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THE MINERAL SOURCES OF SILVER AND THEIR DISTRIBUTION IN THE CARIBOU MASSIVE SULPHIDE DEPOSIT, BATHURST AREA, NEW BRUNSWICK

J.L. JAMBOR AND J.H.G. LAFLAMME

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THE MINERAL SOURCES OF SILVER AND THEIR DISTRIBUTION IN THE CARIBOU MASSIVE SULPHIDE DEPOSIT, BATHURST AREA NEW BRUNSWICK

by

J.L. Jambor* and J.H.G. Laflamme**

ABSTRACT

Tetrahedrite-group minerals and argentian galena are the principal sources of silver in the Caribou massive sulphide deposit, northern New Brunswick. Microprobe analyses indicate that tetrahedrite, tennantite and freibergite are highly variable in composition within the massive sulphide lenses and even within sulphide laminae in a single polished section. Tetrahedrite abundances are also highly variable: the mineral is sparse in the North Sulphide Body and is confined to the hanging wall and footwall of the lense; tetrahedrite content of the South Sulphide Body is extremely low, whereas the East Sulphide Body is mineralogically distinct in that it alone contains widespread tetrahedrite which is locally almost continuous across stratigraphic layering. East Sulphide Body tetrahedrite compositions vary systematically in that only near-surface occurrences are mercurian and footwall occurrences are silver-poor.

Microprobe analyses of Caribou galena indicate that it contains up to 0.11 wt % Sb and 1.58 wt % Bi. The maximum silver content obtained from 465 spot analyses of the galena is 0.66 wt % and the average is 0.10 wt %. For the Caribou ore-reserve average of 1.7 oz Ag/ton (58 g/tonne), solid-solution silver in galena probably accounts for about 0.47 oz (16 g), electrum accounts for 0.04 oz (1.4 g), minor silver minerals account for 0.03 oz (1.0 g), and the remainder is in tetrahedrite-group minerals. However, silver grades in the individual sulphide bodies are not equal, nor are the mineral distributions equal. The East Sulphide Body has an estimated 76% of its silver present in tetrahedrite and 21% in galena; in a lense such as the South Sulphide Body, 75% of the silver may be present in solid solution in galena and only 19% in tetrahedrite. The tetrahedrite-rich East Sulphide Body is considered to have the best potential for silver recovery.

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LES SOURCES MINERALOGIQUES D'ARGENT ET LEUR DISTRIBUTION DANS LES GISEMENTS DE SULFURE MASSIF DE CARIBOU DE LA REGION DE BATHURST AU NOUVEAU-BRUNSWICK

par

J.L. Jambor* et J.H.G. Laflamme**

RESUME

Les minéraux du groupe tétraédrite et la galène argentienne sont les principales sources d'argent dans les gisements de sulfure massif de Caribou au nord du Nouveau-Brunswick. Les analyses effectuées à la microsonde démontrent que la composition de la tétraédrite, de la tennantite et de la freibergite varie considérablement à l'intérieur des lentilles de sulfure massif et même à l'intérieur d'une lamelle de sulfure dans une même section polie. L'abondance de la tétraédrite est aussi très variable: le minéral est clairsemé dans le corps North Sulphide et se limite à la lèvre soulevée et à la lèvre abaissée de la lentille; la teneur en tétraédrite du corps South Sulphide est extrêmement basse, mais par contre, le corps East Sulphide diffère minéralogiquement des précédents car lui seul contient la tétraédrite en grande envergure qui de façon locale est presque continue sur toute la couche stratigraphique. Les compositions de la tétraédrite du corps East Sulphide varient systématiquement du fait que seulement les venues près de la surface sont de nature mercurienne et les venues de la lèvre abaissée sont pauvres en argent.

Les analyses à la microsonde effectuées sur la galène de Caribou ont démontré qu'elle contient jusqu'à 0.11% poids de Sb et 1.58% poids Bi. La teneur maximale de l'argent obtenue à partir de 465 analyses localisées de la galène est de 0.66% poids et la moyenne est de 0.10% poids. La moyenne de réserves de minerais de Caribou est de 1.7 oz Ag/tonne (58 g/tonne); l'argent en solution-solide dans la galène compte pour probablement 0.47 oz (16 g), l'électrum pour 0.04 oz (1.4 g), les minéraux mineurs d'argent pour 0.03 oz (1.0 g) et le reste est composé de minéraux du groupe tétraédrite. Par contre, les teneurs d'argent dans les corps de sulfure individuels ne correspondent pas ni les distributions du minéral. Environ 76% de l'argent provenant du corps East Sulphide est présent dans la tétraédrite et 21% est présent dans la galène; dans la lentille du corps South Sulphide, 75% de l'argent est présent sous forme de solution-solide dans galène et seulement 19% dans la tétraédrite. Le corps East Sulphide riche en trêtraédrite est considéré comme celui qui aurait le meilleur potentiel de récupération de l'argent.

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Study of the geochemistry of silver in the Caribou massive sulphide deposit was undertaken as part of CANMET investigations directed toward improving the efficiency of metal recoveries from fine-grained massive sulphide ores. Comprehensive mineralogical studies of New Brunswick deposits of this type are in progress to provide guidance for mineral dressing procedures and to provide knowledge essential to understanding the behaviour of metals, both major and minor, in currently utilized and experimental ore processing.

Although only a minor element in most New Brunswick massive ores in terms of its weight percentage, silver in some cases ranks second only to zinc in terms of gross dollar value per tonne. However, silver recovery is low and one quarter to one half of the metal in exploited deposits has been lost to the tailings.

Several silver minerals are known to occur in the New Brunswick massive ores. Tentative identification of "argentite", pyrargyrite, owyheeite and matildite has been reported by Boorman (1975), but these seem to be quantitatively insignificant. However, Boorman (1975) concluded that more than 65% of the silver in ore from the Brunswick No. 12 deposit is distributed among tetrahedrite and the various silver minerals and that the remainder is in solid solution in galena, sphalerite, chalcopyrite and pyrrhotite. In the latter group, solid solution in galena was considered to be the most important, with progressively less silver in sphalerite and pyrite. In contrast, Chen and Petruk (1978) concluded that freibergite and argentian galena are the principal silver carriers in massive sulphide ore at the nearby Heath Steele mine (Fig. 1) and Boorman et al. (1976) concluded that tetrahedrite and electrum account for the bulk of the silver at Caribou. The present study was undertaken to define, more specifically, the nature and distribution of argentiferous minerals in the Caribou deposit.

CARIBOU DEPOSIT

The Caribou massive sulphide deposit is about 50 km west of Bathurst, northern New Brunswick (Fig. 1). The western part of the deposit is owned 75% by Anaconda (Canada) Co. Ltd. and 25% by Cominco Ltd., and the eastern part is owned by Caribou-Chaleur Bay Mines Ltd. (Anaconda 67.5%, Cominco 22.5% and Chaleur Bay Syndicate 10%). Indicated ore reserves (Annis et al. 1976) are approximately 48 million tonnes grading 4.48% zinc, 1.7% lead, 0.47% copper, 58 g silver per tonne (1.7 oz/ton), and 1.4 g gold per tonne (0.04 oz/ton). The reserves occur in four steeply dipping stratiform tabular lenses discovered by drilling in 1955 and extensively explored in 1965-70 by underground workings.

The near-surface part of the deposit consisted of a copper-enriched supergene sulphide zone on which open-pit production commenced in 1970-71. Poor copper concentration led to a suspension of operations until 1973-74, when mining was resumed at 4500 tonnes per week from reserves of about 910,000 tonnes, since exhausted, grading 3.4% copper, 2.6% zinc and 1.1% lead (Williams 1978).

The en-echelon sulphide lenses which comprise the Caribou deposit have a total length of nearly 1500 m and widths which locally exceed 30 m. The deposit has been referred to as consisting of three or four principal lenses, the number dependent on whether the North and Northwest Sulphide Bodies (Fig. 2) are considered as separate lenses. According to Davis (1972), the juncture of these two bodies is a large, ruptured parasitic fold with an amplitude of about 60 m. The principal lenses occur in a steeply plunging synform, the "Caribou fold", whose axis strikes about N20°E and plunges steeply west. The East Sulphide Body is on the eastern limb of the fold and the other sulphide bodies are on its western limb. The hinge zone of the synform is marked by numerous minor, symmetrical antiforms and synforms with amplitudes of up to 20 cm and with well de-

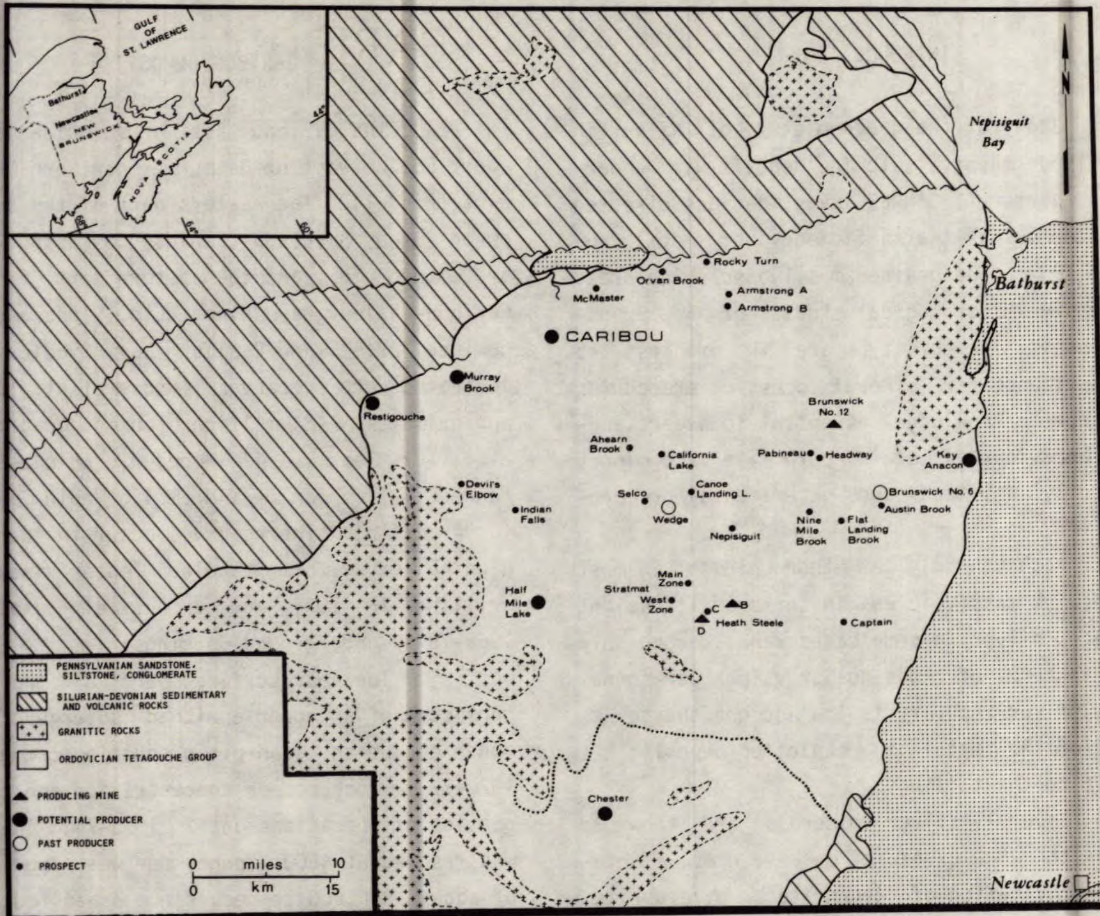

Fig. 1 - General geology and principal massive sulphide occurrences, Bathurst area, New Brunswick; rocks south of the dotted line near the Chester deposit are mainly highly deformed Cambro-Ordovician metasediments; geology compiled from Irrinki (1973), Skinner (1975) and New Brunswick Mineral Resources Branch - Plate 73-10

veloped axial plane fractures (Davis 1972).

The stratigraphic succession in the mine area is meta-basalt, graphitic argillite (graphitic schist), phyllite and massive sulphides, and meta-rhyolite schist (quartz-sericite schist, quartz-feldspar augen schist). The sulphide lenses parallel the stratigraphic layering and foliation. Footwall rocks of the sulphide lenses commonly contain abundant disseminated sulphides whereas hanging-wall contacts are generally sharp.

The footwall graphitic argillite is grey to black, locally pyritiferous, contains abundant contorted quartz layers and veinlets, and is about 35 m thick. Rocks between the graphitic footwall and the hanging-wall meta-rhyolite schist also average about 35 m in thickness; this middle unit, which includes the sulphide lenses, is the "Ore Zone Unit" of Roscoe (1971). According to Roscoe, a sedimentary facies in the Unit is represented by chloritic and sericitic argillite (phyllite) and schist, and a volcanic facies in the Unit consists of metamorphosed tuffaceous material. The sedimentary facies predominates along the footwall and centre of the deposit whereas the volcanic facies predominates along the hanging wall and away from the centre of the deposit. The Ore Zone Unit is

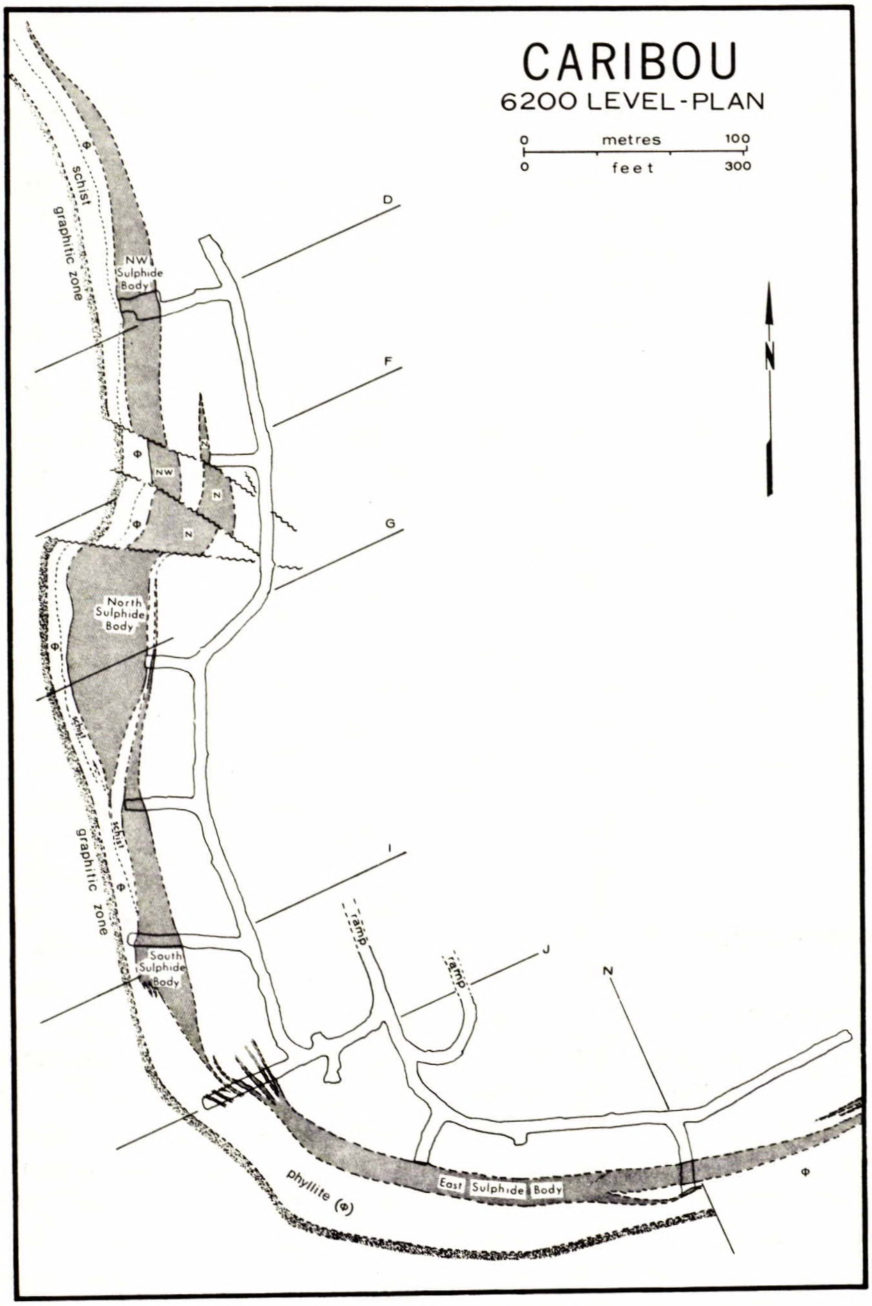

Fig. 2 - Caribou 6200-level, showing configuration of the major sulphide bodies; lettered lines refer to vertical sections

overlain by chlorite-poor silicic tuff and coarse pink lapilli tuff.

Deformation and regional metamorphism

Rocks in the Caribou mine area are part of a complexly folded metasedimentary and metavolcanic sequence comprising the Lower and Middle Ordovician Tetagouche Group. The Group, estimated by Skinner (1974) to be about 10,000 m thick, has been polydeformed, with up to five or six phases of deformation recognized locally (Luff 1975, 1977; McBride 1976). The first phase of regional metamorphism, which was the most penetrative, produced upright isoclinal folds and imparted a regional foliation which is more or less parallel to lithological layering. The second phase of deformation produced a relatively penetrative crenulation cleavage associated with tight second folds; some deformation occurred, but recrystallization was only very minor. Large regional folds were produced by the third deformation.

Metamorphic recrystallization of the first deformation phase and crenulation cleavages of the second phase are attributed (Helmstaedt 1971, 1973a,b; Helmstaedt and Skinner 1978) to Taconian (Middle Ordovician) orogeny whereas the late regional folds may be late Taconian or Acadian. Regional metamorphism (first phase) increases from sub-greenschist facies in the northeast to biotitic greenschist facies farther south. According to Helmstaedt (1973b), most of the area to the north and west of Brunswick No. 12 mine (Fig. 1) is in the chlorite subfacies whereas the area south of the mine is predominantly in the biotite subfacies.

GENERAL MINERALOGY

Various aspects of the mineralogy of the Caribou deposit have been discussed by Boorman et al. (1976), Cavalero (1972), Chen (1978), Johnson (1975), Petruk (1975), and Roscoe (1971); results of a detailed mineralogical study of the deposit will be presented in another paper (Jambor, in prep.). The massive sulphide lenses consist predominantly of fine-grained pyrite, less than 1% arsenopyrite, variable but generally minor magnetite, pyrrhotite which is negligible except at one site, and quantities of galena, sphalerite and chalcopyrite commensurate with the ore-reserve percentages for lead, zinc and copper, respectively.

Possible host minerals for silver at Caribou were investigated by reflected-light microscopy of approximately 600 polished sections of drill core from the 6200-level and the vertical cross sections whose positions are indicated in Fig. 2. Assay data for the drillholes were provided by Anaconda (Canada) Ltd. — the assays and sampling were done in troy oz/ton per drillhole footage, and these units are retained throughout the remainder of this report. Microprobe analyses and supplementary chemical analyses were done at CANMET. The results have shown that minerals in the tetrahedrite-freibergite series are important silver carriers at Caribou. Electrum, on the other hand, is extremely sparse and is concluded to be quantitatively only a very minor silver component of the Caribou ore. The four major sulphide lenses do not contain equal amounts of silver, nor is silver uniformly distributed within an individual lense.

Tetrahedrite-tennantite-freibergite

Few analyses correspond to the ideal formulas for tetrahedrite ($Cu_{12}Sb_4S_{13}$) and tennantite ($Cu_{12}As_4S_{13}$); the minerals form a Sb-As solid-solution series and several elements commonly substitute for Cu. Most tetrahedrite analyses apparently correspond to $(Cu,Ag)_{10}(Fe,Zn,Hg,Cu^*)_2(Sb,As)_4S_{13}$ (Tatsuka and Morimoto 1977), with Cu* limited to less than 0.2 atom (Charlat and Levy 1974). Silver atoms preferentially substitute for the monovalent copper in three-coordinated positions, whereas mercury substitutes for the copper tetrahedrally coordinated with sulphur (Kalbskopf 1971, 1972). Silver solid solution in tetrahedrite is continuous up to about 20 wt % Ag, whereupon either a structural change or a convergence with cuprian freibergite occurs (Riley 1974). The freibergite end-member is theoretically $Ag_{12}Sb_4S_{13}$, but natural material invariably contains other elements, as is the case for tetrahedrite, and the maximum Ag content in freibergite has been predicted by Riley (1974) to be 51 wt %.

Microprobe analyses

Microprobe analyses of tetrahedrite were obtained with a MAC 400 instrument operated at 25 kV and specimen current of 0.03 μA. The following standards and X-ray lines were used: enargite - Cu*Kα*, As*Kα*; chalcostibite - Sb*Lα*, S*Kα*; argentopyrite - Ag*Lα*, Fe*Kα*; synthetic sphalerite 27 - Zn*Kα*; synthetic Pd_3HgTe_3 - Hg*Lα*. For galena analyses, the probe was operated at 25 kV and 0.05 μA specimen current, with 50-second counting periods and the Ag*La* X-ray line. Standards used initially were pure synthetic PbS and synthetic PbS containing 0.40 wt % Ag. Subsequently, metallic silver was found to be a suitable Ag standard and was used for most analyses. Sb and Bi in galena were analyzed with the same operating conditions using Sb*La* and Bi*La* (metals), and synthetic PbS for background corrections.

All microprobe data were processed with a computer program modified from EMPADR VII (Rucklidge and Gasparrini 1969). The minimum detection limits (wt %) in galena are: Ag 0.04, Sb 0.03, Bi 0.15.

EAST SULPHIDE BODY

The East Sulphide Body is the sole major lense on the eastern side of the Caribou fold. The body has a strike length of about 700 m, a maximum thickness of about 25 m, and terminates as multiple thin sulphide bands which gradually pinch out at both extremities of the major lense. Galena and sphalerite are abundant throughout the body, so that across-layer zoning in these metals is not conspicuous. Pb+Zn averages more than 8% and the Zn:Pb ratio is about 2:1. Copper grades are low and generally not distinctly zoned; an exception is present near the eastern end of the lense, where the footwall has a slight but distinct increase in copper grades. Farther east, the termination of the East Sulphide Body is marked (Cavalero 1970) by massive pyrite in which the Zn-Pb content seldom exceeds 2%.

From the assay data available to the writers, the East Sulphide Body (or, for convenience, the East Body) seems to have a silver content higher than the ore-reserve average. The East Body also has by far the most abundant and most frequent occurrences of tetrahedrite-group minerals. As silver is known to be a common solid-solution element in the tetrahedrite-tennantite series and is essential in freibergite, the possibility that these minerals account for the bulk of the Caribou silver was examined in detail.

6200-level

Figure 3 shows the East Body massive sulphide lense and the horizontal drillholes from which cores were examined in detail. Tetrahedrite-tennantite occurs as anhedral grains dispersed throughout much of the massive sulphide zone and is also present in the footwall disseminated zone. Microscopic tetrahedrite veinlets, a few of which contain segments of bourn-

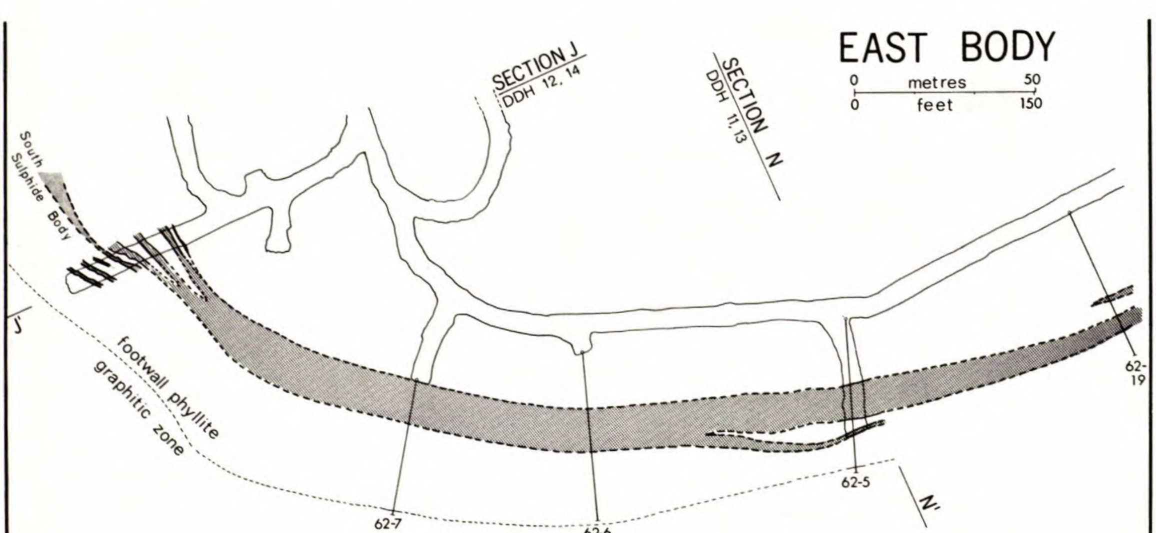

Fig. 3 - Caribou East Body, 6200-level massive sulphide lense and horizontal drillholes from which cores were studied in detail. Tetrahedrite occurrences are shown in Fig. 4 and the cross section drillholes in Fig. 5

onite, are restricted largely to the massive zone. Most tetrahedrite grains are associated with galena, sphalerite, and chalcopyrite, but some are isolated in gangue and there seems to be no special affiliation with any other sulphide. Unusually large tetrahedrite grains, up to 165 x 450 μm, are restricted either to the footwall disseminated zone, or to the borders of gangue-filled pockets in the massive zone.

Layering of sulphides parallel to the stratigraphy and schistosity is conspicuous in the East Body; samples rich in galena and sphalerite are especially well laminated as a result of across-layer abundance variations of these minerals. Tetrahedrite, which also contributes to the layering, commonly is concentrated in parts of a polished section and is absent in others.

The distribution and relative abundance of tetrahedrite-tennantite in the 6200-level drillholes is shown in Fig. 4. The estimated volume of tetrahedrite is less than 0.1% where categorized as "sparse" and the range is generally 0.2-0.5% where categorized as "common". Based on quantitative measurements of grain sizes and abundances in representative samples, the maximum tetrahedrite content in East Body polished sections is 4.0%.

That tetrahedrite abundances alone do not correlate well with silver assays is especially evident in the footwall zone of the 6200-level drillholes (Fig. 4). However, if tetrahedrite abundance __and__ its silver content are

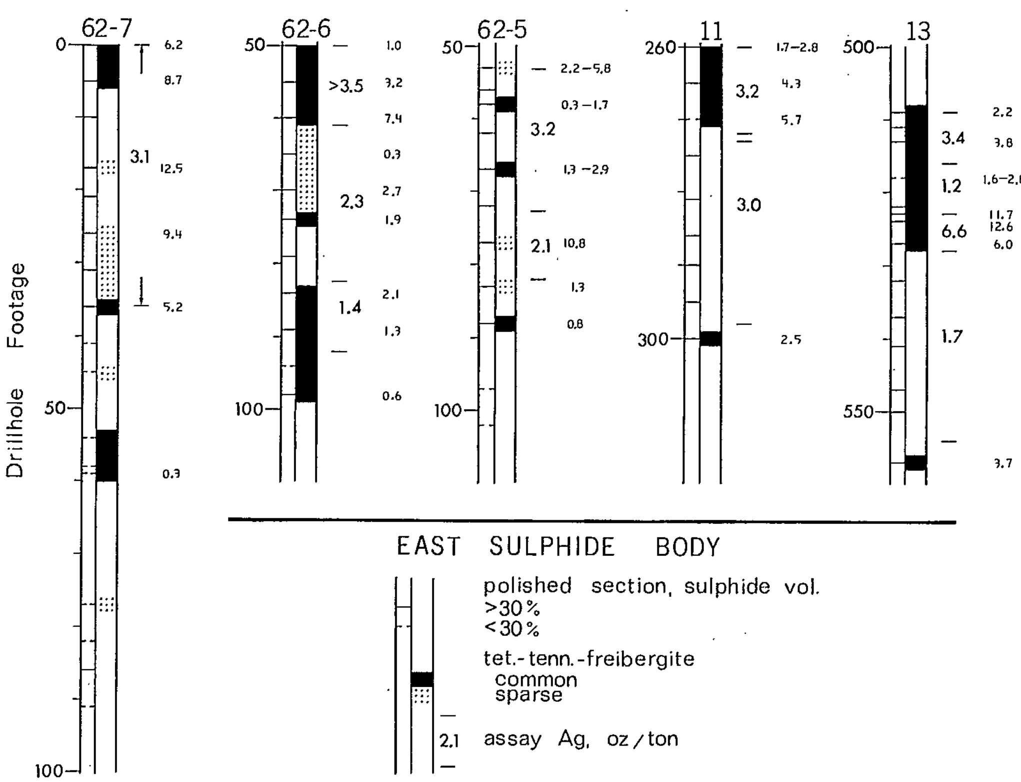

Fig. 4 - East Sulphide Body drillholes, located on Fig. 3 and 5, showing the positions of polished section samples and their total sulphide contents (left columns of drillholes); relative abundances of tetrahedrite are shown in the right column of each drillhole; whole-rock assay data are in Arabic numbers and microprobe-determined weight percentages Ag in tetrahedrite are in italicized numbers

considered, a good correlation becomes evident (Fig. 4 and Table 1). In drillhole 62-7, for example, the massive sulphide zone has numerous tetrahedrite occurrences, all of which are appropriately silver-rich. Although the footwall disseminated zone also has an interval with continuous common tetrahedrite, the silver content of the mineral is appropriately low. A similar trend is evident in drillhole 62-6, for which more detailed assay information is available to the writers. Silver contents of the tetrahedrites are lower, but abundance and persistence (continuity) of occurrence are greater than in drillhole 62-7. The silver-rich hanging wall of 62-6 contains tetrahedrite with up to 7.9 wt % Ag, whereas the range in the lower-grade footwall zone is 0.6-2.1 wt % Ag.

The correlation between assay silver and argentian tetrahedrite is less evident in drillhole 62-5. Locally common tetrahedrite in the footwall is suitably poor in silver (0.8 wt % Ag) and some of the sparse tetrahedrite in the adjacent overlying zone is appropriately silver-rich. In the hanging wall, however, tetrahedrite compositions do not seem to be sufficiently argentian to compensate for the low abundance of the mineral. The possible imbalance is more apparent when the mineralogy of the polished sections is compared with chemical analyses of drill core from which the polished sections had been cut (Table 2). The writers' general experience was that silver-bearing minerals could be observed in polished sections taken from intervals where assay values exceeded 2.5 oz Ag/ton, and thus the samples listed in Table 2 were considered to merit further study. The possibility that galena is an important silver carrier was investigated by microprobe analyses of grains selected by random traverses across the sulphide layers.

The highest Ag value found in galena from drillhole 62-5 is 0.20 wt %, the average of 135 spot analyses is 0.046 wt %, and the average for 23 different areas is 0.051 wt % (Table 2). As lead minerals other than galena are negligible, the average content of the upper, silver-rich zone with 3.2 oz Ag/ton (Fig. 4) can be calculated from assays to be about 3.67 wt % PbS. The average of microprobe analyses of 16 areas of galena from this part of the drillhole is 0.061 wt % Ag [with "not detected" (n.d.) assigned zero], thus indicating that solid-solution silver in galena accounts for only 0.53 oz Ag/ton. If analyses below the Ag detection limit of 0.04 wt % are arbitrarily assigned 0.02 wt % Ag (n.d. = 0.02), the average of the 16 areas is increased only to 0.068 wt % Ag. Therefore, the bulk of the silver is inferred to be present in tetrahedrite. Re-examination of the samples from 56 and 72 ft (Table 2) with a 40X oil-immersion objective lends some credibility to the above inference: (1) no other silver minerals were observed or detected by microprobe; (2) the 56-ft sample contains several previously unobserved grains of tetrahedrite, one of which was analyzed and found to contain 1.6 wt % Ag; (3) in the 72-ft sample, minute inclusions of silver-rich tetrahedrite were detected by microprobe analysis, and several minute grains of possible tetrahedrite also were observed at the margins of galena after etching the section with nitric acid. (Note that Fig. 4 does not include the results of the supplementary observations; this format was adopted to emphasize the apparent divergence between the analytical versus initial microscopical results). In summary, the results of the 6200-level study indicate that silver-rich samples almost invariably contain argentian tetrahedrite. However, tetrahedrite is commonly segregated in specific sulphide laminae and therefore the distribution of the mineral is somewhat erratic on a micro scale.

Cross section N

Holes 11 and 13 were drilled from surface and intersected the East Sulphide Body in a cross section close to drill hole 62-5 (Fig. 5). Data provided by Anaconda Company show that for drillhole 13, silver content in assay intervals of up to 5 ft (1.5 m) fluctuates considerably and ranges from less than 1 to more than 6 oz Ag/ton. The higher assay values are in the upper part of the massive sulphide zone in which tetrahedrite is common but relatively low in silver (Fig. 4 and Table 1). The correlation between tetrahedrite and chemical analyses (Table 3) is satisfactory

Table 1 - Composition of tetrahedrite-group minerals, East Sulphide Body

Drill-hole	Foot-age	Area	No. of spots	Weight %								Formula, based on 29 atoms†								
				Cu	Ag	Fe	Zn	Sb	As	S	Total	Cu	Ag	Fe	Zn	Σ	Sb	As	Σ	S
62-7	0	1	5	34.0	5.2	5.6	1.3	29.0	0.4	25.2	100.7	8.95	0.80	1.68	0.33	11.76	3.99	0.10	4.09	13.1
		2	8	32.4	7.2	5.5	1.4	28.7	0.4	24.7	100.3	8.66	1.12	1.66	0.36	11.80	4.01	0.09	4.10	13.1
	5	1	10	31.1	8.7	4.6	1.9	28.5	0.4	24.3	99.5	8.45	1.40	1.42	0.50	11.77	4.04	0.09	4.13	13.1
	17	1	3	27.7	12.5	3.5	4.0	27.4	0.5	23.6	99.2	7.67	2.05	1.11	1.09	11.92	3.97	0.12	4.09	13.0
	26	1	3	31.4	7.9	4.3	3.9	27.9	0.3	24.6	100.3	8.41	1.24	1.31	1.02	11.98	3.90	0.05	3.95	13.1
		2	5	29.3	10.8	4.9	1.8	28.5	0.6	23.9	99.8	8.03	1.74	1.53	0.49	11.79	4.08	0.14	4.22	13.0
	36	1	8	34.0	5.6	3.1	3.5	28.3	0.8	24.6	99.9	9.09	0.87	0.95	0.90	11.81	3.95	0.17	4.12	13.1
		2	4	34.4	4.8	2.8	4.1	28.7	0.5	24.7	100.0	9.16	0.76	0.85	1.07	11.84	3.99	0.12	4.11	13.1
	59	1	6	37.2	0.3	2.2	4.7	29.6	0.3	25.2	99.5	9.80	0.05	0.65	1.21	11.71	4.07	0.07	4.14	13.2
62-6	50	1	2	37.6	1.0	2.4	6.9	18.0	7.9	26.9	100.7	9.31	0.14	0.69	1.67	11.81	2.31	1.65	3.96	13.2
		2	8	39.4	1.0	1.3	5.9	19.1	7.1	26.5	100.3	9.86	0.14	0.38	1.44	11.82	2.50	1.52	4.02	13.2
	55	1	8	35.0	2.7	0.7	6.3	28.1	1.5	24.9	99.2	9.33	0.42	0.20	1.63	11.58	3.90	0.34	4.24	13.2
		2	4	34.7	3.6	3.4	3.5	29.3	0.3	25.2	100.0	9.19	0.56	1.01	0.89	11.65	4.06	0.07	4.13	13.2
	60	1	4	31.5	7.9	4.6	1.9	28.0	0.7	24.3	98.9	8.57	1.26	1.42	0.50	11.75	3.97	0.16	4.13	13.1
		2	5	32.4	6.9	5.1	2.1	28.7	0.5	24.8	100.5	8.64	1.09	1.54	0.53	11.80	4.00	0.10	4.10	13.1
	65	1	2	38.1	0.3	1.9	7.0	17.6	8.0	27.0	99.9	9.48	0.05	0.52	1.71	11.76	2.27	1.69	3.96	13.3
	70	1	4	35.7	2.7	3.1	5.8	21.0	5.3	25.4	99.0	9.23	0.41	0.90	1.46	12.00	2.83	1.17	4.00	13.0
	74	1	4	36.4	1.9	1.5	6.0	25.4	2.8	25.5	99.5	9.48	0.28	0.45	1.53	11.74	3.45	0.61	4.06	13.2
		2	4	36.7	1.9	1.2	6.4	27.2	1.6	25.2	100.2	9.59	0.30	0.35	1.63	11.87	3.71	0.37	4.08	13.1
	84	1	8	36.3	2.1	1.6	5.3	26.6	2.0	25.2	99.1	9.57	0.32	0.49	1.36	11.74	3.65	0.45	4.10	13.2
	89	1	5	36.5	1.3	2.5	4.6	28.6	0.6	25.1	99.2	9.65	0.20	0.77	1.19	11.81	3.94	0.13	4.07	13.1
	98	1	8	37.3	0.6	1.2	6.0	29.7	0.2	25.3	100.3	9.78	0.08	0.35	1.53	11.74	4.07	0.03	4.10	13.2
62-5*	58	1	1	37.6	1.0	1.5	6.2	28.6	0.4	24.9	100.2	9.86	0.17	0.45	1.57	12.05	3.90	0.10	4.00	13.0
		2	1	39.9	0.3	1.5	7.3	15.4	9.5	26.8	100.7	9.80	0.05	0.41	1.75	12.01	1.97	1.98	3.95	13.1
		1	1	37.1	0.8	1.6	6.8	28.7	0.6	24.9	100.5	9.71	0.12	0.47	1.73	12.03	3.92	0.13	4.05	12.9
		3	1	37.8	1.7	3.7	3.3	28.7	0.6	25.0	100.8	9.85	0.25	1.11	0.83	12.04	3.91	0.13	4.04	12.9
	67	1	1	35.9	2.7	3.2	4.8	27.4	0.8	24.8	99.6	9.48	0.42	0.94	1.22	12.06	3.77	0.18	3.95	13.0
		2	1	36.8	2.7	2.5	4.9	28.5	0.3	25.0	100.7	9.64	0.42	0.75	1.25	12.06	3.90	0.07	3.97	13.0
		3	1	36.6	2.9	2.7	4.5	28.4	0.5	24.8	100.4	9.64	0.45	0.80	1.15	12.04	3.92	0.10	4.02	12.9
		4	1	38.8	1.3	1.8	5.9	21.9	4.9	25.8	100.4	9.85	0.19	0.53	1.45	12.02	2.91	1.07	3.98	13.0
	77**				10.8															
	83**				1.3															
	88	1	1	38.9	0.8	2.0	6.6	21.7	4.8	25.7	100.5	9.88	0.11	0.58	1.63	12.20	2.87	1.02	3.89	12.9
62-19	76	1	4	34.9	3.3	2.4	4.4	28.8	0.4	24.8	99.0	9.33	0.53	0.73	1.14	11.73	4.03	0.08	4.11	13.2
		2	3	34.7	3.5	3.5	3.4	28.8	0.6	24.8	99.3	9.25	0.54	1.07	0.90	11.76	4.01	0.13	4.14	13.1
	86	1	3	33.3	5.8	3.9	3.2	27.9	0.8	24.8	99.7	8.87	0.92	1.19	0.83	11.81	3.89	0.17	4.06	13.1
		2	5	33.2	5.8	2.4	4.8	27.7	1.3	24.7	99.9	8.86	0.92	0.75	1.26	11.79	3.85	0.29	4.14	13.1
11	260	1	1	36.3	2.8	3.8	3.2	28.3	0.8	24.7	99.9	9.59	0.44	1.16	0.81	12.00	3.91	0.17	4.08	12.9
		2	1	36.9	1.7	2.6	4.5	28.5	0.7	24.9	99.8	9.73	0.27	0.77	1.16	11.93	3.92	0.17	4.09	13.1
		3	1	36.4	2.5	2.9	3.7	28.9	0.5	25.1	100.0	9.61	0.39	0.85	0.94	11.79	3.97	0.12	4.09	13.1
	265	1	1	34.7	4.3	3.9	3.2	28.8	0.4	24.7	100.0	9.21	0.67	1.18	0.81	11.87	4.00	0.10	4.10	13.0
	270	1	1	34.6	5.7	2.0	5.2	28.0	0.4	24.3	100.2	9.25	0.88	0.61	1.34	12.08	3.91	0.09	4.00	12.9
	300	1	1	37.2	2.5	1.5	6.8	23.6	3.3	25.3	100.2	9.59	0.38	0.44	1.69	12.10	3.19	0.74	3.93	13.0
13	509	1	8	35.6	2.2	2.5	4.6	28.9	0.6	25.1	99.5	9.42	0.34	0.76	1.19	11.71	3.99	0.13	4.12	13.2
	513	1	8	34.1	3.8	4.4	3.1	29.1	0.3	24.7	99.5	9.10	0.59	1.34	0.80	11.83	4.05	0.07	4.12	13.1
	518	1	8	35.7	2.8	4.0	2.7	28.9	0.5	25.3	99.9	9.39	0.43	1.20	0.68	11.70	3.98	0.12	4.10	13.2
		2	8	35.7	2.5	4.1	2.8	29.1	0.3	25.2	99.7	9.43	0.39	1.22	0.70	11.74	4.00	0.08	4.08	13.2
		3	6	36.4	1.6	1.6	5.7	27.3	1.5	25.1	99.2	9.61	0.25	0.47	1.47	11.80	3.75	0.33	4.08	13.1
	523	1	5	28.8	11.7	2.8	3.5	28.2	0.4	24.2	99.6	7.93	1.89	0.89	0.93	11.64	4.06	0.10	4.16	13.2
	524	-	8		11.3-13.8															
	527	1	6	32.7	6.0	3.2	4.3	29.0	0.2	24.6	100.0	8.78	0.95	0.99	1.11	11.83	4.06	0.03	4.09	13.1
	557	1	10	34.9	4.0	4.0	2.7	28.7	0.4	25.0	99.7	9.27	0.62	1.22	0.68	11.79	3.98	0.08	4.06	13.2
		2	8	34.8	3.5	3.9	3.3	28.9	0.4	25.1	99.9	9.21	0.54	1.18	0.84	11.77	4.00	0.08	4.08	13.2
		3	6	34.8	3.5	3.8	3.3	29.2	0.2	25.2	100.0	9.19	0.55	1.14	0.86	11.74	4.03	0.03	4.06	13.2
50	906	1	1	27.5	13.0	5.8	2.0	27.3	0.7	23.9	100.2	7.52	2.11	1.79	0.54	11.96	3.90	0.16	4.06	13.0
		1	1	31.5	7.9	5.6	1.9	28.0	0.6	23.9	99.4	8.53	1.28	1.74	0.48	12.03	3.97	0.14	4.11	12.9
		2	1	36.2	2.4	3.3	3.7	28.4	0.6	24.5	100.1	9.66	0.37	0.98	0.97	11.98	3.95	0.14	4.09	12.9
		3	1	35.9	2.0	0.9	6.8	28.5	0.6	24.5	100.2	9.59	0.31	0.27	1.75	11.92	3.97	0.14	4.11	13.0

*For 62-5 at 53 feet, wt % Ag for areas 1, 2, and 3 is 3.0, 2.2, and 3.1-5.8. All other results are spot analyses of single grains; for footage 58, grain 2, results are for Sb-rich and As-rich parts of an apparently single grain.

**Average of 3 analyses by T.T. Chen.

†Analytical weight percentages rounded off to 1 decimal; formulas calculated from 2-decimal primary data.

Table 2 - Whole-rock analyses of drill core and microprobe analyses of minerals in drillhole 62-5

Drillhole footage	Ag in rock (oz/ton)	Tetrahedrite in polished section	Wt % Ag in tetrahedrite	Galena analyses, wt % Ag		
				Area	Ag av.	Ag range
53	2.70	sparse	2.2-5.8	1(5)*	0.07	0.05-0.08
				2(7)	n.d.	
				3(5)	n.d.	
56	3.06	not seen initially (sparse)	---	1(7)	n.d.	
				2(9)	0.15	0.13-0.16
				3(5)	0.18	0.16-0.20
58	--	common	0.3-1.7	1(5)	n.d.	
				2(6)	n.d.	
62	--	not seen	---	1(4)	0.14	
				2(2)	0.07	
67	5.34	common	1.3-2.9	1(5)	0.08	
				2(5)	0.06	n.d.-0.08
				3(5)	0.10	
72	2.33	not seen initially (traces)	---	1(5)	0.07	0.05-0.09
				2(6)	0.05	n.d.-0.06
				3(5)	n.d.	
77	2.19	sparse	10.6-11.7	1(5)	0.08	0.06-0.10
				2(6)	0.07	0.05-0.10
				3(6)	0.05	n.d.-0.07
				4(9)	n.d.	
83	1.46	sparse	1.3			
88	3.65	common	0.8	1(8)	n.d.	
				2(8)	n.d.	
				3(7)	n.d.	

*Number of spots analyzed is shown in parentheses. Different areas in each polished section were selected by traversing across the sulphide layering.

n.d.- not detected; the detection limit is 0.04 wt % Ag

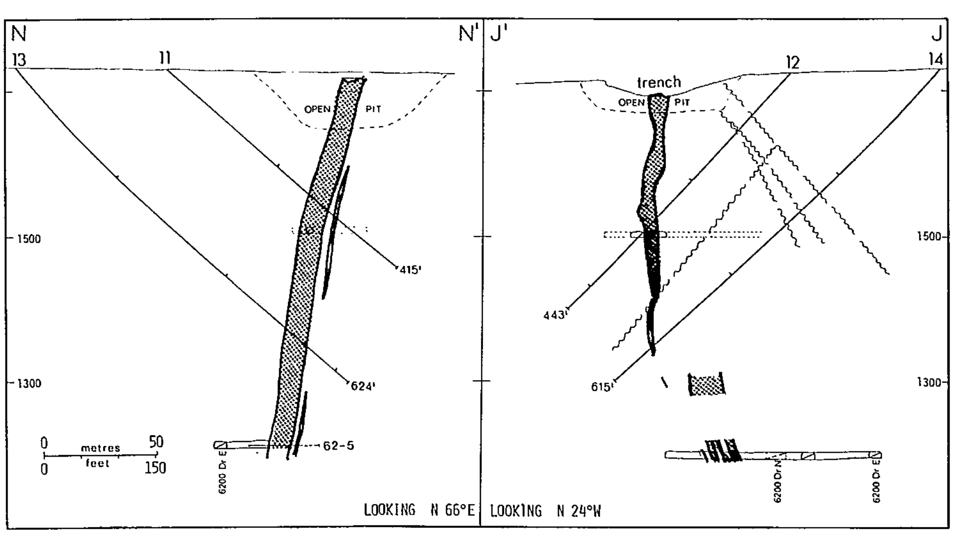

Fig. 5 - Cross sections, located on Fig. 3, of the East Sulphide Body; elevations are in feet; horizontal and vertical scales are identical

Table 3 - Whole-rock analyses of drill core and microprobe analyses of minerals in cross section "N", East Sulphide Body

Drillhole, footage	Ag in rock (oz/ton)	Pb in rock (wt %)	Tetrahedrite in polished section	Wt % Ag in tetrahedrite	Galena analyses, wt % Ag Area	Ag av.	Ag range
13-509	3.55	4.03	abundant	2.2			
-513	4.98	4.39	abundant	3.8			
-518	1.33	0.58	common	1.6-2.8			
-523	3.48	6.50	common	11.7			
-524	5.12	8.07	sparse	11.3-11.8			
-532	2.33	5.97	not seen				
-537	3.48	5.18	not seen		1(5)*	0.06	0.05-0.08
					2(5)	0.07	n.d.-0.14
					3(5)	0.05	n.d.-0.07
					4(6)	0.06	n.d.-0.09
-541	1.42	2.47	not seen				
-547	0.96	3.59	not seen		1(5)	n.d.	
					2(6)	n.d.	
					3(6)	n.d.	
					4(3)	n.d.	
-552	1.63	3.81	not seen				
-557	15.1	4.97	abundant (1.7%)	3.5-4.0			
11-260	4.33	5.33	abundant	1.7-2.8			
-265	4.72	5.55	abundant	4.3	1(5)	n.d.	
					2(5)	0.07	0.04-0.08
					3(5)	n.d.	
-275	2.80	4.64	not seen		1(6)	0.09	0.07-0.11
					2(6)	0.08	0.07-0.10
					3(6)	n.d.	
-281	1.83	5.94	not seen		1(6)	n.d.	
					2(4)	n.d.	
					3(5)	n.d.	
-286	2.55	6.64	not seen		1(6)	0.05	0.04-0.07
					2(6)	n.d.	
					3(6)	n.d.	
					4(6)	n.d.	
-290	1.83	5.30	not seen		1(5)	0.05	0.04-0.07
					2(6)	0.07	0.04-0.08
					3(5)	n.d.	
					4(5)	n.d.	
-295	1.92	4.21	not seen		1(5)	n.d.	
					2(5)	0.08	
					3(5)	0.13	0.09-0.16
-300	2.92	6.25	sparse	6.8			

*Number of spots analyzed is shown in parentheses. Different areas in each polished section were selected by traversing across the sulphide layering.

n.d.: not detected; the detection limit is 0.04 wt % Ag.

except for a conspicuous deviation at 557 ft: company assays show negligible silver for an overlapping 4.3-ft interval, but Quantimet measurements indicate that the polished section contains 1.7 vol % tetrahedrite. As chemical analysis of the remnant drill core gave 15.1 oz Ag/ton, either the assay or the sample number is incorrect.

The importance of argentian tetrahedrite in drillhole 13 is readily evident from Fig. 4, but in drillhole 11 the role of the mineral as a silver host is conspicuous only in the hanging-wall zone. Even though a major part of the massive sulphide zone in drillhole 11 averages 3.0 oz Ag/ton (Fig. 4), the polished section study indicated that the zone is apparently devoid of tetrahedrite and silver minerals other than minute amounts of electrum. Therefore, drill core remnants were analyzed chemically and numerous grains of galena in polished sections were examined by microprobe. The chemical analyses (Table

3) show that the three highest silver results again coincide with the three tetrahedrite-bearing samples.

The five samples in which tetrahedrite was not observed occur in the 25-ft interval 273-298 ft, for which Anaconda assays average 4.3% Pb and 3.0 oz Ag/ton. The chemical analyses of the five drill core remnants average 5.3 % Pb and 2.2 oz Ag/ton, from which it can be concluded: (1) there is not a direct relation between silver and lead abundances; (2) silver distribution is not even approximately uniform, but there is an irregular pattern as discussed below.

The possible contribution of argentian galena to the silver content in drillhole 11 was investigated in detail as shown in Table 3. Of 108 spots analyzed in 20 different galena areas, the highest silver content found is 0.16%, but the average for the 20 areas is only slightly more than 0.03% (with n.d. assigned 0 wt %). The highest average silver content for a specific sample is 0.06%, equivalent to 0.78 oz Ag/ton when related to galena content. These results indicate that although solid-solution silver in galena is appreciable in individual sulphide layers, galena is nevertheless not the most important host contributing to total silver in drillhole 11. The relatively high average silver content in the drillhole is interpreted to arise by combination of below-average values with narrow, tetrahedrite-bearing intervals much above average.

SOUTH SULPHIDE BODY

The South Sulphide Body (or, for convenience, the South Body) has a strike length of about 250 m (800 ft) and an average thickness of about 6 m. Lead and zinc contents are lower than in the East Body, and thus lamination of sulphides is generally less prominent. The comparatively low galena content of the South Body is especially evident in the central, thickest part of the lense, where the average grade is less than 0.7% Pb. The Zn:Pb ratio in this area is high and metal zoning is conspicuous in that high-grade Pb+Zn is confined to a relatively narrow section on the hanging-wall side of the lense. Zoning of copper grades is not prominent, but in some drillholes a trend toward higher footwall values is evident.

The silver content of the South Body varies laterally, but the average for the lense seems to be much less than the Caribou ore-reserve grade of 1.7 oz/ton. Not only is the South Body average low, but assay intervals in which silver exceeds 2.5 oz/ton are rare. Commensurate with this low silver content are the few observed occurrences of tetrahedrite. On the 6200-level, minute tetrahedrite veinlets were found in one sample from drillhole 62-1 and in one from drillhole 62-4 (Fig. 6 and Table 4). In cross section I (Fig. 7), only traces of tetrahedrite were detected in drillhole 16, and none was observed in hole 18. Although high silver values and argentian tetrahedrite are common in the bottom of drillhole 50, these sulphide intersections are narrow lenses which are interpreted to be overlapping extensions of the East Sulphide Body (Fig. 3).

The southern end of the South Body is near cross section J (Fig. 3). The massive sulphide zone pinches out at depth, but a substantial intersection was obtained in drillhole 12 (Fig. 5). All assay intervals in the hole have less than 2 oz Ag/ton, but tetrahedrite-group minerals are common in the bottom 5 m of the massive zone. Microprobe analyses confirm the optical identification that the sulphosalt is tennantite and indicate that the mineral is silver-free (Table 4).

That locally high silver values at Caribou reflect the presence of argentian tetrahedrite has been demonstrated adequately with East Body samples. The principal concern with the South Body is to account for persistent assay values, in the range of 1 to 2 oz Ag/ton, which are not attributable to argentian tetrahedrite or silver minerals. The assay data, as usual, represent silver values averaged over drill core lengths of several feet; therefore, individual core pieces from which the South Body polished sections had been cut were analyzed chemically to establish whether local areas have silver contents substantially above average. The results obtained

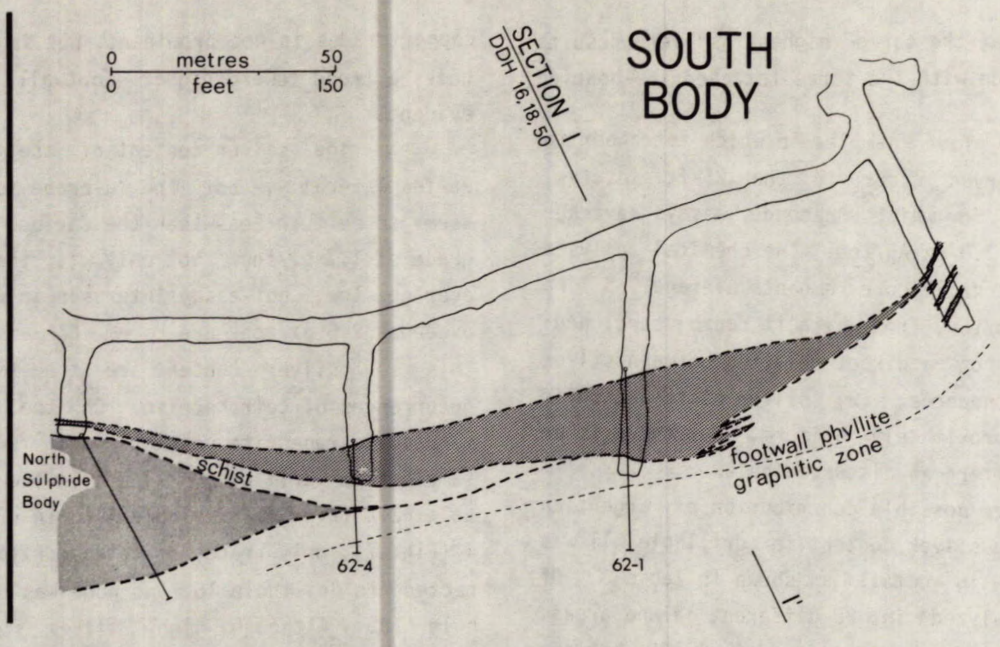

Fig. 6 - South Body massive sulphide lense and 6200-level horizontal drill-holes from which core was studied in detail; tetrahedrite is extremely sparse; locations and compositions of observed grains are given in Table 4

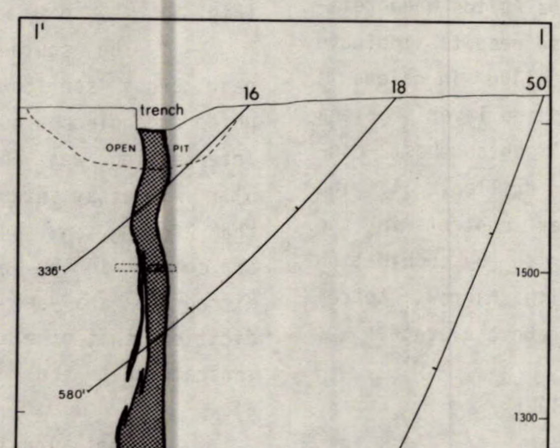

Fig. 7 - Cross section of the South Sulphide Body; elevations are in feet; horizontal and vertical scales are identical

Table 4 - Microprobe analyses of tetrahedrite-group minerals, South Sulphide Body

Drill-hole	Foot-age	No. of spots	Weight % Cu	Ag	Fe	Zn	Sb	As	S	total	Formula, based on 29 atoms Cu	Ag	Fe	Zn	Σ	Sb	As	Σ	S
62-4	21	5		0.3-1.2															
62-1	17	1	35.1	4.0	2.8	6.3	26.2	1.4	25.0	100.8	9.15	0.61	0.86	1.60	12.22	3.57	0.30	3.87	12.9
12[J]	293	6	43.5	n.d.	1.5	6.8	0.7	19.1	29.0	100.6	10.03	0.00	0.38	1.51	11.92	0.09	3.72	3.81	13.3
	298	3	41.3	n.d.	4.2	5.4	2.4	16.7	28.8	98.8	9.68	0.00	1.10	1.24	12.02	0.28	3.31	3.59	13.4
		2	41.9	n.d.	3.3	5.7	1.9	16.9	28.7	98.4	9.85	0.00	0.87	1.30	12.02	0.24	3.38	3.62	13.4
16[I]	189	3	26.6	14.8	1.7	4.2	27.1	1.1	23.9	99.4*	7.42	2.43	0.55	1.15	11.55	3.96	0.27	4.23	13.2
74[F]	1485	2	26.4	15.1	4.2	1.8	26.9	0.6	23.4	98.4	7.45	2.51	1.35	0.50	11.81	3.97	0.14	4.11	13.1
		2	25.6	14.1	2.6	7.6	26.2	0.5	24.2	100.8	6.97	2.27	0.81	2.02	12.07	3.74	0.12	3.86	13.1
	1494	2	24.3	17.0	4.9	3.2	26.5	0.5	24.6	101.0	6.64	2.75	1.53	0.85	11.77	3.77	0.12	3.89	13.3
		5	26.9	13.8	4.2	2.7	27.1	0.7	23.6	99.0	7.51	2.27	1.33	0.74	11.85	3.95	0.16	4.11	13.0
	1505	2	36.3	0.9	2.0	6.3	29.3	0.3	25.3	100.4	9.49	1.60	0.58	0.13	11.80	3.99	0.08	4.07	13.1
		5	37.1	1.5	1.2	6.0	25.7	2.6	25.6	99.7	9.65	0.22	0.35	1.52	11.74	3.49	0.58	4.07	13.2

Analytical standards and conditions are as reported in Table 1. The Ag range for sample 62-4-21 is from analyses of 5 grains by T.T. Chen.

n.d. not detected   [J,I,F]Cross sections (Fig. 1)   *One of the analyzed spots also contains 0.07 wt. % Hg.

Table 5 - Silver contents of drill core, and microprobe analyses of minerals, South Sulphide Body

Drillhole, footage	Ag in rock (oz/ton)	Wt % Ag in tetrahedrite	Wt % Ag in galena area	Ag av.	Ag range
62-4-17	2.55	not seen	1(5)*	0.09	0.06-0.11
			2(5)	0.11	0.08-0.14
			3(5)	0.04	n.d.-0.06
-21	1.02	0.3-1.2			
62-1-17	1.82	3.95			
-22	0.66	not seen			
-27	0.67	not seen			
-42	0.51	not seen			
-46	0.87	not seen			
-50	2.04	not seen			
-63	0.73	not seen	1(5)	0.13	
			2(5)	0.15	0.13-0.17
			3(5)	0.12	0.07-0.13
16-157	2.48	not seen	1(5)	0.31	0.25-0.33
			2(5)	0.24	0.20-0.27
			3(5)	0.35	
-184	1.17	not seen			
-189	4.74	14.8	1(6)	0.20	0.14-0.24
			2(6)	0.24	0.20-0.28
			3(6)	0.24	0.21-0.27
			4(6)	0.09	0.05-0.11
			5(6)	0.08	0.06-0.13
-201	1.09	not seen			
-206	2.70	not seen	1(5)	0.15	
			2(4)	0.10	0.07-0.13

Drillhole, footage	Ag in rock (oz/ton)	Wt % Ag in tetrahedrite	Wt % Ag in galena Area	Ag av.	Ag range
16-220	1.17	not seen	1(5)	0.16	
			2(5)	0.15	
			3(5)	0.17	0.14-0.18
			4(3)	0.16	
-235	0.20	not seen	1(5)	0.16	0.12-0.17
			2(2)	0.14	
			3(2)	0.15	
-260	0.15	not seen			
18-450	3.06	not seen	1(6)	0.08	0.06-0.09
			2(5)	0.07	
			3(6)	0.07	
			4(5)	0.07	n.d.-0.09
-457	3.13	not seen	1(6)	0.61	0.58-0.66
			2(6)	0.46	0.44-0.48
			3(6)	0.45	0.39-0.48
			4(5)	0.37	0.34-0.43
-465	1.60	not seen			
-475	0.36	not seen			
-484	1.24	not seen			
-489	2.04	not seen			
-497	0.23	not seen			
-499	1.09	not seen			
-521	0.26	not seen			

*Number of spots analyzed is given in parentheses.

62-4-21: sparse disseminated tetrahedrite; 62-1-17: sparse tetrahedrite veinlets; 16-189: sparse tetrahedrite and polybasite.

from 27 samples are given in Table 5.

Of the analyzed samples, three were known to contain tetrahedrite – one stands out clearly; even though tetrahedrite in its companion polished section is sparse, microprobe analyses indicate that the mineral is silver-rich (Table 4), and that a polybasite-type silver mineral also is present. In marked contrast, the other two tetrahedrite-bearing samples are anonymous with respect to their bulk silver content, and the tetrahedrites in these are correspondingly sparse and not significantly silver-rich (Table 4).

Four of the 24 samples which apparently lack tetrahedrite have silver contents in excess of 2.5 oz/ton (underlined values in Table 5). Microprobe analyses indicate that the silver content of galena in these samples is highly variable, but does range up to 0.66 wt % Ag; galena is, therefore, locally a very important silver carrier in the South Body.

Table 6 shows the correlation between Pb and Ag obtained from whole-rock analyses versus solid-solution silver in galena. The contribution made by argentian galena is appreciable: sample 18-457 contains 3.13 oz Ag/ton, of which 2.16 oz (69%) is calculated as due to the presence of argentian galena. For the six samples in Table 6, the maximum silver attributable to galena is 77%

Table 6 - Whole-rock silver and lead versus microprobe-determined silver in galena, South Body samples*

Drillhole, footage	Pb in rock (wt %)	PbS (calc.)	Ag in rock (oz/ton)	Wt % Ag in galena†	Ag in solid solution (calc.) (oz/ton)	% total Ag in galena
62-4-17	1.83	2.13	2.55	0.08	0.41	16
16-157	2.28	2.65	2.48	0.30	1.91	77
-206	1.65	1.92	2.70	0.13	0.60	22
-220	0.59	0.69	1.17	0.16	0.26	23
18-450	4.24	4.97	3.06	0.07	0.83	27
-457	1.65	1.92	3.13	0.47	2.16	69

*Tetrahedrite-bearing samples excluded.

†Averages for the areas analyzed by microprobe.

of total silver, and the average for all samples is 39%. Although few in number, the samples nevertheless demonstrate the magnitude of the silver contribution made by argentian galena.

Comparison of the above results for the South Body with those reported for the East Body indicates that silver is partitioned differently in each lense: (1) the preponderance of tetrahedrite as a silver host in the East Body is in striking contrast to its paucity in the South Body; (2) galena in the South Body is more silver-rich than that in the East Body. As shown in Fig. 8, the majority of the South Body galena analyses have silver contents above the maximum found in East Body samples.

NORTH SULPHIDE BODY

The North Sulphide Body is up to 35 m thick. Aside from disruption by faulting in the northern part of the lense (Fig. 9), study of the body is complicated by the presence of pronounced lateral and vertical variations in metal grades. The largest segment of the North lense has a high-grade hanging wall, 1 to 4 m thick, in which combined Pb+Zn exceeds 8 wt %. The underlying thick pyritic zone averages less than 1% Pb, with combined Pb+Zn probably less than 4%. Metal grades are higher in the smaller northern segments and also at depth. Copper grades average about 0.5% and commonly increase toward the footwall.

The silver content of the North Sulphide Body (or, for brevity, the North Body) is extremely low — probably in the neighborhood of 1 oz Ag/ton. Below-average silver values are characteristic of the thick, lower-grade massive pyrite zone, but markedly above-average values are common in the thin, high-grade hanging wall.

In the horizontal drillholes on the 6200-level, tetrahedrite was observed only in hole 62-9 at 103 ft, in 62-16 at 103 ft, and in two of

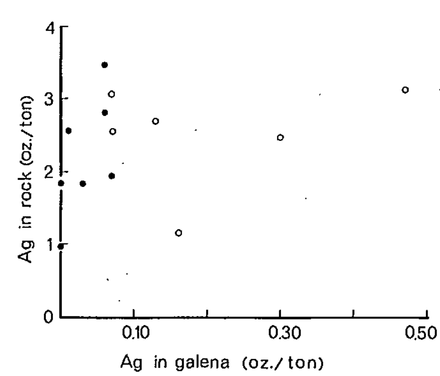

Fig. 8 - Whole-rock Ag versus Ag in solid solution in galena in South Body (open circles) and East Body (filled circles) samples devoid of observed tetrahedrite

the three polished sections from the upper part of 62-20 which intersected the thinner, northern extremity of the North Body (Fig. 9). Assay data for the tetrahedrite-bearing intervals in the first two aforementioned drillholes show that they are not silver-rich, and microprobe analyses (Table 7) are in accord with the assays. Although assay data for drillhole 62-20 were not available to the writers, neither the sparse tetrahedrite at 10 ft nor the abundant tetrahedrite at 21 ft is particularly high in silver (Table 7).

The silver content of the North Body was also examined for cross sections G and F (Fig. 9). In section G (Fig. 10), tetrahedrite in drillhole 10 occurs in both the hanging wall and the footwall, but is more abundant and more silver-rich in the former (Table 7). In drillholes 26 and 52, the only two for which assays are available, the highest silver values occur in their hanging-wall zones. However, silver in the upper part of hole 52 averages only about 1.5 oz/ton; sparse tetrahedrite occurs at 718 ft and 817 ft, but no samples were available from the two hanging-wall intervals which have >3 oz Ag/ton, the highest assay values for the hole.

The first assay interval in drillhole 26 has the highest silver values in the cross section, and only in this interval was a tetrahedrite-group mineral found. The correlation among tetrahedrite compositions, abundances, and high silver assays is remarkably consistent in that the tetrahedrite at this site contains more than 18 wt % Ag (Table 7).

Cross section F (Fig. 11) is complicated by faulting and by the apparent merger of the North Body with the Northwest Body (Fig. 9). However, this section is of particular interest in that drillhole 74 has sulphide intersections which are the second deepest in the Caribou deposit.

Near-surface drillhole 28 has three areas with important massive sulphides (Fig. 11), none of which is rich in silver. Only 3 of the 29 polished sections from the hole were observed to contain tetrahedrite; in each case the mineral is predictably low in silver content, with the maximum being 0.58 wt % Ag.

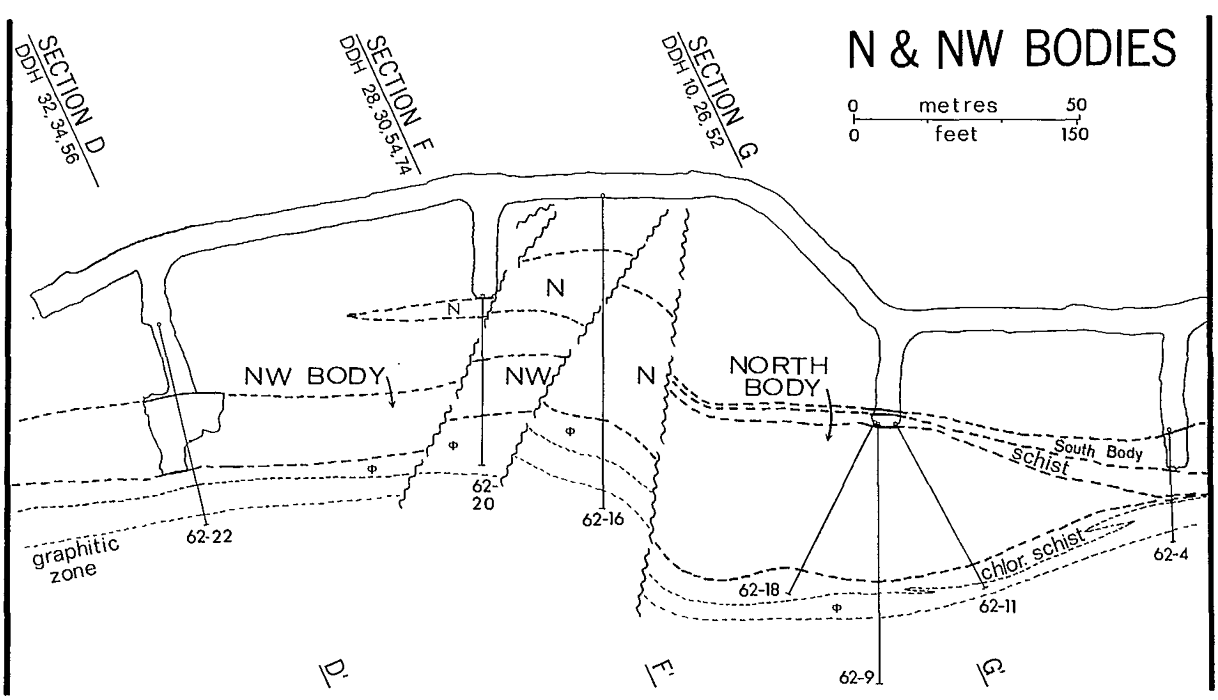

Fig. 9 - North and Northwest Sulphide bodies, 6200-level, showing the horizontal drillholes studied in detail

Table 7 - Compositions of tetrahedrite-group minerals, North and Northwest Bodies

Drillhole, footage	Area	No. of spots	Weight % Cu	Ag	Fe	Zn	Sb	As	S	total	Formula, based on 29 atoms Cu	Ag	Fe	Zn	Σ	Sb	As	Σ	S
62-9-103	1	6		0.8															
	2	5		0.6															
	3	3		0.7															
62-16-103	1	5		1.9-2.6															
	2	3		3.3															
	3	4		1.3-2.6															
62-20-10	1	3	34.9	4.4	3.8	3.4	28.4	0.3	24.5	99.7	9.30	0.68	1.15	0.88	12.01	3.95	0.07	4.02	13.0
	2	2		2.8															
-21	1	5	39.0	1.3	1.2	5.4	22.8	4.5	26.1	100.3	9.94	0.19	0.36	1.34	11.83	3.03	0.97	4.00	13.2
	2	5	38.4	1.3	1.7	5.6	24.4	3.5	25.8	100.7	9.82	0.20	0.50	1.38	11.90	3.25	0.76	4.01	13.1
	3	8	38.8	1.4	1.1	5.4	23.3	4.2	25.8	100.0	9.97	0.21	0.33	1.34	11.85	3.11	0.93	4.04	13.1
10-110	1	3	33.3	6.1	3.4	3.3	28.5	0.1	24.6	99.3	8.96	0.97	1.04	0.87	11.84	4.00	0.02	4.02	13.1
	2	5	34.7	6.0	4.8	1.7	27.4	0.8	24.6	100.0	9.24	0.93	1.45	0.44	12.06	3.81	0.17	3.98	13.0
-117	1	2	37.7	0.3	1.6	8.6	19.8	5.4	26.3	99.7	9.50	0.05	0.45	2.10	12.10	2.59	1.17	3.76	13.2
	2	2	37.5	0.2	3.1	6.5	17.4	7.8	26.7	99.2	9.36	0.03	0.89	1.57	11.85	2.27	1.65	3.92	13.2
-168	1	5	37.6	1.4	2.6	3.8	29.8	0.2	25.0	100.4	9.87	0.22	0.78	0.97	11.84	4.09	0.05	4.14	13.0
	2	6	37.7	1.4	2.8	3.6	30.1	0.1	25.0	100.7	9.89	0.22	0.83	0.92	11.86	4.12	0.03	4.15	13.0
26-324	1	2	23.9	18.4	5.2	0.9	27.5	1.0	23.1	100.0	6.75	3.08	1.67	0.23	11.73	4.07	0.23	4.30	13.0
	2	2	24.0	19.2	5.6	0.9	26.8	1.1	23.1	100.7	6.75	3.18	1.78	0.23	11.94	3.93	0.27	4.20	12.9
28-227	1	5	41.4	0.1	1.5	6.6	5.3	16.6	28.4	99.9	9.78	0.02	0.41	1.50	11.71	0.66	3.32	3.98	13.3
	2	4	40.6	0.1	2.7	6.3	5.5	16.2	28.4	99.8	9.60	0.02	0.71	1.44	11.77	0.68	3.25	3.93	13.3
-240	1	4	39.4	0.6	2.2	6.3	10.8	12.6	27.5	99.4	9.58	0.08	0.62	1.50	11.78	1.37	2.60	3.97	13.3
	2	3	39.6	0.3	2.2	6.5	12.6	10.9	27.3	99.4	9.69	0.05	0.61	1.54	11.89	1.62	2.25	3.87	13.3
-325	1	6	37.1	0.5	1.6	5.1	29.5	0.2	25.4	99.4	9.79	0.07	0.49	1.31	11.66	4.06	0.03	4.09	13.3
	2	8	36.9	0.5	2.2	4.8	29.6	0.2	25.1	99.3	9.76	0.08	0.64	1.23	11.71	4.08	0.05	4.13	13.2
54-621	1	2	28.9	9.8	5.4	3.4	26.9	0.5	24.3	99.2	7.84	1.57	1.67	0.90	11.98	3.81	0.12	3.93	13.1
	2	3	28.7	11.7	1.4	5.0	27.0	1.2	24.0	99.0	7.96	1.90	0.44	1.34	11.64	3.91	0.28	4.19	13.2
74-1632	1	8	34.2	5.1	1.1	5.4	27.2	1.5	24.9	99.4	9.15	0.80	0.34	1.39	11.68	3.79	0.34	4.13	13.2
	2	6	34.6	4.0	1.5	5.4	27.7	1.3	25.2	99.7	9.19	0.62	0.45	1.40	11.66	3.83	0.29	4.12	13.2
32-293	1	2	36.6	0.5	3.3	4.8	28.8	0.3	25.0	99.3	9.64	0.07	0.99	1.22	11.92	3.97	0.05	4.02	13.1
56-1040	1	3	29.5	10.8	5.9	1.2	28.0	0.4	24.0	99.8	8.08	1.74	1.82	0.31	11.95	3.99	0.09	4.08	13.0
	2	3	32.7	5.9	2.1	5.1	28.5	0.4	24.6	99.3	8.82	0.93	0.65	1.34	11.74	4.02	0.10	4.12	13.1
-1130	1	5	36.5	1.3	1.4	5.8	28.3	1.3	25.5	100.1	9.56	0.20	0.41	1.48	11.65	3.87	0.28	4.15	13.2
	2	3	36.1	1.9	1.8	5.9	27.8	1.2	25.2	99.9	9.50	0.28	0.52	1.49	11.79	3.81	0.27	4.08	13.1

Drillholes 62-9, 62-16, 62-20: 6200 level. Drillholes 10, 26: section G. Drillholes 28, 54, 74: section F. Drillholes 32, 56: section D.

Analytical standards and conditions are as reported in Table 1.

Although the average silver content in drillhole 30 exceeds that of drillhole 28, the two highest assay values are only 2.62 oz Ag/ton over 4 ft, and 2.16 oz Ag/ton over 5 ft. Traces of tetrahedrite were observed in only one sample from the hole, but no further studies were undertaken.

Three areas of massive sulphides were intersected in drillhole 54 (Fig. 11). The first area, interpreted to represent lenses of the North Body, is the only area with relatively high silver assays and is the only one containing observed occurrences of tetrahedrite. Microprobe analyses of one sample indicate that the tetrahedrite is appropriately rich in silver (Table 7).

Drillhole 74 contains two major sulphide intersections separated by a thick lense of schist (Fig. 11). The upper intersection may be part of the South Sulphide Body, whereas the lower may be the North Body. Silver content of the lower

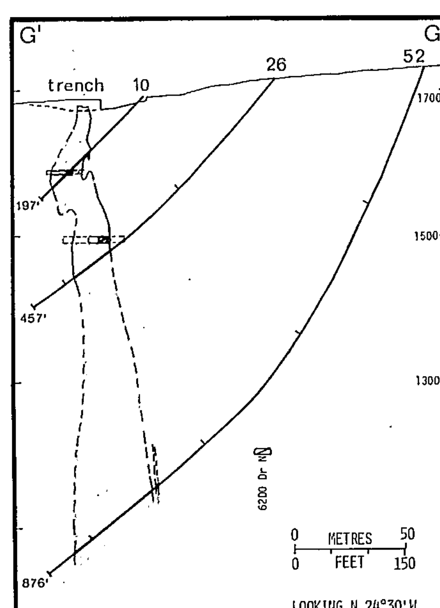

Fig. 10 - Cross section of the North Sulphide Body; elevations are in feet; horizontal and vertical scales are identical

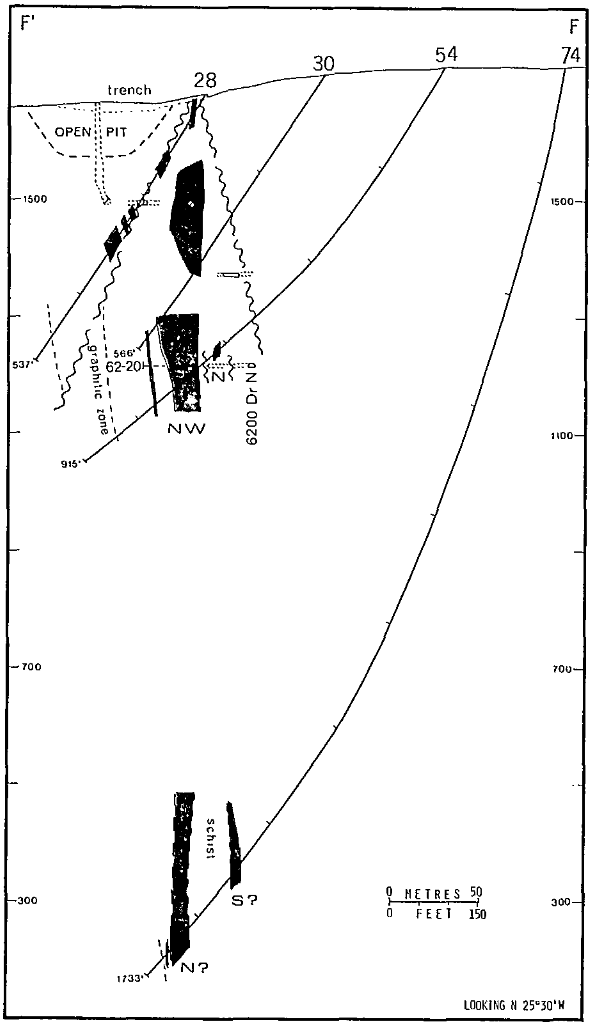

Fig. 11 - Cross section near the junction of the North and Northwest Sulphide Bodies (Fig. 9); elevations are in feet; horizontal and vertical scales are identical

intersection averages less than 2 oz Ag/ton. Moderately high hanging-wall silver values gradually decline towards the footwall. Tetrahedrite was observed only in the hanging wall; the mineral contains only 4.0 - 5.1 wt % silver (Table 7), but is sufficiently abundant to account for the assay values.

The width of the drill-intersected upper sulphide zone, possibly the South Body, is about 10 m. Assays indicate that the upper half of the zone is unusually rich in silver: the average for the first three intervals is more than 6 oz Ag/ton. Only three polished sections of the zone were available for study, and tetrahedrite is common in all. The two samples which are from the silver-rich hanging wall contain tetrahedrite with a minimum of 13.8 wt % Ag; in remarkable contrast, the silver-poor (<2 oz Ag/ton) footwall zone has tetrahedrites containing only 0.89 and 1.45 wt % Ag (Table 4).

NORTHWEST SULPHIDE BODY

The Northwest Sulphide Body may be an extension of the North Sulphide Body. Both have a high-grade hanging wall zone in which Pb+Zn exceeds 8% and in which the highest silver values occur.

The Northwest Sulphide Body on the 6200-level averages about 1 oz Ag/ton. Tetrahedrite was not observed in drillhole 62-22, nor in the relevant part of 62-20 (Fig. 9). In cross section D (Fig. 12), drillhole 32 has low silver contents (maximum: 2.2 oz Ag/ton over 5 ft); gold values are up to 0.3 oz/ton, the highest known to the writers for Caribou ore. Tetrahedrite, observed in only one polished section, is silver-poor as expected (Table 7); minute blebs of electrum are more widespread and account for the gold content.

Drillhole 34 has low silver assay values and no tetrahedrite. The hanging wall of drillhole 56 has some intervals moderately rich in silver. Of the two observed tetrahedrite occurrences, that in the hanging wall is much richer in silver, a trend once again in harmony with the assay data.

OPEN PIT SAMPLES

Although the mined-out, supergene-enriched zone at surface was not sampled systematically, several samples of hypogene and supergene ore were collected and examined microscopically. The primary sulphides are texturally similar to those in drill cores except that some of the surface material is appreciably coarser grained.

Surface samples were slabbed normal to the sulphide layering and, generally, series of

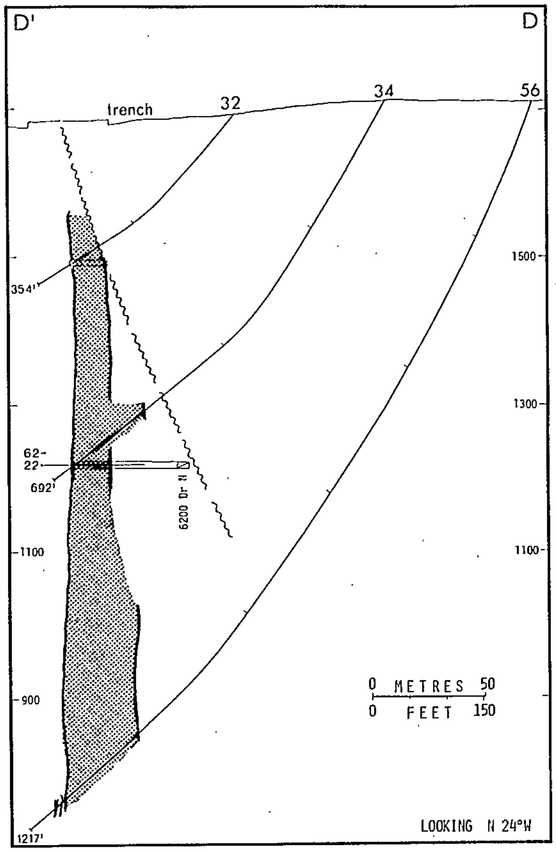

Fig. 12 - Cross section of the Northwest Sulphide Body; elevations are in feet; horizontal and vertical scales are identical

polished sections were prepared to examine the different layers. For example, CE-79A, CE-79B and CE-79C are polished sections cut from stratigraphically sequential layers in surface hand-specimen 79 from the Caribou East Body.

Microprobe analyses of tetrahedrites from four surface samples are given in Table 8; one sample is from the western limb of the Caribou fold and the others are from the East Body. The analytical procedures and standards were the same as for subsurface samples. Mercury, common only in surface samples, was determined by adjusting the specimen current to 0.05 μA and increasing the counting time to 50 seconds. The detection limit with these conditions is estimated to be 0.04 wt % Hg.

All analyzed tetrahedrites in the surface samples are rich in silver. Sample CW-80D (Table 8) is especially notable in that its silver content, the highest obtained in Caribou analyses, extends well into the freibergite part of the tetrahedrite group. In addition to being silver-rich, all except one of the surface tetrahedrites contain up to 0.6 wt % mercury, thus contrasting markedly with subsurface tetrahedrites, only one of which contains detectable mercury.

Table 8 - Compositions of tetrahedrite-group minerals, Caribou open pit

Hand sample	Polished section	Area	No. of spots	Weight %									Formula, based on 29 atoms									
				Cu	Ag	Fe	Zn	Hg	Sb	As	S	total	Cu	Ag	Fe	Zn	Hg	Σ	Sb	As	Σ	S
CE-78	A	1	8	29.0	12.4	3.0	2.4	0.27	28.2	0.5	23.8	99.6	8.06	2.03	0.94	0.64	0.02	11.69	4.08	0.11	4.19	13.1
		2	6	28.6	13.5	3.0	2.3	0.20	28.4	0.2	23.8	100.0	7.93	2.20	0.93	0.64	0.02	11.72	4.11	0.05	4.16	13.1
	C	1	10	33.3	7.1	2.5	2.9	0.39	28.8	0.1	24.4	99.5	9.05	1.14	0.78	0.76	0.03	11.76	4.08	0.03	4.11	13.1
		2	4	31.3	9.1	2.7	2.6	0.47	28.8	0.3	24.5	99.8	8.56	1.46	0.83	0.69	0.03	11.57	4.10	0.07	4.17	13.3
CE-79	A	1	4	28.5	12.6	3.6	2.1	0.30	27.8	0.9	23.9	99.7	7.90	2.06	1.14	0.58	0.02	11.70	4.01	0.21	4.22	13.1
		2	4	30.6	11.1	2.6	3.7	0.20	27.6	0.7	24.5	101.0	8.28	1.77	0.81	0.98	0.02	11.86	3.90	0.15	4.05	13.1
	C	1	4	30.1	11.7	4.6	1.7	0.05	27.3	0.8	24.0	100.2	8.21	1.88	1.42	0.45	--	11.96	3.89	0.17	4.06	13.0
		2	4	30.0	11.9	4.7	1.4	0.10	27.2	0.7	24.0	100.0	8.20	1.91	1.46	0.38	0.02	11.97	3.89	0.16	4.05	13.0
	E	1	5	29.9	9.5	5.0	1.7	0.44	28.5	0.6	24.3	99.9	8.15	1.52	1.56	0.45	0.03	11.71	4.05	0.12	4.17	13.1
		1	5	29.8	10.2	5.1	1.5	0.29	28.3	0.6	24.2	100.0	8.11	1.65	1.59	0.40	0.02	11.77	4.02	0.14	4.16	13.1
		2	5	29.2	11.1	4.9	1.7	n.d.	28.3	0.7	24.4	100.3	7.93	1.78	1.52	0.43	--	11.66	4.01	0.17	4.18	13.2
		3	8	29.1	11.5	4.7	1.7	0.38	27.6	1.3	24.1	100.4	7.93	1.84	1.46	0.45	0.03	11.71	3.94	0.29	4.23	13.1
		4	6	29.0	11.2	4.3	1.7	0.23	27.7	0.4	24.4	98.9	7.99	1.82	1.35	0.47	0.02	11.65	3.97	0.10	4.07	13.3
CE-10		1	5	29.9	11.4	4.4	1.7	0.60	27.7	0.6	24.2	100.5	8.16	1.82	1.37	0.45	0.05	11.85	3.94	0.14	4.08	13.1
		2	4	28.8	13.0	4.5	1.7	0.60	28.0	0.1	23.8	100.5	7.92	2.12	1.42	0.45	0.05	11.96	4.02	0.03	4.05	13.0
CW-80	D	1	6	17.4	9.2	0.4	2.3	0.11	26.7	0.5	21.0		}range in composition									
				31.2	28.8	3.1	4.7	0.35	28.5	0.8	24.3											
		2	6	17.1	24.1	3.6	0.9	0.38	25.9	0.5	20.6		}range in composition									
				20.6	29.4		1.7		29.0		21.9											

Analytical standards and conditions are as reported in Table 1. n.d.: not detected

OTHER SILVER MINERALS

Attention has been focused on the presence of silver in solid solution in galena and in tetrahedrite-freibergite. As etch tests have failed to reveal exsolved or intergrown silver minerals in galena, it is concluded from the microscopical and microprobe studies that no other major silver or silver-bearing minerals are present in the Caribou ore.

Among the lesser silver carriers, electrum is concluded to be the most important. Grains up to 35 μm in diameter have been noted, but most are less than 5 μm. Microprobe analyses of five grains in one sample gave 56.5 - 58.2 wt % Au and 41.4 - 42.5 wt % Ag. Johnson (1975) reported an analysis with Au 48.45 and Ag 49.99 wt %. As the average gold content of the Caribou ore is 0.04 oz/ton, it is concluded that electrum is a very minor component of the silver reserves and accounts for only 0.03 - 0.04 oz Ag/ton.

A polybasite-type mineral which occurs with argentian tetrahedrite was identified in a silver-rich part of drillhole 16 (at 189 ft; Table 4). Microprobe analysis gave Ag 69.0, Cu 3.8, Sb 10.2, S 15.1, (As, Bi n.d.) totalling 98.1 wt %, which corresponds to

$$(Ag_{14.8}Cu_{1.4})_{\Sigma=16.2}Sb_{1.9}S_{11}$$

The grains are too small to identify by X-ray diffraction.

Optically homogeneous silver-bearing chalcopyrite has been noted to occur in the Kidd Creek, Ontario massive sulphide deposit (Thorpe et al. 1976) and in concentrates from the Heath Steele deposit near Bathurst (Chen and Petruk 1978). Argentian chalcopyrite tarnishes rapidly, which aids recognition, but freshly polished grains have much lower silver content than tarnished grains (D.R. Owens, written communication 1978). Thus, much of the silver may be related to secondary diffusion rather than representing true values in solid solution. Although chalcopyrite of this type has been recognized in the Caribou ore, the grains are too small and too few for microprobe analyses.

Other silver minerals are acanthite and stephanite, both identified by microprobe analyses of Caribou copper concentrates (T.T. Chen, oral communication 1978). These, and the aforementioned chalcopyrite and polybasite, make up a negligibly small fraction of the silver in the deposit.

GEOCHEMISTRY OF TETRAHEDRITE-GROUP MINERALS AND GALENA

Tetrahedrite group

Small amounts of tetrahedrite-group minerals are widely but irregularly dispersed in the Caribou deposit. Microprobe analyses indicate that tennantite and freibergite are rare, and that tetrahedrite is highly variable in its silver content. The various textures of tetrahedrite, e.g., veinlet versus disseminated, are not correlative with composition, and contact with various sulphide and gangue minerals also seems to have had no influence on composition.

Most individual, apparently homogeneous, tetrahedrite grains are variable in composition, but within a relatively narrow range. Adjacent tetrahedrite grains, even if in the same sulphide layer, generally do not have identical compositions, nor do the grains necessarily have overlapping compositions. However, this chemical heterogeneity is not unlimited: individual elements in tetrahedrite from a single polished section rarely vary by more than 4 wt %. Thus, with only one exception, the coexistence of silver-rich and relatively silver-poor tetrahedrite has not been observed.

In terms of total composition range, Caribou tetrahedrite is extremely variable but not patternless with respect to metal affinities. For example, substitution of silver for copper is readily apparent, but also evident is that silver is abundant only in the tetrahedrite-group minerals richest in antimony (Fig. 13). All Caribou tetrahedrite with more than 3 wt % Ag contains less than 26 wt % Sb; nevertheless, when Sb exceeds 26%, silver content may still be low.

Tetrahedrite iron and zinc contents,

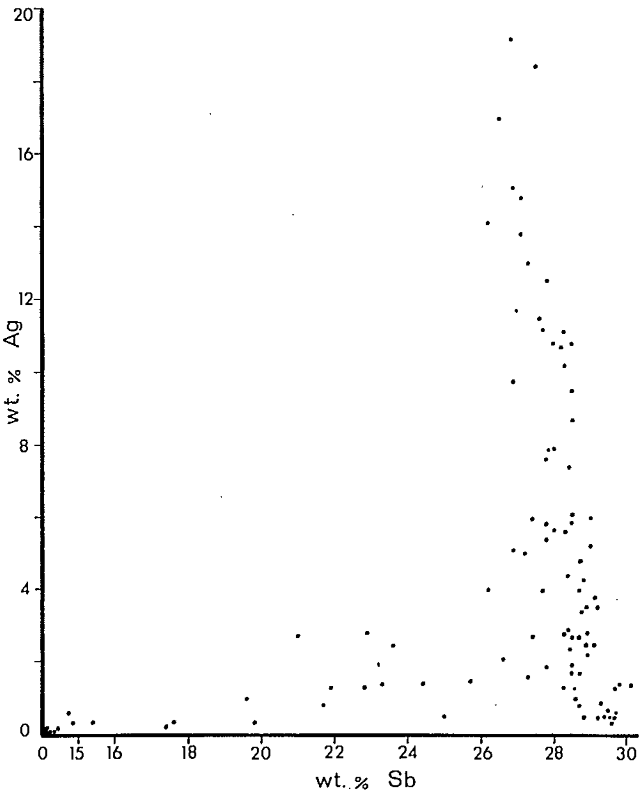

Fig. 13 - Microprobe wt % Ag versus wt % Sb of Caribou tetrahedrite-group minerals; high Ag is present only with high Sb

seemingly random from a perusal of the microprobe analyses, show some degree of correlation with silver: the number of iron atoms per formula increases as silver increases (Fig. 14) and zinc therefore has an opposite trend.

Correlations among stratigraphic position and tetrahedrite abundances and compositions are generally ambiguous. Tetrahedrite occurrences in the North Sulphide Body are few, but are confined to the hanging wall, the footwall, or both. The East Body is mineralogically distinct in that it alone contains widespread tetrahedrite; the occurrences are locally almost continuous across the stratigraphic layering, but in other drillholes a separation into hanging-wall and footwall zones is evident. Tetrahedrites from the basal part of the footwall are generally low in silver, and none is silver-rich. In addition to this across-layer cryptic zoning, along-layer changes occur; if these lateral variations are systematic, the pattern remains unidentified. However, a conspicuous example of lateral variation is present in the East Body, where normal tetrahedrite compositions are supplanted by mercurian tetrahedrite and freibergite in primary ore at surface.

Cavalero (1972) stated that sulphide lenses on the west limb of the Caribou fold (South, North and Northwest Bodies) have lead and zinc concentrated along their hanging walls, and that silver values vary in proportion to the Pb+Zn content. A more correct statement is that silver, as well as lead and zinc, is concentrated in the hanging-wall zones and all three metals decrease toward the footwall zones. Most important is that a direct crystallochemical relationship between silver and lead-zinc not be inferred. Assays with high silver values almost invariably can be traced to the presence of silver-rich tetrahedrite, viz., higher Pb and Zn which occur along the hanging walls reflect either the common occurrence of tetrahedrite which is moderately silver-rich, or the sparse occurrence of tetrahedrite containing copious silver.

Galena

About half of the analyzed Caribou galena samples contain silver at or above the microprobe detection limit of 0.04 wt % Ag. The silver, antimony and bismuth contents of galena are given in Table 9. The values listed for silver were derived by averaging the results per area as given in Tables 2, 3 and 5. The same procedure was used to obtain average antimony and bismuth; for all three elements, results below the detection limit were assigned 0 wt %. For the 88 areas analyzed for silver, assigning n.d. = 0 leads to an average of 0.102 wt % Ag; if results below the detection limit of 0.04 wt % Ag are assigned half this value (n.d. = 0.02), the average for the 88 areas is 0.108 wt % Ag, i.e., there is no significant change.

Although neither Sb nor Bi is discussed in terms of overall averages, it can been seen in Table 9 that relatively few Sb analyses exceed the detection limit of 0.03 wt %. Therefore, the overall Sb average is largely dependent on the

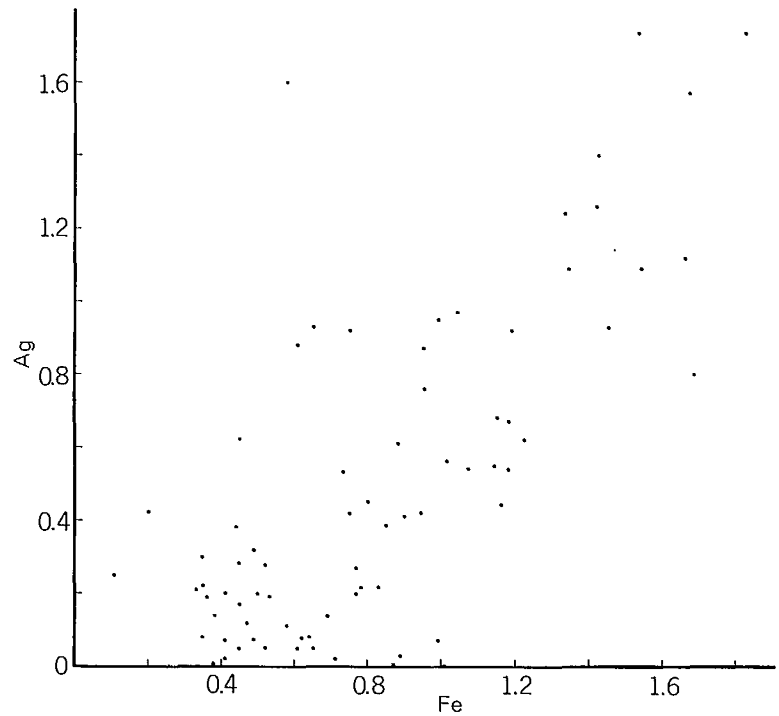

Fig. 14 - Microprobe analyses of Caribou tetrahedrite, showing the correlation between the formula atoms of Ag versus Fe

value assigned to n.d.; with n.d. = 0, the 77 analyzed areas average 0.016 wt % Sb, and with n.d. = 0.015 the average is 0.027 wt % Sb. More relevant, however, is that only nine of the Sb values in Table 9 are numerical (the others are n.d.); these nine values represent 30 analyzed areas for which Sb averages 0.041 wt % with n.d. = 0, and 0.043 wt % with n.d. = 0.015. Table 9 also contains 24 Bi averages, of which 11 are n.d. and 13 are numerical. The latter represent 41 analyzed areas for which the average wt % Bi is 0.322 with n.d. = 0, and 0.340 with n.d. = 0.075.

Individual analyzed spots show that Caribou galena contains up to 0.11 wt % Sb, up to 0.66 wt % Ag, and up to 1.58 wt % Bi. Antimony is more erratic than bismuth from spot to spot, and only bismuth correlates well with silver content. For individual areas (the average of several spots), Fig. 15 shows that bismuth-rich galena is also silver-rich when Bi exceeds 0.2 wt %. For the numerous galena samples without detectable Bi, the maximum Ag content was found to be 0.11 wt %.

Table 9 - Silver-antimony-bismuth contents of Caribou galena

	drillhole, footage	no. of areas analyzed*	av wt % Ag	wt % Sb av	wt % Sb range	wt % Bi av	wt % Bi range
EAST BODY	62-5-53	3	0.02	0.09	n.d.-0.11	n.d.	
	-56	3	0.11	n.d.		0.28	n.d.-0.60
	-58	2	n.d.	n.d.		n.d.	
	-62	2	0.11	n.d.		0.13	n.d.-0.28
	-67	3	0.08	0.04	n.d.-0.08	0.09	n.d.-0.26
	-72	3	0.04	n.d.		n.d.	
	-77	4	0.05	n.d.		n.d.	
	-88	3	n.d.	n.d.		n.d.	
	13-537	4	0.06	0.04	n.d.-0.05	n.d.	
	-547	4	n.d.	n.d.		n.d.	
	11-265	3	0.02	0.06	0.05-0.09	n.d.	
	-275	3	0.06	0.01	n.d.-0.05	0.06	n.d.-0.23
	-281	3	n.d.	0.04		n.d.	
	-286	4	0.01	0.03	n.d.-0.04	n.d.	
	-290	4	0.02	0.05		0.11	n.d.-0.50
	-295	3	0.07	n.d.		0.14	n.d.-0.38
	12-277	6	0.18				
SOUTH BODY	62-1-63	3	0.13	n.d.		0.26	0.17-0.36
	62-4-17	3	0.08	0.02	n.d.-0.05	n.d.	
	16-157	3	0.30	n.d.		0.70	0.56-0.79
	-189	5	0.17				
	-206	2	0.13	n.d.		0.29	0.22-0.37
	-220	4	0.16	n.d.		0.32	0.25-0.43
	-235	3	0.15	n.d.		0.26	0.22-0.43
	18-450	4	0.07	n.d.		0.12	n.d.-0.27
	-457	4	0.47	n.d.		1.21	0.92-1.58

Microprobe analyses at 25kV, 0.05μA, 50-second counting periods, using Ag*Lα*, Sb*Lα*, Bi*Lα* (metals), and synthetic PbS for background corrections. Minimum detection limits in wt %: Ag 0.04, Sb 0.03, Bi 0.15.

*Each area represents an average of 6 analyzed spots.

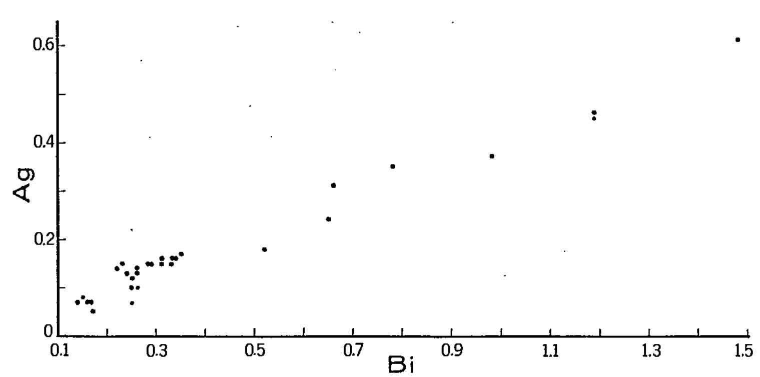

Fig. 15 - Correlation between wt % Ag and wt % Bi obtained by microprobe analyses of Caribou galena; each dot represents the average obtained from several spot analyses in a single area

SILVER BUDGET

The lead content of the Caribou ore reserves is 1.7% Pb; as all except traces of the metal is attributable to galena, the average grade is 1.96% PbS. The maximum silver content found in 465 spot analyses of galena is 0.66 wt %, and the average is 0.10 wt %. The spot analyses were obtained from B8 different areas; the average silver content of galena in these areas is also 0.10 wt %. The areas represent 29 polished sections in which galena averages 0.09 wt % Ag.

Regardless of which of the above silver values for galena is used, the average is low. Nevertheless, it was suspected that there may have been bias toward a high average because of the inclusion of several silver-rich samples known to be devoid of tetrahedrite and therefore highly likely to contain argentiferous galena. However, from microscropic studies and a plot of whole-rock silver versus silver in galena (Fig. 16), it is concluded that the rocks with low silver values mainly reflect a paucity of galena. Thus, the suspected bias toward a high average is probably slight or unfounded, and the value accepted is

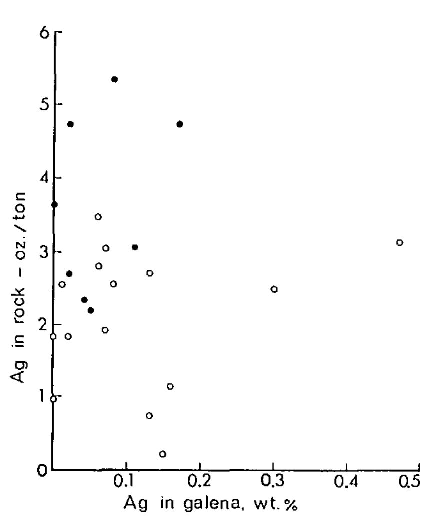

Fig. 16 - Whole-rock silver versus microprobe-determined silver in galena; solid circles represent samples which are tetrahedrite-bearing; open circles represent samples without observed tetrahedrite

taken as 0.10 wt % Ag. Therefore, solid-solution silver in galena probably accounts for only about 0.47 oz Ag/ton in the ore reserves.

The gold content of the Caribou ore, 0.04 oz/ton, is attributable to electrum with the Au:Ag ratio roughly 1:1 or higher. Accordingly, the maximum amount of ore-reserve silver assignable to the presence of electrum is about 0.04 oz/ton. Silver sulphosalts and acanthite are extremely rare and unlikely account for more than 0.03 oz Ag/ton.

The sum of the contribution of galena and the lesser silver carriers mentioned above is 0.54 oz Ag/ton, and the remainder of the silver in the ore-reserve grade is concluded to be present in tetrahedrite-freibergite. The average grade, 1.7 oz Ag/ton, is apportioned as follows: 68% (1.16 oz) in tetrahedrite-freibergite, 28% (0.47 oz) in galena, and 4% (0.07 oz) in minor minerals, the most abundant of which is electrum.

The above distribution is based on average metal grades for the whole of the Caribou deposit. Grades in the individual sulphide bodies are not equal, nor are the mineral distributions equal. In particular, the East Body has an above-average silver grade and also has the most abundant and most persistent occurrences of tetrahedrite. As well, there are indications that galena in the East Body is low in silver and bismuth, and thus silver allocation to tetrahedrite undoubtedly exceeds the 69% average for the whole deposit. It is evident, therefore, that the three sulphide lenses on the western limb of the Caribou fold have below-average tetrahedrite contents, but above-average solid-solution silver in galena. These facts have an important bearing on concentrate production and metal recoveries.

Almost all tetrahedrite in the Caribou deposit occurs as disseminated anhedral grains which are texturally uncomplicated and amenable to liberation. Therefore, ore from the East Body should give good silver recoveries and most of the silver should report to a copper rather than a lead concentrate. The general absence of fine-grained, inclusion-type tetrahedrite indicates that most copper losses to the tails will be as chalcopyrite and that the proportion of recoverable tetrahedrite will be higher than that of chalcopyrite.

Although ore grades and tonnages for the individual Caribou sulphide bodies are not known to the writers, the following rough calculations demonstrate the pronounced effects of silver-host variations. If the results for solid-solution silver in East Body galena as given in Table 9 are indicative, and if it is assumed that the East Body grades 2 oz Ag/ton and 2.5% Pb, then roughly 76% of the silver in this lense is present in tetrahedrite and 21% in galena. On the other hand, a sulphide lense with, say 1.2 oz Ag/ton and 1.7% Pb, and with argentian galena similar to that indicated for the South Body (0.19% Ag) would contain 75% of the silver in solid solution in galena and only 19% of the silver in tetrahedrite. Thus the bulk of the silver would report to the lead concentrate regardless of whether lead and copper separates were prepared. Of even more significance is that the high percentage of Caribou lead lost to the tailings will carry proportionately high losses of silver. Therefore, it is critically important that bulk samples for milling tests be identified precisely with respect to a sulphide orebody and drawpoints within that body. In terms of possible recoveries of silver, the East Sulphide Body has the highest ore-reserve silver grade, the most favourable host mineralogy, and the best potential for high silver recovery.

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