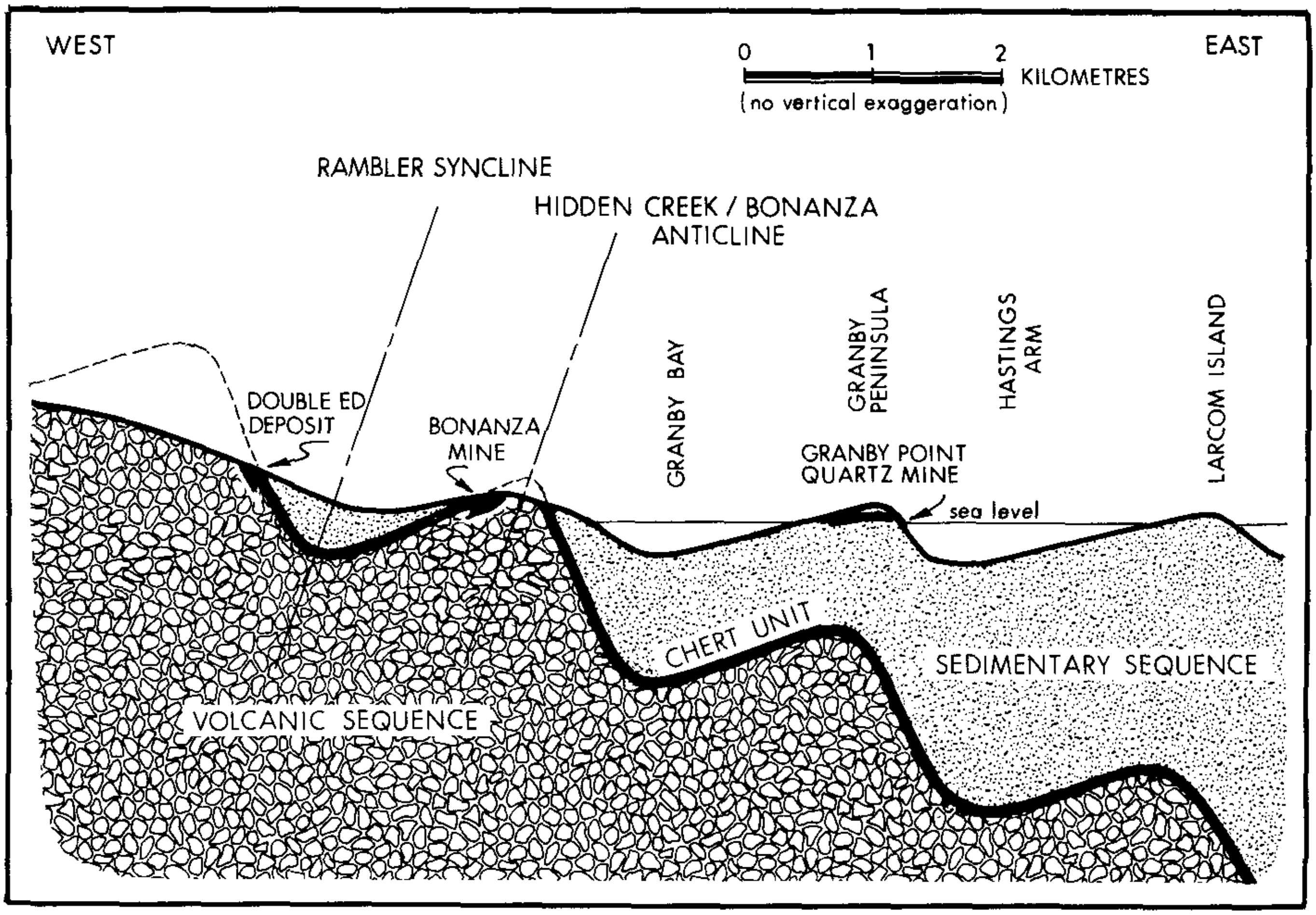


Figure 29-3. Schematic east-west cross-section in the southeastern Anyox pendant.

Interference patterns between intersecting F_1 and F_2 minor folds have produced complex, undulating fold noses and troughs at outcrop scale that resemble sheath folds of more intensely deformed terranes.

METAMORPHISM

The metamorphic grade of the Anyox pendant is, at most, lower greenschist facies. Much of the chloritic alteration in the pillow volcanics is attributed to ore-forming, hydrothermal processes. The sedimentary sequence is essentially unmetamorphosed since it has not undergone sufficient recrystallization to produce 'argillite' (Potter, *et al.*, 1980, p. 91). Primary hornblende occurs in porphyritic mafic dykes, sills, and flows that are scattered within the volcanic sequence; these were noted as evidence of amphibolite facies metamorphism by early workers.

QUARTZ VEINS

Sharp (1980, p. 31) recognized two distinct styles of quartz veining; both types were examined in this study and are as follows:

Type 1: Massive white bull quartz veins up to 5 metres wide are emplaced along bedding planes or along fractures within the sedimentary sequence. These veins may host patchy or disseminated base metal sulphides and recoverable gold (for example, Golskeish, Rambler, and Granby Point).

Type 2: Quartz vein networks or swarms are localized in basal sedimentary strata near fold axes. Silica in the vein networks was likely remobilized during deformation and recrystallization of the chert unit. Where fold axes coincide with sulphide deposits, the quartz vein networks host disseminated pyrite, pyrrhotite, and base metal sulphides, thus these vein swarms may be proximal hangingwall indicators of ore.

Type 1 veins occur in three settings: (i) along bedding planes throughout the sedimentary strata (Granby Point quartz quarry), (ii) in fractures parallel to the axial planar cleavage of F_2 folds within the hangingwall sedimentary rocks adjacent to the chert unit, (iii) along the contacts of dykes (Goldleaf, northern Golskeish quarry).

The massive, extensive vein at Granby Point is the best example of the 'stratabound' quartz veins. This vein lies along a bedding plane on the flat limb of an F_1 fold; minor folds are conspicuously absent. In this area, disharmonic stress was accommodated by bedding plane slip and dilation rather than by formation of parasitic folds.

The best example of Type 2 vein networks is in the hangingwall of the Hidden Creek deposit (Sharp, 1980). Another extensive outcrop area of these vein swarms lies along the crest and on the eastern shoulder of the bedrock ridge which trends south from the Anyox smelter stack (Fig. 29-1); quartz vein networks are exposed discontinuously for 1.5 kilometres. No sulphides were noted in the veins, but adjacent country rock carries minor disseminated pyrite. Significantly, these vein networks coincide with the projected trend of the Hidden Creek-Bonanza anticline and may indicate that the volcanic sequence is less than 200 metres below surface in this area.

AGE RELATIONSHIPS

No absolute age has been determined for rocks of the Anyox pendant. Grove (1973, 1983, in press) correlates Anyox strata with rocks of the Lower Jurassic Hazelton Group. However, the Anyox volcanic and sedimentary strata do not resemble Hazelton Group rocks exposed 20 kilometres to the east at the Kitsault River (Dawson and Alldrick, this volume). Sharp (1980, p. 13) suggested that Anyox stratigraphy correlates with Upper Triassic Karmutsen Formation units described on the Queen Charlotte Islands by Sutherland Brown (1968). The Anyox rocks are low-K tholeiitic basalts and are lithologically and chemically similar to Triassic volcanic-sedimentary formations of the Taku and Wrangellia Terranes; they differ signficantly in composition from Triassic volcanic-sedimentary formations of the Alexander and Stikine Terranes which are calc-alkaline to alkaline in composition (D. MacIntyre, pers. comm., 1985).

Sharp provided Anyox ore samples to Dr. R. V. Kirkham at the Geological Survey of Canada for lead isotope studies of the volcanogenic massive sulphide deposits. Analytical results are presented in Table 29-1.

TABLE 29-1
LEAD ISOTOPE RATIOS OF ANYOX SULPHIDES*

Sample and Location	$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
Galena No. 6 Zone Hidden Creek Mine	18.691	15.562	38.267
Sphalerite No. 6 Zone Hidden Creek Mine	18.570	15.521	38.064
Pyrite Bonanza Mine	18.795	15.592	38.389

* Provided by R. V. Kirkham, Geological Survey of Canada, Ottawa.

'Common lead' isotope data can yield crude absolute age determinations if suitable models are available for their interpretation. A large data base from similar rocks and sulphides must be assembled before meaningful interpretations can be attempted. Lead isotope data are, however, useful for indicating relative age relationships between deposits, and between deposits and their host rocks. They may also provide indications about the source of lead in an ore deposit.

Anne Andrew compared the Anyox data from Table 29-1 to lead isotope ratios from whole rock lead and galena lead from the Sicker Formation, the Karmutsen Formation, and three intrusions on Vancouver Island (Andrew, in prep.). The plotted Anyox data coincide with a cluster of whole rock initial ratios and galena lead ratios from the Kartmutsen Formation on Vancouver Island and Texada Island. The coincidence of ratios for Anyox and Karmutsen leads suggests that the sulphide minerals at Anyox have a similar age and origin to the Karmutsen Formation volcanic rocks and sulphide minerals (A. Andrew, pers. comm., 1985). This supports Sharp's correlation of Anyox and Karmutsen stratigraphy.

The Karmutsen Formation is Late Triassic with a 'stratigraphic' age of 228 ± 5 Ma, and a new U/Pb zircon age of 215 to 218 Ma (Armstrong, *et al.*, in press).

DISCUSSION

It is unlikely that additional exploration work will be conducted in the Anyox area during the present cycle of depressed copper prices, but the area offers high potential for ore discovery and attractive logistics for a mining operation.

Fifteen volcanogenic massive sulphide lenses in seven deposits have been discovered within the Anyox pendant. Eleven of these lenses were exposed in outcrop; the other four are near-surface lenses that are part of the Hidden Creek deposit. Additional, blind deposits must exist along the down-dip continuation of the volcanic-sedimentary contact. The contact has been thoroughly prospected for outcropping sulphides but has not yet been mapped in detail along its entire length for proximal indicators of ore that were documented by Sharp (1980).

Although most volcanogenic massive sulphide deposits respond to both ground and airborne electromagnetic surveys, sulphide responses in the Anyox pendant will probably be 'overshadowed' by much stronger responses from graphitic shear planes within the carbonaceous phyllites near the base of the sedimentary sequence. A recent helicopter-borne Input survey did not detect any additional sulphide deposits; anomalies over known deposits were substantially weaker than those related to carbonaceous strata and graphitic shear zones (S. Quinn, pers. comm., 1984). One strategy would be to systematically drill all primary, secondary, and tertiary EM conductors, or at least to make ground checks for proximal ore indicators.

Future exploration programs in the Anyox pendant will require:

(1) Detailed mapping of the volcanic-chert-sediment contact area that focuses on: locating proximal ore indicators; detailed lithogeochemical analysis of volcanic, chert, and sedimentary rocks; and documenting evidence for analysis of paleotopography in order to locate either seamount or rift structures.

The lithogeochemical sampling would provide a direct exploration tool for near-surface deposits, and also a data base for the ultimate exploration program within the Anyox pendant:

(2) Systematic fence or grid drilling of the down-dip extension of the volcanic-sedimentary contact, similar to programs conducted in the Noranda district.

ACKNOWLEDGMENTS

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