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MAJOR GOLD-SILVER DEPOSITS OF THE NORTHERN CANADIAN CORDILLERA

Field Note Book September 22-26, 1988

Coordinated and sponsored by:

Geological Survey Branch

British Columbia Ministry of
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Hosted by:

City Resources (Canada) Limited

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SEG TOUR 1988
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TABLE OF CONTENTS

SEG FIELD TRIP, SEPTEMBER 22-26, 1988
MAJOR GOLD-SILVER DEPOSITS OF THE NORTHERN CANADIAN CORDILLERA

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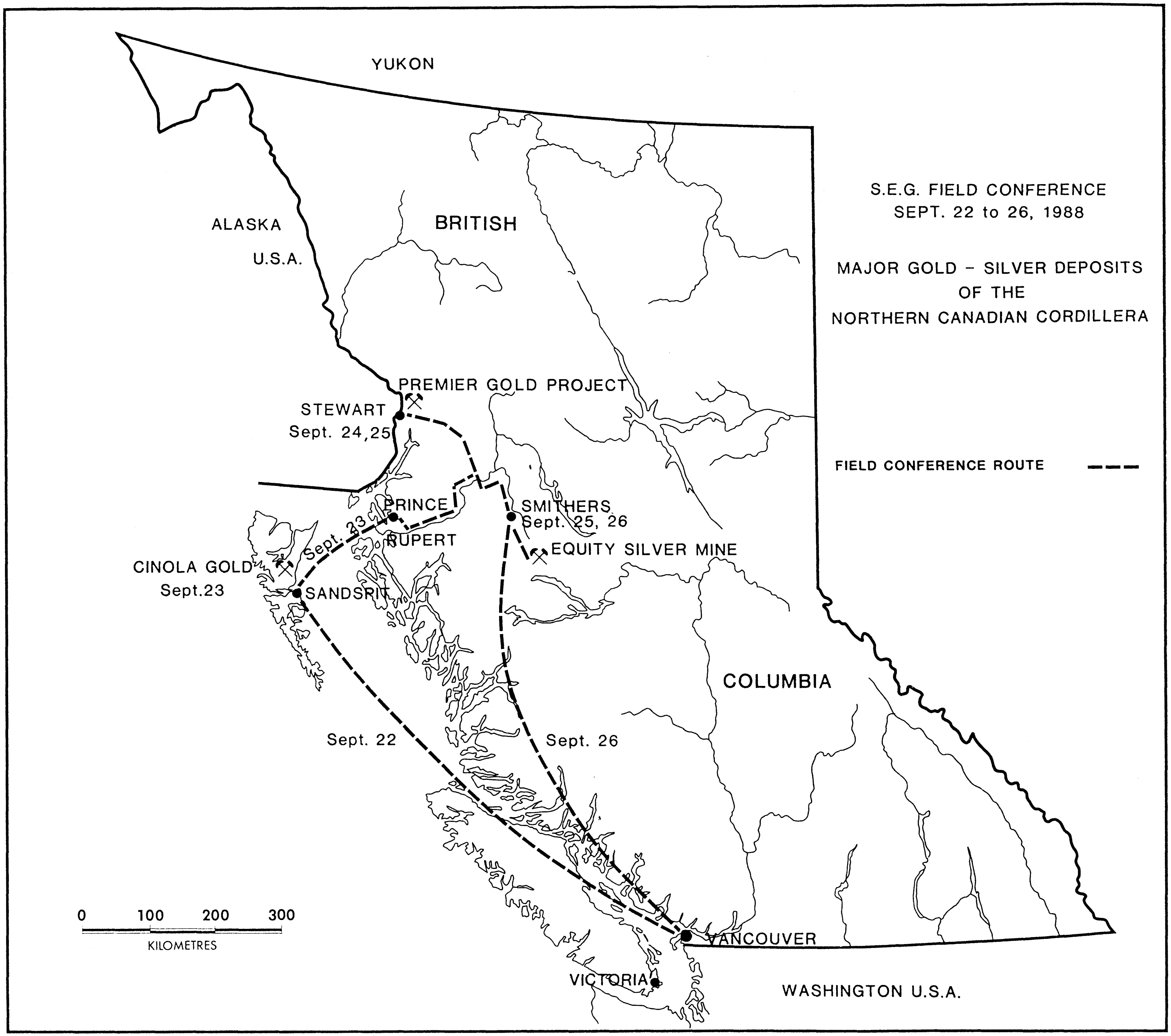
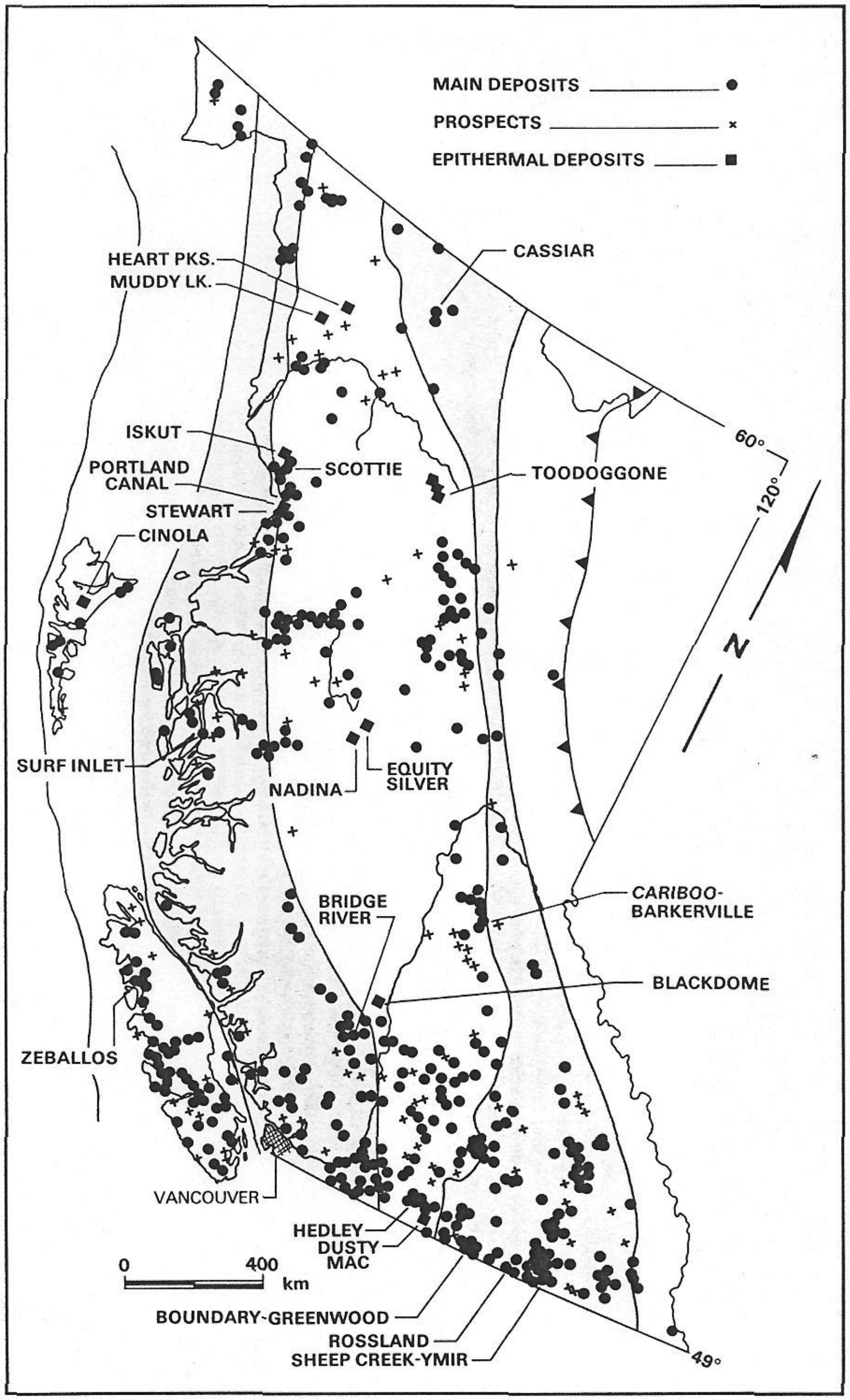

S.E.G. FIELD CONFERENCE
SEPT. 22 to 26, 1988
MAJOR GOLD - SILVER DEPOSITS
OF THE
NORTHERN CANADIAN CORDILLERA
FIELD CONFERENCE ROUTE
YUKON
BRITISH
COLUMBIA
ALASKA
U.S.A.
PREMIER GOLD PROJECT
STEWART
Sept. 24,25
PRINCE
RUPERT
Sept. 23
SMITHERS
Sept. 25, 26
EQUITY SILVER MINE
CINOLA GOLD
Sept.23
SANDSPIT
Sept. 22
Sept. 26
VANCOUVER
VICTORIA
WASHINGTON U.S.A.
0
100
200
300
KILOMETRES



Distribution of gold deposits in British Columbia showing major camps, individual deposits and areas of recent exploration activity. Lines indicate major tectono - physiographic boundaries. Crystalline - metamorphic terranes of the Coast Plutonic Belt in the west and Omineca Belt in the east are shown by the hachured pattern.

SEG Major Gold-Silver Deposits of the Northern CanadianCordillera
September 22 to 26, 1988.

September 22, Day 1:

- Depart: Vancouver at 6:50 PM (18:50 hours) via
  Canadian Airlines International Flight #177
  -Flight tickets to be picked up at Canadian Airlines counter in your name at Vancouver International Airport.
  Watch for the SEG sign and representatives.
  Convene in flight lounge at designated gate.
- Arrive: Sandspit, Queen Charlotte Islands 9:15 PM
- Overnight: The Sandspit Inn
  P.O. Box 215, Sandspit, B.C.
  V0T 1T0 Tel. (604) 637-5334
- Welcome/briefing session: Cinola Project 10 - 11 PM

September 23, Day 2:

- Breakfast: Sandspit Inn 6:00 AM
- Visit: Cinola Mine, City Resources Ltd
- Depart: Sandspit to Prince Rupert via Trans-Provincial Airlines charter
  first group at 4:30 PM, second group at 6:30 PM.
- Overnight: Prince Rupert Hotel
  Box 338, Prince Rupert, B.C.
  V8J 3P9 Tel. (604) 624-6711

September 24, Day 3:

- Breakfast: Prince Rupert Hotel, 7:30 AM
- Depart: Bus ride to Stewart, arrive 3 PM
- Briefing session: Stewart area and deposits/Equity Silver Mine @ 4-6 PM
- Group Dinner: King Edward Hotel
- Overnight: King Edward Hotel
  Box 86, Stewart B.C.
  V0T 1W0 Tel. (604) 636-2244

September 25, Day 4:

- Breakfast: King Edward Hotel
- Visit: Premier Gold Mine, Westmin Resources
- Happy Hour in Hyder, Alaska
- Depart: Bus ride to Smithers for late Supper
- Arrive: Hudson Bay Lodge approx 8:30 PM
- Overnight: Hudson Bay Lodge
  P.O. Box 3636, Smithers, B.C.
  V0J 2N0 Tel. (604) 847-4581

September 26, Day 5:

- Breakfast: Hudson Bay Lodge, 6:30 AM
- Depart: 7:30 AM, bus ride to Equity Silver Mine
- Visit: Equity Silver Mine, depart 1 PM
- Depart: Smithers at 3:40 PM (15:40 hours) via
  Canadian Airlines International Flight #678
- Arrive: Vancouver 5:55 PM (17:55 hours).

Lode Gold-Silver Deposits in Northwestern British Columbia*

T.G. SCHROETER and A. PANTELEYEV
British Columbia Ministry of Energy, Mines and Petroleum Resources
Victoria, British Columbia

Abstract

Lode gold-silver deposits in northwestern British Columbia have been mined since the turn of the century. The deposits can be subdivided into five genetic classes: vein-replacement and porphyry copper-epithermal transition types, in which precious metals are the primary products, and porphyry copper, massive sulphide, and skarn deposits, in which precious metals are by-products. Two deposits, Silbak Premier and Equity Silver (Sam Goosly) account for nearly one half of the total gold and silver produced. Altogether 151 deposits in 19 main areas or 'camps' of northwestern British Columbia have yielded nearly 117 700 kg gold (3.7 million ounces) and 3.66 million kg silver (117.6 million ounces). This represents 20 per cent of British Columbia's total production. Tables listing all recorded gold-silver production and reserves for 172 deposits are given.

Exploration for new deposits and reassessment of known prospects is ongoing, particularly for higher grade epithermal type deposits but also for larger, bulk-minable replacement deposits.

Introduction

This report outlines lode gold-silver production and geological reserves in northwestern British Columbia in NTS areas 114, 104, 103, 94, and 93 (Figs. 1 and 2) and lists all deposits with recorded gold production (Tables I, II, and III). For geological descriptions of individual deposits and major camps refer to Barr (1980).

The first chronicled discovery of lode gold in the Province of British Columbia was in 1851 at Thetis Cove (Mitchell Inlet) on the west coast of Moresby Island, Queen Charlotte Islands where the Hudson's Bay Company reportedly recovered 'appreciable' amounts of gold from open cuts on rich shoots in a small vein exposed at tidewater (Galloway, 1932). This was the first gold mining venture in British Columbia and preceded the discovery of placer gold by six years.

* Excerpts from Canadian Institute of Mining and Metallurgy Special Volume 37, Mineral Deposits of Northern Cordillera, J.A. Morin, ed, pp. 178-190.

The earliest major gold production in northwestern British Columbia began in 1861 following discovery of placer gold along the Stikine River. Placer deposits discovered in the Omineca (Germanson River), 1869-1871, Stikine (Dease Lake-Cassiar), 1873-1874, and Atlin, 1898, Mining Divisions resulted in recorded production of nearly 1 million ounces of gold (Holland, 1950).

Interest in lode gold-silver deposits increased at the beginning of this century as returns from the rich placer fields diminished and the miners and prospectors turned their attention to the bedrock sources of the placer gold. The first mining venture to ship more than 100 tons of ore was the Imperial mine near Atlin, where quartz veins yielded nearly 100 ounces of gold from 290 tons of ore in 1899-1900. The first undertaking leading to major lode gold production began in 1902 at the Princess Royal Group, later Surf Inlet Mines (Plate 1). This north coast vein mining operation continued until 1943 and became the fourth largest precious metal producer in northwestern British Columbia; production was almost 390,000 ounces of gold and 200,000 ounces of silver from approximately 1 million tons of ore.

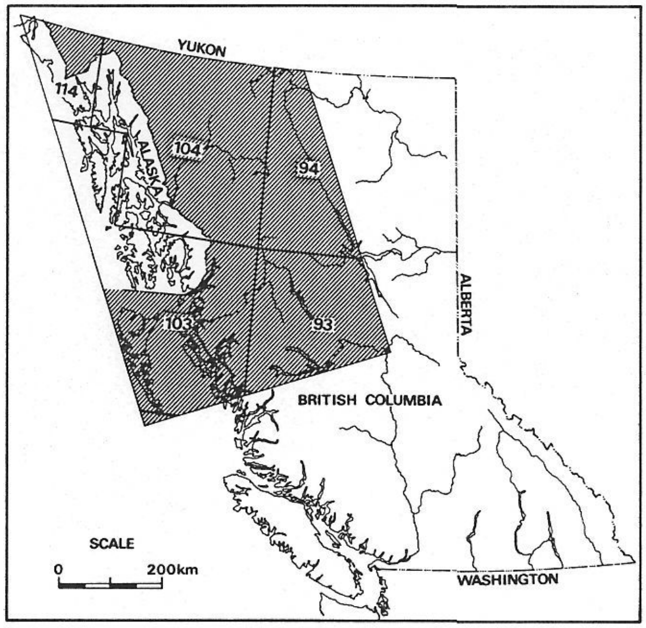


Figure 1: Location of northwestern British Columbia lode gold-silver deposits

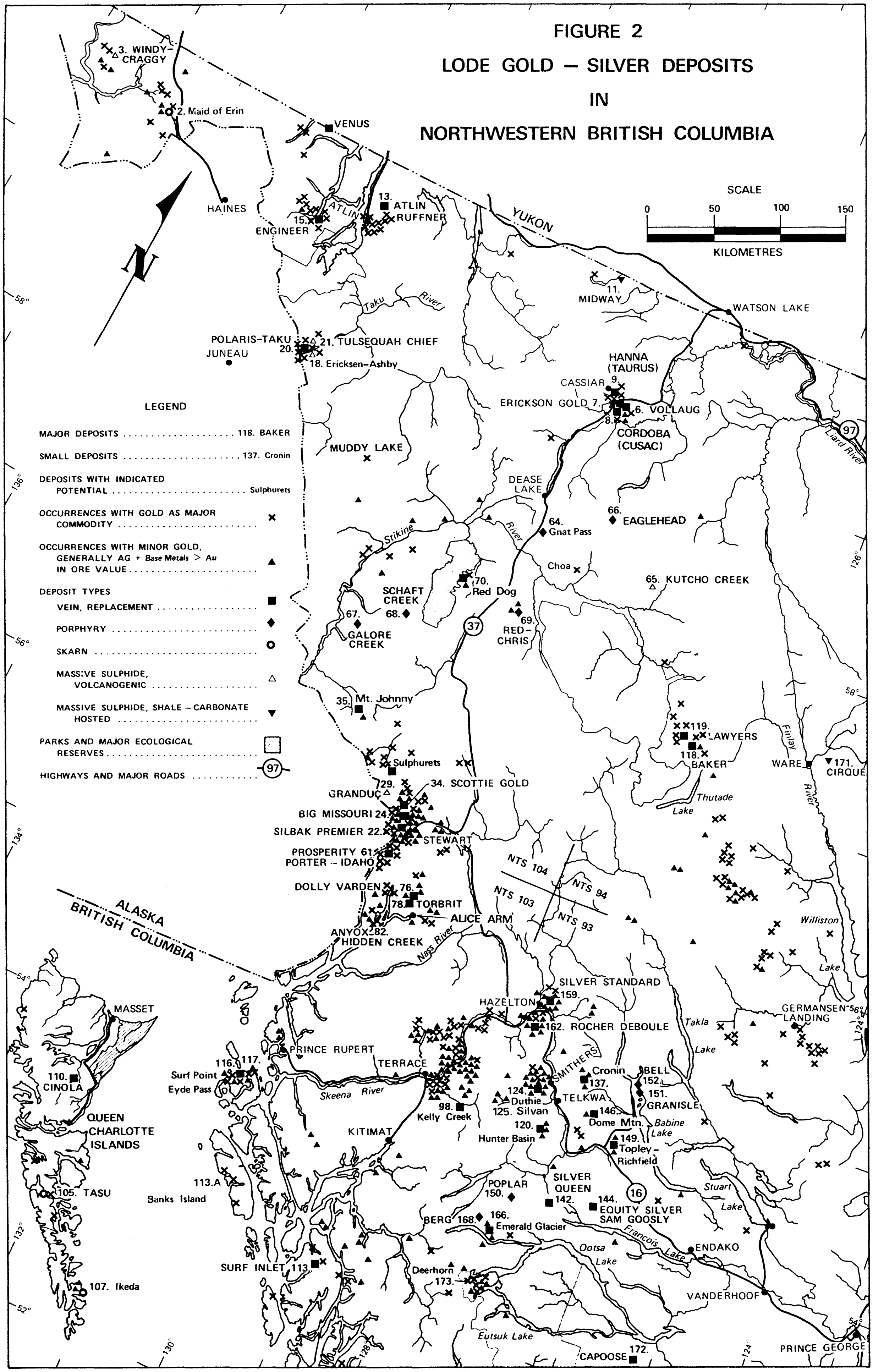


FIGURE 2
LODE GOLD – SILVER DEPOSITS
IN
NORTHWESTERN BRITISH COLUMBIA
SCALE
0 50 100 150
KILOMETRES
LEGEND
MAJOR DEPOSITS .... 118. BAKER
SMALL DEPOSITS .... 137. Cronin
DEPOSITS WITH INDICATED POTENTIAL .... Sulphurets
OCCURRENCES WITH GOLD AS MAJOR COMMODITY
OCCURRENCES WITH MINOR GOLD, GENERALLY AG + Base Metals > Au IN ORE VALUE
DEPOSIT TYPES
VEIN, REPLACEMENT
PORPHYRY
SKARN
MASSIVE SULPHIDE, VOLCANOGENIC
MASSIVE SULPHIDE, SHALE – CARBONATE HOSTED
PARKS AND MAJOR ECOLOGICAL RESERVES
HIGHWAYS AND MAJOR ROADS
97
3. WINDY-CRAGGY
2. Maid of Erin
VENUS
HAINES
13. ATLIN
RUFFNER
15.
ENGINEER
YUKON
11. MIDWAY
WATSON LAKE
POLARIS-TAKU
20.
21. TULSEQUAH CHIEF
18. Ericksen-Ashby
JUNEAU
Taku River
HANNA (TAURUS)
CASSIAR 9.
ERICKSON GOLD 7.
6. VOLLAUG
8.
CORDOBA (CUSAC)
Liard River
MUDDY LAKE
DEASE LAKE
64. Gnat Pass
66. EAGLEHEAD
Stikine
Choa
65. KUTCHO CREEK
70. Red Dog
SCHAFT CREEK
68.
67.
GALORE CREEK
69. RED-CHRIS
37
35. Mt. Johnny
119. LAWYERS
118. BAKER
WARE
171. CIRQUE
Finlay River
Sulphurets
29.
34. SCOTTIE GOLD
GRANDUC
BIG MISSOURI 24.
SILBAK PREMIER 22.
STEWART
Thutade Lake
PROSPERITY 61.
PORTER – IDAHO
NTS 104
NTS 94
NTS 103
NTS 93
DOLLY VARDEN
76.
78. TORBRIT
ALICE ARM
ANYOX 82.
HIDDEN CREEK
Nass River
ALASKA
BRITISH COLUMBIA
Williston Lake
SILVER STANDARD
HAZELTON
159.
162. ROCHER DEBOULE
GERMANSEN LANDING
MASSET
PRINCE RUPERT
TERRACE
Takla Lake
116. 117.
Surf Point
Eyde Pass
110. CINOLA
Skeena River
SMITHERS
Cronin
137.
BELL 152.
151. GRANISLE
124. Duthie
125. Silvan
TELKWA
98. Kelly Creek
146. Dome Mtn.
Babine Lake
QUEEN CHARLOTTE ISLANDS
KITIMAT
120.
Hunter Basin
149. Topley-Richfield
113.A
Banks Island
105. TASU
POPLAR 150.
SILVER QUEEN 142.
144. EQUITY SILVER
SAM GOOSLY
16
Stuart Lake
BERG 168.
166. Emerald Glacier
Ootsa Lake
Francois Lake
ENDAKO
SURF INLET 113.
Deerhorn
173.
107. Ikeda
VANDERHOOF
Eutsuk Lake
172.
CAPOOSE
PRINCE GEORGE
58°
56°
54°
52°
136°
134°
132°
130°
128°
126°
124°

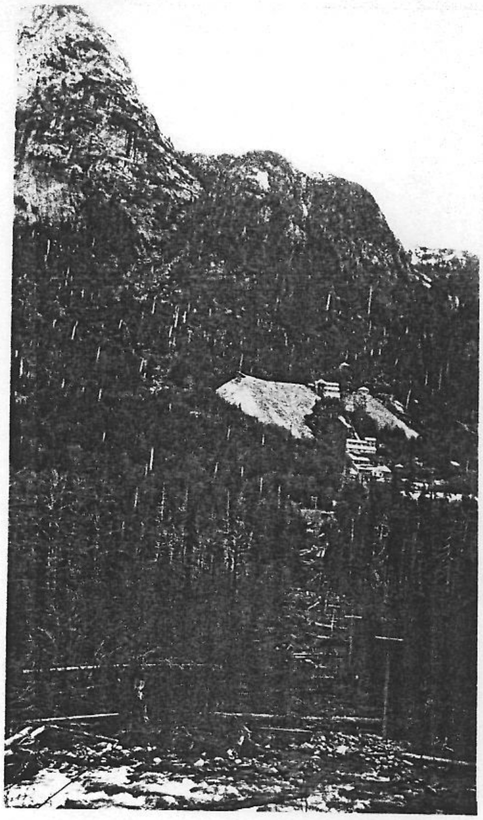


Plate 1: Surf Inlet Consolidated Gold Mine Limited, 1935; production from 1902 to 1943, 1 million tons, 389,000 ounces. A typical north coast mining operation. Quartz veins within sheared zones in gneissic quartz diorite.

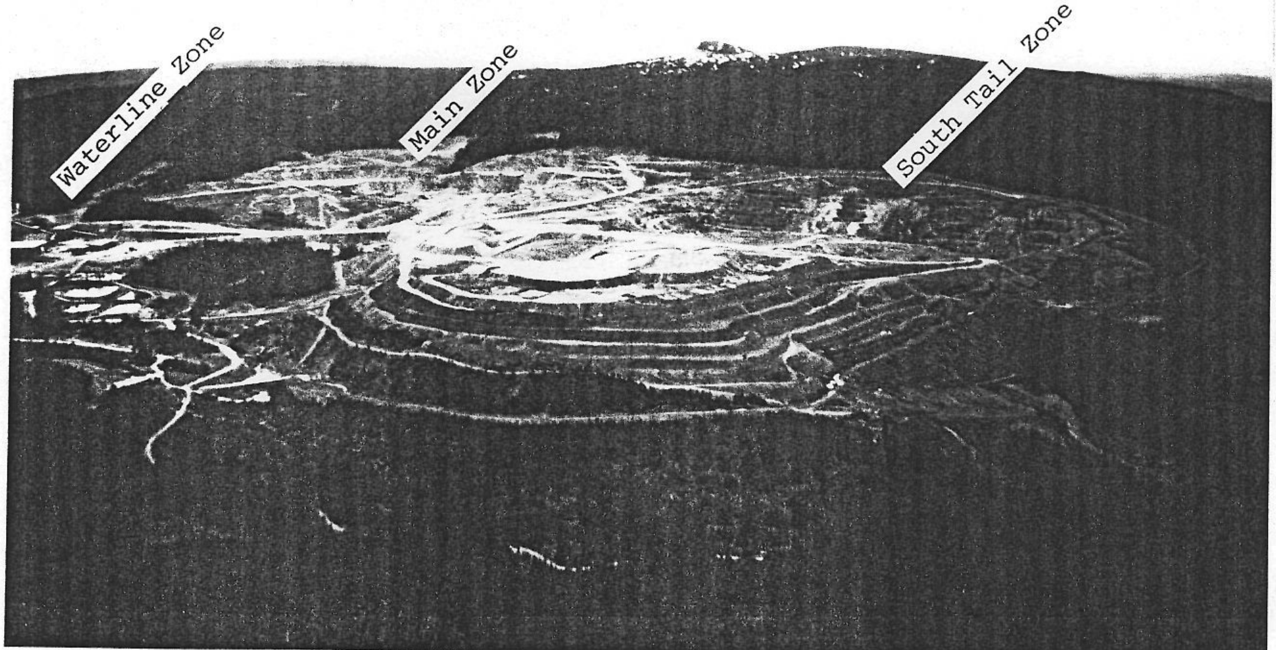


Plate 2: Equity Silver Mine (Sam Goosley Deposit), July 1984, View looking Easterly

Significant precious metal production as a by-product from base metal mines started when mining commenced in 1906 at both the Japanese-owned and operated Lily-Ikeda skarn deposit on the Queen Charlotte Islands and the Outsider Group vein deposits near Anyox. World War I and succeeding years prior to the Great Depression saw development of many mines, including the major precious metal deposits near Stewart and Alice Arm and base metal mines with significant precious metal by-products at Anyox and Tasu.

Deposit Types

Lode precious metal deposits can be categorized into five main deposit types according to their style of mineralization and mode of origin. These include: vein and replacement, porphyry copper, porphyry copper-epithermal transition (Equity Silver/Sam Goosly type), skarn, and massive sulphide (Table I). Deposits in Table I classed as porphyry copper, skarn, and volcanic-hosted massive sulphide are typical of these well-established genetic deposit types.

We consider vein deposits to include those in which all manner of epigenetic open space filling and replacement has occurred in both structurally and lithologically controlled hydrothermal channelways. We also include mineralized stockworks and breccias in this class. These deposits can be further subdivided with respect to their ore and gangue mineralogy and texture into 'epithermal' or 'mesothermal' types according to traditional depth-classification schemes. There is controversy whether some replacement deposits, such as Big Missouri and nearby deposits, are of syngenetic or epigenetic origin (Alldrick, 1984) but we consider them to be epigenetic and include them in this category.

The 'porphyry copper-epithermal transition' classification is derived from the Equity Silver mine (Sam Goosly deposit). We regard this to be the model for a number of similar, but yet unproven, prospects in northwestern British Columbia. The deposit type is characterized by a distinctive alteration suite; it consists of a central zone with an advanced argillic, aluminous assemblage including andalusite-kaolinite-pyrophyllite, dumortierite, scorzalite, corundum, and tourmaline, within a broader zone of illite-muscovite alteration (Wojdak and Sinclair, 1984). Ore composition and mineralogy are also distinctive. The copper-silver-gold ore is arsenic/antimony-bearing, highly sulphidized and contains abundant pyrite with chalcopyrite, tetrahedrite/tennantite, arsenopyrite, and minor amounts of sulphosalts and other minerals. We interpret this transitional geologic setting, as described by Ney et al. (1972) and Cyr et al. (1984), to intermediate between that of an intrusive-related porphyry copper system and that of a near-surface epithermal fluid-streaming zone (Plate 2). This geological setting is similar to that of commonly enargite-bearing deposits or to parts of deposits such as Chinkuashih, Taiwan (Folinsbee et al., 1972; Knight, 1977); El Salvador, Chile (Gustafson and Hunt, 1975); Butte, Montana (Brimhall, 1979); and Lepanto, Phillipines; Frieda River, Papua-New Guinea; Bor, Yugoslavia; and Recsk, Hungary (Sillitoe, 1983).

Massive sulphide deposits hosted by sedimentary rocks, such as the Cirque deposit (Jefferson et al., 1983), are typical of the large, stratabound, shale-hosted lead-zinc±barite deposits found during the past decade in Paleozoic sedimentary basins in northern British Columbia and Yukon Territory (Carne and Cathro, 1982; MacIntyre, 1982). None of the deposits has been developed to date but they constitute very significant silver reserves. The Midway deposit is in a similar geologic terrane but is clearly epigenetic in origin and associated with brecciated rocks at a carbonate-shale transition (Stollery and Selmer, 1982; MacIntyre, 1983). This deposit is especially noteworthy for its high silver content, 403.9 g/t silver, along with approximately 18 per cent combined lead and zinc.

Production

Precious metal production, average grades, and relative proportions of total production for the various deposit types are shown in Table IV. Altogether, 151 deposits in 19 main geographic areas or 'camps' in northwestern British Columbia (Tables I and II) have produced nearly 117 700 kg gold (3.7 million ounces) and 3.66 million kg silver (117.6 million ounces). This represents approximately 20 per cent of British Columbia's total gold and silver production to date. Most of the precious metal production (95 per cent of the gold and 91 per cent of the silver) has come from 20 deposits (Table III). Of these major deposits, the vein-replacement deposits at Silbak Premier, and the porphyry copper-epithermal transition deposit at Equity Silver mine account for about one half of the total production. Silbak Premier with 55 118 kg gold (1.8 million ounces) and 1.27 million kg silver (40.9 million ounces) is the third largest gold producer in British Columbia - the Bridge River (Bralorne-Pioneer) and Rossland deposits were larger. Equity Silver (Sam Goosly) with production of 0.7 million kg silver (22 million ounces) and reserves of approximately 2.36 million kg (76 million ounces) is the second largest silver deposit after the Sullivan mine.

Precious metals are the primary ore constituents in vein and porphyry copper-epithermal transition deposits. These deposits account for 79 per cent of gold production and nearly 85 per cent of total silver prduction in the study area. The remaining precious metal production is derived as a by-product from base metal concentrates from skarn, porphyry copper, massive sulphide, and a few vein deposits with significant base metal content, such as Silver Queen, or which provided silica smelter flux, such as Granby Point (Fig. 3). Volcanogenic massive sulphide deposits display two distinct levels of precious metal content. The larger cupriferous pyrite deposits associated with basic volcanic rocks, such as the Anyox deposits, or those found in thin-bedded sedimentary strata, such as the Granduc deposit, have relatively low precious metal contents of approximately 0.1 g/t gold and 10 g/t silver. In contrast, the smaller, lenticular, Kuroko-type deposits associated with acidic volcanic rocks, such as the Tulsequah Chief and Kutcho Creek deposits have very economically significant concentrations - close to 3 g/t gold and 100 g/t silver. Despite the low precious metal content of skarn and porphyry copper deposits, because of their large size and scale of production, they constitute important precious metal reserves and account for significant gold and silver production in the Province.

Exploration Trends

A concerted search for precious metal deposits as well as base metal deposits with significant gold-silver content is underway in northwestern British Columbia, as it is throughout the entire North American Cordillera. Following sharply elevated prices for precious metals in 1979, almost all important past producers and prospects are being reassessed and aggressive exploration for precious metals is being conducted. The high prices of gold and silver have significantly changed the economic viability of many base metal deposits that contain appreciable gold and silver, most notably a number of skarn and massive sulphide deposits. However, costs have also risen and no new base metal mines have opened in northwestern British Columbia nor has production been sustained at established mines (Tasu, Granduc, Bell, Granisle) on account of expected increased earnings from high precious metal prices.

TABLE II: CUMULATIVE PRODUCTION BY DISTRICTS

MAP NO.	AREA OR DISTRICT	NO. OF MINES PRODUCING ORE >10 tons	TONS	TONNES	GOLD oz	GOLD kg	RECOVERED SILVER oz	RECOVERED SILVER kg	COPPER tons	LEAD tons	ZINC tons	APPROXIMATE PRODUCTION RATIO Ag:Au
1,2	A. RAINY HOLLOW-ALSEK RIVER	1	3,630	3 293	10	0.3	48,238	1 500	271	-	-	4800:1
4-10	B. CASSIAR	5	323,996*	293 924	123,496*	3 841	93,654*	2 913	-	0.7	0.7	1:1
12-17	D. ATLIN	4	19,989	18 134	18,272	568	76,472	2 379	1	150	15	4:1
19-21	E. TULSEQUAH	2	1,782,346	1 616 918	325,862	10 135	3,413,547	106 173	13,692	13,464	62,347	10:1
22-63	F. STEWART	27	22,311,931	20 241 049	2,002,369	62 281	48,313,002	1 502 703	192,677	32,813	14,286	24:1
71-81	I. ALICE ARM	10	1,421,486	1 289 551	401	12	20,195,080	628 138	1.6	5,388	321	>50,000:1
82-90	J. ANYOX	5	24,924,386	22 611 029	134,780	4 192	7,141,917	222 139	372,842	0.5	-	53:1
91-100	K. TERRACE	7	3,505*	3 180	1,026	32	7,612	237	72	39	2	7:1
101-103	L. PORTLAND CANAL	1	509	462	331	10	572	18	0.8	5	-	2:1
104-110	M. QUEEN CHARLOTTE ISLANDS	7	22,226,892*	20 163 903	46,794	1 455	1,648,619	51 278	6,663	0.3	-	35:1
111-117	N. NORTH COAST	6	1,081,232	980 877	409,713	12 744	211,554	6 580	3,200	-	-	1:2
118	O. TOODOGGONE	1	85,428	77 499	37,558	1 168	742,198	23 085	-	-	-	20:1
120-141	P. SMITHERS	17	111,434*	101 091	4,313*	134	2,109,337*	65 608	133*	5,451*	4,917*	490:1
142-150	Q. HOUSTON	5	7,210,572*	6 541 323	110,068	3 424	22,848,121	710 657	25,710*	802	5,584*	208:1
151,152	R. GRANISLE (BABINE LAKE)	2	105,467,827	95 678 805	452,754	14 082	2,755,652	85 710	413,152	-	-	6:1
153,154	S. FRENCH PEAK	1	62*	56	3	0.1	12,488	388	1.4	10	0.8	4200:1
155	T. MORICETOWN	1	275	250	12	0.4	22,440	698	-	11	7	1870:1
156-165	U. HAZELTON	9	368,051	333 890	20,470	637	7,901,678	245 770	3,372	9,056	13,661	386:1
166-170	V. TAHTSA	1	9,193	8 340	48	1.5	83,678	2 603	10	846	983	1740:1
	TOTAL (151 deposits)		187,352,744	169 963 574	3,688,270	114 717	117,625,859	3 658 577	1,031,799	68,037	102,125	32:1

Footnote: *denotes partly estimated quantity

TABLE III: PRODUCTION AND GEOLOGICAL RESERVES OF MAJOR GOLD-SILVER DEPOSITS IN NORTHWESTERN BRITISH COLUMBIA

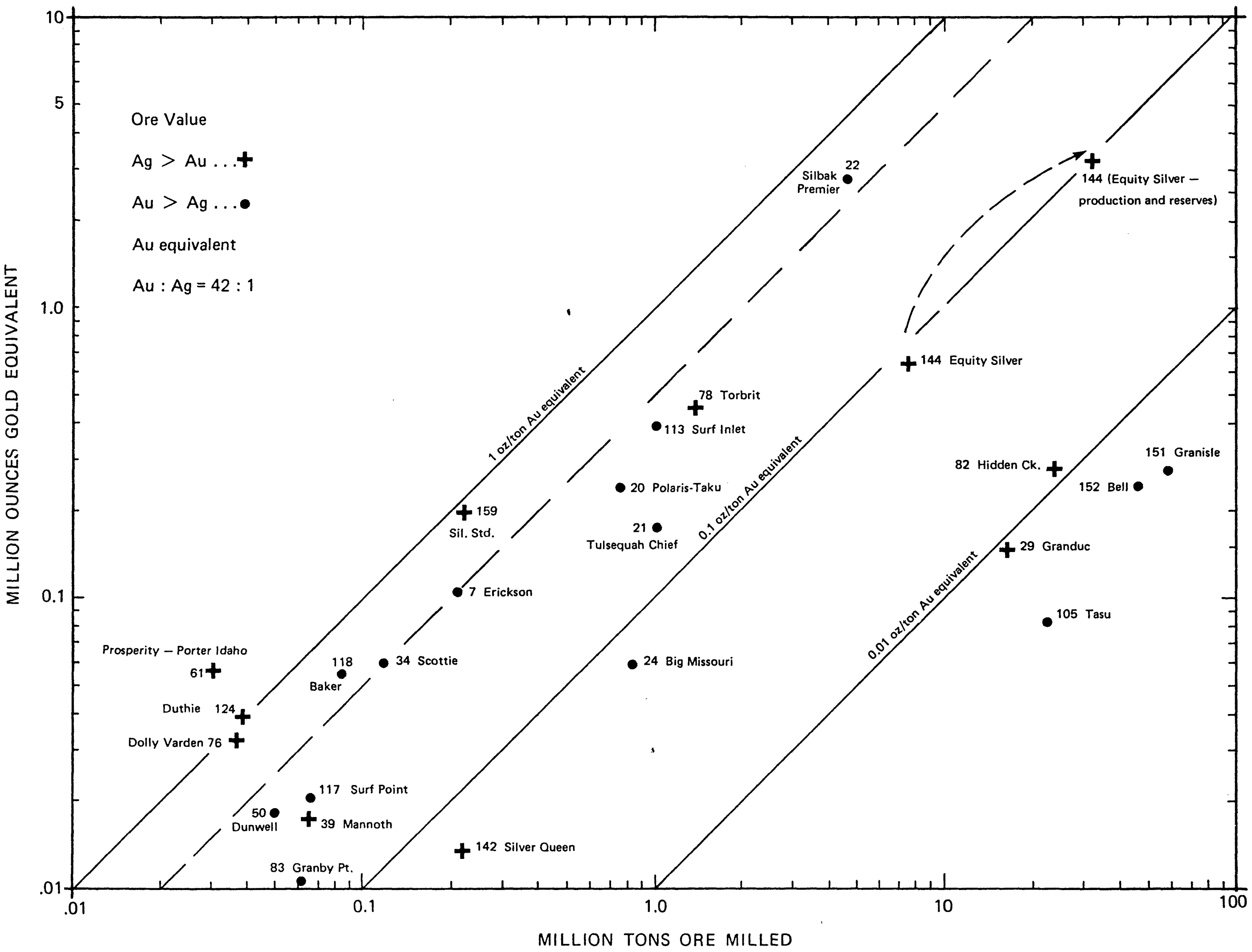
			PRODUCTION									
		MAP	GOLD		SILVER		GOLD-EQUIVALENT (million ounces, Au = 42 Ag)		GOLD-EQUIVALENT GRADE (ounces) (Au = 42 Ag)		PRODUCTION PLUS RESERVES GOLD-EQUIVALENT million	
	DEPOSIT	NO.	oz	kg	oz	kg	oz	kg	oz	g/t	oz	kg
1	SILBAK PREMIER	22	1,804,218	56 118	40,863,280	1 270 971	2.777	86 375	0.59	20.2	3.28	102 020
2	EQUITY SILVER (Sam Goosly)	144	106,640	3 317	22,385,660	696 272	0.640	19 900	0.091	3.1	3.14	97 665
3	TORBRIT	78	110	3	18,646,304	579 956	0.444	13 810	0.32	11.0	0.63	19 595
4	SURF INLET	113	388,881	12 095	201,210	6 258	0.394	12 255	0.39	13.4	0.40	12 440
5	HIDDEN CREEK (Anyox)	82	121,298	3 773	6,633,087	206 309	0.279	8 680	0.012	0.41	1.21	37 635
6	GRANISLE	151	219,680	6 833	2,242,630	69 753	0.273	8 490	0.0046	0.16	0.27	8 400
7	BELL	152	233,074	7 249	513,022	15 957	0.245	7 620	0.0053	0.18	0.25	7 775
8	POLARIS-TAKU	20	231,603	7 204	11,760	366	0.232	7 615	0.31	10.6	0.31	9 640
9	SILVER STANDARD	159	14,877	463	7,586,202	235 954	0.196	6 095	0.87	29.8	0.21	6 530
10	TULSEQUAH CHIEF	21	94,257	2 932	3,400,772	105 776	0.175	5 440	0.17	5.8	0.71	22 085
11	GRANDUC	29	63,717	1 982	3,613,091	112 380	0.150	4 665	0.0091	0.31	0.25	7 775
12	ERICKSON GOLD	7	103,179	3 209	91,400	2 843	0.105	3 265	0.50	17.1	0.18	5 600
13	TASU	105	44,425	1 382	1,620,228	50 395	0.083	2 580	0.0036	0.12	0.083	2 580
14	SCOTTIE GOLD	34	59,328	1 845	31,285	973	0.060	1 860	0.51	17.5	0.15	4 665
15	BIG MISSOURI	24	58,384	1 816	52,676	1 638	0.060	1 860	0.07	2.4	0.13	4 045
16	PROSPERITY-PORTER IDAHO	61	870	27	2,360,929	73 433	0.057	1 770	1.90	65.1	0.44	13 685
17	BAKER (Chappelle)	118	37,558	1 168	742,198	23 085	0.055	1 710	0.65	22.3	0.055	1 710
18	DUTHIE	124	1,745	54	1,582,000	49 215	0.039	1 215	1.01	34.6	0.045	1 400
19	DOLLY VARDEN	76	1	.03	1,364,847	42 451	0.033	1 025	0.88	26.6	0.31	9 640
20	SURF POINT	117	20,333	632	7,187	224	0.021	655	0.31	10.6	0.024	7 465

ADDITIONAL GEOLOGICAL RESERVES (ounces gold-equivalent):

>1 million: Windy-Craggy, Schaft Creek (Liard Copper), Cinola, Galore Creek (Stikine Copper), Cirque, Midway
>500,000: Capoose, Kutcho
>200,000: Eaglehead, Lawyers, Ericksen-Ashby

*Footnotes: Silver content converted to gold-equivalent at Au:Ag = 42.1
Map numbers refers to Table I and Figure 2

Figure 3: Precious Metal Production – Major Deposits in Northwestern British Columbia to 1983



The newest mining ventures in northwestern British Columbia are small, relatively high-grade vein gold deposits (Baker, 1980; Erickson Gold, 1979; Scottie Gold, 1981; Taurus mine, 1981). Exploration near these active new mines, as well as in or near old workings near Stewart, has succeeded in discovering additional ore. Also new discoveries, not yet classified as to deposit type, have been reported from other areas including Muddy Lake, Mount Johnny, Toodoggone River area, and in the vicinity of Alsek River and the Windy-Craggy deposit in the extreme northwesterly corner of the Province.

Recently much exploration initiative and innovative thinking has been directed towards the search for epithermal-type deposits. Comparison of British Columbia deposits with similar mineralization in younger volcanic settings in the western United States gives useful insights into the controls and geometries of orebodies. Application of modern epithermal models as defined by Buchanan (1981), Berger and Eimon (1982), Heald-Wetlaufer et al. (1983), and others, provides better understanding of the significance of characteristic alteration assemblages and allows interpretation of depth zoning relationships. Exploration models that consider mineralizing environments from porphyry copper to hotspring discharge sites provide a conceptual framework for a variety of gold-silver deposits being examined in Jurassic rocks in the Toodoggone River area near Baker mine and in the Stewart area, in Jurassic and Cretaceous rocks in the Tahtsa-Whitesail Lake area southwest of Equity Silver mine, and in Tertiary rocks on the Queen Charlotte Islands and elsewhere.

A notable epithermal deposit is the Baker mine (Chappelle deposit, Barr, 1978). This is a small, high-grade vein-silicified fault zone deposit that came into production in 1980; it was a strictly air-supported mining operation. Reserves were approximately 91 000 tonnes with 28 g/t gold and 560 g/t silver. Nearby, the Lawyers deposit (Vulimiri et al., 1985 - this volume) has recently been announced to contain more than 1 million tonnes with 7.27 g/t gold and 254 g/t silver. Larger deposits being considered for their open pit potential include the Big Missouri property (Soregaroli and Meade, 1983), the glory hole area at Silbak Premier and the Cinola property (Babe or Specogna property). At the Big Missouri property four potential open pit zones contain close to 2 million tonnes with 3.2 g/t gold-equivalent and at Silbak Premier open pittable reserves of close to 4 million tonnes with 2.43 g/t gold and 110.4 g/t silver have been announced. The Cinola deposit contains over 30 million tonnes with slightly more than 2 g/t gold. It is Miocene in age and has been compared to Carlin-type deposits (Richards et al., 1976; Champigny and Sinclair, 1982) although some geologists favour a comparison with modern day hotspring deposits, such as those found in New Zealand (Henley and Ellis, 1983) or the sedimentary rock hosted Pueblo Viejo deposits, Dominican Republic (Kesler et al., 1981).

TABLE IV: CUMULATIVE GOLD-SILVER PRODUCTION ACCORDING TO DEPOSIT TYPE

	GOLD						SILVER					
		Production						Production				
	No. of	million		Average Grade		per cent	No. of	million		Average Grade		per cent
DEPOSIT TYPE	Deposits	oz	kg	oz/T	g/t	of total	Deposits	oz	tonnes	oz/T	g/t	of total
VEIN, REPLACEMENT	102	2.799	87 060	0.25	8.4	76	131	77	2 395	6.7	230	65.5
PORPHYRY COPPER	2	0.453	14 090	0.0035	0.12	12.5	2	2.8	87	0.02	0.83	2
PORPHYRY-EPITHERMAL TRANSITION (Sam Goosly/Equity type)	1	0.107	3 330	0.022	0.75	3	1	22.4	697	2.9	100	19
VOLCANOGENIC MASSIVE SULPHIDE	4	0.282	8 770	0.0061	0.21	7.5	4	13.8	429	0.3	10.3	12
SKARN	7	0.046	1 430	0.0035	0.12	1	7	1.7	53	0.07	2.3	1.5
	Total	3.687					Total	117.7				

Note: 64% of vein and 49% of total gold production, and 53% of vein - and 35% of total silver production is from Silbak Premier Mine

In summary, the search for precious metal-bearing deposits of all types that has accounted for much of the recent exploration activity in northwestern British Columbia is continuing. Much attention will be focused on epithermal-type small to medium-sized, high-grade deposits as well as larger, low-grade bulk-minable prospects. Aside from the normal economic constraints of metal prices, logistics and infrastructure will continue to dictate future mining developments in northwestern British Columbia. It is anticipated that exploration successes will continue and the high level of activity should produce significant developments in the next few years in the Stewart, Toodoggone, and Cassiar areas.

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GEOLOGY OF THE
CINOLA GOLD DEPOSIT
Queen Charlotte Islands, B.C.
Canada

by

R.S. Tolbert, and N.V. Froc

August, 1988

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The Cinola deposit represents the exposed mid-upper levels of an epithermal hot-springs-type precious metal system.

The deposit can be separated into three distinct lithologic groups:

1) a sedimentary sequence (predating the following two);
2) an intrusive igneous sequence; and
3) an epithermal hot-spring suite.

The sedimentary sequence is comprised of two formations; black-dark grey variably calcareous mudstones and argillites of the Late Cretaceous Haida Formation, and coarse to fine clastic sediments of the Tertiary Mio-Pliocene Skonun Formation. These two formations are separated by a normal right-lateral fault, the Specogna Fault, with the downdropped block consisting of Skonun Formation sediments (east of the fault).

The intrusive igneous sequence is comprised of at least two separate rhyolite intrusions localized along the Specogna Fault. The rhyolite intrusions have been dated as Middle Miocene, predating or contemporaneous with the hot-spring suite. These intrusions of rhyolite initiated the movement of meteoric water and the development of a hot-spring system.

The epithermal hot-spring suite is comprised of a hydrothermal breccia unit which has been traced along the Specogna Fault (on strike) for at least 800 m, stockwork silica veining, and silica veining developed along extensional faults. Associated with the hot-spring development and extending laterally away from the hydrothermal breccia unit is a region of intense pervasively silicified Skonun Formation sediments. This zone parallels the

Specogna Fault and forms a rough "mushroom" shaped area normal to the Specogna Fault. Beyond the area of the pervasive silicification is a region of argillically altered Skonun Formation sediments dominated by the presence of kaolinite-illite with minor alunite and sericite.

The Cinola orebody is essentially wedge shaped extending 800 m in a northwest - southeast direction. Near surface the upper portion of the "wedge" is approximately 200 m wide. It thins at depth to 50 m wide at sea level.

Precious metals are localized by hydrothermal brecciation, stockwork veining, vein development along extensional faults and pervasive silicification events. Minor pyrite and marcasite occur throughout the deposit but do not appear to correlate directly with the gold mineralization. Trace levels of mercury, arsenic and antimony are found in varying amounts in the deposit. Their exact relationship to the precious metals is uncertain, however relationships between higher levels of these metals and localized lithologic units have been identified. Argillic alteration is peripheral to the zone of pervasive silicification and contains minor gold occurring in veins.

INTRODUCTION

The Cinola deposit is located 770 kms north of Vancouver, British Columbia on Graham Island, the northern and largest of the Queen Charlotte archipelago. It is easily accessible by logging roads from the towns of Masset and Queen Charlotte City.

The deposit was discovered in 1970 by a prospector Efrem Specogna and his brother-in-law Johnny Trico. Subsequently, the deposit was examined by a number of companies including Kennco, Canex Aerial Exploration, UMEX, Silver Standard Mines Ltd., Quintana Minerals Corporation, Consolidated Cinola Mines Ltd. and Energy Reserves Group.

City Resources (Canada) Limited obtained the deposit through purchase of Consolidated Cinola Mines Limited in November, 1986.

The first major report on the deposit was written by Richards et al (1976) who described the deposit as a Carlin-type gold deposit. Champigny et al (1980, 1981) also classed the deposit as Carlin-type with sediments being deposited in a braided stream environment and gold mineralization being formed under normal hydrostatic pressure at 1100 metres below surface.

Brooks et al (1980) was the first to separate out lithologically distinct sedimentary units and a breccia unit which occurs on the footwall of the deposit. These sedimentary units were recognized by City Resources geologists (1986) as occurring in an alluvial fan environment and the breccia was recognized as a hydrothermal breccia, typical of epithermal hot-spring gold deposits which have recently been recognized elsewhere as a distinct deposit type, particularly in the Pacific Rim area (Berger et al 1985).

The understanding of this deposit has been helped by the utilization of the epithermal hot-springs model which characteristically has gold depositing in a near surface environment, under elevated water pressures due to silica sealing of pore spaces, etc. Boiling of solution at shallow depths is typical of an epithermal hot-springs deposit. Recognition of textures present in this deposit which are typical of boiling at shallow depths include quartz after calcite, colloform banding of quartz crustification, multiple brecciatian and fluidised breccias.

The work by City Resources has outlined geological reserves of 43.5 million tonnes grading 1.65 g/t Au, at a 0.69 g/t Au cut-off.

Proven and probable minable reserves at a 1.1 g/t cut-off are 40.7 million tonnes grading 1.65 g/t Au.

Tour Update: Sept. 22, 1988 (R.Tolbert)
Mineable Reserves 24.8 m/tonnes @ 2.45 g/t Au and ~ 3 g/t Ag

REGIONAL GEOLOGY

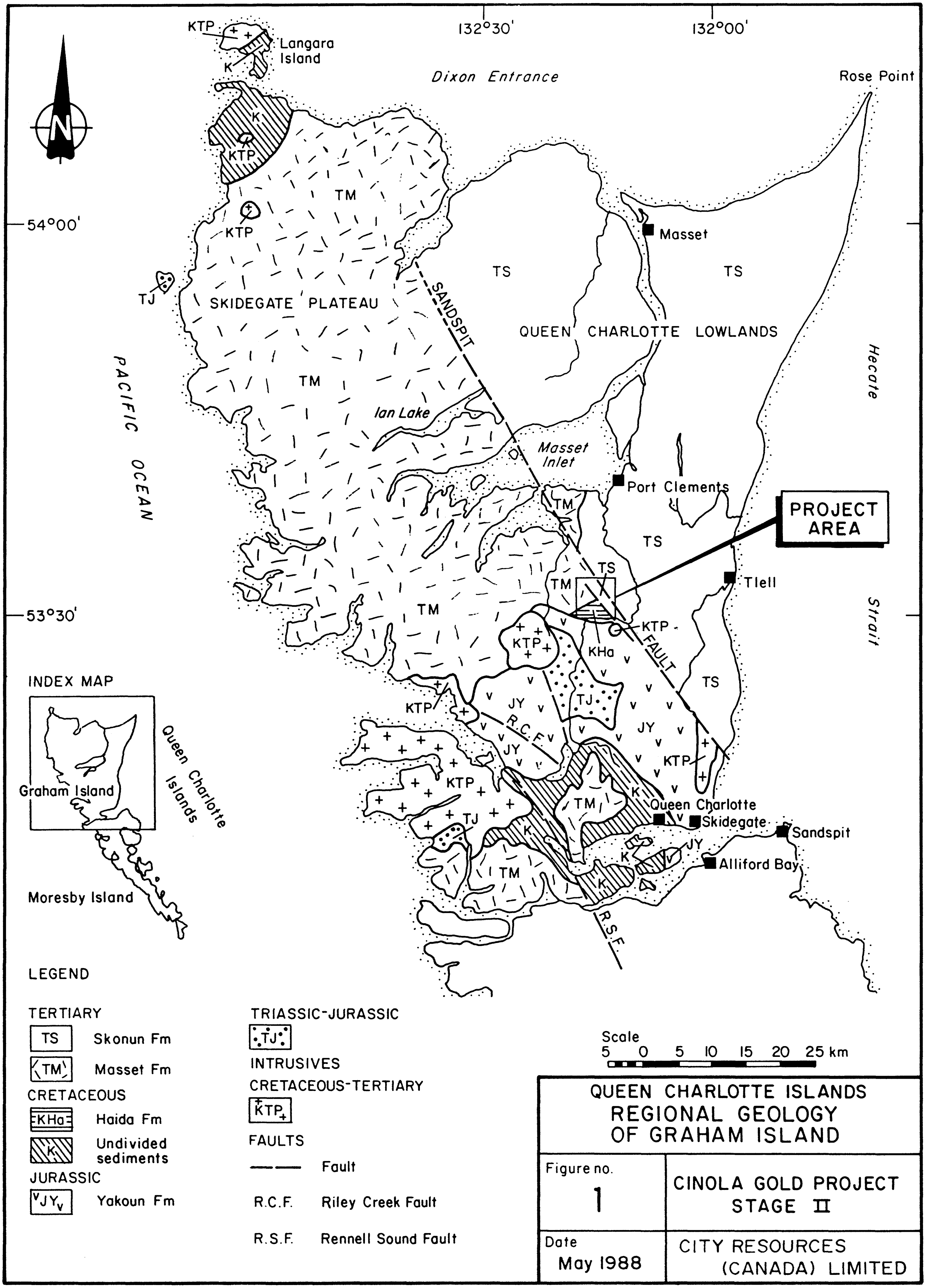
The Cinola gold deposit on Graham Island is situated on the physiographic boundary between the Queen Charlotte lowlands to the east and the Skidegate plateau to the west (Figure 1). The boundary is marked by the northwest-southeast trending Sandspit Fault system, evidence of which can be observed on surface as a series of weakly developed fault scarps and as abrupt changes in stream drainage patterns.

Regionally, the Sandspit Fault system forms the western boundary of the Queen Charlotte basin. The basin appears as a graben structure into which sediments were shed, predominantly during the Tertiary Mio-Pliocene period. These sediments range from fine to coarse grained and comprise the Skonun Formation. West of the Sandspit Fault system are Mesozoic and Lower Tertiary rocks, including mafic to rhyolitic volcanics and volcanociastics, carbonates, epiclastics, and intermediate to granitic intrusive rocks.

The dominant lithologic unit west of the Sandspit Fault system, south of the Cinola deposit and the Yakoun River, is the Yakoun Formation of middle to upper Jurassic age. This is primarily a volcanic unit dominated by pyroclastic rocks of porphyritic andesite composition.

Further west and south of the Cinola deposit this formation includes volcanic sandstone, conglomerate, shale, siltstone and minor coal. The Yakoun Formation originated in an eugeosynclinal environment and is equivalent to the Bonanza Formation on Vancouver Island.

The area immediately west of the deposit is underlain by grey to black argillites and siltstones of the Early to Late Cretaceous



132°30'
132°00'
54°00'
53°30'
Langara Island
Dixon Entrance
Rose Point
Masset
SKIDEGATE PLATEAU
QUEEN CHARLOTTE LOWLANDS
SANDSPIT FAULT
PACIFIC OCEAN
Hecate Strait
Ian Lake
Masset Inlet
Port Clements
PROJECT AREA
Tlell
R.C.F.
R.S.F.
Queen Charlotte
Skidegate
Sandspit
Alliford Bay
INDEX MAP
Graham Island
Queen Charlotte Islands
Moresby Island
LEGEND
TERTIARY
TS Skonun Fm
TM Masset Fm
CRETACEOUS
KHa Haida Fm
K Undivided sediments
JURASSIC
JY Yakoun Fm
TRIASSIC-JURASSIC
TJ
INTRUSIVES
CRETACEOUS-TERTIARY
KTP
FAULTS
Fault
R.C.F. Riley Creek Fault
R.S.F. Rennell Sound Fault
Scale
5 0 5 10 15 20 25 km
QUEEN CHARLOTTE ISLANDS
REGIONAL GEOLOGY
OF GRAHAM ISLAND
Figure no.
1
CINOLA GOLD PROJECT
STAGE II
Date
May 1988
CITY RESOURCES
(CANADA) LIMITED

Haida Formation, which also originated in a marine eugosynclinal environment. The area northwest of the Cinola deposit, extending to the west coast of Graham Island, is underlain by basaltic to rhyolitic extrusive volcanic and pyroclastic rocks of the Tertiary Mio-Pliocene Masset Formation.

Porphyritic rhyolitic sills and dykes similar to the Masset Formation rhyolites intrude the deposit and the Haida Formation argillites adjacent and west of the deposit. Intrusive rocks of diorite to quartz diorite composition occur as plugs and stocks in the region south of the Yakoun River and southwest of Sheila Lake.

PROPERTY GEOLOGY

Data Acquisition

The Graham Island (Cinola) gold deposit represents the exposed middle-upper levels of an epithermal, hot-springs-type, precious metal system. This interpretation is based on the results of the work conducted by City Resources (Canada) Limited from November, 1986 through March, 1987. City Resources geologists logged approximately 3450 m of new core from 29 NQ(47 mm diameter) and HQ(63 mm diameter) sized diamond drill holes, plus 6220 m of cuttings from 63 air reverse circulation (146 mm diameter) holes. Both the diamond and air reverse circulation drill holes were drilled at an inclination of -50°. Other work in 1986-1987 included relogging of 27 900 m of core stored on-site from 227 diamond drill holes completed prior to 1984, most of these holes were drilled vertically.

City Resources also conducted an underground exploration program in March 1987. Two new cross-cuts totalling 117 m in length were driven from the existing undergroound drift. The new cross-cuts were sampled and mapped in detail, and previously drifted underground workings were also mapped in detail. The ribs and backs of the new cross-cuts and of 340 m of previous underground workings were geologically mapped, as was the face of each new cross-cut advance.

All drill hole logging information was transferred to a computer data-base on-site and at the Vancouver office utilizing Gemcom Services Inc's. PC-XPLOR data-base system. Information stored in the data-base included lithologic, survey, and assay data, which were checked, verified, and edited for transcript errors.

The information in the data-base was used to create 23 lithologic/alteration and assay/vein cross-sections that completely encompassed the Cinola deposit. Oriented at N 65°30'E and spaced approximately 30 m apart, these cross-sections were used to interpret lithologic, grade, and alteration (silicification and argillic) boundaries for the deposit. Continuity from cross-section to cross-section was maintained by used of a "hanging acetate" model at a scale of 1:500.

Bench plan geology was derived from the completed cross-sections utilizing a computer program designed for City Resources (Canada) by Interactive Computer Applications Systems Ltd. of North Vancouver. The geologically interpreted cross-sections, which were digitized and stored on disk, were "sliced" horizontally at 6 m intervals and plotted on bench plans. These bench plans were then integrated into a consistent, three-dimensional interpretation.

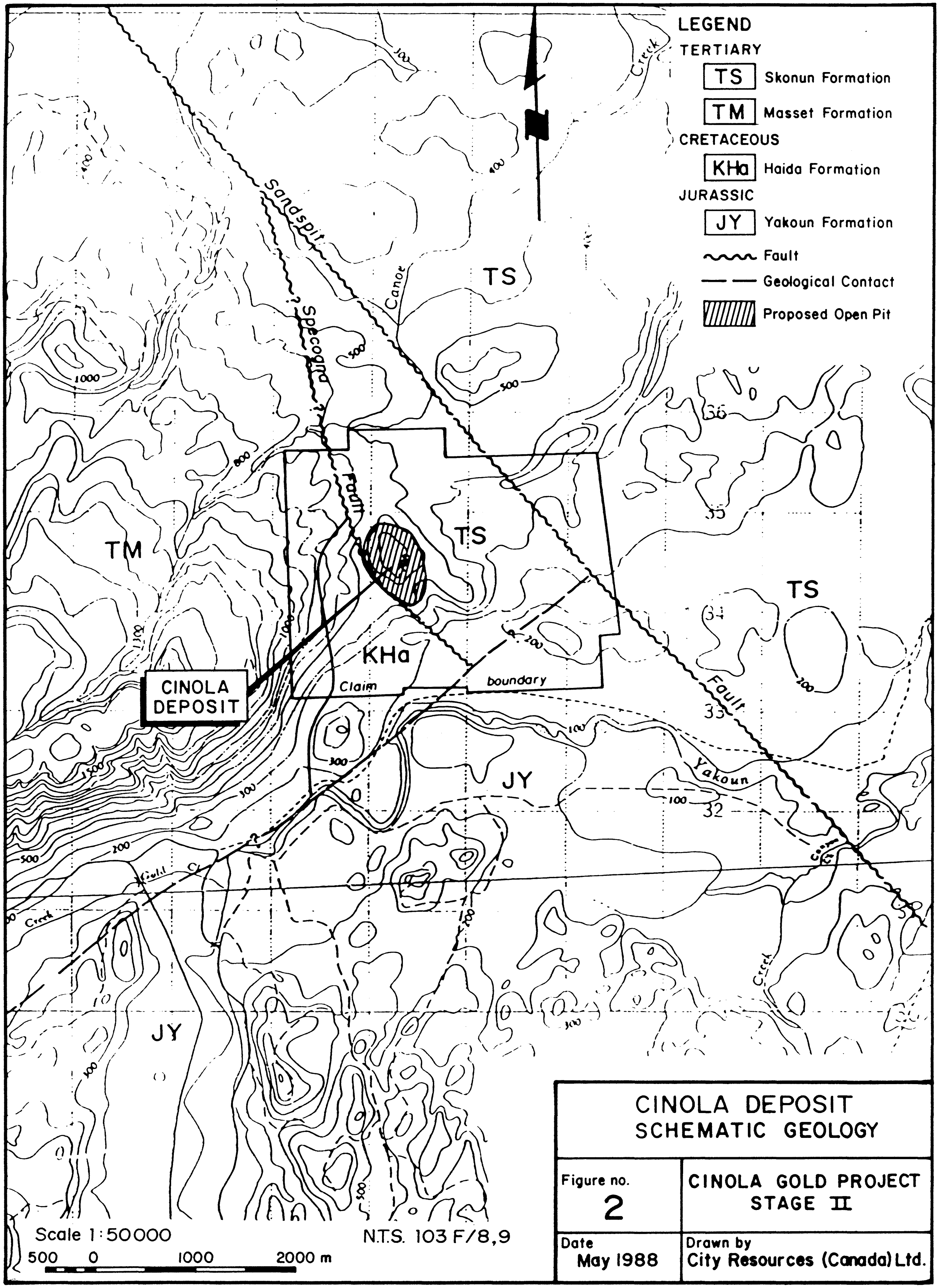
The geological cross-sections and bench plans formed the basis for assay sections and assay bench plans (on 6 m intervals), and subsequently for the hand-calculated geological and mineable reserves; they also provided the geologic basis for the separately derived geostatistical reserve models.

Structure

The Cinola deposit is localized between the Sandspit Fault to the east and the footwall Specogna Fault 1500 m to the west (Figure 2). Both faults strike at 143° in the area of the deposit. While subsidiary, parallel faults may exist between the Sandspit fault and the area of past detailed drilling, which extends 400 m east of the Specogna Fault, no other major faults at this trend have been observed (Figures 2 and 3).

Locally, the Specogna Fault is the true western margin of the Queen Charlotte basin. Movement on the fault was syngenetic to deposition of the Skonun Formation and was dominantly normal, dipping 45 to 50° to the east. The zone of major faulting appears to be up to at least 70 m in width and to have been active during and beyond the period of mineralization. During mineralization, right lateral movement on both the Specogna and Sandspit faults created a conjugate set of fractures trending at 30°. These fractures filled with silica, forming a series of 'seismic', high grade gold veins.

Post-mineralization movement is evident at the "Marino Showing" in the northwest corner of the deposit. Detailed drilling in this area has revealed a large block of rhyolite surrounded by sheared argillite of the Haida Formation, the rhyolite was displaced vertically at least 200 m along the Specogna Fault after being "cut" by numerous silica veins containing visible gold.



CINOLA DEPOSIT SCHEMATIC GEOLOGY	
Figure no. 2	CINOLA GOLD PROJECT STAGE II
Date May 1988	Drawn by City Resources (Canada) Ltd.

Lithologies

The lithologic units comprising the Cinola deposit can be separated into three packages: the sedimentary sequence (predating the following two), the intrusive igneous sequence, and the epithermal hot-spring suite.

Table 1 provides a summary description of Cinola Gold Project deposit lithologies.

Sedimentary Sequence

The sedimentary sequence includes two formations, the Late Cretaceous Haida and the Teritary Mio-Pliocene Skonun (Figures 3 and 4).

Late Cretaceous Haida Formation

(Units 1a, 1b, 1c)
This formation outcrops west of the Specogna Fault on the western side of the deposit and is dominated by black-dark grey variably calcareous indurated mudstone. Minor sandstone and siltstone layers are also present. Drilling indicates it extends to a depth of at least 220 m below surface.

The major mine units within the Haida Formation are as follows:

a) Unit 1a is a competent grey-black mudstone with minor siltstone or sandstone;
b) Unit 1b is sheared, soft grey-black mudstone that occurs predominantly within the Specogna Fault zone; and
c) Unit 1c consists of the Haida Formation mudstone/ siltstone, which has undergone silicification, subsequent brittle fracturing, resilicification, and veining.

TABLE 1
DESCRIPTION OF CINOLA DEPOSIT LITHOLOGIES

A. Sedimentary Units

AGE	FORMATION	UNIT	DESCRIPTION
Tertiary (Mio-Pliocene)	Skonun	2a	Mudstone/Siltstone
		2b	Sandstone
		2c	Conglomerate, cast-supported
		2d	Conglomerate, matrix-supported
		2e?	Boulder Conglomerate (see intrusive unit description)
		4c	Mudflow Breccia with mudsupported angular clasts predominantly rhyolitic
		4cu	
Cretaceous	Haida	1a	Mudstone/Siltstone, competant, grey-black
		1b	Mudstone, sheared soft, grey-black
		1c	Mudstone,silicified, veined fractured, grey-black

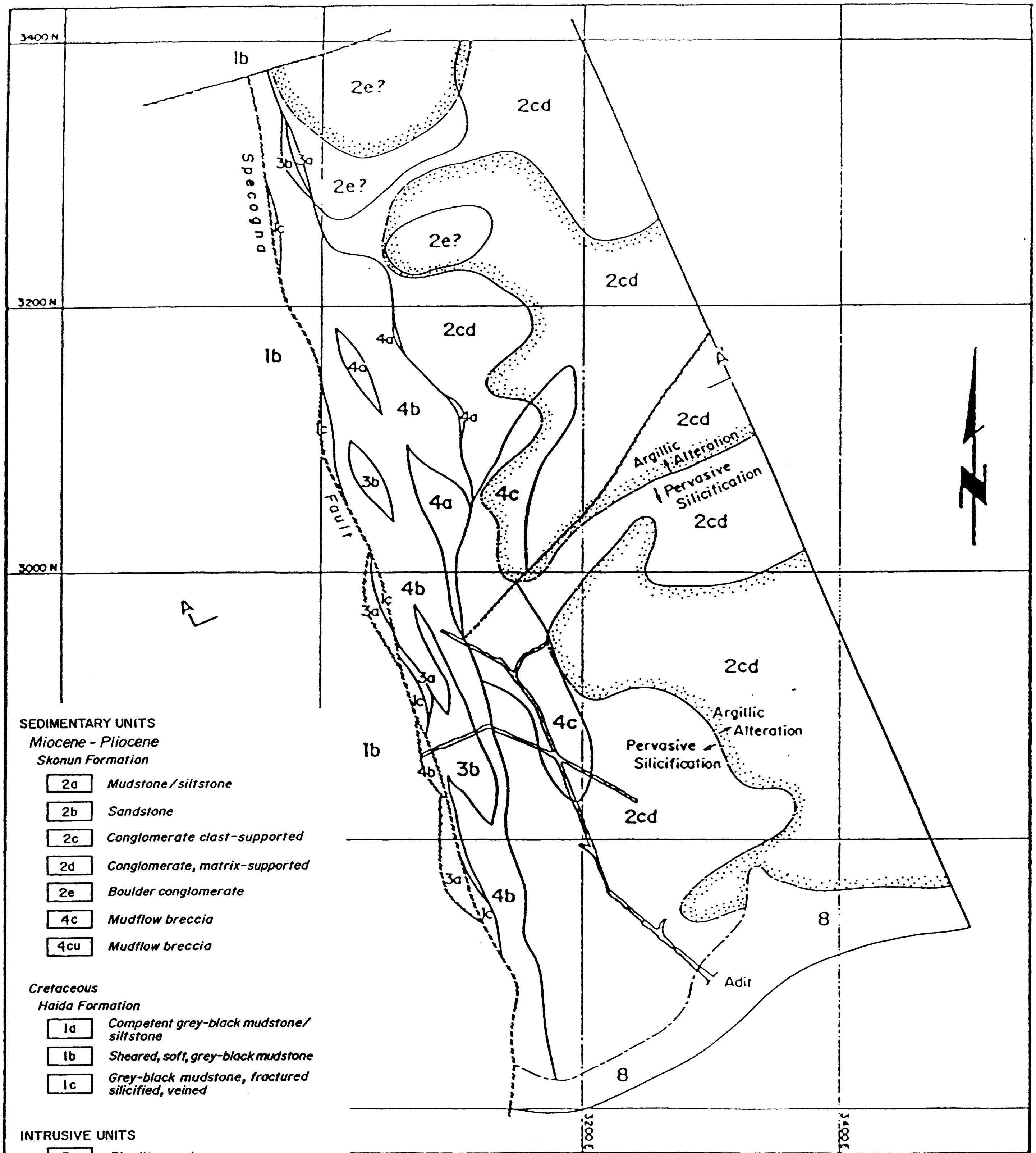
*NB-Argillic alteration and silicification overprint the sedimentary units and are not defined separately as units.

B. Intrusive Igneous Units

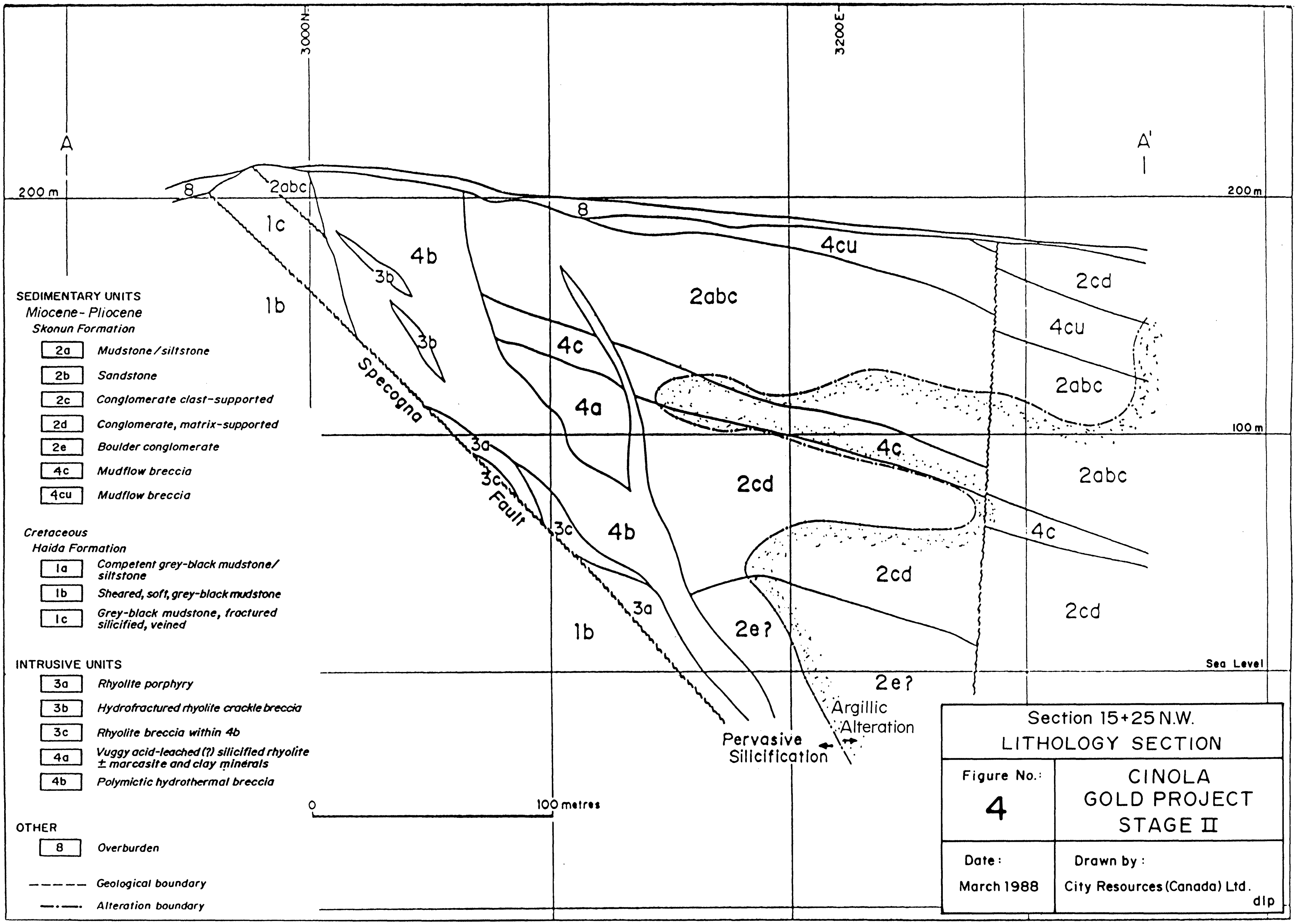
AGE	FORMATION	UNIT	DESCRIPTION
Tertiary (Miocene-14 Ma.)		3a	Rhyolite Porphyry
		3b	Hydrofracted Rhyolite Crackle Breccia
		3c	Rhyolite Breccia within 4b
		4a	Vuggy, rhyolite, acid-leached(?), silicified +- marcasite and clay minerals
		2e?	Mixed Boulder Conglomerate and Rhyolite

C. Epithermal Hot-spring Units

AGE	FORMATION	UNIT	DESCRIPTION
Tertiary (Miocene-Younger than 14 Ma.)		4b	Polymictic Hydrothermal Breccia
		5a	Vein, calcite
		5b	Vein, silica after calcite
		5c	Vein, drusy quartz
		5d	Vein, white silica
		5e	Vein, silicified breccia
		5f	Vein, brown hematitic silica
		5g	Vein, grey chalcedonic silica



Section 114 m HORIZONTAL LITHOLOGY SECTION	
Figure No.: 3	CINOLA GOLD PROJECT STAGE II
Date: March 1988	Drawn by: City Resources (Canada) Ltd. dlp


3000N
3200E
A
A'
200 m
200 m
100 m
Sea Level
8
2abc
1c
1b
4b
3b
3b
4c
4a
2abc
4cu
2cd
4cu
2abc
2abc
4c
2cd
4c
2cd
2cd
3a
3c
3c
4b
3a
1b
2e?
2e?
Specogna Fault
Pervasive Silicification
Argillic Alteration
SEDIMENTARY UNITS
Miocene- Pliocene
Skonun Formation
2a Mudstone/siltstone
2b Sandstone
2c Conglomerate clast-supported
2d Conglomerate, matrix-supported
2e Boulder conglomerate
4c Mudflow breccia
4cu Mudflow breccia
Cretaceous
Haida Formation
1a Competent grey-black mudstone/siltstone
1b Sheared, soft, grey-black mudstone
1c Grey-black mudstone, fractured silicified, veined
INTRUSIVE UNITS
3a Rhyolite porphyry
3b Hydrofractured rhyolite crackle breccia
3c Rhyolite breccia within 4b
4a Vuggy acid-leached (?) silicified rhyolite ± marcasite and clay minerals
4b Polymictic hydrothermal breccia
OTHER
8 Overburden
Geological boundary
Alteration boundary
0
100 metres
Section 15+25 N.W.
LITHOLOGY SECTION
Figure No.:
4
CINOLA
GOLD PROJECT
STAGE II
Date:
March 1988
Drawn by:
City Resources (Canada) Ltd.
dlp

Tertiary Mio-Pliocene Skonun Formation
(Units 2a, 2b, 2c, 2d, 2e?, 4c, 4cu)

In general, the base of the Skonun Formation within the present limit of the Cinola deposit consists of coarse conglomerate. Subsequent deposition, although dominantly conglomerate, reveals increasing proportions of siltstone and sandstone northward and eastward from the south end of the deposit area. The finer-grained sediments also increase in proportion up-section, culminating into a sandy debris flow unit containing pelecypods indicative of a marine environment.

Wood fragments, particularly in the finer-grained sediments, account for 3 to 5% of the total rock volume. Locally, the wood fragments can be present as rare large logs, such as have been observed in the underground workings; these logs are apparently oriented northeast-southwest.

The major mine units within the Skonun Formation are as follows:

a) Unit 2a consists of grey to brown mudstone/ siltstone with minor carbon in the form of plant and tree fragments;
b) Unit 2b is a light grey to brown, medium to coarse grained sandstone with bedding and graded bedding commonly apparent;
c) Unit 2c is a clast-supported, medium grey to pale brown, polymictic conglomerate with rounded to subrounded pebble to cobble size clasts;
d) Unit 2d is a matrix-supported, medium grey to pale brown, polymictic conglomerate with rounded to subrounded pebble to cobble size clasts;
e) Unit 2e is a medium grey to pale brown polymictic, conglomerate containing pebble, cobble, and boulder sized andesite to rhyolite clasts, as well as an interstitial

matrix of rhyolite and/or sand sized particles of quartz and rock fragments. This unit is also found in the intrusive igneous sequence;

f) Unit 4c is a greyish-brown to maroon coloured, mud matrix-supported sedimentary breccia, containing grey to pale brown, angular to subangular clasts of predominantly rhyolite and wispy to fragmental pyrite and marcasite; and

g) Unit 4cu consists of a grey to brown, sandy/mud matrix-supported sedimentary breccia containing grey to pale brown, angular to subangular clasts, occasionally including pelecypods.

The combined unit designation was applied at the geologic cross-section interpretation stage of model development when it became difficult to separate out individual units from an intermixed package of sediments. In notating the combined unit, the major units were listed in order of decreasing volume. For example, an intermixed sandstone/mudstone sequence consisting of 60% sandstone would be noted as 2ba.

Intrusive Igneous Sequence

The intrusive igneous sequence includes at least two separate rhyolite intrusions localized along the Specogna Fault (Figures 3 and 4). The rhyolite intrusions in Unit 3 have been dated as middle Miocene (about 14 Ma), predating or contemporaneous with the hot-spring suite.

a) Unit 2e? is described within the Skonun Formation above. The cross-section interpretation of Unit 2e? indicates a distinct arched contact with the overlying sediments and the apparent predominance of rhyolite in localized areas within the Cinola deposit.

Overall this "boulder conglomerate" gives the impression of an unconsolidated coarse sediment intruded by a highly fluidized rhyolite, which ascended through these sediments and incorporated them into what appears as a porridge-like mixture of conglomerate and rhyolite;

b) Unit 3a is a grey to blue, tan to flesh coloured, quartz-feldspar rhyolite porphyry that contains quartz and plagioclase feldspar phenocrysts 2 to 5 mm in size;

c) Unit 3b consists of a tan to grey, silicified, hydrofractured rhyolite with a stockwork of pyrite/silica veinlets containing local minor hematite;

d) Unit 3c consists of a tan to grey, silicified, brecciated rhyolite with minor Haida mudstone fragments; and

e) Unit 4a is typically a tan to grey, highly silicified, vuggy rhyolite with honeycomb-like texture containing up to 10% ubiquitous pyrite.

Epithermal hot-spring suite

Both the sedimentary and the intrusive igneous rock sequences have been subjected to overprinting by argillic alteration and silicification. Associated with these alteration features is extensive silica-vein development peripheral to a hydrothermal breccia. The hydrothermal breccia is spacially related to the Specogna Fault (Figures 3 and 4).

The lithologic features of the epithermal hot-spring suite are summarized below.

a) Hydrothermal Breccia Unit 4b is commonly a bluegrey to black, coarse to finely-commuted polymictic breccia with a siliceous matrix. This unit has been traced along the Specogna Fault (on strike) for at least 800 m. It is up to 100 m wide near ground level, narrows at depth (~200 m) to a width of 10 m, and is generally tabular in structure with dyke-like offshoots extending into the wall rocks. The breccia unit itself consists of numerous generations of breccia, visible in both drill core and the underground workings, with gold grades consistently greater than 1.71 g Au/t.

The margins of the breccia are characterized by silica and by "floating" fragmental and rounded clasts of wall rock units, indicating violent pressure release and sudden precipitation of silica;

b) Stockwork Veining extends into the wall rock for several metres as a hydrofractured zone. Gold values consistently greater than 1.71 g Au/t occur in this stockwork, particularly on the hanging wall of the hydrothermal breccia. Stockwork veining is also found peripheral to the larger, vertical "seismic" veins described in e) below;

c) Pervasive Silicification characterizes an extensive region of Skonun sediments east of the hydrothermal breccia and stockwork veining. The evidence of silicification includes cryptocrystalline silica cement binding pebbles and smaller clasts of the original sediment, silica after calcite, chalcedonic silica veins, and drusy quartz crystals occurring as void fillings, vugs, and veins. The zone of silicification extends laterally, parallel to the Specogna Fault, and is roughly mushroom-shaped (Figure 3).

d) Argillic Alteration is found beyond the area of pervasive silicification in a region of Skonun sediments dominated by kaolinite-illite with minor alunite and sericite. Generally, the contact between argillic alteration and silicification marks the 0.69 g Au/t gold grade boundary, as there is an abrupt drop to gold value grades of less than 0.69 g Au/t within the argillically altered sediments; and

e) "Seismic" Veining within the pervasively silicified bedrock is an important localizer of high grade gold values. The veins are vertical to subvertical bands of chalcedonic quartz, striking 25 to 30°, and are related to conjugate sets of fractures created by differential movement on the Specogna and Sandspit faults while the hot-spring system was active.

Several types of veins have been recognized and recorded on drill logs. The vein unit divisions are based on visual characteristics and consist of the following:

a) Unit 5a is crystalline white calcite;
b) Unit 5b is clear, white to grey silica containing remnant calcite crystal outlines;
c) Unit 5c is clear, euhedral, drusy quartz often occurring as void filling or vugs (crystals from 1 to 5 mm);
d) Unit 5d is milky-white silica;
e) Unit 5e is white to light grey silica containing numerous breccia fragments;
f) Unit 5f is brownish-pink hematitic (?) silica (colour may be related to hydrocarbons); and
g) Unit 5g is grey-black cryptocrystalline to chalcedonic silica.

Ore types and distribution of mineralization

The orebody is essentially wedge-shaped and extends 800 m northwest-southeast. The wedge is approximately 200 m wide at surface, thinning with depth to 50 m wide at sea level (Figures 3 and 4).

The ore (>1.1 g Au/t) is distributed in four silicified lithologies: Skonun sediments, comprising 55% of the total ore tonnage; hydrothermal breccia, 30%; rhyolite, 13%; and Haida mudstone, 2%. Higher grade stockwork and "seismic" veining are distributed through all the ore types.

Genesis

Champigny et al. (1981) have hypothesized, based on evidence from borehole drilling at Tow Hill at the northern end of Graham Island, that the Cinola gold deposit was formed 1000 to 1500 m below the ground surface in an old braided stream, alluvial plain environment. (Tow Hill is a geographic feature 80 km northwest of Cinola on the eastern margin of the Queen Charlotte basin). The boreholes indicated the presence of conglomerates at a depth of 1000 to 1500 m, and it was assumed that the conglomerates at Cinola were buried to at least that depth when gold was deposited. More recent data obtained from relogging of Cinola exploration drill core and mapping of underground workings, however, strongly suggest that the gold was deposited in a hot-spring system near the surface in an alluvial fan environment.

Although most evidence of the hot-spring has eroded away, some material thought to be sinter was observed in DDH 80-88. If this material is indeed sinter, then only 100 to 200 m of bedrock may have been removed from the original ground surface (during the time of gold deposition), exposing the deposit at its present level. This would confirm the deposition of gold at Cinola in a near surface alluvial fan environment.

Rapid tectonic uplift along the western margin of the Queen Charlotte basin is believed to have created a fault scarp, accompanied by rapid erosion and the development of alluvial fans. One of these, the "Cinola Fan", originated along the

Specogna Fault and was intruded by a highly fluidized rhyolite (Unit 2e?); this intrusion initiated the movement of groundwater and the development of a hot-spring system.

The magma chamber, or source of this intrusion, was positioned near the surface and able to sustain high heat flow long enough to allow the intrusion of a later rhyolite (Unit 3a) along the Specogna Fault and the generation of the hot-spring system.

The unconsolidated, porous nature of the alluvial fan sediments allowed extensive migration of hydrothermal fluids, both vertically and laterally, away from the Specogna Fault during the early stages of hot-spring development. With the migration of hydrothermal fluids came the deposition of silica and various elements, including gold. Silica deposition slowly sealed the sediment pores, restricting the movement of hydrothermal fluids to the vicinity of the Specogna Fault. The silica sealing process eventually created significant overpressuring within the hot-springs system, and hydrothermal fluids erupted explosively. These eruptions caused the supersaturated silica solutions to boil suddenly and gold to precipitate.

Numerous overpressuring and explosive hydrothermal eruption events are thought to have taken place at the Cinola deposit, each event resulting in the increase in the quantity and grade of gold in the deposit. These eruptions were localized along the Specogna Fault and are evident as hydrothermal breccia units within the present deposit.

This understanding of the hot-spring genesis of the Cinola deposit has proven very useful in successfully outlining gold grades throughout the various lithologic units. Further geological study is required and is in progress to obtain a more complete interpretation of the detailed nature of the hot-spring system.

ACKNOWLEDGEMENTS

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We would also like to thank Janet Galay, Sandra Heiman, Tara Holt and Nicole Beaudoin for typing the multiple editions of the manuscript as well as Dave Phillips for drafting the figures.

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CITY RESOURCES (CANADA) LIMITED

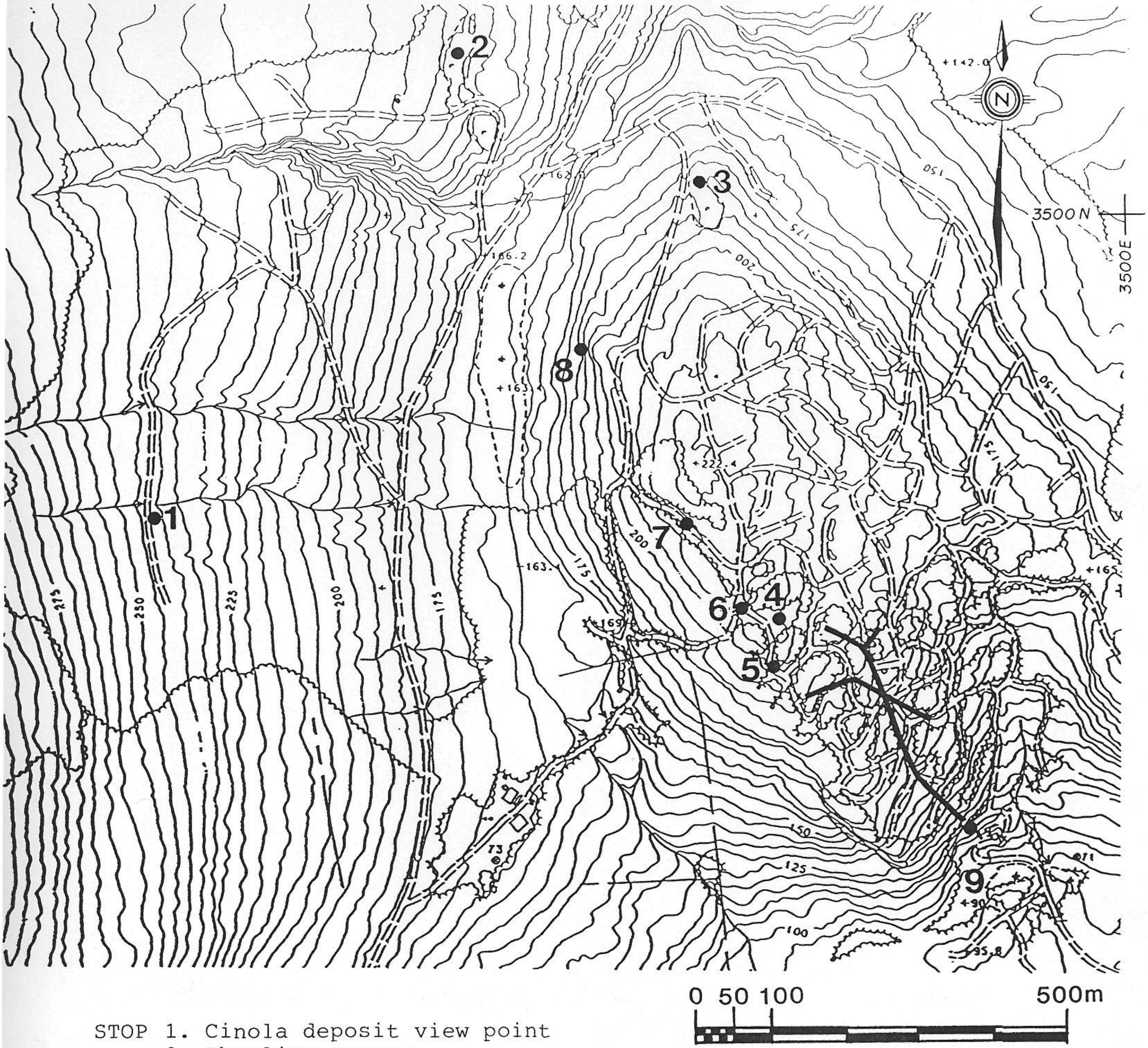
CINOLA GOLD DEPOSIT

SEG FIELD TOUR

SEPT. 23, 1988

by

R.S. Tolbert
N.V. Froc
J. Deighton
T. Borschneck



STOP 1. Cinola deposit view point
2. Rhyolite quarry
3. Silicified Skonun Formation sediments
4. Multiphase breccia and intense veining
5. Multiphase breccia and hydrofractured rhyolite
6. Silicified Haida Formation mudstone breccia
7. Specogna Fault
8. Marino Showing
9. Adit

Fig.1 Selected tour stop locations

The following field guide provides location maps and brief geologic descriptions for the various stops which will be taken on the Cinola Tour. The selected tour stop locations are shown on Figure 1, which also serves as an index for the remainder of the guide.

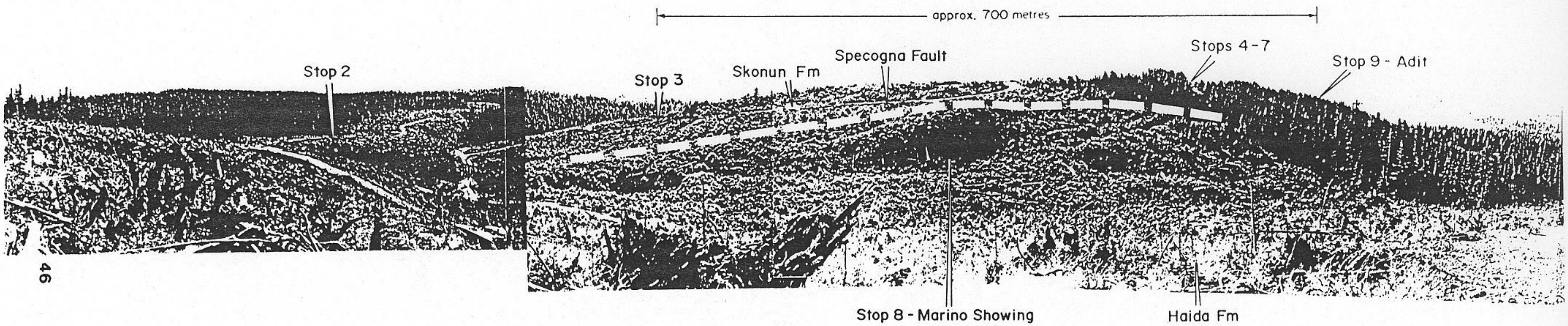


Fig. 2 STOP 1: View of silicified knoll containing the Cinola deposit (East)

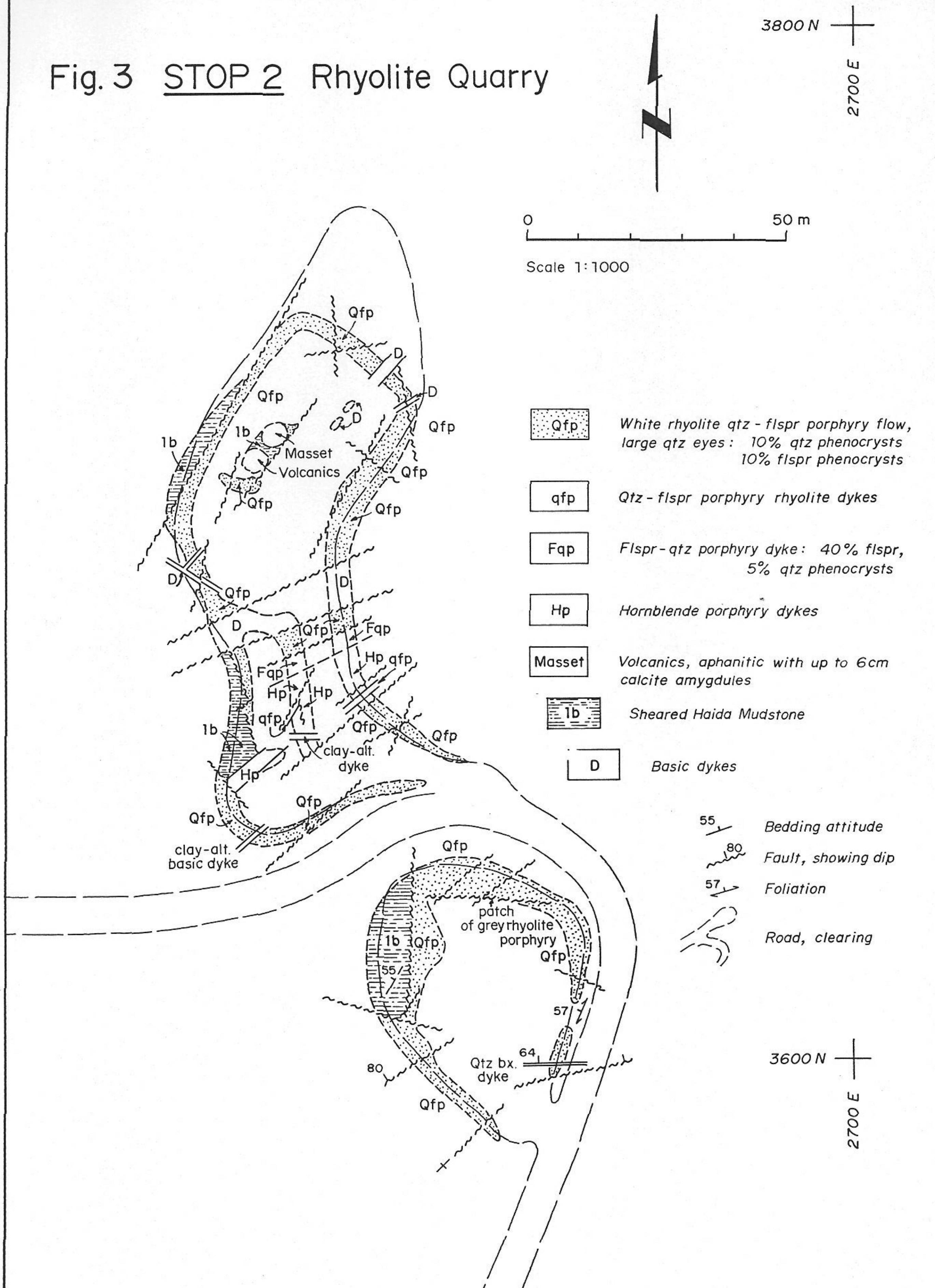
STOP #1 <u>CINOLA DEPOSIT VIEWPOINT</u>

(See Figures 1,2)

From this vantage point almost the full extent of the western side of the Cinola deposit can be viewed. It appears as a slight knoll with the Queen Charlotte Lowlands, Hecate Strait and the British Columbia mainland in the background.

<u>Notes:</u>

Fig. 3 STOP 2 Rhyolite Quarry



STOP #2 <u>RHYOLITE QUARRY</u>

(See Figures 1,3)

Exposed in this MacMillan Bloedel rock quarry is a probable Tertiary age intrusive sheet of quartz-feldspar porphyry. The porphyry unit is a sill intruding older Cretaceous Haida Formation mudstones. Both these units are intruded by later dykes of basic to felsic composition trending 30° to 50°.
Argillic alteration within this quarry is quite prominent.

<u>Notes:</u>

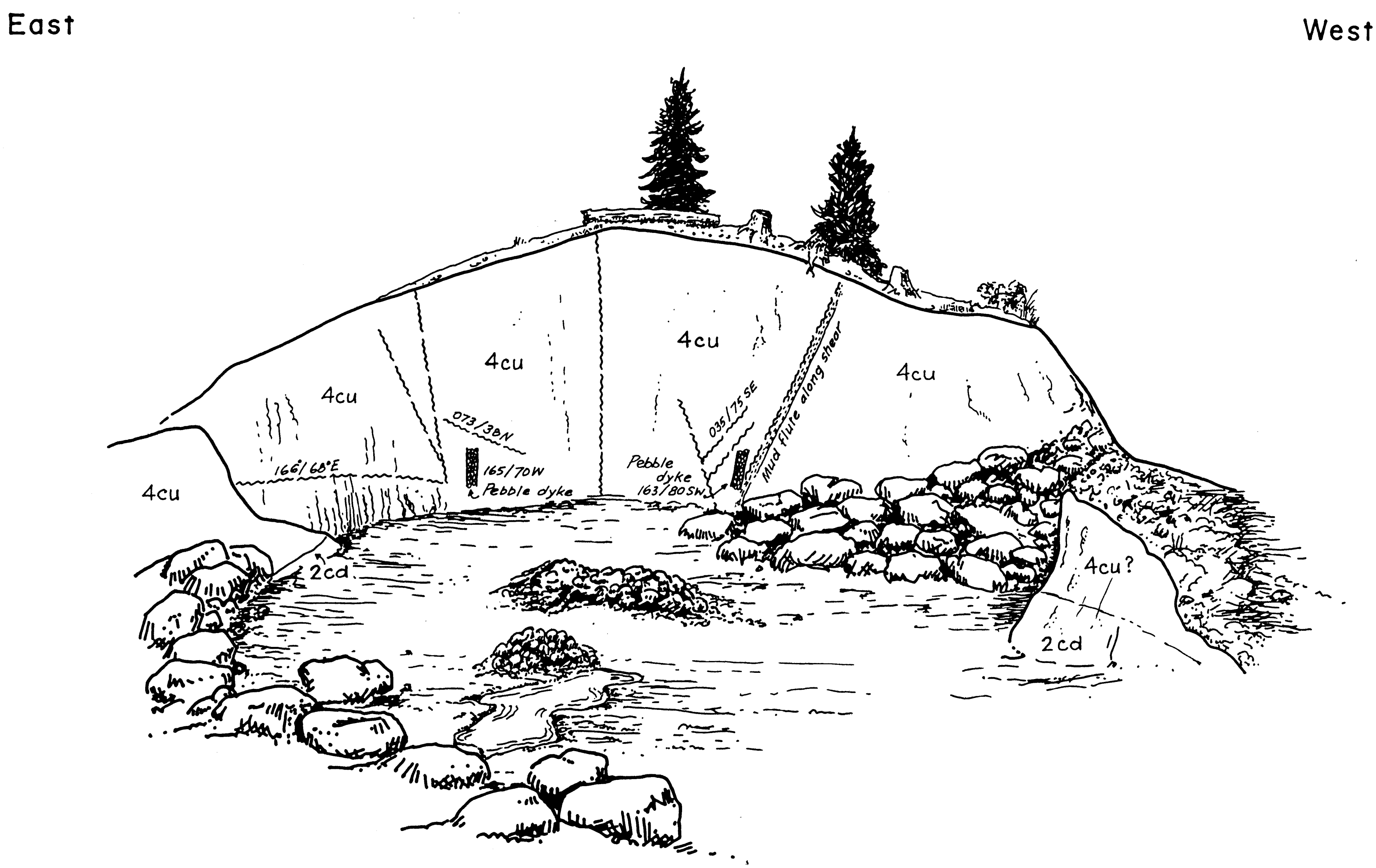


Fig. 4 STOP 3: Skonun Fm. sediments quarry (South)

STOP #3 <u>SKONUN FORMATION SEDIMENTS QUARRY</u>
(See Figures 1,4,5)

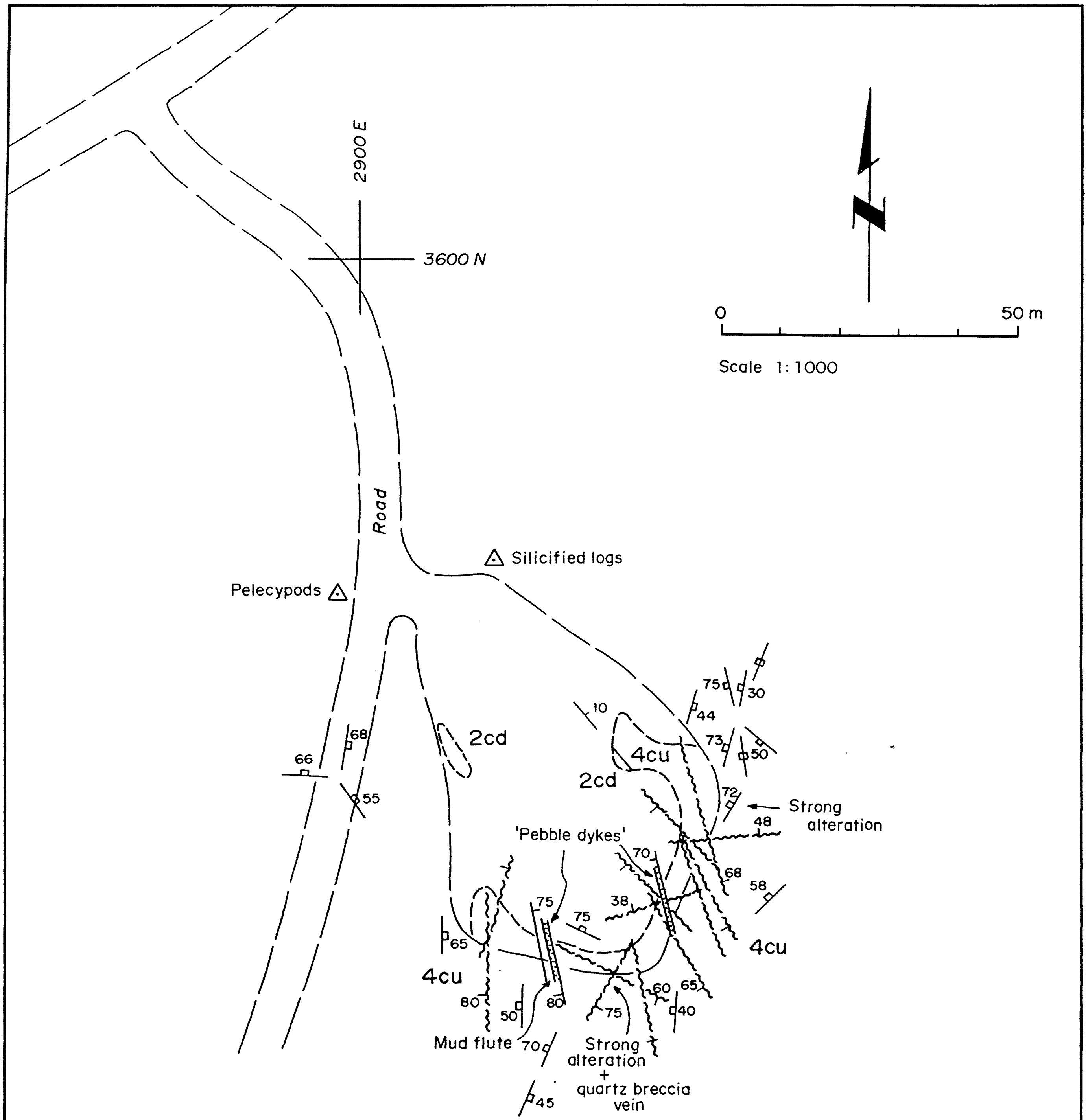
This north facing quarry exposes Unit 4cu overlying typical pebble conglomerate of the Tertiary Skonun Formation.

Unit 4cu is the uppermost exposed unit of the Skonun Formation in the deposit. It consists of sandy debris flow sediments (conglomeratic siltstone/sandstone?) containing pelecypods. The distinctive nature of this lithologic unit make it an excellent marker unit for stratigraphic correlation between drill holes.

Unit 2cd is a combined conglomerate unit consisting of both clast and matrix supported polymictic conglomerate with rounded to subrounded pebble to cobble sized clasts.

Both units are moderately silicified with local intense silicification along fractures.

<u>Notes:</u>



SEDIMENTARY UNITS

MIOCENE - PLIOCENE: *Skonun Formation*

2cd	*Conglomerate, clast- and matrix-supported*
4cu	*Sandy debris flow*

Fig. 5 STOP 3: Skonun Fm. sediments quarry

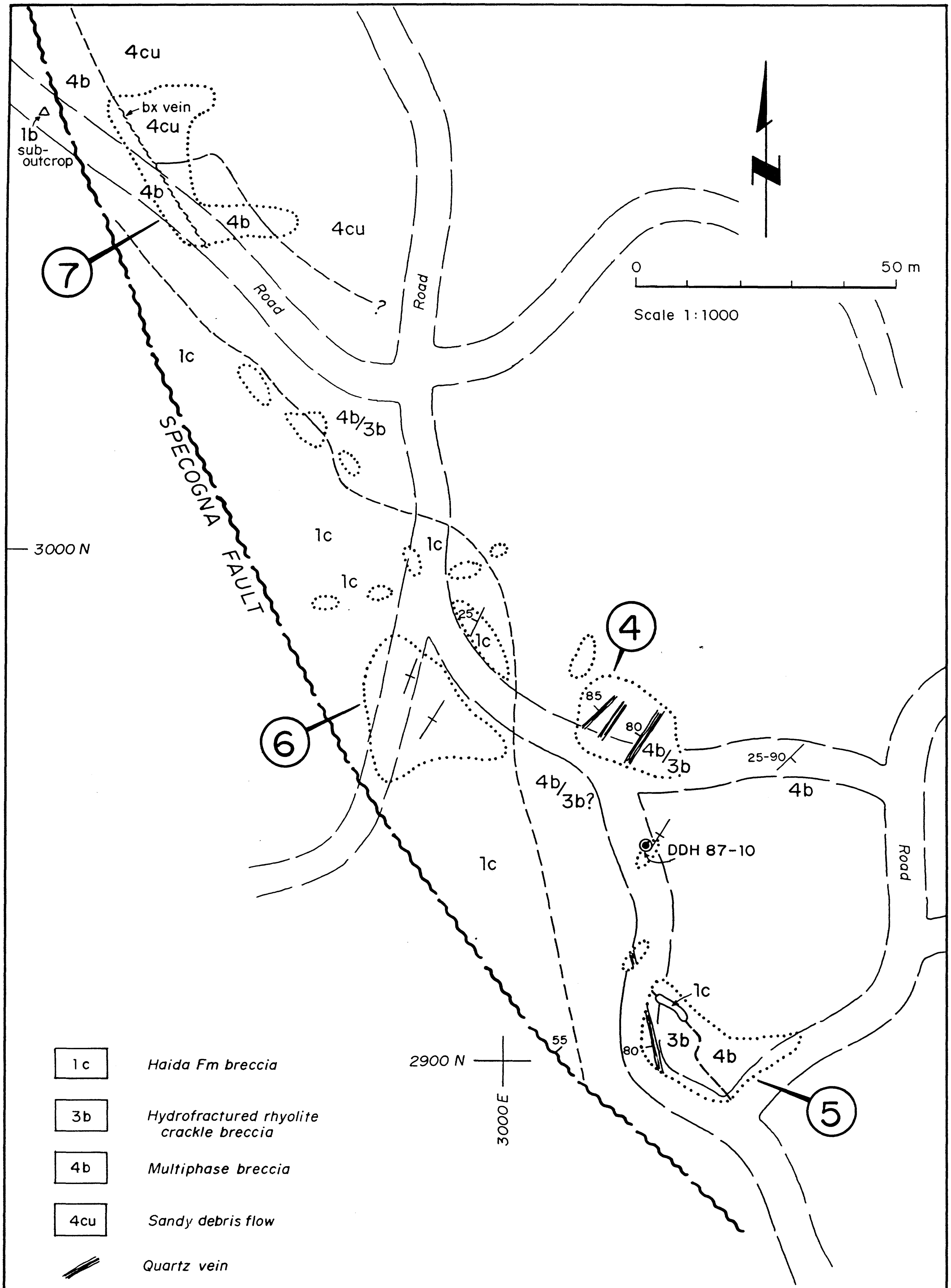


Fig. 6 STOPS 4,5,6,7

STOP #4 <u>MULTIPHASE BRECCIA AND INTENSE VEINING</u>
(See Figures 1,6)

This prominent outcrop at the crest of the hill exposes stockwork veined silicified rhyolite, unit (3b), within the hydrothermal breccia unit 4b.

Veins exhibit honeycombed, colliform banded, vuggy textures. Quartz is chalcedonic to drusy ranging from white to grey with light brown coloured quartz possibly due to inclusions of hydrocarbons. They dip vertically to subvertically, trend 020° to 045° and range in true width from 0.1 cm to 50 cm.

On the road to stop 5 (Figure 6), 30 metres east of Stop 4, are; honeycombed, limonitic, brown banded vuggy quartz veins, and a silicified pebble dyke with fragments of Skonun Formation sandstone.

<u>Notes:</u>

STOP #5 MULTIPHASE BRECCIA AND HYDROFRACTURED RHYOLITE
(See Figures 1, 6)

This outcrop, located 40m south of Stop 4, exposes the hydrothermal breccia unit 4b and hydrofracted rhyolite Unit 3b.

The hydrothermal breccia contains fragments of dark silica, rhyolite, silicified Haida Formation mudstone and possibly pebble dykes.

The hydrofracted rhyolite contains red hematite (jasper?) and pyrite along fractures which have been cross-cut by later quartz veining.

Notes:

STOP #6 SILICIFIED HAIDA FORMATION MUDSTONE BRECCIA
(See Figures 1,6)

This outcrop exposes silicified stockwork-veined Haida Formation argillite/mudstone (1c) with honeycombed, milky-white, banded, drusy, vuggy quartz veining. The prominent vein trend is 020° to 045°.

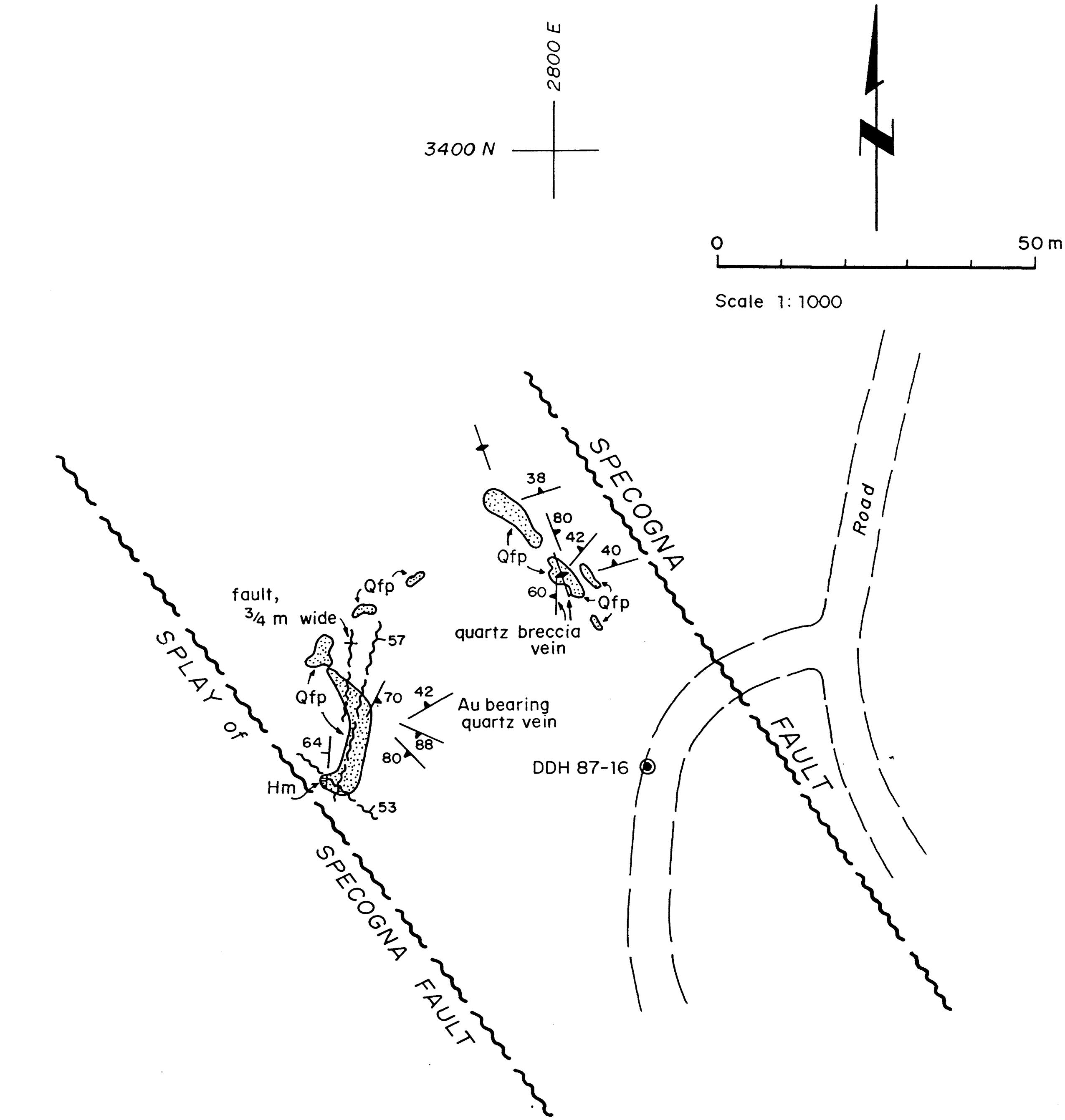
Notes:

STOP #7 <u>SPECOGNA FAULT</u>
(See Figures 1, 6)

This outcrop located approximately 150m northwest of Stop 4 is proximal to the Specogna Fault and exhibits hydrothermal breccia (4b) crossing into stockwork-veined hydrofracted Skonun Formation sandstone (4cu). The general strike of veining is 025°.

Evidence for the location of the Specogna Fault is from drilling results and the presence of Haida Formation mudstones (1b) subcropping just west of the Stop 7 hydrothermal breccia outcrop.

Notes:



Qfp White rhyolite qtz - flspr porphyry flow

1b Sheared Haida Mudstone

Flow structure; inclined, vertical

Fig. 7 STOP 8: Marino Showing

STOP #8 MARINO SHOWING
(See Figure 1,7)

This outcrop forms a cliff 50 metres to the west of DDH 87-16.

At the base of the cliff is a quarry mined by E. Specogna which produced 6.4 tonnes (7 tons) of handcobbed ore grading 143 g/T Au (4.17 oz/t Au).

This outcrop is a faulted, isolated upthrown block of blue-grey quartz-feldspar porphyry cut by a number of northeasterly trending quartz veinlets (< 2cm wide) containing visible gold.

Notes:

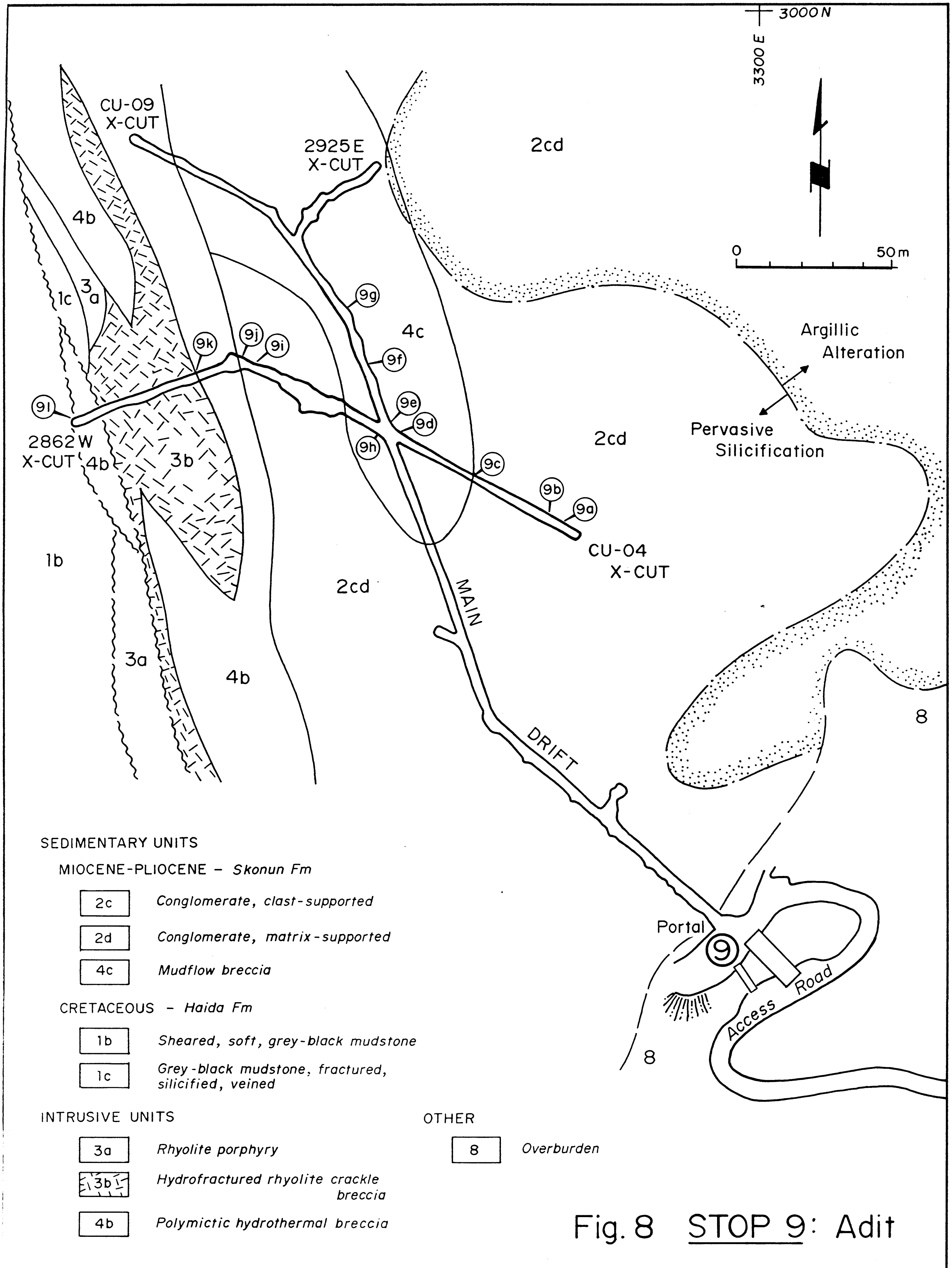


Fig. 8 STOP 9: Adit

STOP #9 <u>ADIT</u>
(See Figures 1,8)
*Note - NO ROCK PICKS

<u>9a</u> End of Cu-04 cross-cut.
Epithermal vein in Skonun Formation sandstone/siltstone (Unit 2ab) sequence exhibiting colliform banding and crustification of quartz and chalcedonic silica. Moderate pervasive silicification.

<u>9a to 9b</u>
Conglomerate (Unit 2cb) and sandstone (Unit 2ab) beds dipping easterly with evidence of plant roots in finer grained sediments. Note cross-cutting nature of epithermal veins.
Average grade from 9a to 9b is 2.43 g/T Au (0.071 oz/t Au) over 10m.

<u>9b to 9c</u>
Typical Skonun Formation conglomerate (Unit 2cd) pervasively silicified with cross-cutting predominantly vertical epithermal veins.
Average grade from 9b to 9c is 2.26 g/T Au (0.66 oz/t Au) over 25m.

<u>9c to 9d</u>
Faulted contact of Skonun Formation conglomerate (Unit 2cd) and underlying mudflow breccia (Unit 4c).
Note the amount of veining gradually increases westward.
Average grade from 9c to 9d is 10.08 g/T Au (0.294 oz/t Au) over 30m.

<u>9e</u> Junction of Cu-04 cross-cut and the main drift.
Note large veins trending in 030° to 040° direction and large log in back oriented in a NE-SW direction.

9f
Mudflow breccia (Unit 4c) with two large slumped boulders of interbedded conglomerate/sandstone/siltstone and maroon colored pyroclastics (possibly Masset Formation?) which were transported in the mudflow.

9f to 9g Main drift.
Silicified mudflow breccia (Unit 4c) with cross-cutting subvertical epithermal veins trending 020° - 040°.
Average grade from 9f to 9g is 3.12 g/T Au (0.091 oz/t Au) over 25m.

9g
Fine grained rhyolite dyke (Unit 3) which has intruded unconsolidated presilicified sediments.
Note 'wrap-around' and 'flame' textures. This may represent an earlier phase of rhyolite which initiated hotspring activity.

9h to 9i Start of 2862 W cross-cut.
Silicified Skonun Formation conglomerate (Unit 2cd) and minor interbedded finer grained sediments cut by increasingly frequent subvertical epithermal 'seismic' veins trending at a general 030° direction.
Note the increased finer stockwork veining occurring peripheral to the larger veins.
Average grade from 9h to 9i is 3.02 g/T Au (0.088 oz/T Au) over 45m.

9i to 9j
Silicified conglomerate near hydrothermal breccia (Unit 4b) exhibiting intense stockwork veining.
Average grade from 9i to 9j is 3.12 g/T Au (0.91 oz/t Au) over 5m.

9j

Hanging-wall contact of hydrothermal breccia (4b) and overlying conglomerate (2cd).

Note 'ripped out' and 'floating' clasts of sediment in the breccia and stockwork veining caused by hydrofraction.

9j to 9k

Hydrothermal breccia (Unit 4b)

Note dark silica and finely comminuted fragments in breccia, quartz after calcite texture and late veins cross-cutting breccia.

Average grade from 9j to 9k is 3.36 g/T Au (0.098 oz/t Au) over 8m.

9k

Footwall contact of hydrothermal breccia (4b) and hydrofracted rhyolite (3b).

9k to 9l

Hydrofracted rhyolite (Unit 3b) and hydrothermal breccia (4b).

9l Specogna or footwall fault.

Silicified tectonically brecciated rhyolite (3c) and Haida Formation mudstone (1c) on hanging-wall of Specogna fault striking 134° and dipping 45° east. Below the fault contact is sheared and gouged unsilicified Haida Formation mudstone.

Notes:

GEOLOGY OF THE STEWART MINING CAMP

by

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Geological Survey Branch
B.C. Ministry of Energy, Mines and Petroleum Resources
Victoria, B.C.

LITHOSTRATIGRAPHY

Grove (1986) established the stratigraphic succession used in this report. Only one modification is made: the felsic volcanic member, Monitor Rhyolite, has been raised to formational status and renamed the Mount Dilworth Formation or Mount Dilworth Dacite.

Hazelton Group

Unuk River Formation

The Unuk River formation is a thick sequence of massive green to greenish grey andesitic tuff and volcanic flows with minor interbedded sedimentary rocks. This unit hosts all the major mineral deposits in the map area.

The formation is exposed continuously along a north-south belt through the centre of the map area. The base of this andesitic volcanic sequence has not been identified and probably lies to the west, but the formation is at least 4500 metres thick within the map area. The upper contact is typically a sharp, ragged to smoothly undulating boundary between porphyritic andesite flows or tuffs and overlying regolithic grits to conglomerates of the Betty Creek formation.

The formation is a thick, monotonous sequence of medium green andesitic rocks which are preserved as weakly to moderately foliated greenschists. Volcanic rocks range from dust to ash tuff, crystal tuff, lapilli tuff, monolithic pyroclastic breccia and lava flows. The volcanics are generally porphyritic, characterized by plagioclase and, less commonly, hornblende or augite crystals or crystal fragments. Within individual beds the tuffs show little evidence of sorting, or preferred orientation of crystals or lithic fragments (except in zones of ductile deformation). Intermittent exposures and rapid lateral facies changes in the tuffs make correlation of individual strata along strike difficult.

Lower Andesite Member

The lower member is composed of massive to well-bedded ash tuffs. No phenocrysts or lapilli were noted in outcrop, but a thin section of ash tuff has abundant fine scattered pyroxene crystals.

Lower Siltstone Member

The lower siltstone member lies west of the map area along most of the Salmon River valley, and consists of rhythmically bedded, thin-bedded dark grey siltstones, shales and wackes.

Middle Andesite Member

This unit is at least 1500 metres thick and comprises dust tuff, ash tuff, lapilli tuff and minor tuff breccia with interbedded medium to coarse volcaniclastic sedimentary rocks. Grading indicates tops towards the synclinal axis on Mount Dilworth.

Upper Siltstone Member

Near the north end of the Trojan Horse road tunnel the lower contact of this member is marked by a coarse, heterolithic boulder conglomerate exposed for a few tens of metres strike length and varying up to a maximum thickness of 3 metres. Clasts of coralline limestone were recovered from this conglomerate that is interpreted as a stream channel deposit. The immediately overlying thin-bedded rocks are alternating light grey limestone and dark grey calcareous siltstone. Southwest of the Silbak-Premier mine, alternating greywacke-shale beds in the upper part of the upper siltstone sequence have been interpreted as Bouma cycle turbidites by Brown (1987).

These thin-bedded strata have a sharp upper contact against a massive black rock that is the basal facies of the overlying upper andesite member.

The unit provides evidence for major offsets along the Millsite fault, the Morris Summit fault and the Slate Mountain fault.

Upper Andesite Member

The upper andesite member is a thick sequence of massive tuffs with minor flows and local lenses of sedimentary rock. The member is about 2000 metres thick and is capped by regionally extensive porphyritic flows and crystal tuffs of the Premier Porphyry member.

Black Tuff Facies

The base of the upper andesite member is marked by a variable thickness, 0 to 250 metres, of massive black fine-grained to locally fragmental rock. The upper limit of this unit is a narrow gradation (10 to 50 centimetres) to green chloritic tuffs. This gradational colour boundary undulates across large, texturally uniform outcrops.

Thin-section study shows that the massive black rocks include carbon-impregnated ash tuff, feldspar crystal tuff and lapilli tuff textures, but also include massive siltstone, feldspathic wacke and granule to pebble conglomerates of roughly rounded volcanic debris. Therefore these black rocks are intimately mixed massive sediments and tuffs, transitional between underlying thin-bedded black siltstones and overlying massive green andesite tuff.

Main Sequence

The main sequence of the upper andesite member is a monotonous succession of greenstones and minor sedimentary lenses. It is difficult to distinguish individual units because of uniform green colour and pervasive foliation of the rocks. Massive fine-grained aphanitic ash tuffs locally have fine plagioclase and hornblende phenocrysts set in an altered ash matrix. These rocks are characterized by pervasive chloritic alteration and disseminated fine-grained pyrite. Chlorite is oriented along the penetrative foliation of the rocks and gives a phyllitic sheen to some broken surfaces.

Deep green to greyish green fragmental rocks are typically monolithic; matrix-supported fragmental textures are most common and are best displayed in buff-coloured weathered surfaces (Plate 00). Fragmental rocks contain lithic, pumice and crystal fragments. Lithic fragments are varieties of ash tuffs, variable plagioclase and hornblende-rich porphyritic rocks and lithified fragmental rocks. The groundmass is composed of fine lithic fragments and glass shards in a fine-grained matrix of quartz, feldspar, sericite, chlorite and carbonate plus indistinguishable ash and dust material. Fragments are typically angular, but exposures displaying subrounded and well-rounded monolithic fragments have been documented. Fragment size ranges from granular andesitic tuff through lapilli tuff to medium to coarse tuff breccias. Regionally, angular fragments range up to 40 centimetres long but in one local area on Mount Dilworth a single bed contains blocks up to 1.5 metres across. The coarsest fragmental rocks are at the top of the member. Fragmental rocks are open framework volcanic breccias and may represent airfall lapilli tuff, flow breccias, ungraded pyroclastic flow breccias, or lava flow breccias. Weathered exposures of more resistant fragments in recessive matrix and of more resistant matrix with recessive fragments have been noted; possibly the former represent airfall lapilli tuffs and the latter represent either hot pyroclastic flows or flow top breccias. Exposures are typically massive, with no preferred orientation, but local zones of ductile deformation result in plate-like flattened fragments.

Near the top of the upper andesite member several exposures of welded and partially welded tuffs have been noted by Galley (1981) in the Big Missouri area and the writer in the Silbak Premier mine area. Welded rocks show alignment of elongate lithic fragments and partially collapsed pumice.

Pyrite is disseminated in both fragments and groundmass ì as angular subhedral chips to euhedral cubes. Typically pyrite makes up about 2 per cent of these rocks, but local exposures of intense chlorite-pyrite alteration with up to 5 per cent disseminated medium-grained pyrite has been noted within 2 kilometres of the Silbak Premier mine. Near most mineral zones pyrite content increases and is roughly proportional to the intensity of the associated sericite and carbonate alteration.

Conformable flows or sills of potassium feldspar megacrystic, plagioclase-hornblende porphyry, or "Premier Porphyry", have been identified in outcrop and drill core by McGuigan and Dawson (1985) on the ridge north of the Indian mine. These units dip steeply eastward and lie within 300 metres of the base of the upper andesite member. Lack of flow breccia textures suggests they are sill units.

Within the upper andesite member, local lenses of maroon to purple to grey siltstone, sandstone and conglomerate are preserved. Epiclastic rocks record quiescent periods of erosion during the development of the andesitic volcano. These hematitic sedimentary units are distinctive and may be useful marker horizons on a property scale.

The top of the upper andesite member is marked by andesitic lapilli tuff to coarse tuff breccia. On Mount Dilworth this upper tuff breccia contains fragments up to 1.5 metres in diameter, including an intact hexagonal fragment of columnar-jointed andesite, 1.2 metres across.

Premier Porphyry Member

This distinctive member contains bimodal feldspar plus hornblende phenocrysts and is exposed at the top of the Unuk River formation throughout the map area. Regionally the unit can be divided into three members, on more local scales a variety of additional facies are preserved.

These rocks are texturally identical to dykes of Premier Porphyry which cut the underlying strata and Texas Creek batholith. A common name is used to stress the genetic link between the intrusive and extrusive phases of these economically and stratigraphically important rocks. All mineral deposits in and around the Silbak Premier mine occur stratigraphically below this member.

Welded Plagioclase Porphyry

The lowest regionally mappable unit of this package is the thickest and most continuous. The rock is a massive to crudely laminated plagioclase-hornblende porphyry. Plagioclase phenocrysts ($\leq$6 millimetres) stand out clearly but the hornblende crystals are smaller and only evident with careful hand-sample study. Layering is typically 1 to 2 centimetres thick. The rock appears more indurated and less foliated than andesitic tuffs lower in the sequence, and thus is interpreted as welded or partially welded airfall crystal tuff. The degree of sorting in this layering varies down to exposures that are essentially massive. This unit does not normally display K-feldspar crystals; a few small and/or broken orthoclase rhombs have been noted in widespread outcrops. Good examples of this rock type are found ì below the treeline eastward and uphill of the Silbak Premier mine, on the west slope of Troy Ridge, and in a striking exposure over several hundred meters immediately southeast of Brucejack Lake (Alldrick and Britton, 1988).

Premier Porphyry Flow (Green)

Premier Porphyry flow is a dark green to medium greyish green to grey to black, massive, indurated richly porphyritic rock hosting megacrystic K-feldspar and smaller plagioclase and hornblende phenocrysts. Good exposures of these bimodal feldspar-porphyritic andesite flows outcrop on the western slopes of Mitre Mountain and Troy Ridge, along the bottom of Daisy Lake (which drains annually), along the west side of Mount Dilworth, on the ridge crest south of the peak of Slate Mountain, and uphill from the Silbak Premier minesite. This unit occurs in exposures up to 100 metres thick on the northern part of the west face of 49 Ridge.

Phenocrysts include small (3 to 5-millimetre) white, subhedral to euhedral plagioclase crystals and larger (1 to 5-centimetre) buff-coloured, euhedral orthoclase crystals; locally 5 to 10-millimetre hornblende crystals are evident, but they are most often obscured by strong chloritic alteration. The matrix is fine grained and usually chloritic.

In thin section the rock shows embayed, partially resorbed quartz grains. The large euhedral feldspar crystals show little rounding or fracturing. Plagioclase may occur as glomeroporphyritic clusters (Plate 00) and all feldspars show a ìthin clear inclusion-free rim which may represent the last layer of crystal growth as the extruded flow cooled. An interlocking, felted groundmass of microlites indicates the rock is a flow. Both Read (1979) and Galley (1981) report minor biotite in thin-section examination of samples near Big Missouri. No biotite was noted in samples examined in this study, perhaps because of replacement by chlorite.

Premier Porphyry Tuff (Maroon)

A similar K-feldspar megacrystic, plagioclase and hornblende porphyritic rock has been noted in several outcrop areas between the High Ore prospect and Daisy Lake. This rock is distinguished from the underlying green Premier Porphyry flow by its hematite content which produces a purple to greyish purple colour and by its non-crystalline aphanitic matrix seen in thin section. This unit was first defined by Plumb (1957) as "purple tuff" and was termed "dacite maroon porphyry flow" by Brown (1987). Based on microscopic textural features summarized in the following table, this rock is interpreted as massive, subaerially deposited airfall crystal tuff.

TEXTURAL DISTINCTIONS BETWEEN PREMIER PORPHYRY FLOW AND PREMIER PORPHYRY TUFF

Flow	**Tuff**
rimmed feldspars	no feldspar rims
few or no lithic chips	lithic clasts common
euhedral phenocrysts	broken and/or rounded phenocrysts
interlocking crystalline matrix	fine ash matrix
glomeroporphyritic feldspars	

Continuity of this unit south of High Ore or north of Daisy Lake has not been demonstrated, but it may continue as a green, chloritized tuff; distinction between tuff and flow facies are best made by thin-section study, although Read (1979) felt slabbed samples were adequate.

Petrochemistry

The petrochemistry of the Unuk River formation has been studied by Galley (1981), Alldrick (1985) and Brown (1987) and has been evaluated as part of regional-scale comparative studies by de Rosen-Spence and Sinclair (1988) and Thorkelson (in preparation). The volcanic rocks are sub-alkaline, calc-alkaline, potassium and iron-rich andesites and dacites.

Provenance

The rocks of the Unuk River formation represent an andesitic volcanic pile and locally derived intraformational volcaniclastic sedimentary rocks. Facies relationships indicate proximity to one or more volcanic vents and the formation is regarded as a well-preserved lower Jurassic composite stratovolcano, with paleotopographic peaks at or near Mount Dilworth (upper andesite member) and at the northeast end of Long Lake (middle andesite member).

Depositional Environment

Most workers have interpreted strata of the Unuk River formation as a subaqueous volcanic pile. Brown (1987) tentatively considered these rocks to be a predominantly submarine sequence with final emergence to a subaerial phase by growth of the volcanic pile. In this study the composite stratovolcano is regarded as a predominantly subaerial structure with two brief periods of marine transgression recorded by the thin-bedded siltstone members.

Age

The base of the Unuk River formation has not been defined in the map area and rocks low in the sequence have not been dated. The flow rocks of the uppermost Premier Porphyry member are interpreted to be 195 Ma old based on correlation with U/Pb zircon ages from nearby Premier Porphyry dykes. The entire Unuk River formation is regarded as a Sinemurian (?) to mid-Pleinsbachian volcanic pile composed of onlapping to overlapping volcanic and sedimentary members from a series of nearby sequentially erupting volcanic vents.

Betty Creek Formation

This formation is a complex succession of andesitic to dacitic tuffs and flows interbedded with distinctively coloured red and green epiclastic sedimentary rocks. The formation varies in thickness from 4 metres to 1200 metres and is exposed continuously throughout the map area except for the 2-kilometre interval between Union Lake and Fetter Lake where it may be absent or overprinted and obscured by intense alteration.

The basal contact is typically marked by a sharp colour change from greenish chloritic andesitic tuffs of the Unuk River formation to maroon clastic sedimentary rocks. The basal sediments are commonly immature conglomeratic regoliths lithologically similar to the underlying andesites. The contact varies from irregular to smoothly undulating.

The upper contact is a sharp smooth boundary between purple, hematitic grits or wackes and overlying aphanitic massive dust tuffs of the Mount Dilworth formation.

Sedimentary Facies

The brightly coloured sedimentary rocks display textures ranging from mudstones, siltstones, sandstones, wackes and grits up to coarse boulder conglomerates. The bedding, textures and colouring of these beds are distinctive. The matrix of these hematitic sedimentary rocks is typically brick red to maroon to purple, but local greenish and mottled purple and green units occur near the base of the sequence. The iron oxide which gives the sandstones their strong reddish shades lies within the intergranular clay fraction.

Most of the clasts are andesitic volcanics similar in texture and composition to the rocks in the underlying Unuk River formation. Conglomerates are predominantly matrix supported. Individual conglomeratic beds are massive to crudely sorted, and the latter may show either reversely graded or symmetrically graded beds that are characteristic of lahars (Fisher and Schminke, 1984).

The general depositional environment is subaerial although some sedimentary units exhibit waterlain textures. Scattered exposures of grit to mudstone beds show normal grading, crossbedding, scour marks and rhythmic bedding and are thought to represent stream channel deposits where debris flow fans have been reworked on the lower flanks of a stratavolcano. These sedimentary structures show consistent stratigraphic tops toward the synclinal axis on Mount Dilworth.

Volcanic Facies

Volcanic facies include dust tuff, ash tuff, feldspar crystal tuff, lapilli tuff and porphyritic lava flows interbedded with the sedimentary rocks. As a generalization, within a single stratigraphic section, volcanic units grade upward from andesitic to dacitic composition.

Provenance and Depositional Environment

The clastic sediments have likely been derived by weathering and erosion of Unuk River formation tuffs and flows. The Betty Creek formation is interpreted as a subaerial clastic apron of poorly sorted lahars deposits and reworked debris flows interbedded with onlapping andesitic to dacitic volcanic rocks on the flanks of an andesitic stratovolcano constructed of Unuk River formation rocks. Areas where Betty Creek formation thins or wedges out represent paleotopographic highs.

Age

No fossils or isotopic dates have been obtained from the Betty Creek formation. The most likely age range for accumulation of the sediments, tuffs and flows of the formation is mid-ì Pliensbachian to mid-Toarcian time (195 to 190 Ma), coeval with deposition of the lithologically similar Nilkitkwa formation (Tipper and Richards, 1976). Typical time intervals for growth and erosion of subaerial stratovolcanos suggest the actual time span for accumulation of the Betty Creek formation was somewhat shorter, in the range of 1 to 3 million years (Cas and Wright, 1987, pages 294-295). Therefore deposition of thé Betty Creek formation is interpreted as a Lower to Middle Toarcian event lasting about 2 million years.

Mount Dilworth Formation

The felsic volcanic sequence in the map area is composed of dense, resistant, variably welded dacite tuffs. Individual members display distinct lateral facies variations and textural changes that can be related to volcanic centres, paleotopography and depositional environment. This felsic volcanic package is thin but continuous throughout the region and thus warrants formational status. This distinctly coloured unit is resistant, a cliff-former, and is an important regional stratigraphic marker.

The formation is exposed in a continuous, north-south elongated oval outcrop pattern within the map area. This sub-circular distribution reflects the regional doubly-plunging "synclinorium" in the center of the map area. Thickness ranges from 20 to 120 metres.

Despite local heterogeneities and facies variations, the three major members of the formation -- the Lower Dust Tuff, Middle Welded Tuff, and Upper Lapilli Tuff -- can be ìdistinguished in sections throughout the map area.

Lower Dust Tuff Member

The lowest member of the Mount Dilworth formation is a massive aphanitic dust tuff (fine ash tuff) composed of volcanic dust and fine lithic particles.

Middle Welded Tuff Member

The Middle welded ash flow tuff is the most variable of the three regionally extensive members of the Mount Dilworth formation. It is a series of laterally varying dacitic facies sandwiched between two members that are texturally more consistent.

In the Mount Dilworth to Monitor Lake area, sections through this member show mixed fiamme and angular felsic lapilli at the base, overlain by pumice lapilli tuff. Well exposed sections show progressively more intense welding and compaction down-section; equidimensional pumice clasts grade downward into black glassy fiamme. Outside the Mount Dilworth area subrounded pumice lapilli are mixed with varied siliceous lithic clasts but the rocks are not obviously welded.

Upper Lapilli Tuff

The regionally extensive upper member of the Mount Dilworth formation is a siliceous lapilli tuff to tuff breccia. Fragments are predominantly swirled flow-banded dacite bombs or spatter, but clasts of other siliceous volcanic rocks are also common. Regionally the fragment size ranges up to a maximum or 10 ì to 15 centimetres and the overall size range is that of a lapilli tuff (Plate 00). However along the southwest edge of the Mount Dilworth snowfield, large swirled flow-banded bombs up to 50 centimetres long are preserved (Plate 00). This local increase in fragment size suggests that the southern part of Mount Dilworth was a proximal, near vent area for this member. The unit may be partially welded but contains neither pumice fragments nor fiamme. Along much of its strike length the matrix is medium to dark grey (Alldrick, 1985, Figure 117).

Pyritic Tuff Facies

A prominently gossanous, pyritic, fragment-rich unit is exposed along the west side of Mount Dilworth and the east side of Summit Lake. This member ends abruptly in a massive, gossanous cliff at the south end of Mount Dilworth but progressively thins northward, finally wedging out high on the western slope of Troy Ridge.

Mapping shows that the pyritic unit is not continually exposed along strike but instead occurs as a series of discontinuous lenses of strong pyritic impregnation. This unit seems complex and may represent diagenetic or penecontemporaneous post-depositional impregnation of pyrite into a variety of lithologies. Although the predominant rock type is lapilli tuff identical to the underlying upper lapilli tuff member, in other exposures the pyritic lithology is a carbonate-mudstone-cemented debris flow with heterolithic volcanic and carbonate clasts. For these reasons the pyritic facies is interpreted as pyrite iimpregnation around localized fumarolic centers, possibly with related calcareous mud-filled brine pools (Figure 00). The host lithology is therefore the upper layer of the upper lapilli tuff member.

Black Tuff Member

The black tuff member is a thick unit of carbonaceous crystal and lithic lapilli tuffs with local argillaceous mudstone to siltstone lenses. Lapilli consist of crowded feldspar porphyry flows or crystal tuffs, limestone and rare pumice.

This member has been traced in outcrop from the south end of Mount Dilworth southward to the crest of Slate Mountain and is also exposed in a few discontinuous outcrops south and southeast of Monitor Lake. The black tuff member overlies the lapilli tuff member and either overlies or is the stratigraphic equivalent of the pyritic tuff facies to the north. The contact between the black tuff and the underlying upper lapilli tuff is gradational, both units host disseminated sulphides and pyritic lithic clasts. The black tuff also hosts angular clasts of massive, medium-grained pyrite aggregate.

In thin section the crystal-rich tuffs host up to 50 per cent feldspar crystals and up to 5 per cent ragged chlorite flakes after biotite, plus a few well-rounded quartz grains. The rock matrix is composed of volcanic ash, dust and fine carbon, and some samples show crude bedding as a slight change in overall matrix grain size. Some samples are cut by very fine microcrystalline quartz in fractures.

Two alternate interpretations might account for the i limited strike extent of this thick, distinctive black tuff unit; (i) it may represent an erosional remnant of an originally extensive unit or, (ii) deposition was restricted to the area now occupied by the unit. The latter interpretation requires that the black tuff was deposited in a topographic low such as a volcanic crater or a caldera. If this depression was an anoxic water-filled basin it would account for local sediment lenses and the intense carbon impregnation throughout the unit. Pumice is a minor but widespread clast-type within the unit; there is a thin (30-centimetre) bed of pumice pebble conglomerate exposed along the crest of Slate Mountain, perhaps recording a raft of floating pumice near one edge of the flooded crater.

Petrochemistry

All lithologies of the Mount Dilworth formation appear highly siliceous and have been identified as rhyolites during field examination. On the basis of all the analytical data these lithologies should be termed dacites.

Provenance and Depositional Environment

The formation represents airfall deposits from a series of subaerial explosive felsic volcanic eruptions that proceeded in quick sucession, apparently becoming progressively more violent. Based on clast size, one vent area was near the south end of Mount Dilworth. The formation was deposited subaerially on the flanks of an exposed volcanic cone. The general absence of sedimentary deposits between units confirms there was little or no pause between eruptions. The uppermost black tuff member represents local sub-aqueous conditions, perhaps in a central fault-bounded caldera, or a crater lake.

Age

The Mount Dilworth formation records a voluminous but short-lived volcanic event in Middle to Late Toarcian time (190-187 Ma).

Salmon River Formation

The Salmon River formation is a thick assemblage of complexly folded, thin to medium-bedded siltstones and wackes. The formation must be at least 1000 metres thick in the map area, although its top has not been identified.

Basal Fossiliferous Limestone Member

Thin, pyritic, fossiliferous limestone crops out at the base of the formation throughout the area. The unit comprises dark grey to black carbonate-cemented grit with interbedded lenses, pods and nodules of fossiliferous gritty limestone. Both the calcareous grits and fossiliferous limestones host sparsely disseminated pyrite, which is more abundant where the unit is underlain by the pyritic volcanic facies.

Lower Thin-bedded Siltstone Member

The lower 50 to 100 metres of the main sedimentary succession consists of black to grey, thin to medium-bedded calcareous siltstones and shales with minor intercalated siliceous beds and locally fossiliferous limestones. The rhythmically interbedded siltstones to fine-grained sandstones occur as beds 5 to 10 centimetres thick. Shale partings between these layers are a few millimetres thick. The siltstone is well bedded and finely laminated; shale is massive, intensely cleaved or weakly phyllitic. The slates and siltstones locally contain minor amounts of disseminated pyrite, and pyrite seams outline some bedding planes producing characteristic banded, iron-stained weathered surfaces.

This member is interpreted as a sequence of rhythmically bedded marine clastic sediments derived form the erosion of predominantly volcanic terrane.

Upper Medium-bedded Wacke Member

Conformably overlying the lower siltstone member are medium to light grey wackes and intraformational conglomerates. Most of these rocks form fairly massive beds a few metres to several metres thick, intercalated with minor thin-bedded siltstone. The conglomerates consist of subparallel black siltstone slabs and cobbles in a grey sandstone matrix. The beds within this member may represent stacked turbidite fans, possibly recording a period of repeated seismic activity.

Provenance

The clastic rocks of this formation have been derived mainly from weathering and erosion of clastic debris from a volcanic complex. Some beds are thought to form by mixing of varying proportions of medium to fine-grained, water-transported detritus with airfall ash and crystals from waning felsic pyroclastic activity.

Depositional Environment

The sediment was deposited on the distal flanks of a volcano in a shallow to moderately deep marine basin, relatively near subaerial source rocks. The basal limestone member may have been deposited in the littoral zone, so that the members of this unit progressively document a major marine transgression that eventually covered all subaerial terrains. The rhythmic, thin to medium-bedded units and relatively good grading suggest transport was predominantly by mass-flow processes such as turbidity flows. Waning pyroclastic eruptions and related seismic activity may have triggered the density currents. The high carbon content and general absence of fossils and bioturbation through most of the sequence indicate the beds were deposited in a quiet anoxic basin.

Age

The basal fossiliferous limestone is Toarcian, possibly mid-Toarcian in age.

Bowser Lake Group

The upper sedimentary package in the map area has a Toarcian fossil assemblage at its base and its upper age is undetermined.

On the basis of existing paleontological evidence, a correlation with Bowser Lake Group cannot be supported for any strata within the map sheet. The upper sedimentary strata are called the Salmon River formation of the Hazelton Group and are correlative with the Smithers formation of Tipper and Richards (1976). It is still possible that Bowser-age strata may be identified within the core of the Mount Dilworth syncline.

INTRUSIVE ROCKS

The intrusive rocks of the region are grouped into two suites: the early Jurassic Texas Creek Granodiorite suite and the middle Eocene Hyder Quartz Monzonite suite.

Texas Creek Granodiorite

This plutonic suite includes two major intrusive bodies and a widespread dyke phase. These rocks are characterized by overall coarse grain size, coarse hornblende and locally by potassium feldspar megacrysts.

The largest pluton is the Texas Creek batholith, covering roughly 200 square kilometres. Two phases have been recognized: in the central and western area, a very coarse-grained equigranular rock without the K-feldspar phenocrysts, but with both orthoclase and plagioclase crystals about 1.0 centimetre long and with hornblende crystals up to 2.5 centimetres long; along the eastern edge of the batholith the rock is porphyritic with a medium-grained matrix, hornblende crystals up to 2.0 centimetres long and large orthoclase phenocrysts, typically 3.0 centimetres long. At the eastern contact with the volcanic country rock, the batholith is sheared and strongly chloritized for several tens of metres.

The Summit Lake stock is a medium to coarse-grained hornblende granodiorite. The rock is generally equigranular, with only rare potassium feldspar phenocrysts, and is remarkably fresh. Contact relationships suggest passive emplacement.

The dyke phase of the Texas Creek Granodiorite suite has been termed Premier Porphyry because of the relationships between these distinctive dykes and all the major ore zones at the Silbak Premier mine. The dykes are medium to dark green, fine-grained massive rock with large (up to 5.0 centimetres) potassium feldspar megacrysts, plagioclase phenocrysts (up to 8.0 millimetres) and hornblende phenocrysts (up to 6.0 millimetres long). Remnant resorbed quartz eyes have been noted in some areas. The matrix is strongly chloritized. Whole rock analyses straddle the andesite-dacite boundary. These dykes cut all the lower members of the Unuk River formation and the eastern margin of the Texas Creek batholith. They do not cut the Premier Porphyry member of the Unuk River formation or any of the younger overlying strata. They are regarded as subvolcanic feeder dykes coeval with the tuffs and flows of Premier Porphyry rock that mark the top of the Unuk River formation.

Hyder Quartz Monzonite

This plutonic suite includes a batholith, several minor plugs and a widespread dyke phase. These rocks are characterized by overall medium grainsize, biotite, white plagioclase and orthoclase, and trace amounts of fine golden sphene.

The batholith lies within the eastern margin of the Coast Plutonic Complex. Intrusive contacts are marked by biotite hornfels of argillaceous country rocks, epidote veining in tuffaceous country rocks and local skarn development in calcareous sediments.

The smaller stocks are satellites of the Coast Plutonic Complex that are mineralogically and texturally similar. In some cases they represent coalescing of a dyke swarm into a mappable, massive body.

The dykes, termed Hyder Dykes, occur as two prominent parallel swarms of regional extent and as random isolated dykes in the intervening country rocks. All dykes have a southeast strike and steep southwest dip. Textures and compositions are highly variable, but plagioclase porphyry in a biotite-rich, fine-grained to aphanitic light grey matrix is most common.

STRUCTURE

The regional structural pattern is a north-northwest-striking fold system of open to tight folds. The axial plane dips steeply west-southwest and the folds are doubly plunging, creating a series of canoe-shaped synclinal troughs in the Long Lake area.

Local areas of shallow to moderately west-dipping penetrative foliation are common in the wallrocks adjacent to brittle and ductile faults.

METAMORPHISM

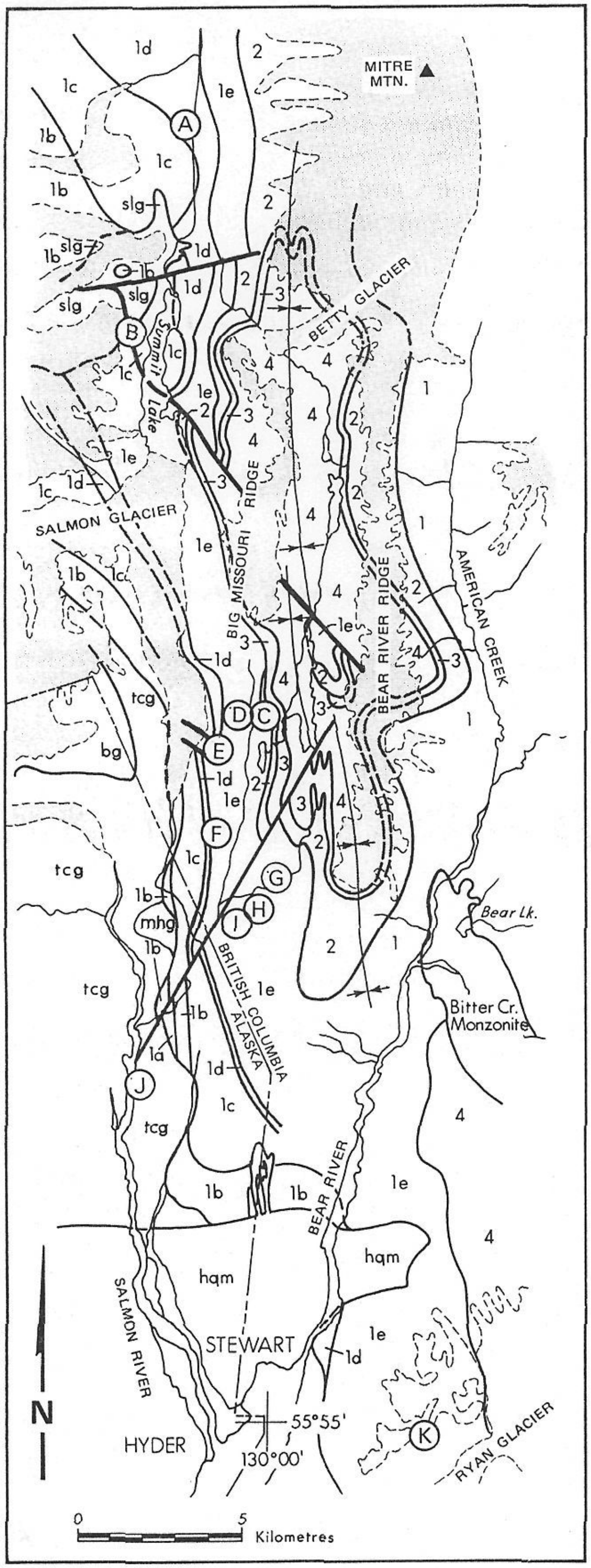
The metamorphic grade is at most lower greenschist facies. Pervasive chlorite alteration of mafic minerals and partial to complete resetting of K/Ar dates from biotite separates indicate a thermal peak of 300^{o}C was reached about 110 million years ago (Alldrick et al., 1987).

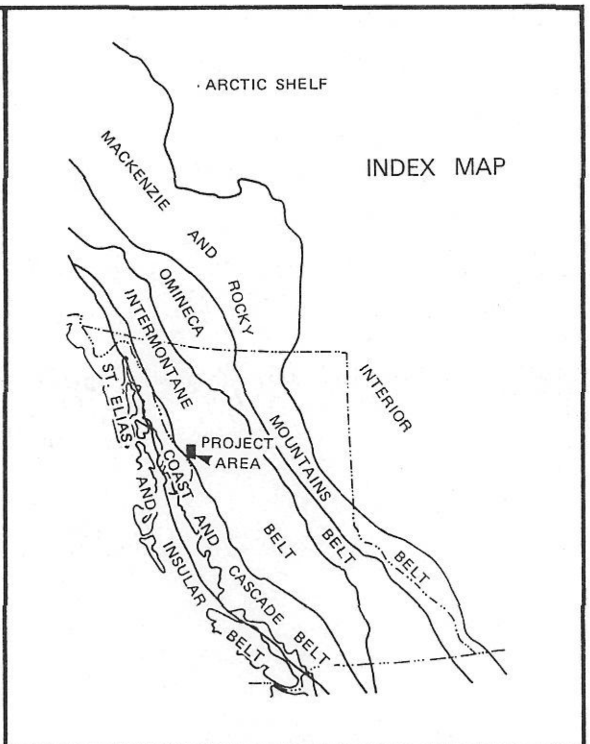
ALTERATION

The regional scale alteration assemblage consists of moderate chloritic alteration with trace to minor disseminated pyrite that is attributed to the mid-Cretaceous metamorphic event.

Broad areas of more intense chlorite-pyrite alteration are common throughout the mineralized areas of the Unuk River formation, and encompass localized zones of intense carbonate flooding (up to 35 per cent fine calcite) within the massive andesite tuffs. These large zones are attributed to circulation of chloride and carbonate-rich brines which are characteristic of hydrothermal convection cells within recent andesitic stratovolcanos (Henley and Ellis, 1983).

In the immediate area of ore zones and sub-economic sulphide bodies the wallrocks are flooded with pervasive silica-carbonate-sericite-pyrite alteration that often obscures original rock textures. This alteration preceded, accompanied and followed





MAJOR MINERAL DEPOSITS

EAST GOLD MINE	A
SCOTTIE GOLD MINE	B
DAGO HILL DEPOSIT	C
BIG MISSOURI MINE (S–1 ZONE)	D
SILVER BUTTE DEPOSIT	E
INDIAN MINE	F
SEBAKWE MINE	G
B.C. SILVER MINE	H
SILBAK PREMIER MINE	I
RIVERSIDE MINE	J
PROSPERITY AND PORTER IDAHO MINES	K

LEGEND

hqm, bg, mhg	Eocene biotite granodiorite stocks
tcg, slg	Lower Jurassic hornblende granodiorite stocks
4	Argillite, siltstone, sandstone
3	Dacite pyroclastic formation
2	Epiclastic rocks, hematitic
1e	Andesite tuffs and flows
1d	Argillite, siltstone
1c	Andesite tuffs
1b	Argillite, siltstone
1a	Andesite tuffs

Figure ·1. Geology and mineral deposits of the Stewart area (from Alldrick, 1985).

sulphide deposition along long-lived or reactivated channelways within the stratovolcano.

REFERENCES

A reference list is included on the accompanying folded map, Open File Map 1987-22 (in pocket).

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WESTMIN RESOURCES LIMITED

PREMIER GOLD PROJECT
GEOLOGICAL SETTING AND MINERALIZATION OF THE SILBAK PREMIER AND BIG MISSOURI DEPOSITS

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INTRODUCTION

The Silbak Premier and Big Missouri gold/silver deposits are located 21 km north of Stewart within Hazelton volcanics of the Stewart gold-silver camp (Figure 1).

The Premier Gold Project will develop separate open pit gold/silver mines on the near surface portions of the famous Silbak Premier underground gold/silver mine which operated from 1918 to 1968 and several deposits on the Big Missouri property. Initial production emphasis will be on the higher grade portion of the Silbak Premier pit. Production, at a rate of 2,000 tonnes per day, is scheduled to begin in early 1989. Final feasibility studies indicate an annual output of approximately 77,000 ounces of gold and 890,000 ounces silver over the first four years of operation. Currently, defined (September 1987) open pit mineable reserves include 5.9 million tonnes at Silbak Premier, grading 2.16 g/tonne gold and 80.23 g/tonne silver and 1.8 million tonnes at Big Missouri, grading 3.60 g/tonne gold and 29.49 g/tonne silver, sufficient for 10.5 years production.

Silbak Premier reserves are based on single pit surrounding the upper part of the old mine workings and include some caved stope fill as well as in situ material. Reserves at Big Missouri are situated in four small pits ranging in size from 300,000 tonnes to greater than one million tonnes (Figure 2).

The emphasis of ongoing exploration at Silbak Premier is to define underground mineable reserves surrounding previously stoped areas and to extend the known deposits to depth, beyond areas explored during past operations. At Big Missouri emphasis is still on open-pittable reserves as there are numerous surface showings which have had only minimal exploration.

Past production from Premier included 4.7 million tons grading 0.384 oz/ton gold and 8.03 oz/ton silver over a period of 46 years, starting in 1918 and operating continuously to 1954 and intermittently to 1968. In contrast, mining at Big Missouri took place for a short period between 1938 and 1943, producing 822,000 tons grading .077 oz/ton gold including less than 1.00 oz/ton silver.

REGIONAL GEOLOGICAL SETTING

Stratigraphy and genesis of both Silbak Premier and Big Missouri deposits continues to generate controversy both within Westmin and with other geological groups working in the area.

The regional stratigraphy consists of Hazelton Group volcanic rocks, are unconformably overlain by Bowser Group sedimentary rocks present to the east, and grade into a sedimentary sequence to the west. Within Westmin we believe the regional stratigraphy is shallow (Big Missouri) to moderate (Silbak Premier) westerly dipping. This observation is based on limited evidence of primary layering in flow banded and fragmental rocks and interpretation of the genesis of "cherty-tuff" horizons which suggest interflow volcanic exhalative beds or sub-seafloor replacement of interflow tuff horizons.

Regionally a potential stratigraphic marker has been identified, called the "Ground Hog Marker", which is indicated to extend from Big Missouri to Silbak Premier. There is considerable warping of these rocks due to folding and/or thrust and block faulting which is particularly evident on the west side of the property where the volcanic rocks grade into predominantly sedimentary rocks.

Recent mapping of the volcanic stratigraphy in the Silbak area has differentiated andesites and dacites, however, the distinction is subtle and often based visually on slight differences in color. In general, it appears however that the dacites are concentrated mainly to the north and west of Silbak Premier (Figure 3). Recent fresh rock exposures in road cuts have shown a greater abundance of fragmental rocks than was previously thought. This is due to subtle differences between fragments and matrix. These fragmentals tend to rapid facies variations and are often discontinuous over short distances and hence have proven difficult to use for developing stratigraphy. Hence, mapping and correlations have generally been on the basis of rock type rather than time-stratigraphic units.

Based on extensive regional mapping particularly along the west side of the properties and along the Granduc Road, Aldrick (1986) has suggested a steep easterly dip to the stratigraphy and a synclinal structural whose axis bounds the east side of the Big Missouri property.

SILBAK PREMIER - GEOLOGICAL SETTING AND MINERALIZATION

The Silbak Premier deposit is situated within generally massive, fine-grained green andesites, locally with monolithic fragmental zones. These andesites are moderately to intensely foliated with an attitude subparallel to the apparent original layering (N-S strike with approximate 40° westerly dip).

The andesite is intruded by very irregular bodies of K-feldspar megacrystic, plagioclase-amphibole porphyritic rock of dacite composition called Premier Porphyry. Although considered intrusive, many porphyry-andesite contacts are very indistinct suggesting emplacement close to the time the andesites were laid down. Both andesite and porphyry are partially overlain by a flow unit which looks compositionally and texturally similar to the intrusive porphyry.

Mineralization consists of silica-K-feldspar-carbonate-sulphide vein and breccia zones, footwall stockwork veining and occasional crustiform banded veins. Some lenses of semi-massive sulphides consisting of pyrite with lesser sphalerite and galena. The main gold bearing mineral is electrum while silver occurs primarily within tetrahedrite and polybasite.

Precious metal mineralization is generally centred within intense silica-K-feldspar alteration zones which are flanked by pyrite-sericite-carbonate alteration. Mineralization appears both concordant and discordant to andesite-porphyry stratigraphy. Siliceous breccia zones, around which the more intense alteration is focused, tend to host the most extensive, precious metal bearing zones although gold and silver mineralization is not uniformly distributed within these bodies. Higher silver ratio mineralization is generally hosted in stockwork veining.

The Glory Hole deposit is centred on the richest part of the old Premier Mine workings. It consists of two zones, the Main and West zones, that intersect roughly perpendicular. The West zone has been chopped into several segments which have been offset by right-lateral faulting resulting in an apparent accurate shape to the deposit. The Northern Lights deposit occurs in the hanging wall of the Main deposit in the Glory Hole and demonstrates two distinct zone orientations similar to the main deposit (Figure 4).

Ore lenses within the Glory Hole deposit vary in width from a few tenths of metres in the footwall stringer zone to 20 metres wide in the hanging wall area. Overall strike length of the Main plus West zones is 1800 metres and dip length is over 500 metres. The Main zone dips about 60° north near the top and flattens to about 30° near 6 Level, whereas the West zone is vertical to steeply north dipping throughout its vertical extent.

BIG MISSOURI - GEOLOGICAL SETTING AND MINERALIZATION

The Big Missouri property is underlain by a southwest-facing, moderately dipping sequence of volcanic and volcaniclastic rocks of the Hazelton Group (Figure 5, 6).

Green andesite flows, tuff and agglomerate form a thick upper sequence that hosts the mineralized zones on the property. They are generally feldspar and amphibole porphyritic with a weak to moderate foliation. Thin (up to 5 m) cherty tuff horizons of exhalative origin separate the individual flows, tuff and agglomerate units. These cherty tuff horizons are silica-rich beds containing sericite and silicified (bleached) andesite fragments, occasional rounded cherty fragments, carbonate and sulphide mineralization. The footwall andesite usually is brecciated and filled with quartz and/or carbonate, while the hanging·wall andesite is generally a light grey bleached colour, due to silica-sericite alteration.

Cretaceous granitic dykes of the Portland Canal dyke swarm, Tertiary andesite dykes and abundant quartz, quartz-carbonate and carbonate veins cut the volcanic sequence.

Three regionally extensive horizons of cherty tuff and altered andesite are recognized. In the Lower Horizon, the cherty tuff bands within the andesite sequence generally are 8-10 m apart and contain abundant carbon; bands occurring in the Middle Horizon are generally 25-30 m apart and have abundant carbonate; those in the Upper Horizon are thickest and characterized by intense silica-sericite alteration.

In the lower part of the andesite sequence, irregular-shaped intrusions of Premier porphyry can be locally identified. Such intrusions are varied in texture and consist of quartz, plagioclase, amphibole and large potassium feldspar phenocrysts in a fine to medium, dark green andesitic matrix.

In general, semi-massive to massive lenses, pods and stringer zones of pyrite, sphalerite, galena and chalcopyrite occur within and at the contact of thin, cherty tuff horizons. Andesite in the footwall to these zones is bleached from green to grey with abundant sericite and fine, disseminated pyrite. Pyrite commonly replaces altered amphibole phenocrysts. Altered andesite is pervasively silicified and cut by numerous quartz-sulphide veins with or without chlorite and/or carbonate. Andesite tuffs overlying the cherty tuff are similarly bleached and altered, but silicification is more intense. In the immediate hanging wall, abundant sphalerite and galena with appreciable amounts of gold and silver are present in well-developed quartz stringer zones. Further up in the hanging wall, bleaching and disseminated pyrite are less intense, with only minor spalerite and galena. The altered porphyritic andesite may correspond to what was previously termed "Premier Porphyry" and the cherty zones to what were referred to as quartz veins or breccia zones.

Three stratabound mineralized horizons have been recognized based on geological correlation of the host units. The Lower Horizon hosts the Terminus, Golden Crown, Calcite Cuts, S-1, Unity-Unicorn and Martha Ellen zones and, finally, the Upper Horizon hosts the Province, Buena Vista, Northstar-Lindeberg and Rambler zones.

SUMMARY OF MINERALIZATION TYPES, ORE CONTROLS AND MODELS FOR ORE GENESIS AT SILBAK PREMIER AND BIG MISSOURI

At a district scale the ore zones occur in green andesite at similar stratigraphic levels, although there are significant facies differences between the two properties.

The geometry, distribution and textural features of the ores at Big Missouri suggests the ores to be stratabound and syngenetic. The ore zones occur at several stratigraphic levels with deposits at different stratigraphic levels having distinctive features. Use of a stratigraphic model has given good exploration success.

The timing of emplacement of Premier porphyry is controversial; some evidence suggests that at least part of the Premier porphyry is extrusive. Mineralization is hosted in porphyry, and Premier porphyry may intrude earlier mineralized andesite. Within the Glory Hole the contacts of andesite and Premier porphyry are favourable for high-grade ore. Elsewhere, the relationship of mineralization to Porphyry is less clear. Discordant stockwork vein and silica-breccia mineralization at Premier occur within and adjacent Premier porphyry. The intensity of silica-sericite-K-feldspar alteration is greatest in the Glory Hole area and decreases laterally to the West zone and at depth where alteration is mainly silica-chlorite-K-feldspar with little bleaching due to sericite.

Syngenetic Model

The apparent stratabound character of mineralization at Big Missouri is interpreted as an indication that the mineralization was formed essentially at the same time as the enclosing host andesites. Recent work on massive sulphide deposits in offshore spreading ridges indicates mineralization forming both on the seafloor and in porous zones immediately beneath the seafloor, giving rise to evidence for both syngenetic and epigenetic styles of mineralization both of which are interpreted to occur at Big Missouri.

Semi-massive sulphide deposits found at Premier with associated sulphide-matrix breccias and fine cherty silica deposits demonstrate features of synvolcanic deposition. Relationship of mineralization to stratigraphy at Silbak Premier is less clear, however, where stratigraphy is known the deposits appear to occur over specific stratigraphic intervals and to be grossly stratabound.

Vein Replacement Model

The massive silica-K-feldspar alteration with attendant silica-breccias and peripheral stockwork veining and pyrite-sericite-carbonate alteration, particularly evident at Premier, suggest the mineralization has developed within an epithermal system. Structural control appears to dominate and several pulses of mineralization may be interpreted from the overprinting of numerous vein types.

The zoning of Ag and Au abundance at Premier is complex. A generalized model of high Ag:Au ratios at surface, decreasing to low Ag:Au ratios at depth is misleading and is the reverse of zoning in most epithermal vein systems.

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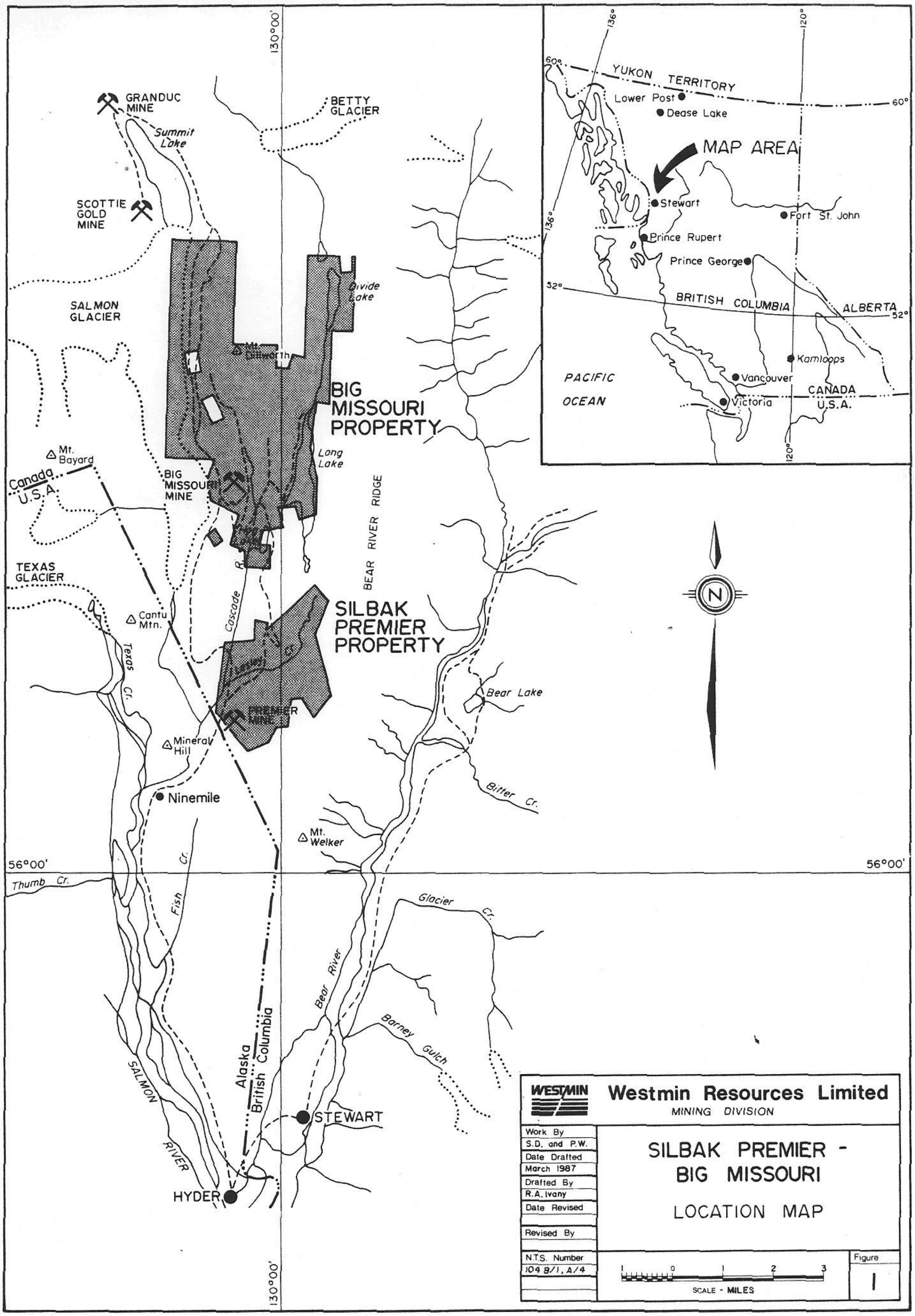

GRANDUC MINE
Summit Lake
SCOTTIE GOLD MINE
BETTY GLACIER
SALMON GLACIER
Divide Lake
Mt. Dillworth
BIG MISSOURI PROPERTY
Mt. Bayard
Canada
U.S.A.
BIG MISSOURI MINE
Long Lake
BEAR RIVER RIDGE
TEXAS GLACIER
Cantu Mtn.
Cascade
SILBAK PREMIER PROPERTY
Texas Cr.
PREMIER MINE
Bear Lake
Mineral Hill
Ninemile
Bitter Cr.
Mt. Welker
56°00'
56°00'
130°00'
130°00'
Thumb Cr.
Fish Cr.
Glacier Cr.
Bear River
Barney Gulch
SALMON RIVER
Alaska
British Columbia
STEWART
HYDER
YUKON TERRITORY
Lower Post
Dease Lake
MAP AREA
Stewart
Fort St. John
Prince Rupert
Prince George
BRITISH COLUMBIA
ALBERTA
PACIFIC OCEAN
Kamloops
Vancouver
Victoria
CANADA
U.S.A.
60°
52°
136°
120°
N
WESTMIN
Westmin Resources Limited
MINING DIVISION
Work By
S.D. and P.W.
Date Drafted
March 1987
Drafted By
R.A. Ivany
Date Revised
Revised By
N.T.S. Number
104 B/1, A/4
SILBAK PREMIER - BIG MISSOURI
LOCATION MAP
SCALE - MILES
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2
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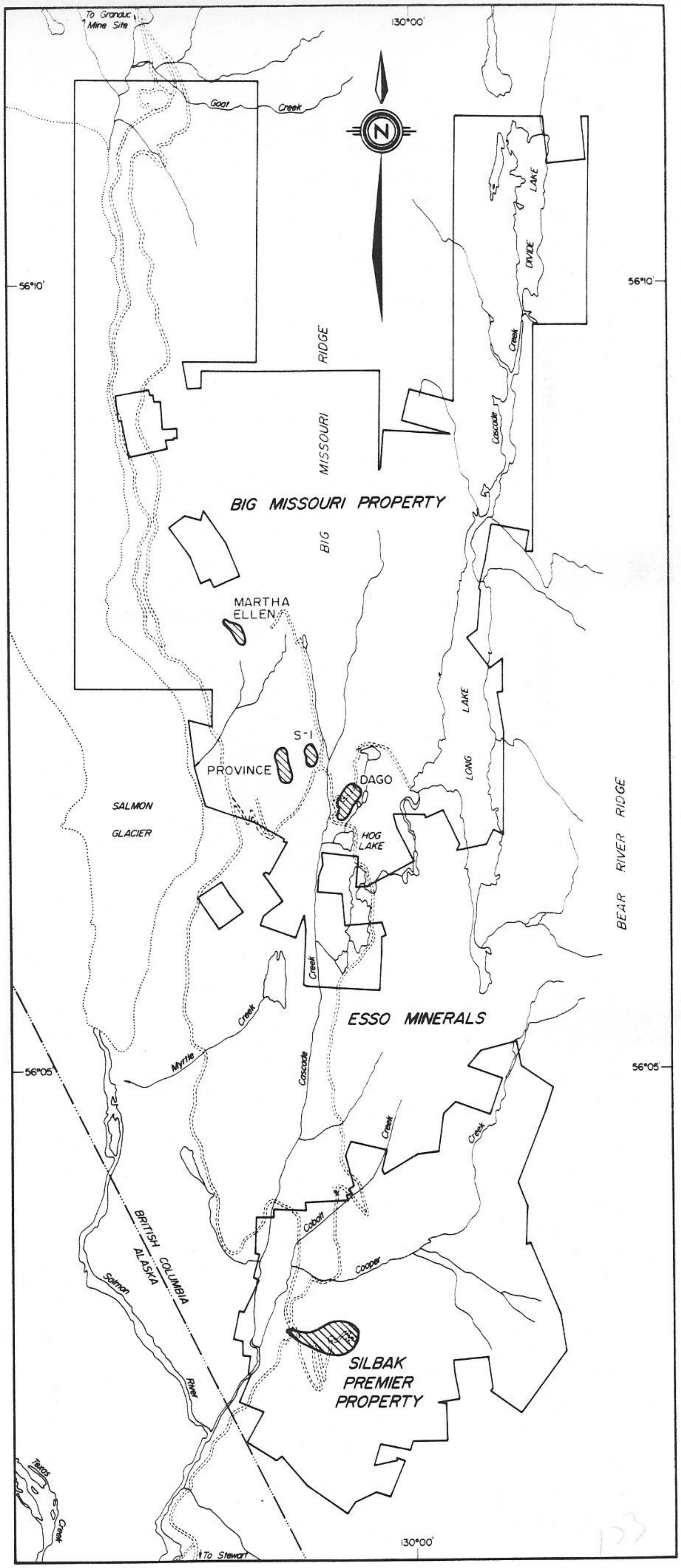
Figure
1

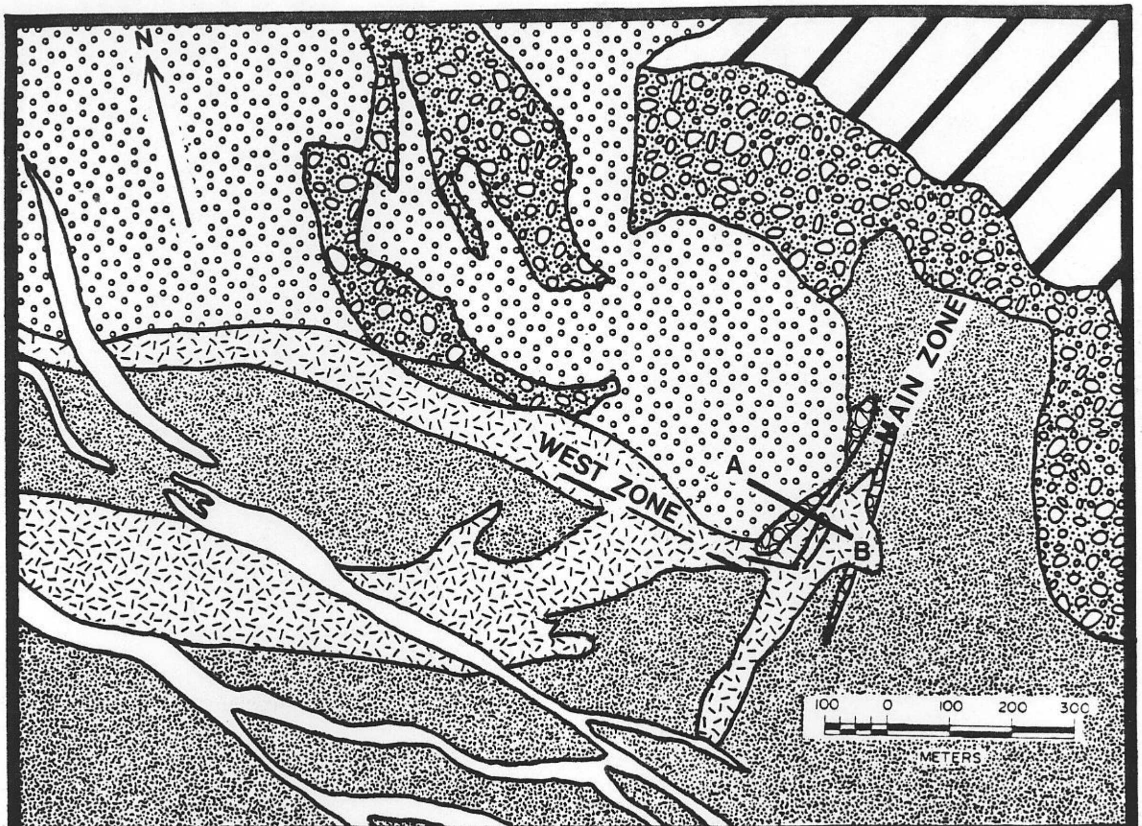


OPEN PIT AREAS

LOCATION MAP

1280 640 0 1280 2560 3840 metres

Figure 2



modified from Brown (1987), Payne & Sisson (1987)

SILBAK-PREMIER

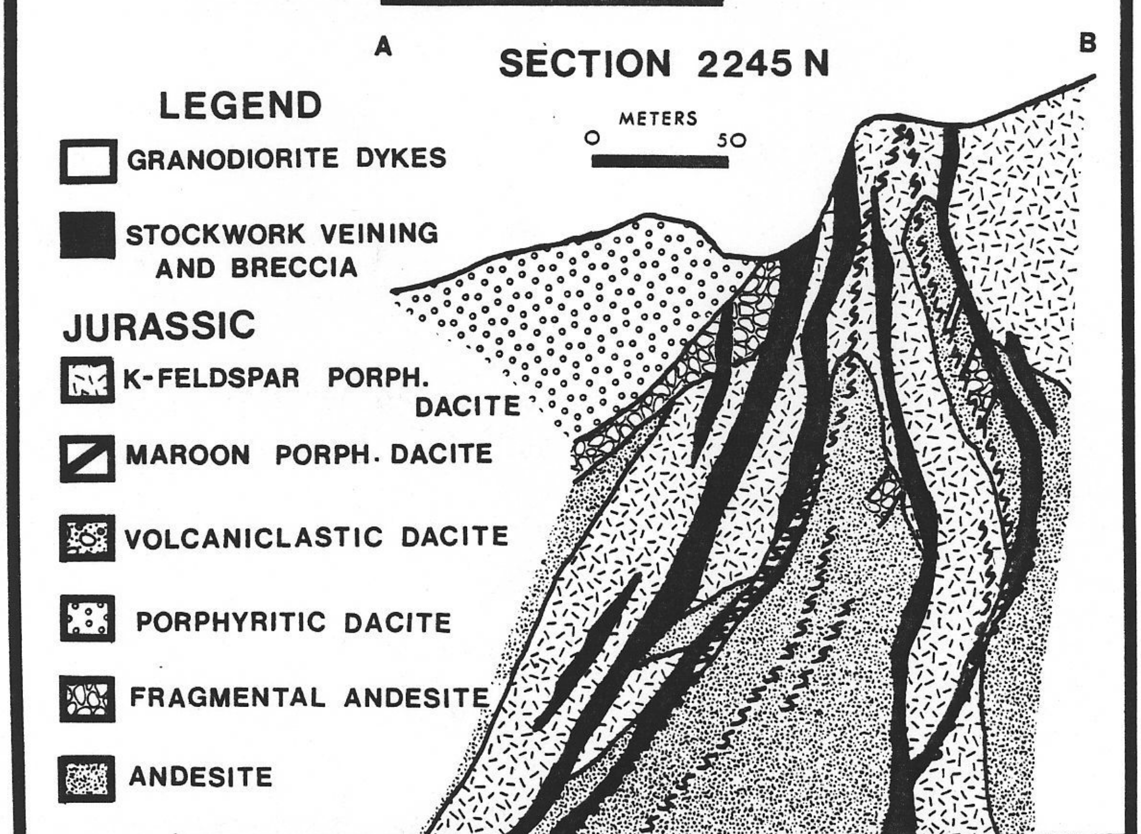
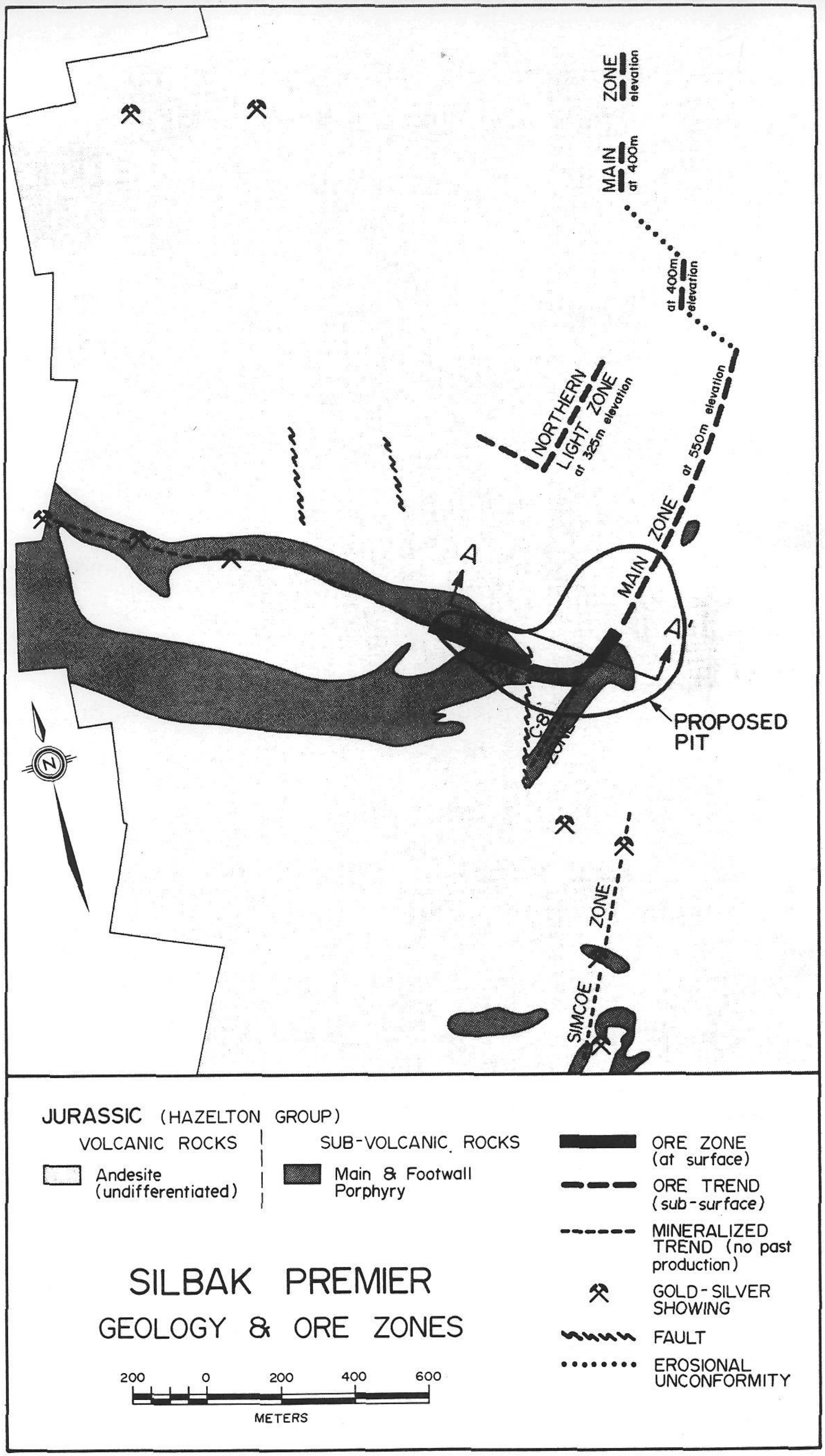


Figure 3



SILBAK PREMIER
GEOLOGY & ORE ZONES

Figure 4

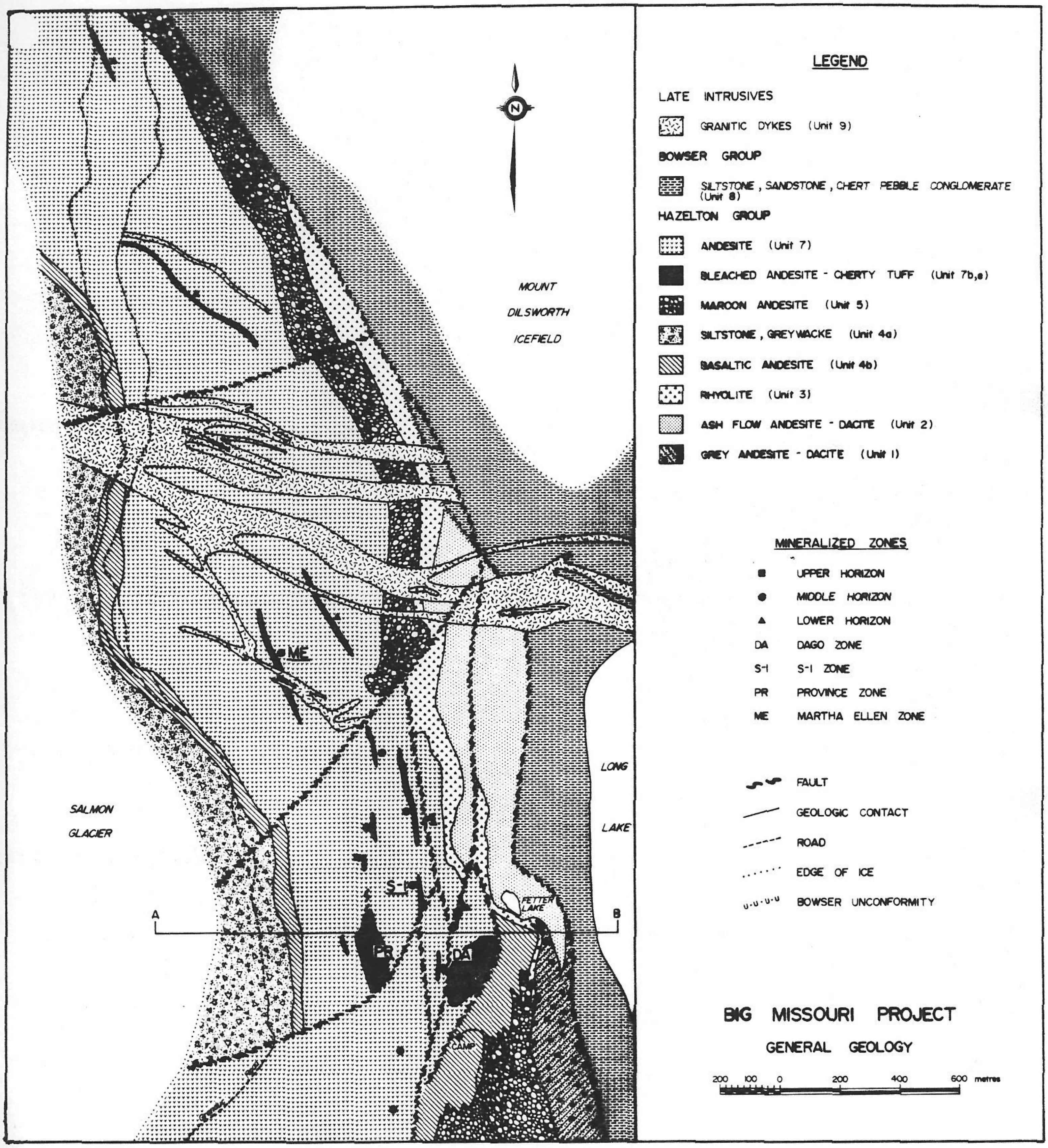

LEGEND
LATE INTRUSIVES
GRANITIC DYKES (Unit 9)
BOWSER GROUP
SILTSTONE, SANDSTONE, CHERT PEBBLE CONGLOMERATE (Unit 8)
HAZELTON GROUP
ANDESITE (Unit 7)
BLEACHED ANDESITE - CHERTY TUFF (Unit 7b,a)
MAROON ANDESITE (Unit 5)
SILTSTONE, GREYWACKE (Unit 4a)
BASALTIC ANDESITE (Unit 4b)
RHYOLITE (Unit 3)
ASH FLOW ANDESITE - DACITE (Unit 2)
GREY ANDESITE - DACITE (Unit 1)
MINERALIZED ZONES
UPPER HORIZON
MIDDLE HORIZON
LOWER HORIZON
DA DAGO ZONE
S-1 S-1 ZONE
PR PROVINCE ZONE
ME MARTHA ELLEN ZONE
FAULT
GEOLOGIC CONTACT
ROAD
EDGE OF ICE
BOWSER UNCONFORMITY
BIG MISSOURI PROJECT
GENERAL GEOLOGY
200 100 0 200 400 600 metres
N
MOUNT
DILSWORTH
ICEFIELD
SALMON
GLACIER
LONG
LAKE
FETTER LAKE
CAMP
ME
S-1
PR
DA
A
B

Figure 5

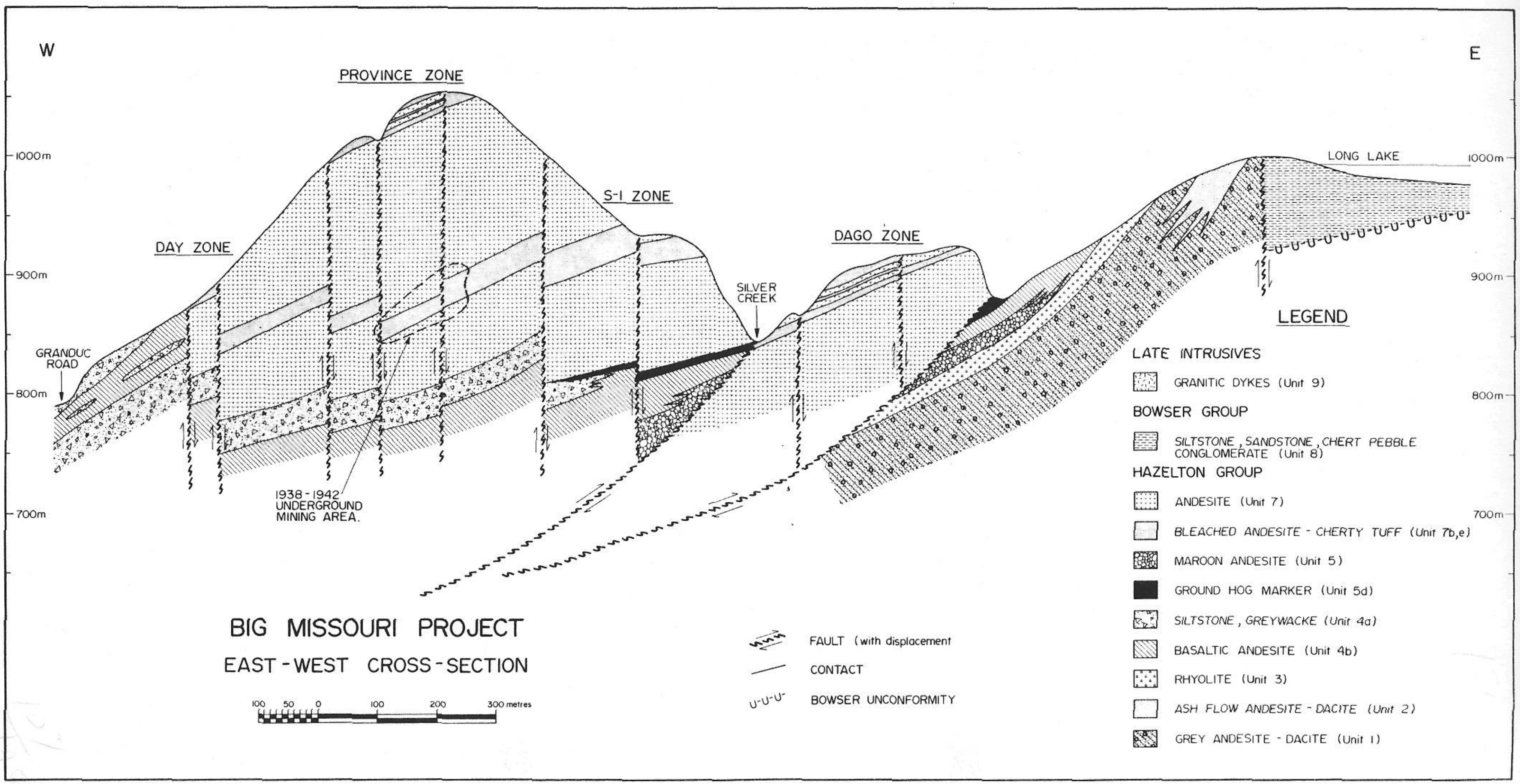

W
E
PROVINCE ZONE
DAY ZONE
S-1 ZONE
DAGO ZONE
SILVER CREEK
LONG LAKE
GRANDUC ROAD
1938-1942 UNDERGROUND MINING AREA.
1000m
900m
800m
700m
LEGEND
LATE INTRUSIVES
GRANITIC DYKES (Unit 9)
BOWSER GROUP
SILTSTONE, SANDSTONE, CHERT PEBBLE CONGLOMERATE (Unit 8)
HAZELTON GROUP
ANDESITE (Unit 7)
BLEACHED ANDESITE - CHERTY TUFF (Unit 7b,e)
MAROON ANDESITE (Unit 5)
GROUND HOG MARKER (Unit 5d)
SILTSTONE, GREYWACKE (Unit 4a)
BASALTIC ANDESITE (Unit 4b)
RHYOLITE (Unit 3)
ASH FLOW ANDESITE - DACITE (Unit 2)
GREY ANDESITE - DACITE (Unit 1)
FAULT (with displacement
CONTACT
U-U-U-
BOWSER UNCONFORMITY
BIG MISSOURI PROJECT
EAST-WEST CROSS-SECTION
100 50 0 100 200 300 metres

Figure 6

Big Missouri precious-base metal deposit, northwest British Columbia

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Vancouver, British Columbia

Summary prepared for: SEG Northern Cordilleran Precious Metal Deposits
Field Trip, September 22-26, 1988

A. ABSTRACT

A southwest-facing, moderately dipping sequence of andesitic to rhyolitic volcanic and volcaniclastic rocks of the lower Middle Jurassic Hazelton Group hosts the stratabound precious-base metal deposits of the Big Missouri property. Pyrite, sphalerite, galena and chalcopyrite with significant gold and silver occur in siliceous cherty tuff layers within a siliceous and sericitic andesite flow, tuff and agglomerate unit. The andesites overlie a mixed volcaniclastic and rhyolite fragmental sequence characterized by rapid facies variation related to synvolcanic faulting.

Three mineralized horizons, each consisting of several cherty tuff layers with disseminated sulphides to semi-massive sulphide lenses, are recognized. Electrum, acanthite, native silver and tetrahedrite occur as small grains on grain boundaries and fractures in the sulphides and within quartz gangue. Wallrock alteration, sulphide meralogy, precious-base metal ratios and style or habit of mineralization are variable for deposits at the three stratigraphic levels.

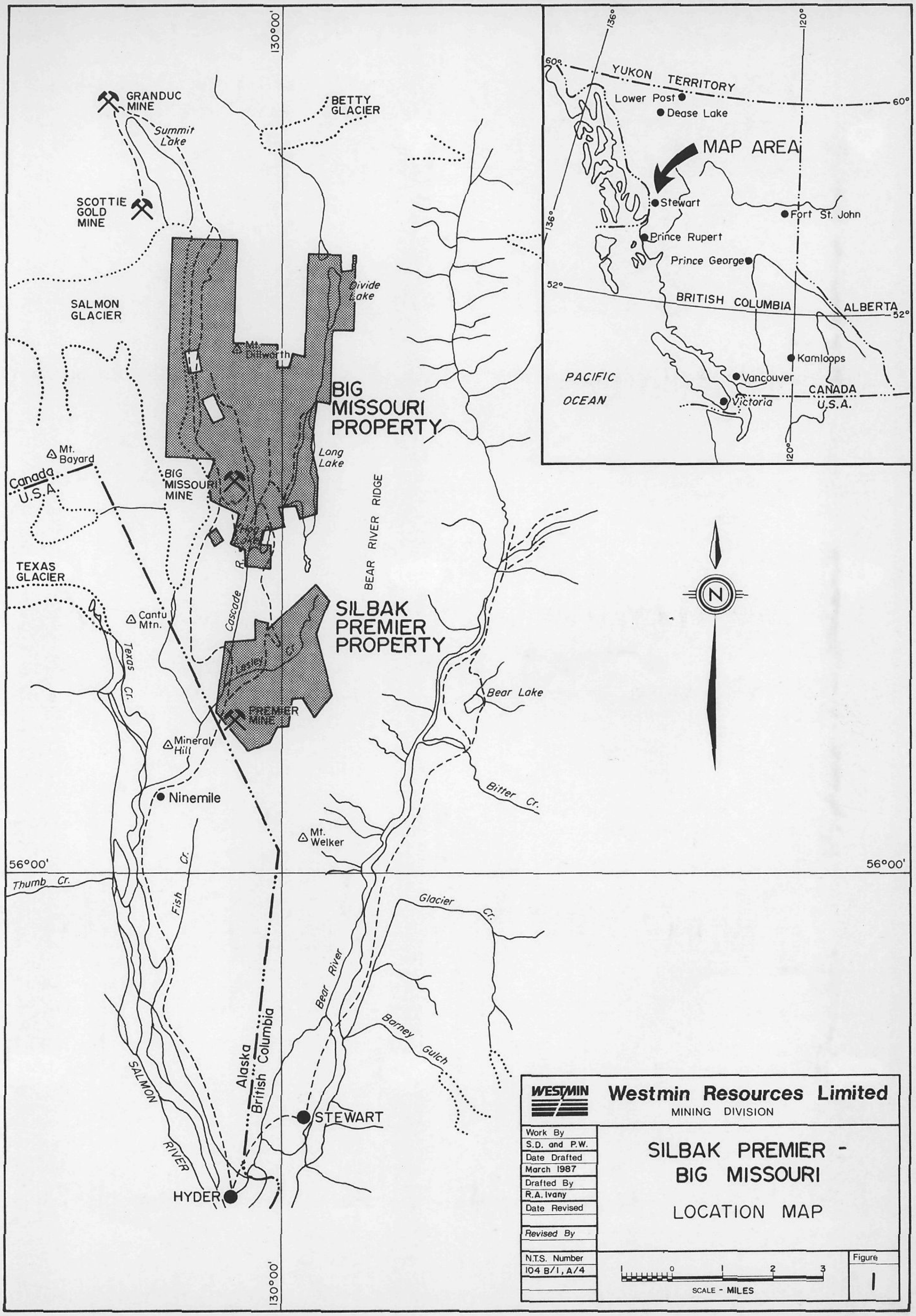
Precious-base metal mineralization in the cherty tuff and silica and sericite alteration of the andesite are interpreted to have formed on or near the seafloor as the result of submarine exhalative activity. Cherty layers and sulphide lenses were deposited during periods of quiescence. Distribution of sulphide mineralization is stratigraphically controlled and is associated with footwall quartz-sulphide stringer zones (vents). Favourable topographic traps on the seafloor near these vents results in sulphide-rich accumulations of chemical sediment. Both of these features are possibly related to synvolcanic faults that controlled distribution of lithology lower in the volcanic sequence.

B. INTRODUCTION

The Big Missouri property is located in northwestern British Columbia, 25 km north of the town of Stewart (Fig. 1). Several other important mineral properties occur in the immediate vicinity, including the Granduc Mine (copper), Scottie Mine (gold) and the British Silbak Premier Mine (gold, silver, zinc, lead, copper). The Granduc Mine road provides access from the town of Stewart to the property. Elevations range from 760m to 1060m.

Discovered by prospectors in 1904, the Big Missouri Mine was put into production between 1938 and 1942 by the Buena Vista Mining Company, a subsidiary of Cominco Ltd. During this period 746,000 tonnes of ore with a recovered grade of 2.66 g/t gold and minor amounts of silver, lead and zinc were mined from an underground operation. Grove (1971) has an excellent summary of the mining history of the Stewart area and the reader is referred to his report for details.

Subsequent to mine closure in 1942, there were several attempts by various mining companies to re-evaluate mineral potential of the area. These attempts were hampered by subdivision of the property into small claim blocks. In 1973, Tournigan Mining Explorations Ltd. began acquiring the various claim blocks that form the property and in 1979 optioned the ground to Westmin Resources Limited (formerly Western Mines Limited). Since 1979, the majority of work has been concentrated on the open-pit mining potential of the property. Geological reserves, as of April 1, 1988, stand at 3,685,000 tonnes grading 2.50 g/t Au and 21.3 g/t Ag with minor zinc, lead and copper.



130°00'
GRANDUC MINE
BETTY GLACIER
Summit Lake
SCOTTIE GOLD MINE
SALMON GLACIER
Divide Lake
Mt. Dillworth
BIG MISSOURI PROPERTY
Mt. Bayard
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SILBAK PREMIER PROPERTY
Lesley Cr.
Texas Cr.
PREMIER MINE
Bear Lake
Mineral Hill
Ninemile
Bitter Cr.
Mt. Welker
56°00'
Thumb Cr.
Fish Cr.
Glacier Cr.
Bear River
Barney Gulch
SALMON RIVER
Alaska
British Columbia
STEWART
HYDER
N
YUKON TERRITORY
60°
136°
120°
Lower Post
Dease Lake
MAP AREA
Stewart
Fort St. John
Prince Rupert
Prince George
52°
BRITISH COLUMBIA
ALBERTA
Kamloops
PACIFIC OCEAN
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104 B/1, A/4
SILBAK PREMIER - BIG MISSOURI
LOCATION MAP
SCALE - MILES
Figure
1

99A - 2
110

C. REGIONAL GEOLOGIC SETTING

The Big Missouri precious-base metal deposits are contained within a belt of deformed volcanic, sedimentary and metamorphic rocks known as the Stewart Complex that lies between the Coast Crystalline Belt to the west and the Bowser Basin to the east (Grove, 1971). The Stewart Complex extending from Alice Arm in the south to the Iskut River in the north is one of the major mineral belts in British columbia (Fig. 3).

Andesitic to rhyolitic tuffs, agglomerates and flows, with lesser volcanic breccia and conglomerate, lithic wacke and siltstone belonging to the Early to Middle Jurassic Hazelton Group, underlie the Big Missouri property. They general strike southeast and dip moderately to steeply southwest. The rocks are weakly schistose and have undergone several periods of faulting. Chert pebble conglomerate and siltstone of the Middle to late Jurassic Bowser Group unconformably overlie rocks of the Hazelton Group. The Texas Creek granodiorite pluton of probably Upper Triassic-Lower Jurassic age (198 and 206 $\pm$6 Ma, Smith, 1977) intrudes the Hazelton Group and their metamorphic derivatives. Probable Tertiary-Cretaceous granodiorite, quartz monzonite of the Coast Range intrusive complex and lamprophyre dykes cut rocks of the Hazelton Group and the Texas Creek granodiorite pluton.

Mineral occurrences in the Salmon River area consist of quartz veins, stockwork vein replacement zones and lenses, lenses of exhalative stratabound massive sulphide and horizons of disseminated and stringer sulphide mineralization.

D. GEOLOGY OF THE BIG MISSOURI PROPERTY

The Big Missouri property is underlain by a southwest facing, moderately dipping sequence of volcanic and volcaniclastic rocks belonging to the Hazelton Group (Figure 4, Table 1). Figures 5 and 6 show an east-west orientated stratigraphic sections of the Hazelton Group as it appears on the Big Missouri property while figure 8 shows a stratigraphic correlation diagram for the property. The basal unit consists of dark grey heterolithic andesite to dacite flows, tuffs and agglomerates (Map Unit 1). To the north a facies change occurs to a dark grey, highly variable ash sequence, which contains glass shards, rhyolitic welded tuff and pumice fragments (Map Unit 2). Overlying the basal sequence is the Dillworth rhyolite (Map Unit 3) consisting of rhyolite fragmental units containing pumice and argillaceous tuff fragments. The unit thickens to the north toward Mount Dillworth. All these units are believed to belong to an earlier volcanic cycle.

Following the Dillworth rhyolite, the volcanics become more intermediate in composition with deposition of a sequence of maroon andesitic volcanic and volcaniclastic rocks (Map Unit 5). The maroon volcanics are present at the north and south ends of the property. Between the two exposures, a facies change, believed to be structurally controlled, is evident (Figures 4 to 8). Dark to medium green basaltic andesite flows, tuffs and agglomerates occur within this zone (Map Unit 4b). To the south of the property the maroon andesite unit exhibits well developed sedimentary structures indicative of reworking - for example, cross and graded bedding. On the west side of the property a facies change occurs to an intermixed sequence of the basaltic andesite to Dacite, tuffs and agglomerates and carbonaceous, tuffaceous siltstone, argillaceous limestone and volcanic wacke (Map Units 4a, b). These units are exposed along the Granduc road.

Green andesite flows, tuffs and agglomerates (Map Unit 7) form a thick sequence which host the mineralized zones on the property. They are generally feldspar and amphibole porphyritic and have a weak to moderate foliation. Within the sequence, separating the individual flows, tuff and agglomerate units, thin (up to 5m) cherty tuff horizons (Map Unit 7e) of exhalative origin are found. These cherty tuff horizons are silica-rich beds containing sericite and silicified (bleached) andesite fragments, occasional rounded chert fragments and sulphide mineralization. The footwall andesite is usually brecciated and filled with quartz and/or carbonate, while the hanging wall andesite is generally light grey, silicified and sericitic due to alteration (Map Unit 7b). In the lowermost horizon, the cherty tuff bands within the andesite sequence are generally 8 to 10m apart and contain abundant carbon; bands occurring in the middle horizon are generally 25 to 30m apart and have abundant carbonate; while those in the uppermost horizon are the thickest and contain minor amounts of carbon and/or carbonate.

In the lower part of the andesite sequence, irregular shaped intrusions, dykes and sills of Premier porphyry (Map Unit 6) can be identified. These are varied in texture, and consist of quartz, feldspar, amphibole, plagioclase and large potassium feldspar phenocrysts in a fine to medium, dark green andesitic-dacitic matrix.

Siltstones, sandstones and chert pebble conglomerates of the Middle to Late Jurassic Bowser Group (Map Unit 8) unconformably overlie rocks of the Hazelton Group and crop out on the east side of the property (Figure 4).

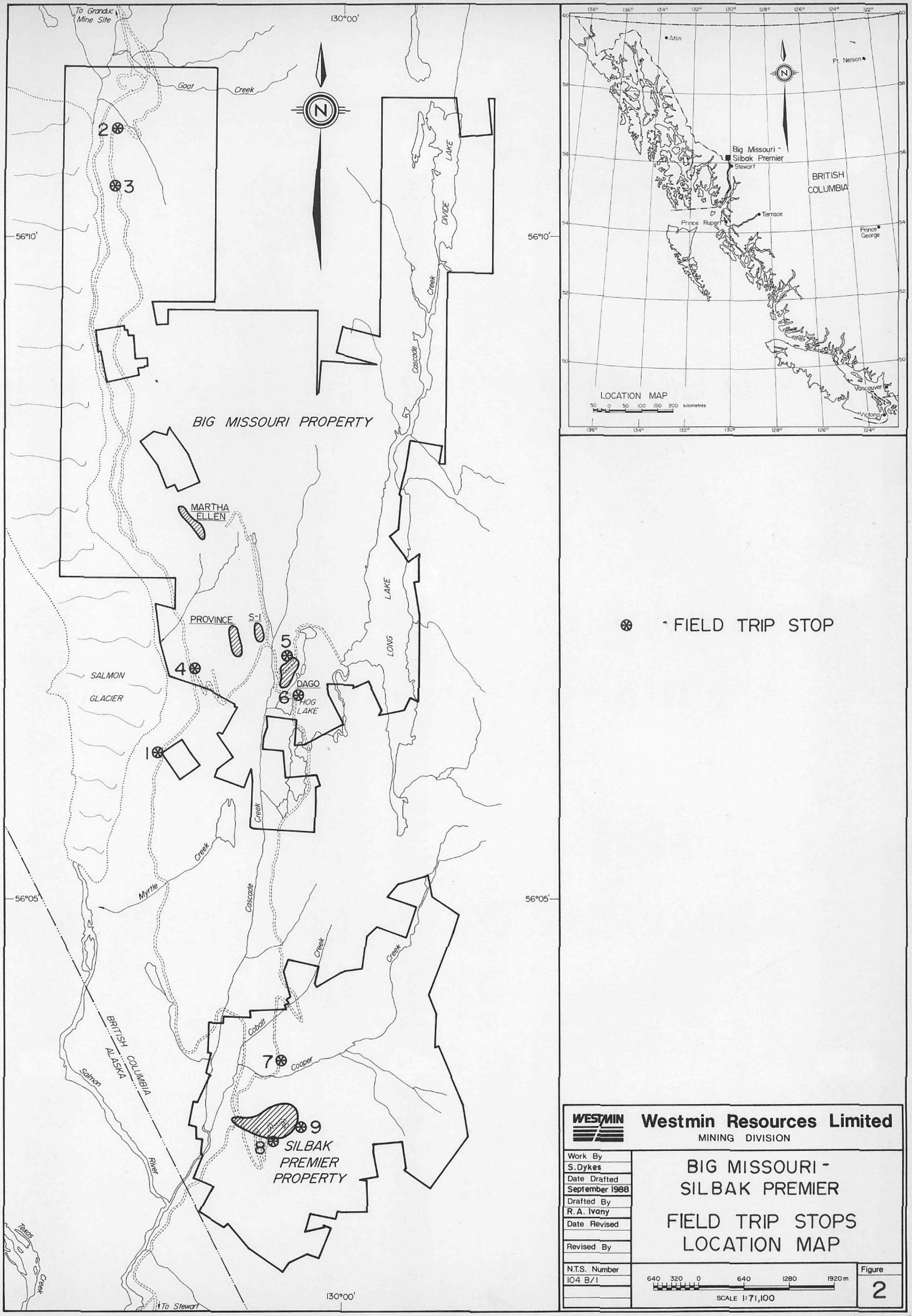
Cretaceous granitic dykes of the Portland Canal dyke swarm (Map Unit 9), Tertiary andesite dykes (Map Unit 10) and abundant quartz, quartz-carbonate and carbonate veins cut the volcanic sequence.

General Structure

During a moderate north-south compression, bedding was gently warped to isoclinally folded in sedimentary rocks, and gently warped in other units. In much of the map area, the major geological units trend north and dip moderately to locally steeply to the west. In places a weak to prominent foliation was developed, which generally is roughly axial planar to warps and folds. It generally strikes within 20 degrees of east-west and dips steeply north or south. A lineation was developed as the intersection of bedding and foliation, it generally trends west-southwest and plunges moderately to the west. Bedding planes commonly are not folded about the foliation, but extends through as if the foliation were not there. An exception to this is that in some of the economic deposits, quartz and pyrite were remobilized from stratabound deposits into veins parallel to foliation. Folding in the argillite along the Salmon Glacier indicates a high degree of crustal shortening during deformation.

Later the region was compressed strongly, probably from the west to southwest, generally at a higher tectonic level than the earlier compressional deformation. Along the eastern margin of the area, dips are generally steep and locally overturned(?) to the east. This is interpreted as the result of rotation above a major eastwardly directed thrust fault along which the volcanic rocks were thrust over the sedimentary rocks further to the east. The fault is steeper at surface and flattens to the west. On the edge of the Dillworth glacier to the east, a small block is separated from the main zone; in this block, rocks dip moderately to the east, with the top of the section reversed from that to the west (Fig. 6). This rotation could have occurred along a branching set of eastwardly directed thrust faults, or by later normal faulting and rotation along the leading edge of the main thrust block. Along the Salmon glacier, argillite was folded complexly, and fold axes were rotated into a wide range of orientations from flat to vertical.

Major, generally north-south trending faults are widespread and control the orientation of creek valleys and smaller ridges throughout the area. These faults have near vertical displacements. Numerous smaller faults with gouge, breccia zones and carbonate-sericite altered borders have offsets of a few metres to a few hundred metres; many of these strike east to northeast (090-045) and dip moderately to steeply north.



Westmin Resources Limited
MINING DIVISION

Work By	S. Dykes
Date Drafted	September 1988
Drafted By	R.A. Ivany
Date Revised	
Revised By	
N.T.S. Number	104 B/1

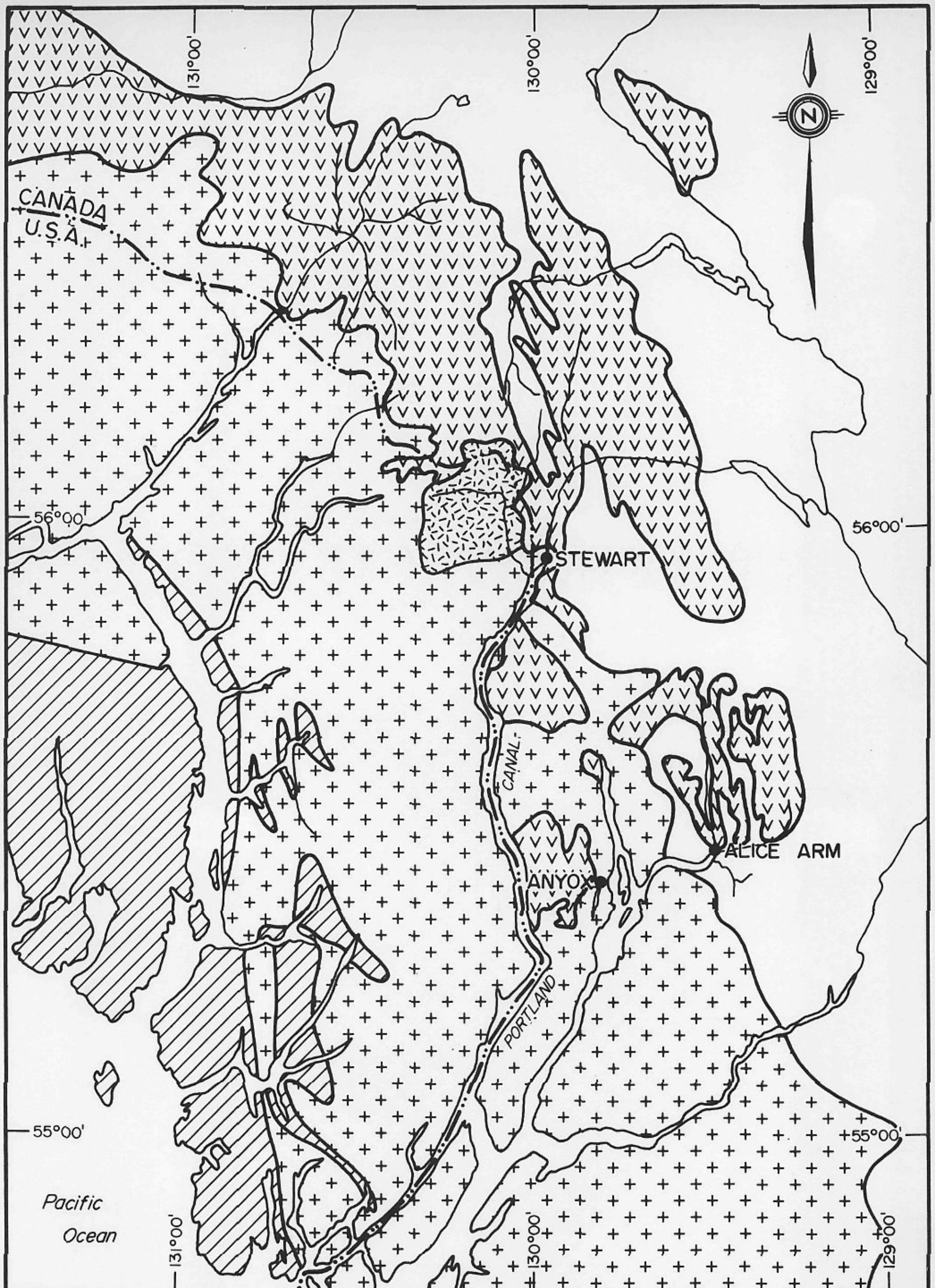
BIG MISSOURI - SILBAK PREMIER

FIELD TRIP STOPS LOCATION MAP

SCALE 1:71,100

Figure 2

99 A - 5 113



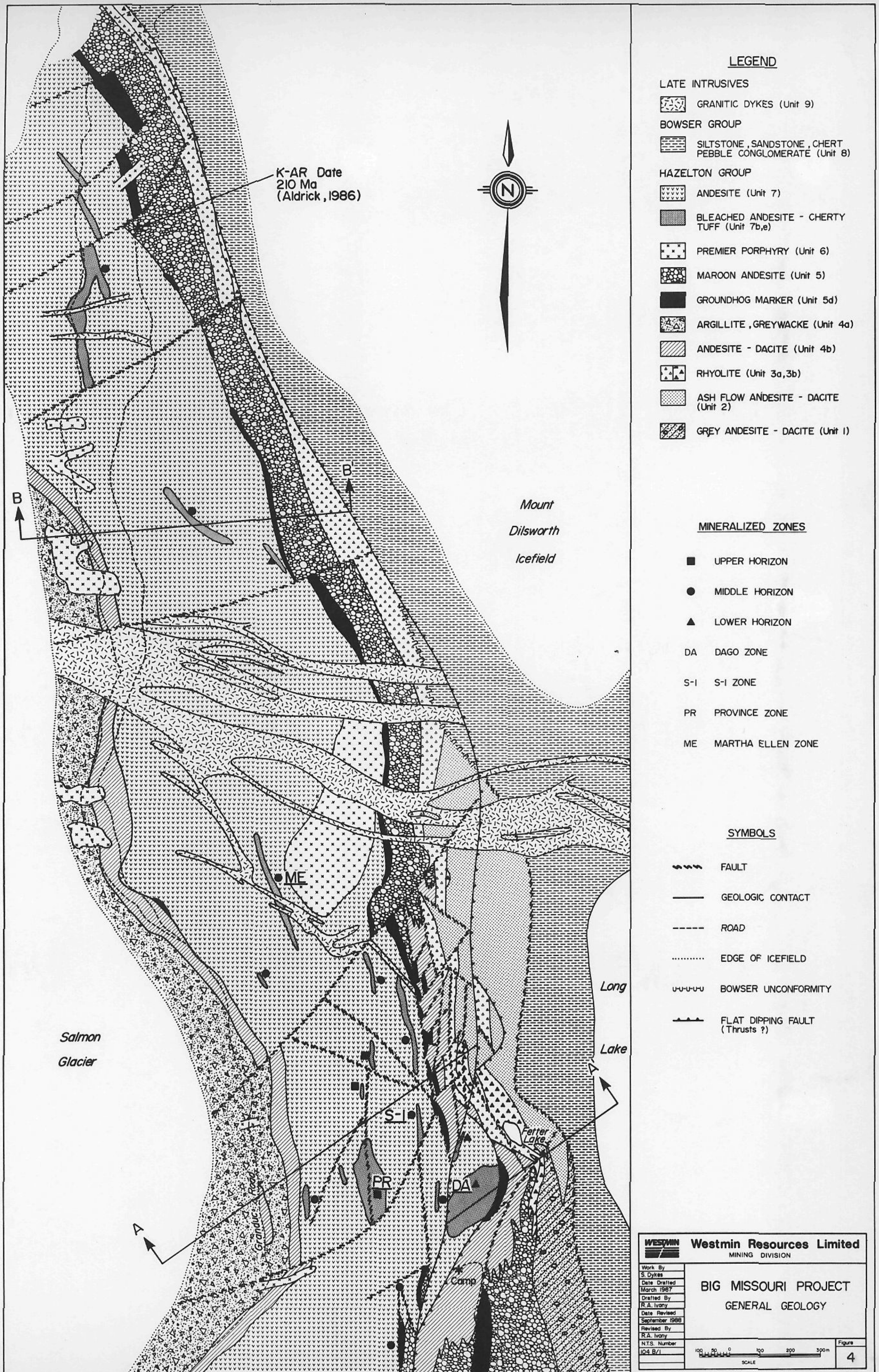
LEGEND

- LOWER - MIDDLE JURASSIC BOWSER ASSEMBLAGE
- UPPER TRIASSIC - LOWER JURASSIC TAKLA & HAZELTON ASSEMBLAGE (STEWART COMPLEX)
- WRANGELL METAMORPHIC BELT (UNDEFINED AGE)
- UPPER TRIASSIC - LOWER JURASSIC TEXAS CREEK INTRUSION
- CRETACEOUS - TERTIARY COAST RANGE INTRUSIONS

REGIONAL GEOLOGY OF THE STEWART - ANYOX AREA

20 10 0 20 40 60 kilometres

Figure 3


K-AR Date
210 Ma
(Aldrick, 1986)
N
B
B'
A
A'
Mount
Dilsworth
Icefield
Salmon
Glacier
Long
Lake
Fetter
Lake
ME
S-1
PR
DA
Camp
Granduc Road
LEGEND
LATE INTRUSIVES
GRANITIC DYKES (Unit 9)
BOWSER GROUP
SILTSTONE, SANDSTONE, CHERT PEBBLE CONGLOMERATE (Unit 8)
HAZELTON GROUP
ANDESITE (Unit 7)
BLEACHED ANDESITE - CHERTY TUFF (Unit 7b,e)
PREMIER PORPHYRY (Unit 6)
MAROON ANDESITE (Unit 5)
GROUNDHOG MARKER (Unit 5d)
ARGILLITE, GREYWACKE (Unit 4a)
ANDESITE - DACITE (Unit 4b)
RHYOLITE (Unit 3a,3b)
ASH FLOW ANDESITE - DACITE (Unit 2)
GREY ANDESITE - DACITE (Unit 1)
MINERALIZED ZONES
UPPER HORIZON
MIDDLE HORIZON
LOWER HORIZON
DA DAGO ZONE
S-1 S-1 ZONE
PR PROVINCE ZONE
ME MARTHA ELLEN ZONE
SYMBOLS
FAULT
GEOLOGIC CONTACT
ROAD
EDGE OF ICEFIELD
U-U-U-U BOWSER UNCONFORMITY
FLAT DIPPING FAULT (Thrusts ?)
WESTMIN
Westmin Resources Limited
MINING DIVISION
Work By
S. Dykes
Date Drafted
March 1987
Drafted By
R.A. Ivany
Date Revised
September 1988
Revised By
R.A. Ivany
N.T.S. Number
104 B/1
BIG MISSOURI PROJECT
GENERAL GEOLOGY
100 50 0 100 200 300m
SCALE
Figure
4

99 A - 7

TABLE 1
Detailed Stratigraphy of the Big Missouri Property

Intrusive Rocks (Cretaceous - Tertiary)

---

10. **Andesite Dyke (undefined)**

    a. Type A - medium grey-green, acicular hornblende, feldspar phenocrysts, magnetic.
    b. Type B - medium green, feldspar porphyry, non-magnetic, non-calcareous.
    c. Type C - dark grey-green, magnetic, commonly with calcite amygdules.

9. **Granitic Dykes - Portland Canal Dyke Swarm**

    Diorite, Granodiorite and Quartz Porphyritic Quartz Monzonite and Felsite.

Layered Rocks - Bowser Group (Middle to Late Jurassic)

---

8. **Siltstone - Sandstone - chert Pebble Conglomerate**

Hazelton Group (Lower to Lower Middle Jurassic)

---

7. **Andesite-Cherty Tuff Unit** Several Units
    a) Unbleached andesite flows, agglomerate, lapillistone and tuff
    b) Bleached andesite tuff, lapillistone and agglomerate
    c) Bleached andesite tuff, lapillistone and agglomerate: carbonaceous
    d) Andesite tuff and lapillistone: minor fhyolite fragments
    e) Cherty tuff, andesite and rhyolite; silica-rich beds with bleached or unbleached andesite fragments, disseminated to semi-massive sulphides

6. **Premier Porphyry** (subvolcanic intrusive)
    a) Coarse porphyritic, >15% quartz-plagioclase-amphibole phenocrysts, generally lacks large K-spar phenocrysts
    b) Fine-medium porphyritic, <15% quartz-plagioclase-amphibole phenocrysts, large up to 6-10 cm K-spar phenocrysts

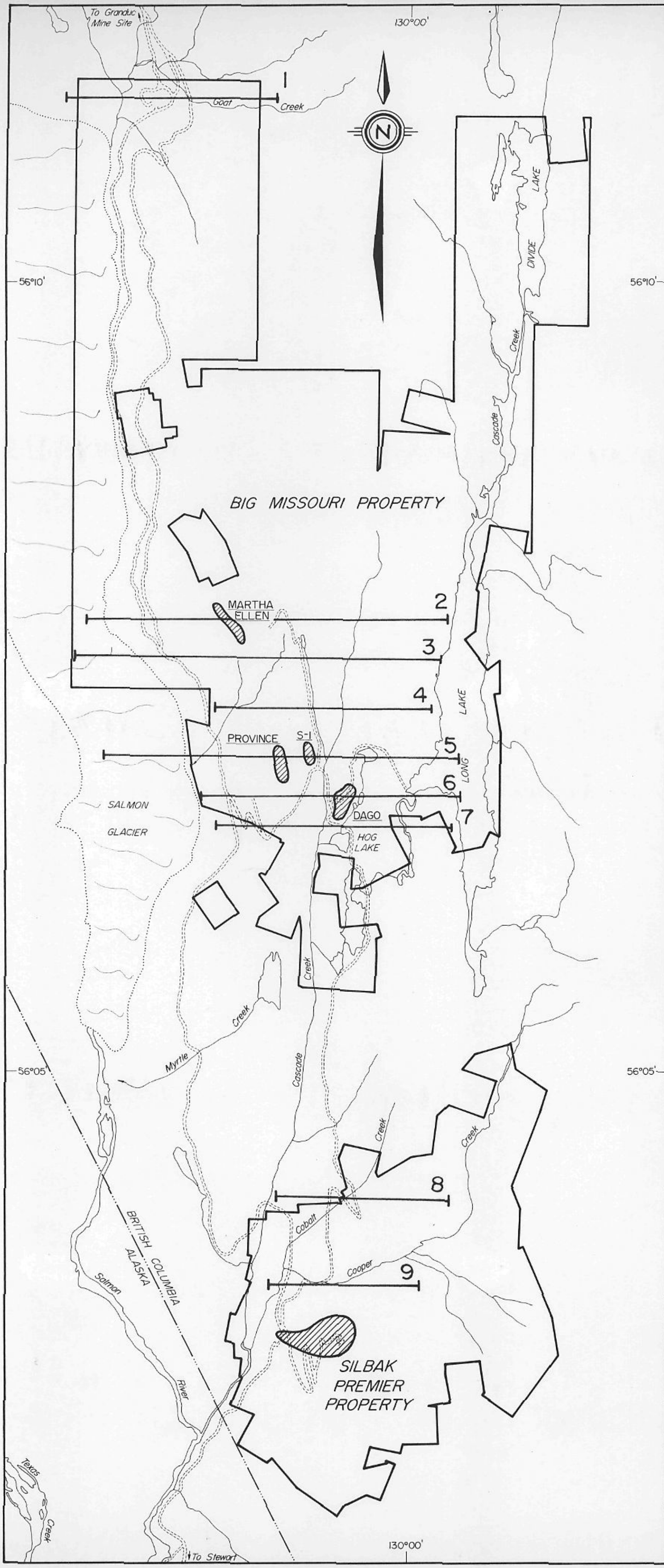
5. **Maroon Andesite Volcaniclastic Unit**
    a) Agglomerate, volcanic conglomerate and tuff; mixed maroon and green
    b) Volcanic wacke; maroon
    c) Dacite; lapillistone, tuff, agglomerate-quartz phenocrysts
    d) Ground Hog marker - extrusive equivalent of 6a

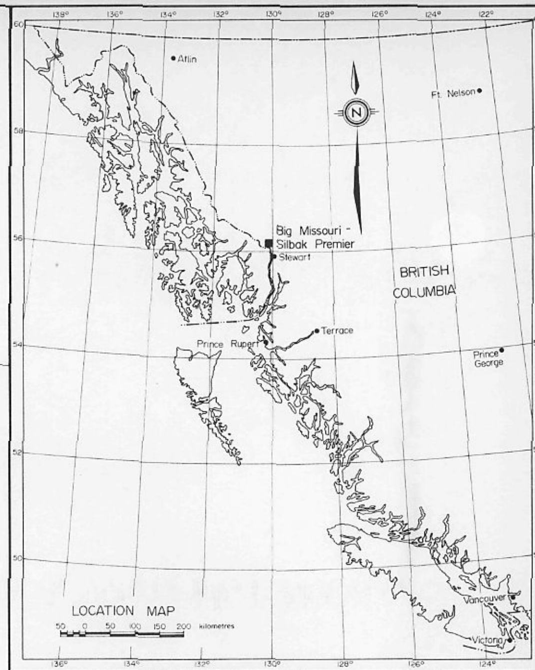
4. **Siltstone Unit** (Facies equivalent Unit 5)
    a) Black carbonaceous tuffaceous siltstone, argillaceous limestone and volcanic wacke
    b) Basaltic andesite to dacite flows, tuff and agglomerate

3. **Dillworth Rhyolite Unit**
    a) Rhyolite Agglomerate to Tuff; tan, vesicular, lateral gradation from coarse to fine, coarse agglomerate is pyritic with calcareous interfragment matrix.
    b) Fine Lapilli Tuff in carbonaceous silty matrix of Unit 2.
    c) Rhyolite-Andesite Mixed Lapilli Tuff; feldspar detritus, minor carbon and limonite spots.
    d) Limestone

2. **Ash Tuff Unit**
   a) Carbonaceous Ash Tuff; black, siliceous, poorly stratified, rhyolitic (Unit 3) welded tuff and pumice fragments.
   b) Carbonate Marker Horizon.
   c) Carbonaceous Tuffaceous Ash and Breccia; dark grey, heterolithic andesite and rhyolite detritus.

1. **Lower Andesite Unit**
   Andesite Flows, Lapilli Tuff and Agglomerate; dark grey, heterolithic, coarse feldspar phenocrysts, locally welded ash flow tuff.





LIST OF PROFILES

1 Troy Canyon
2 Martha Ellen
3 Rambler
4 "A" Vein - Unicorn
5 Province - S-1
6 Dago - Calcite Cuts
7 Powerhouse - Golden Crown
8 Big Missouri Road Switchback
9 Cooper Creek + Hole 80-22

WESTMIN **Westmin Resources Limited**
MINING DIVISION

Work By: S. Dykes	BIG MISSOURI - SILBAK PREMIER
Date Drafted: March 1987	
Drafted By: L. Hassard	GEOLOGICAL PROFILE LOCATION MAP
Date Revised:	
Revised By:	
N.T.S. Number: 104 B/1	640 320 0 640 1280 1920 m SCALE 1:71,100 — Figure 7

99A - 12 118

E. STRATABOUND PRECIOUS-BASE METAL MINERALIZATION

In general, stratabound semi-massive to massive lenses, pods and stringer zones of pyrite, sphalerite, galena and chalcopyrite with appreciable amounts of gold and silver occur within and at the contact of thin cherty tuff beds. Andesite in the footwall of these beds is silicified with abundant sericite, chlorite and fine disseminated pyrite. Altered andesite (termed bleached andesite) is also cut by numerous quartz-sulphide veins with or without chlorite and/or carbonate. Close to the cherty tuff, the footwall consists of altered andesite fragments in a quartz-sulphide matrix. These quartz stringer zones and silicified breccias are commonly discordant in detail, but grossly stratabound. Andesite units overlying the cherty tuff beds are more intensely sericitized and silicified (bleached). In the immediate hanging wall, abundant sphalerite and galena are commonly present in well developed quartz stringer zones. Further in the hanging wall, the relative abundance of alteration and disseminated pyrite are less and only a few quartz-sulphide veins are present.

Three stratabound mineralized horizons consisting of several cherty tuff bands have been recognized based on geologic correlation of the host units. The Lower Horizon is readily identified by the presence of abundant black carbon in the cherty tuff. Abundant calcite and iron carbonate readily identifies the Middle Horizon. Finally, the Upper Horizon contains only minor amounts of carbon and carbonate in the host rocks and the andesite is more intensely sericitized. In all three mineralized horizons, the thickness of the mineralized zones is greatest in the centre, decreasing laterally outward. Semi-massive to massive sulphide is confined to small discontinuous pods and lenses at the base of the thickest parts of the cherty tuff beds. Locally, base metal-rich massive sulphide is well laminated in beds up to 0.3 m thick. It should be noted that the cherty tuff beds occur throughout the andesite sequence as interflow units with only three horizons containing significant mineralization. Barren interflow cherty tuff beds are similar in appearance to mineralized cherty tuff beds, but lack extensive alteration (bleaching) and have a lower sulphide content. They are geochemically anomalous in gold and silver and their syndepositional relationship with flows and flow top breccias is well preserved.

Mineralogy of the sulphides is simple with pyrite and sphalerite making up 70% to 80% of the sulphide minerals. Galena and chalcopyrite are locally abundant. Most of the chalcopyrite is present as blebs within or intergrown with sphalerite. Electrum, native silver, argentite and minor amounts of freibergite account for nearly all the gold and silver.

Two distinct precious-base metal relationships are indicated. Native silver and argentite have a strong association with galena and chalcopyrite. Electrum on the other hand, has a preference for sphalerite.

In addition to stratabound mineralization, there are numerous late crosscutting quartz veins containing coarse-grained pyrite, sphalerite and galena. Figure 4 shows the location of the various mineralized zones and showings on the property.

Lower Horizon

Although rock types are varied, the horizon is identified by the presence of abundant carbon. The Dago zone is the most significant mineralized area within the Lower Horizon.

Dago Zone

Located at the south end of the property, the Dago Zone is one of the main near-surface zones. Green plagioclase-amphibole andesite agglomerate and lapilli tuff predominate with lesser bleached andesite and cherty tuff. The three cherty tuff beds that make up the Dago Zone are 1 to 5m thick and separated by 6m to 8m of andesite commonly with quartz-sulphide stringers. Bleaching of the andesite resulting from pervasive sericitization and silicification varies from weak to intense, the latter resulting in both the agglomerate fragments and tuff matrix being altered. Pyrite commonly pseudomorphs amphibole. Quartz and/or carbonate veining is intense. Several different types and ages are present, most containing little or no precious metal values.

The gentle to moderately southwest dipping sequence of rocks has been cut by north-northwest and northeast-trending faults which form pronounced topographic lineaments. They are steeply dipping and have moderate to steeply plunging slickensides.

Correlation of lithology between drill hole, underground workings and surface outcrops indicates that the mineralized zone is on the northwest limb of a shallow amplitude, anticlinal structure. The fold axis trends northeast, plunges 15 to 22 degrees southwest and has a 20- to 30-degree dipping northwest limb. North-northwest-trending faults are in the A-C joint plane of the fold and the northeast-trending faults parallel the axial plane.

The Dago Zone consists of three mineralized beds labelled D, E, and F (Fig. 9). These consist of crudely laminated carbonaceous cherty tuff buds, grey mottled quartz stringer zones and/or carbonaceous, siliceous and sericitic andesite. Base of the mineralized stratigraphy is identified by a coarse feldspar amphibole porphyritic andesite containing up to 5 mm long, subhedral plagioclase feldspar and up to 10 mm subhedral amphibole crystals (Map unit 5d - Groundhog Marker).

The "D" bed is the thickest, most extensive and has the best grade of the three beds. It consists of an upper and lower cherty tuff bed approximately 8 m apart separated by andesite containing abundant quartz stringers. Numerous veins and veinlets of remobilized cherty tuff material (grey mottled quartz) crosscut the zone making it difficult to identify the original beds. Total sulphide content within the zone rarely exceeds 15% and is generally 5% to 10%. Disseminated pyrite is ubiquitous in the mineralized zone forming 5% to 10% of the rock. Higher-grade gold and silver values are associated with steel grey galena and sphalerite intergrowths which are present as patches and/or in discontinuous small stringers. Gold occurs as discrete grains of electrum along fractures and grain boundaries of sulphides and in the quartz-carbonate-sericite matrix. Relatively coarse-grained electrum is found in both pyrite and sphalerite. Silver minerals consist of acanthite, native silver and freibergite which occur as complex intergrowths with galena, siderite and chalcopyrite along narrow fractures, as rims on the galena and chalcopyrite or as interstitial fillings in the gangue minerals (Holbeck, 1983).

Figures 10a and 10b show a postfault and prefault topographic contour plan of the base of the lower cherty tuff bed of "D" zone. the over-all shallow dip and plunge of the bed is evident and contoured assay values indicate a linear southwest-trending zone prior to deformation. This distribution is believed to reflect syn-depositional basin features.

Located approximately 10m stratigraphically above the top of "D" bed is the "E" bed. It consists of a poorly developed cherty tuff bed intercalated with silicified carbonaceous bleached andesite. The zone is generally thin (1m to 2m), discontinuous, and of low grade (<1.7 g/t Au equiv.).

The uppermost mineralized bed, "F", is located about 8 m above the top of the "E" bed. It consists of a single very siliceous cherty tuff bed underlain by an altered andesite with intense quartz-sulphide stringers. As a result of the combined effects of faulting and erosion, the F zone is only observed in two fault blocks. The zone is 4m to 5m thick and is characterized by high silver to gold ratios.

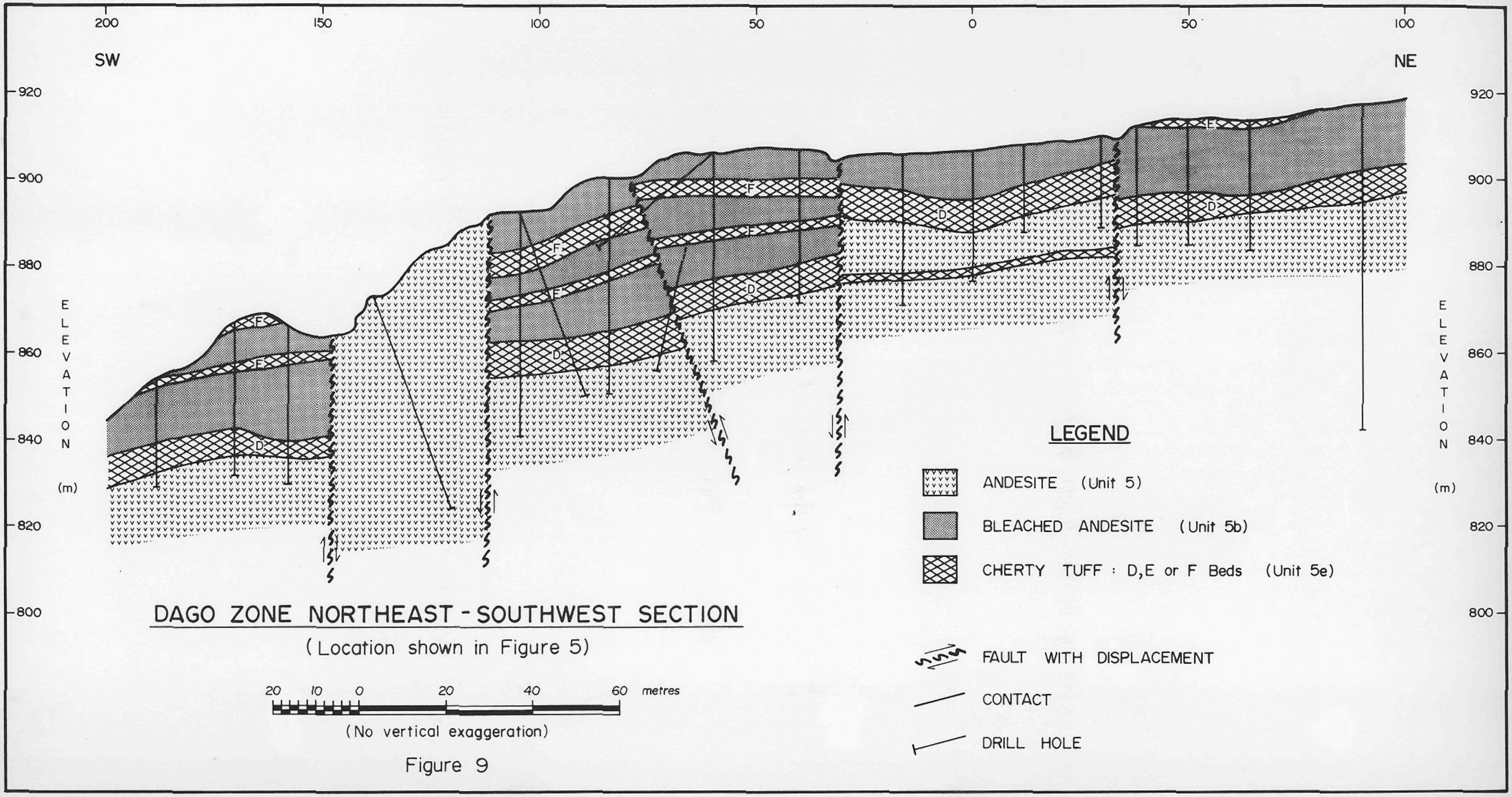
Geological reserve estimates indicate 557,000 tonnes grading 2.92 g/tonne Au equivalent (Au equivalent is based on 1 g/t Au = 100 g/t Ag) within the Dago Zone.

Middle Horizon

The Middle Horizon hosts the mineralization which was mined in the Big Missouri underground (Fig. 5), and is best exemplified by the S-1 Zone (Fig. 4). The horizon is characterized by the presence of abundant carbonate in veins in andesite and as patches and bands within cherty tuff and footwall breccia. A total of six mineralized zones (identified by a solid circle in Fig 4) are recognized over a distance of 2.5 km.

S-1 Zone

Three distinct, southwest-dipping cherty tuff beds approximately 20m apart make up the Middle Horizon (Figs. 6 and 11). These beds separate individual green plagioclase-amphibole porphyritic andesite

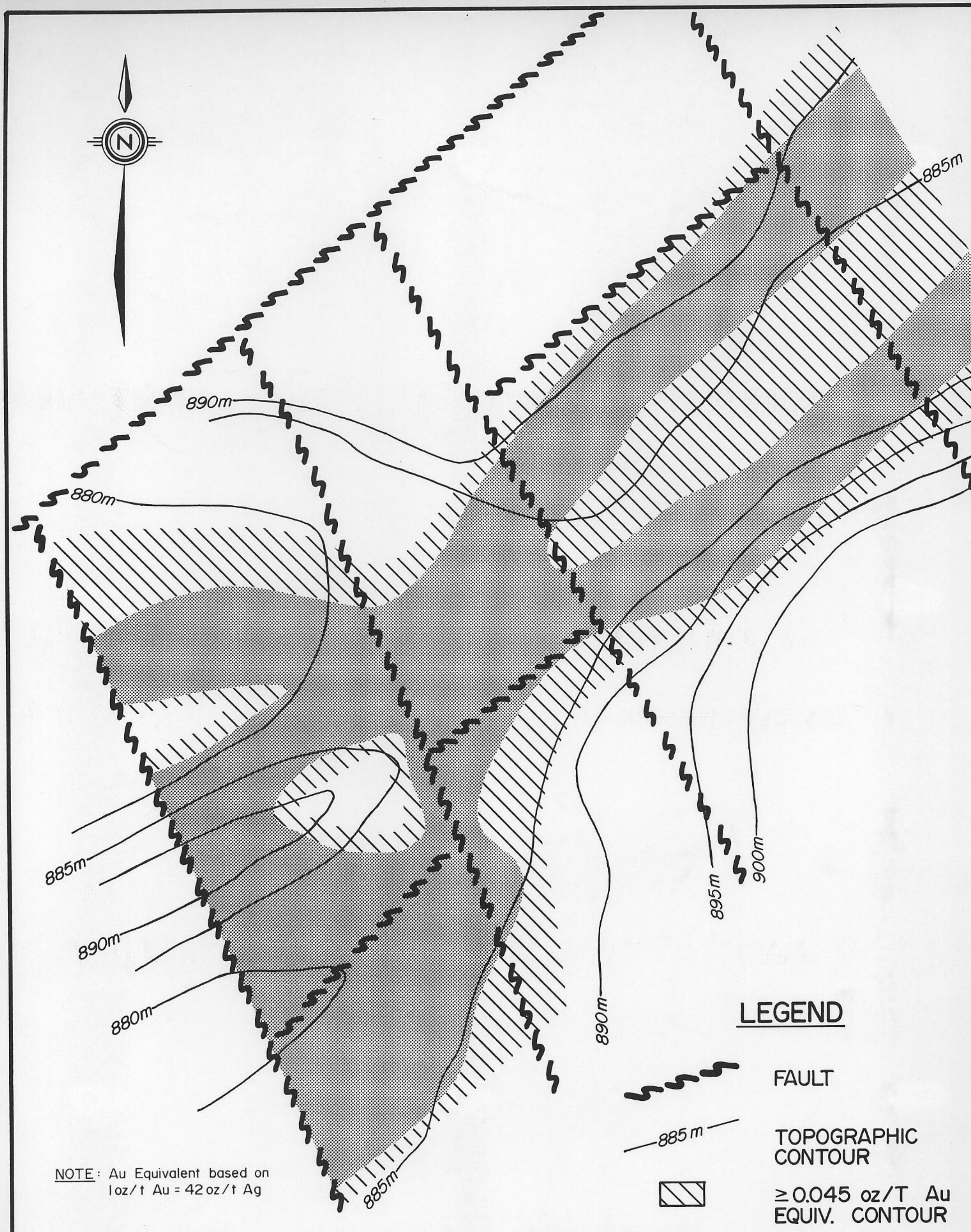


DAGO ZONE NORTHEAST - SOUTHWEST SECTION

(Location shown in Figure 5)

Figure 9

99A - 15



PRE-DEFORMATION GRADE and TOPOGRAPHIC CONTOUR MAP for BASE of D-ZONE, DAGO ZONE

Figure 10b

99A - 16

fragmental units. Sericite and silica alteration is only weakly developed resulting in the matrix being more intensely altered than the fragments. Cherty tuff beds are generally 1m to 2m thick and contain carbonate, andesite fragments, laminated and/or mineralized chert fragments and sulphide mineralization. A well developed footwall breccia occurs beneath the central part of each cherty tuff bed. This consists of medium green, silicified andesite fragments suspended in a quartz-carbonate-sulphide matrix. The breccia grades upward into cherty tuff and downward into a well developed stringer zone which decreases in intensity with depth.

The andesite sequence strikes southeast and dips 20 to 30 degrees southwest. Preliminary work indicates a gentle warping of the sequence around northeast-trending axes. Several steeply-dipping north-northwest and northeast-trending faults juxtapose the strata.

Mineralization consists of pyrite, sphalerite, galena and chalcopyrite that occur as disseminations, lenses, pods and stringers within the cherty tuff, footwall breccia and footwall and hanging wall stringer zones. Weakly laminated, semi-massive to massive sulphide occurs locally at the base of the cherty tuff beds. The lower cherty tuff-footwall breccia zone within the Middle Horizon has the greatest sulphide content.

Gold and silver occur only as electrum which is strongly associated with sphalerite. Electrum also occurs within galena and along sulphide grain boundaries. All of the sulphides are closely associated, and commonly intergrown in polycrystaline aggregates along veinlets. Multiple phase crystallization is demonstrated by overgrowth textures. Occlusion of large amounts of gangue within the sulphides is common (Holbek, 1983). Sphalerite often contains up to 12% exsolved chalcopyrite.

Geological reserve estimates indicate 1,240,000 tonnes grading 2.78 g/tonne Au equivalent within the S-1 Zone.

<u>Upper Horizon</u>

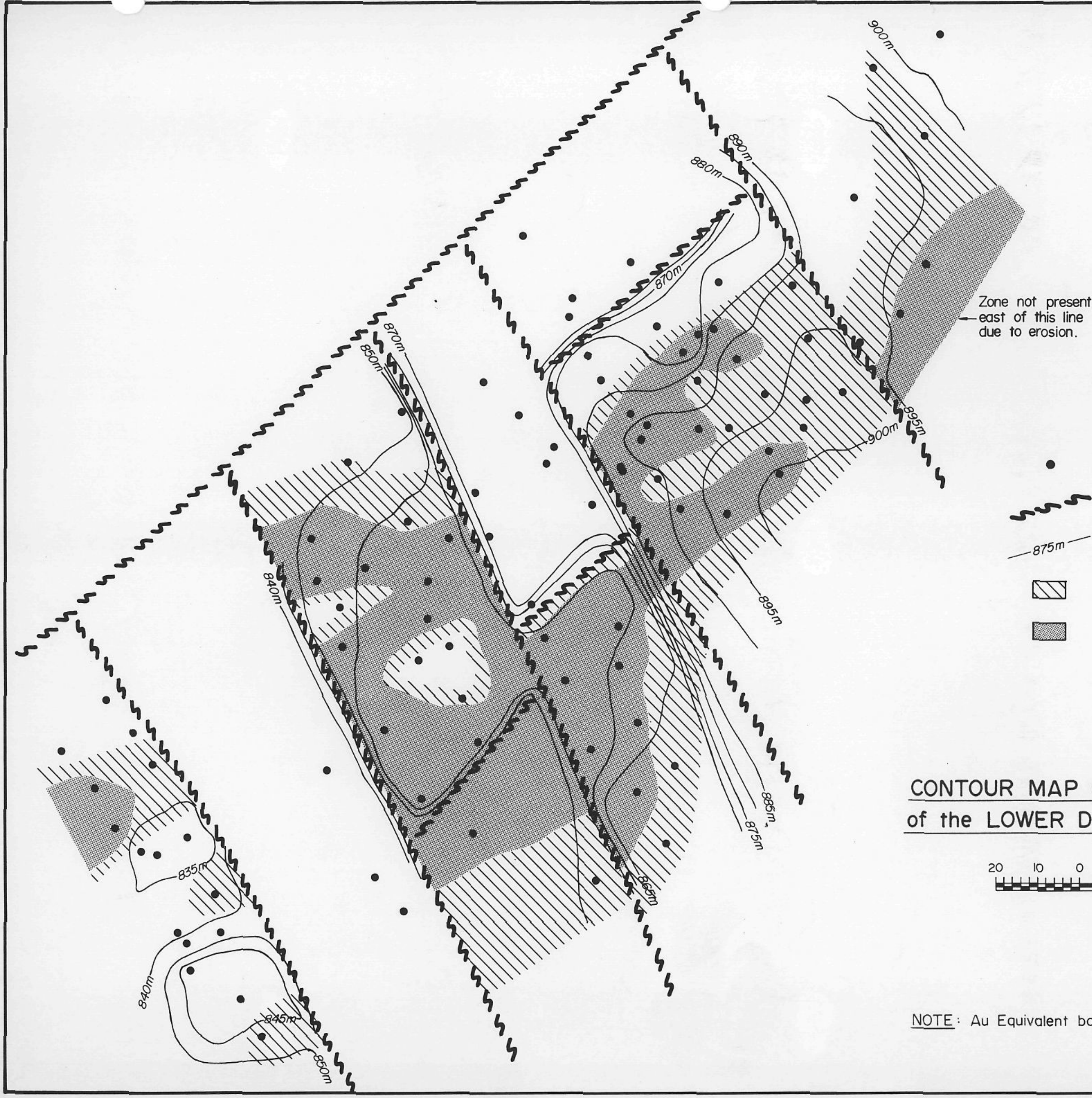
Best illustrated by the Province zone, the Upper Horizon is characterized by a general lack of carbon or carbonate and a well developed chlorite footwall.

Province Zone

Located at the south end of the property, the Province Zone consists of thick (up to 7m) beds of mixed cherty tuff and altered andesite the footwall consists of green feldspar-amphibole porphyritic andesite lapilli tuff. Where more chloritic, the footwall andesite has a banded appearance. Quartz, quartz-carbonate and carbonate veins are moderately well developed in the footwall. Cherty tuff contains intensely sericitized and silicified andesite fragments, recrystallized chert and sulphide minerals. From a sharp footwall contact, the amount of altered andesite decreases and the amount of recrystallized cherty material increases toward an almost pure siliceous top. Andesite in the hanging wall is intensely bleached (sericitized and silicified).

The mineralized horizon dips shallowly to moderately southwest and has been crosscut by several north and northeast-trending faults (Fig. 12). North-trending faults are steeply dipping and have moderate to near vertical slickensides, while the northeast trending faults are moderately dipping and exhibit both lateral and vertical displacements. Gentle drag folding of the mineralized horizons in the vicinity of the larger faults is common.

Pyrite, sphalerite, galena and lesser chalcopyrite occur as patches, thin lenses and disseminated grains within the bleached andesite-cherty tuff. There is a decrease upwards in the amount of precious-base metal sulphide present with most of the sulphides being concentrated in the mixed bleached andesite-cherty tuff zone. In the footwall, gold and silver values associated with base metals are confined to narrow (generally less than 20cm thick) quartz veins. In addition to the indicated vertical zoning, a lateral zonation is evident. Gold decreases while silver and the base metal content of the horizon increase from east to west across the zone. Based on assay data to date, the east side give values of 1.0 g/t Au and 10 g/t Ag for each 1% Pb + Zn while those on the west side give values of 0.1 g/t Au and 13.6 g/t Ag for each 1% Pb + Zn.



LEGEND

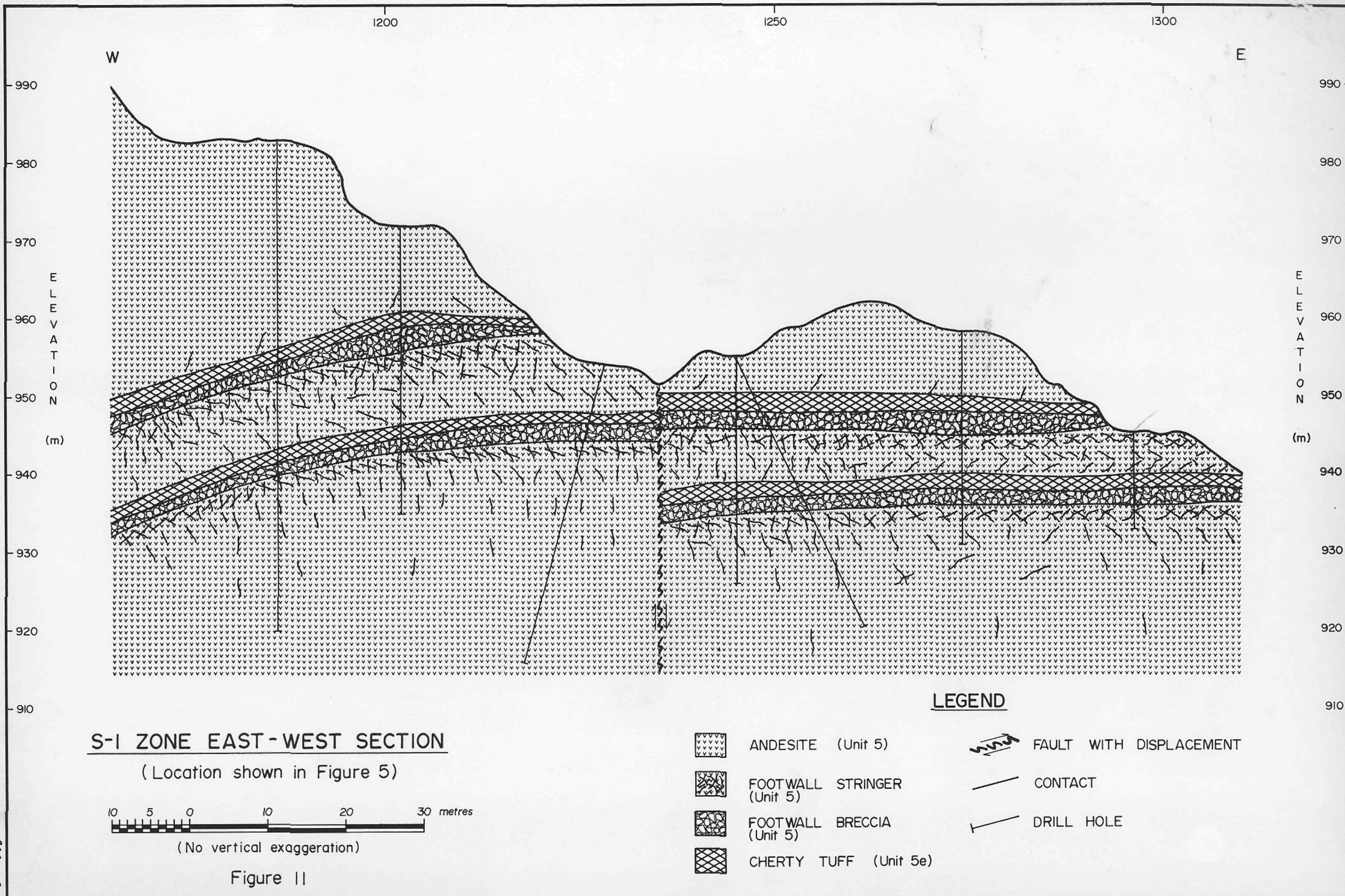
- DRILL HOLE
- FAULT
- 875m — TOPOGRAPHIC CONTOUR
- ≥ 0.045 oz/T Au EQUIV. CONTOUR
- ≥ 0.090 oz/T Au EQUIV. CONTOUR

CONTOUR MAP of TOPOGRAPHIC ELEVATION of the LOWER D-ZONE CONTACT, DAGO ZONE

20 10 0 20 40 60 metres

Figure 10a

NOTE: Au Equivalent based on 1 oz/t Au = 42 oz/t Ag

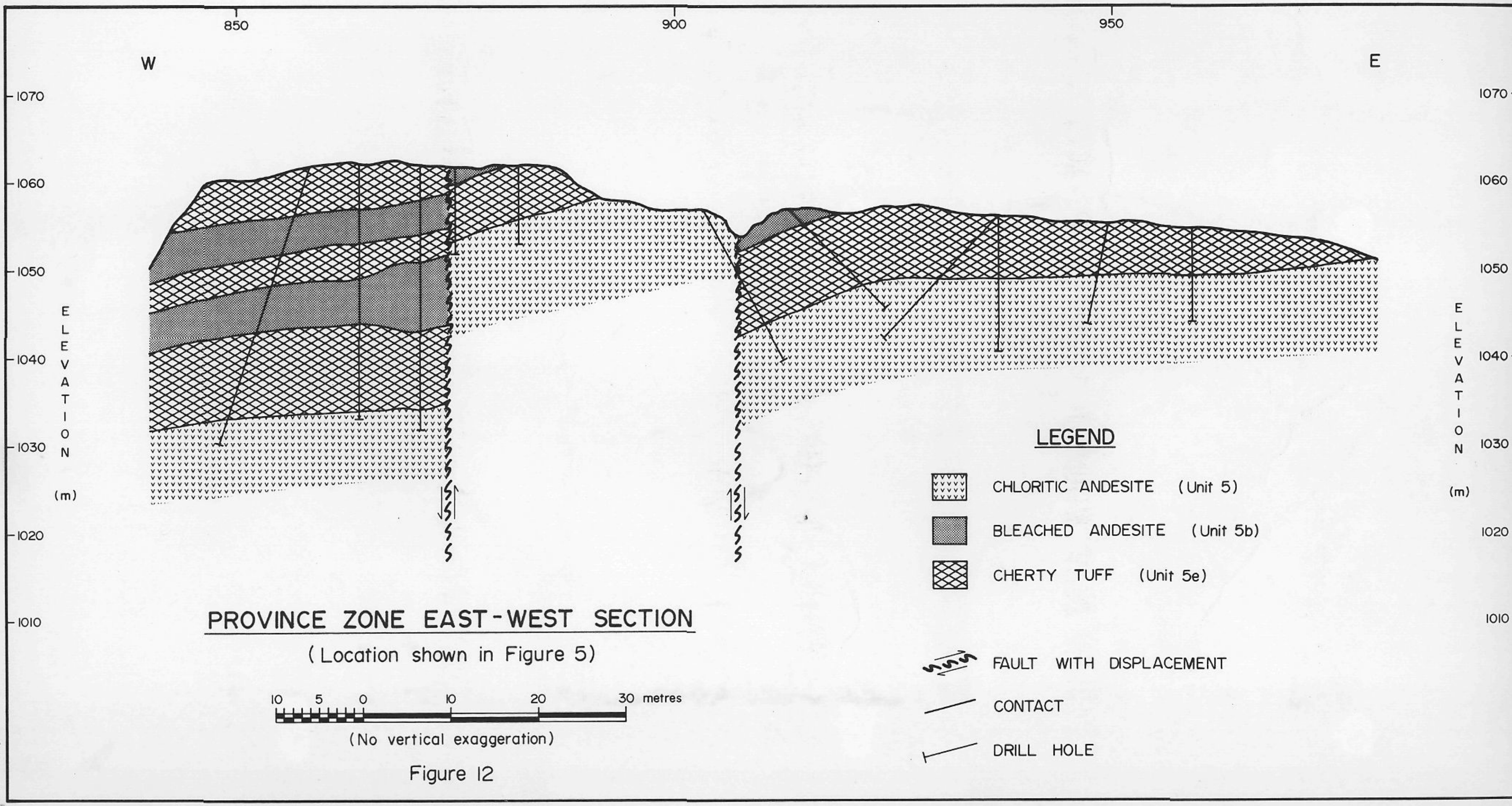


S-1 ZONE EAST-WEST SECTION

(Location shown in Figure 5)

Figure 11

94 - 20 | 25



PROVINCE ZONE EAST-WEST SECTION

(Location shown in Figure 5)

Figure 12

996-2-1/26

Gold is present in the Province Zone as discrete grains of electrum along sulphide grain boundaries and as variable sized grains within the gangue. Silver minerals are native silver, argentite and rare freibergite and are intergrown with galena and/or chalcopyrite. Freibergite forms "cauliflower" like overgrowths on pyrite and sphalerite grains.

Geological reserve estimates for the Province Zone indicate 287,000 tonnes grading 2.59 g/tonne Au equivalent.

F. GENESIS OF THE PRECIOUS-BASE METAL DEPOSITS

Presence of both precious-base metal-bearing cherty tuff horizons and barren interflow chert beds suggests variable hydrothermal processes. Barren interflow cherty beds may represent distal siliceous accumulations occurring laterally from the main precious-base metal-bearing cherty tuff. Alternatively, the barren interflow cherty beds may form from local hydrothermal systems developed in response to cooling of individual volcanic units. Leaching of metals in this local hydrothermal system is only weakly developed resulting in only slightly anomalous precious and base metal contents.

Precious-base metal mineralization in the Big Missouri deposits developed as the result of precipitation from hydrothermal fluids at or near the seawater-rock interface. The various mineralized zones are considered to be related to a large hydrothermal system that was active throughout the extrusion of the andesites of Unit 5. Cherty tuff and the associated stringer mineralization developed as the result of episodic exhalation of hydrothermal fluids during periods of quiescence in the volcanic activity. Variation in alteration and sulphide mineralization reflects the depositional environment at the point of exhalation.

A structurally controlled restricted basin, developed early in the volcanic history, controlled the deposition of the submarine andesite units which host the mineralization. It may also have created an area of crustal weakness through which hydrothermal fluids could migrate. On reaching the near-surface unconsolidated rock zone, the upward moving fluids migrated laterally and precipitated silica, sulphide and carbonate in the interstices between fragments creating footwall breccia zones. Siliceous and sulphidic chemical sediment or cherty tuff beds were deposited when the fluids reached the seawater-rock interface. Thickness and extent of the cherty tuff zone was dependent upon the duration of the volcanic quiescence, the volume of fluids and the availability of paleotopographic traps. Renewed eruptive activity blanketed cherty tuff horizons. Fluid circulation continued resulting in silicification and sericitization of the newly deposited andesite unit. Silica, carbonate and sulphides were either remobilized from the cherty tuff beds into the overlying newly deposited andesite or precititated from ongoing exhalative activity. Numerous veins with quartz, calcite, potassium feldspar, chlorite and sulphide minerals are evidence of the circulation of the fluids. Elsewhere, larger alteration zones formed with extensive bleaching of the andesite and formation of disseminated pyrite and sulphide stringers.

G. SUMMARY OF FIELD TRIP STOPS

Stop 1 -Granduc Road, km-20 (note km-0 at Granduc Millsite). Overview of Salmon Glacier and west side of Big Missouri Ridge. If weather co-operates, the following can be observed.

a) Position of the Big Missouri relative to Scottie Gold, Granduc, Silver Butte and Outland Silver Bar properties.

b) Location of the old Big Missouri underground mill and workings (1938-1942) and the Province and Martha Ellen mineralized zone.

c) Examples of the structurally deformed sediments exposed on the west side of the Big Missouri Ridge.

Stop 2 -Granduc Road km-8 - Troy Canyon

Troy Canyon contains the northern continuation of the Cascade Creek Fault zone. To the north lie the strongly deformed middle to late Jurassic Bowser sediments. Although not observed in outcrop, boulders of chert pebble conglomerate which mark the base of the Bowser may be found.

The roadcuts on the southside of the canyon expose typical examples of the mixed Dacite - Rhyodacite clastic unit of the Dillworth Rhyolite (map unit 3) in contact with the maroon and green volcaniclastic (map unit 5).

Stop 3 -Granduc Road km-12 - The "Summit"

An excellent example of the Groundhog Marker (map unit 5d) crosscut by a Premier porphyry dyke is exposed in the roadcut. The Groundhog exhibits the strong east-west elongation of the fragments perpendicular to the major stratagraphic contacts.

Stop 3-4- Granduc Road km-12 to km-16

Continuing south along the Granduc Road it should be possible to observe:

a) The fault controlled repetition of units within the lower part of the stratigraphy. This is especially evident by the repetition of a coarse fragmental to pyroclastic andesite to Dacite unit exhibiting large angular, chloritic fragments contained in a lighter, sericitic and more siliceous matrix.

b) The Cretaceous-Tertiary Portland canal dyke swarm.

c) The contorted, highly fissile, locally bedded argillaceous sediments.

Stop 4 -Granduc Road km-16 - Big Missouri Turnoff

Exposed in the roadcuts are examples of the argillaceous sediments intruded by irregular bodies of Premier Porphyry. Looking to the south, the large gossaneous cliffs of the Silver Butte property currently being explored by Tenajon Silver Ltd. may be seen.

Stop 5 - Dago Open-Pit

The Dago is the first pit being mined at Big Missouri. In the pit it should be possible to see the mineralized cherty tuff horizons in relation to the strongly altered host andesite units and the numerous barren cross-cutting quartz and quartz-carbonate veins. Depending on the progress of mining, the main high grade "D" horizon should be exposed.

Stop 6 -Big Missouri Powerhouse

Exposed alongside the powerhouse is an excellent example of the mixed maroon and green andesite-dacite volcaniclastic (map unit 5) showing felsic, jasperiodal and a wide variety of andesite-dacite fragments. This unit immediately underlies the Groundhog Marker. These outcrops are located on the south margin of the structurally controlled basin developed in the lower units 1 to 5.

H. ACKNOWLEDGMENTS

The authors wish to thank the management of Westmin Resources Limited and Tournigan Mining Explorations Ltd. for permission to publish this paper. In particular, we thank H. Meade and A. E. Soregaroli for their assistance, helpful discussions and critical reading of the manuscript and R. Ivany, and S. Loftsgard for their technical assistance.

Microscopic studies of Big MIssouri sulphide mineralogy were done by P. Holbek under the supervision of A.J. Sinclair at the University of British Columbia.

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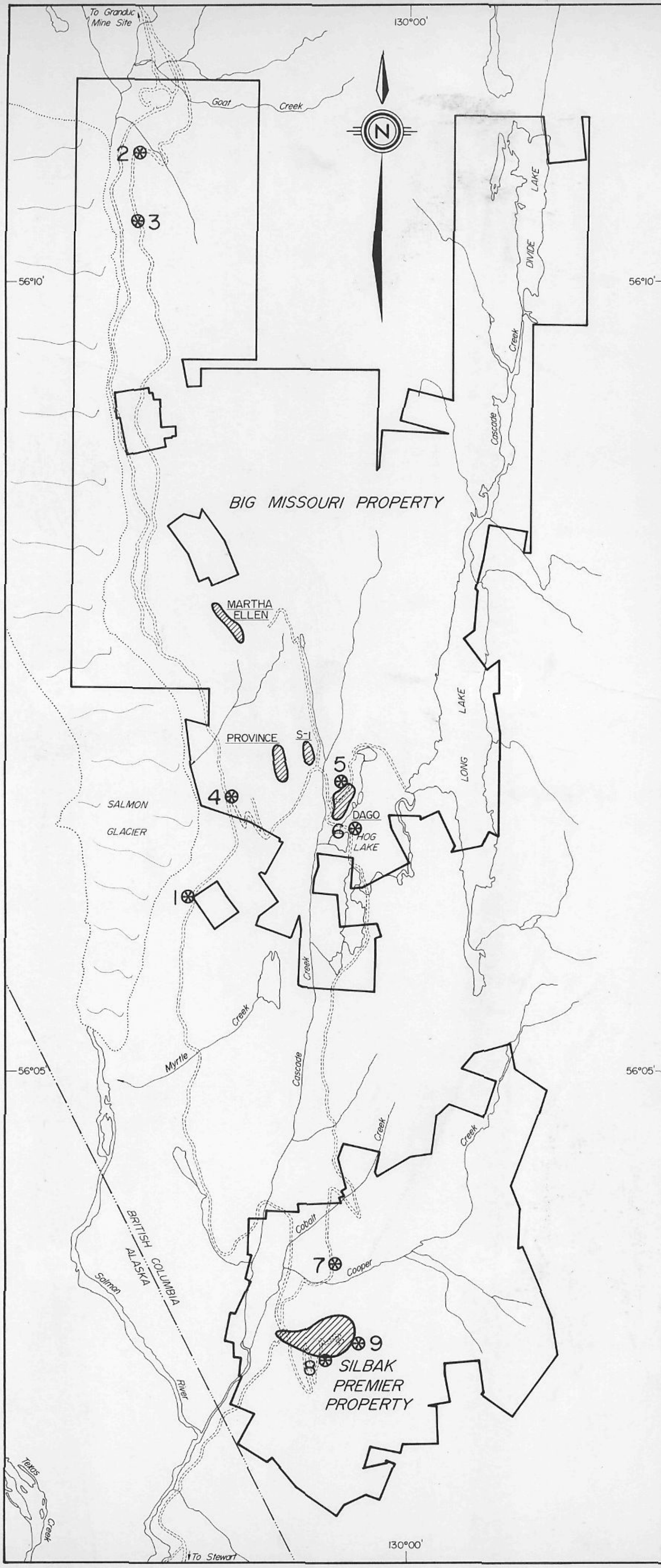

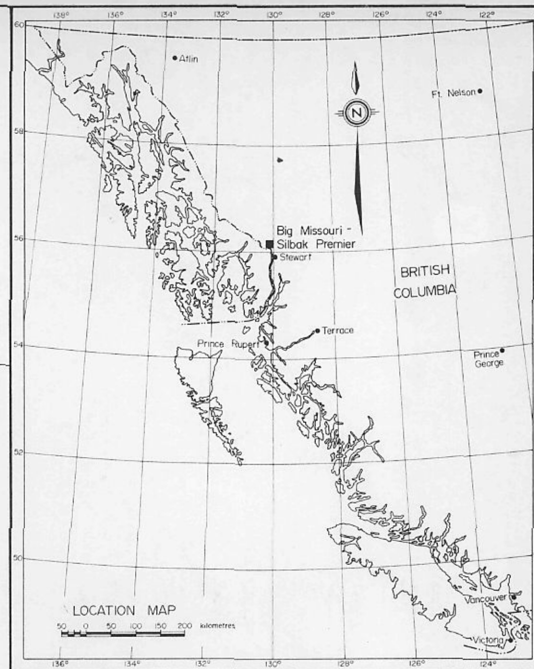

⊛ FIELD TRIP STOP

WESTMIN **Westmin Resources Limited**
MINING DIVISION

Work By: S. Dykes	BIG MISSOURI - SILBAK PREMIER
Date Drafted: September 1988	
Drafted By: R. A. Ivany	FIELD TRIP STOPS LOCATION MAP
Date Revised	
Revised By	
N.T.S. Number: 104 B/1	640 320 0 640 1280 1920 m — SCALE 1:71,100
Figure	2

99A - 25 | 30

SEG NORTHERN CORDILLERAN PRECIOUS METAL DEPOSITS
FIELD TRIP STOPS - SEPTEMBER 25, 1988
SILBAK PREMIER - BIG MISSOURI AREA

Stop 1 - Granduc Road, km-20 (note km-0 at Granduc Millsite).

Overview of Salmon Glacier and west side of Big Missouri Ridge. If weather co-operates, the following can be observed.

a) Position of the Big Missouri relative to Scottie Gold, Granduc, Silver Butte and Outland Silver Bar properties.

b) Location of the old Big Missouri underground mill and workings (1938-1942) and the Province and Martha Ellen mineralized zone.

c) Examples of the structurally deformed sediments exposed on the west side of the Big Missouri Ridge.

Stop 2 - Granduc Road km-8 - Troy Canyon

Troy Canyon contains the northern continuation of the Cascade Creek Fault zone. To the north lie the strongly deformed middle to late Jurassic Bowser sediments. Although not observed in outcrop, boulders of chert pebble conglomerate which mark the base of the Bowser may be found.

The roadcuts on the southside of the canyon expose typical examples of the mixed Dacite - Rhyodacite clastic unit of the Dillworth Rhyolite (map unit 3) in contact with the maroon and green volcaniclastic (map unit 5).

Stop 3 - Granduc Road km-12 - The "Summit"

An excellent example of the Groundhog Marker (map unit 5d) crosscut by a Premier porphyry dyke is exposed in the roadcut. The Groundhog exhibits the strong east-west elongation of the fragments perpendicular to the major stratagraphic contacts.

Stop 3-4- Granduc Road km-12 to km-16

Continuing south along the Granduc Road it should be possible to observe:

a) The fault controlled repetition of units within the lower part of the stratigraphy. This is especially evident by the repetition of a coarse fragmental to pyroclastic andesite to Dacite unit exhibiting large angular, chloritic fragments contained in a lighter, sericitic and more siliceous matrix.

b) The Cretaceous-Tertiary Portland canal dyke swarm.

c) The contorted, highly fissile, locally bedded argillaceous sediments.

Stop 4 - **Granduc Road km-16 - Big Missouri Turnoff**

Exposed in the roadcuts are examples of the argillaceous sediments intruded by irregular bodies of Premier Porphyry. Looking to the south, the large gossaneous cliffs of the Silver Butte property currently being explored by Tenajon Silver Ltd. may be seen.

Stop 5 - **Dago Open-Pit**

The Dago is the first pit being mined at Big Missouri. In the pit it should be possible to see the mineralized cherty tuff horizons in relation to the strongly altered host andesite units and the numerous barren cross-cutting quartz and quartz-carbonate veins. Depending on the progress of mining, the main high grade "D" horizon should be exposed.

Stop 6 - **Big Missouri Powerhouse**

Exposed alongside the powerhouse is an excellent example of the mixed maroon and green andesite-dacite volcaniclastic (map unit 5) showing felsic, jasperiodal and a wide variety of andesite-dacite fragments. This unit immediately underlies the Groundhog Marker. These outcrops are located on the south margin of the structurally controlled basin developed in the lower units 1 to 5.

Stop 7 - **Pyrite Cube Showing**

This outcropping with its distinctive pyrite cubes ranging up to 3 cm across is considered to be the same or equivalent to the mixed maroon and green andesite noted at the previous stop (Big Missouri Power House) and represents part of a possible link between the geology at Big Missouri and Premier.

Stop 8 - **2-Level Portal**

Classic intrusive Premier Porphyry (snow flake porphyry) is exposed in the road cut adjacent the 2-Level Portal of the old Premier mine workings. Indistinct, irregular contact relationships with adjacent andesite may be noted.

Also present is a controversial pod of massive sulphides demonstrating characteristics of both epigenetic and syngenetic styles of mineralization for those of either leaning. Sulphide-matrix breccias, massive fine silicification, stockwork veining, banded massive pyrite with varying amounts of sphalerite galena, and some copper mineralization are present. Contact relations with adjacent volcanics and porphyry are unclear but appear to be faulted.

Samples across this deposit returned 23.5 meters grading 0.462 oz/ton gold, 3.75 oz/ton silver, 2.7% lead and 2.4% zinc and included a zone of massive banded pyrite grading 0.785 oz/ton gold.

Stop 9 - Premier Open-Pit

i) Footwall rocks - predominantly andesite.
ii) Altered andesite and porphyry close to mineralized zones.
iii) Ore zones - siliceous breccias
iv) Hanging wall rocks
- maroon and green volcaniclastics
- Premier porphyry "extrusive" equivalent

v) Major cross-cutting structures

Stop 10 - Drill Core (Summary Logs)

A. Premier

DDH86-94 Section through Premier deposit from HW to FW showing most geological units and siliceous breccia.

0-10'	OVERBURDEN
10-46.2'	ANDESITE - PPAN - possible flow banding?
46.2-177	ANDESITE - fragmental. 46.2-69 - ALTX. 69.0-109 APLT (Maroon). 109-177 ALTX - medium to coarse euhedral py to 10%.
177-209'	SIBX - AFLW in-situ breccia overprinted by SIBX. Layercake quartz-vein at 148 with grey interbeds, could be interflow exhalative horizon.
209-253.5'	AFLW - 30% veining, also in-situ breccia. 249.5-252.5 - stope/working - open.
253.5-269.5'	AFLW
269.5-478.5'	PPX2 - Moderately to intensely altered, with local zones of extensive veining, approaching SIBX. Scattered veins with GL-SS especially in the interval 411-453.
478.5-497'	ANDESITE - mixed fragmental and flow interlayered.

ASSAY RESULTS

Interval (ft)	Length (ft)	Au oz/ton	Ag oz/ton
167.0 - 177.0	10	0.1185	1.270
177.0 - 181.0	4	2.860	228.56
181.0 - 187.0	6	0.084	14.870
187.0 - 209.0	22	0.0145	1.875
253.5 - 271.5	18	0.0758	3.890
271.5 - 325.0	53.5	0.0073	0.950
344.5 - 377.0	32.5	0.0178	10.914
467.0 - 472.0	5	0.038	2.28

B. Big Missouri

DDH 88-28	Section on immediate edge of the S-1 high grade core zone.
0.00 - 1.30m	OVERBURDEN
1.30 - 43.40m	ANDESITE LAPILLI TUFF - typical hangingwall andesite

MIDDLE HORIZON

43.40 - 54.70m	CHERTY TUFF - Footwall stringer zone - well mineralized, pyrite dominant with sphalerite
54.70 - 71.90m	ANDESITE TUFF - porphyritic and weakly silicified.

ASSAY RESULTS

Interval (ft)	**Length** (ft)	**Au** oz/ton	**Ag** oz/ton
42.80 - 55.10	12.3	0.221	0.45
43.40 - 49.10	5.7	0.351	0.55

DDH 88-46 — Stratigraphic hole drilled from immediate footwall to Province through the Andesite section and into the Footwall Argillite unit

0.0 - 1.30m	OVERBURDEN
1.30 - 15.6m	ANDESITE: chloritic, moderately altered
15.6 - 16.8m	CHERTY TUFF: sharp upper contact, well-developed footwall breccia
16.8 - 160.3m	ANDESITE: several faults and dykes, locally silicified 151.2 - 153.6 underground working

MIDDLE HORIZON

160.30 - 197.39m	ANDESITE-CHERTY TUFF: three cherty tuff beds with stringer zones weakly developed and mineralized
197.30 - 256.20m	ANDESITE TUFF: locally crudely bedded

LOWER HORIZON

256.20 - 277.10m	ANDESITE-CHERTY TUFF: three cherty tuff beds, weakly mineralized
277.10 - 291.40m	ARGILLACEOUS WACKE: Note pyritic fragments, possibly represents debris flow.

Assays: not currently available

DDH 88-89 — Section through sulphide rich core zone at Martha Ellen

0.00 - 4.90m	OVERBURDEN
4.90 - 46.60m	ANDESITE: chloritic cut by dioritic dykes

MIDDLE HORIZON

56.60 - 63.20m	ANDESITE-CHERTY TUFF: weakly mineralized, patchy sulphides
63.20 - 72.40m	ANDESITE LAPILLI TUFF: sporadic patches of mineralization and weak stringers, chloritic
72.40 - 78.00m	CHERTY TUFF-FOOTWALL BRECCIA: heavy sulphide, well-developed breccia textures
78.00 - 118.2m	ANDESITE LAPILLI TUFF: shows typical fragmental texture with darker chloritic fragments in a lighter, more sericitic and siliceous matrix
118.20 - 120.40m	GRANODIORITE DYKE: Portland Canal

ASSAY RESULTS

INTERVAL (ft)	Length (ft)	Au oz/ton	Ag oz/ton	
67.7 - 82.9	15.2	0.092	2.53	4% Zn
76.8 - 81.4	4.6	0.201	2.19	1.5% Pb 12.3% Zn

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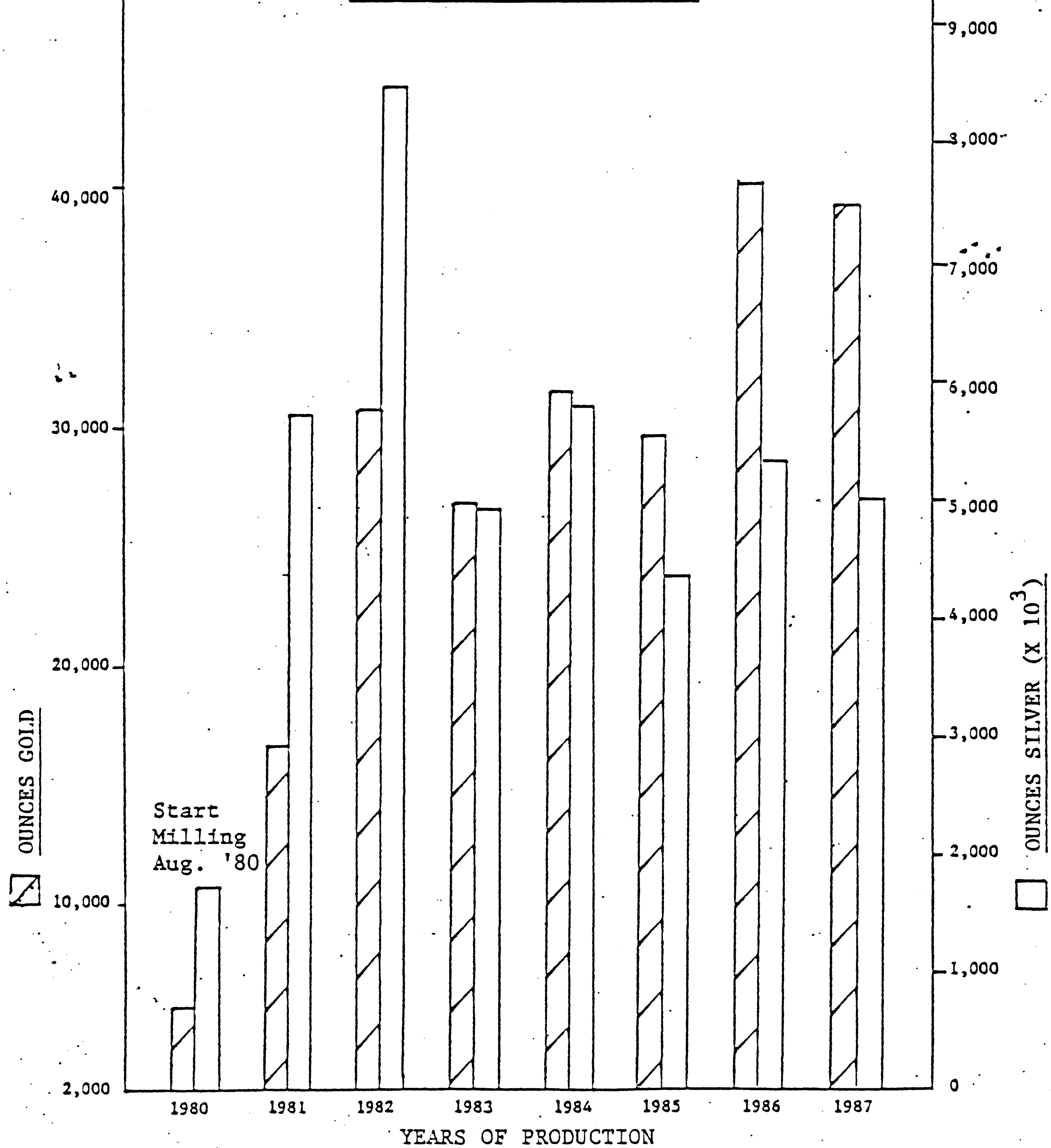
EQUITY SILVER MINE

GOLD AND SILVER PRODUCTION

1980 - 1987



TOTAL PRODUCTION(1980 - 1987 incl.)			RESERVES(to Apr.'88)
Tons Milled	OZ.Gold	OZ. Silver	16.2 M Tons @
19,124,359	220,902	41,570,364	2.52 OPT Ag
			.032 OPT Au
For SEG Tour, Sept. 26, 1988(Schroeter)			.25% Cu

* From Economic Geology, Vol. 79, 1984, pp. 947-968 , updated May 1988

GEOLOGY AND MINERALIZATION AT EQUITY SILVER MINE *

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Equity Silver Mines Limited, P.O.Box 1450, Houston,B.C.V0J 1Z0

and T. G. Schroeter

British Columbia Ministry of Energy, Mines and Petroleum Resources, 159 Hornby St. Vancouver, B.C.

Abstract

Equity Silver mine occurs in a homoclimal Upper Jurassic to Cretaceous inlier consisting of sedimentary, pyroclastic and volcanic rocks plus intrusions overlain and surrounded by younger, unconformable Tertiary andesitic to basaltic flows and flow breccias. Four stratigraphic conformable subdivisions, termed the Goosly sequence, are recognized in the inlier and consist of a basal conglomerate and minor argillite (clastic division); intercalated subaerial tuffs, breccias and minor reworked pyroclastic debris (pyroclastic division); interbedded volcanic conglomerate, sandstone, and tuff (sedimentary-volcanic division); and bedded andesitic to dacitic flows (volcanic flow division). A quartz monzonite stock with an approximate age of 58m.y., and a gabbro-monzonite complex with an approximate age of 49 m.y. intrude the Goosly sequence. Post mineral andesitic and quartz latite dykes with an approximate age of 49 m.y. cross-cut the Goosly sequence and the gabbro-monzonite complex. Copper-silver-antimony sulphides and sulfosalts with associated gold occur as tabular zones with attitudes grossly conformable to the Goosly sequence. Sulfides were deposited as disseminations, open-space fracture fillings, veins and crackle and breccia zones with an associated advanced argillic alteration suite including andalusite, corundum, pyrite, quartz, tourmaline and scorzalite; they are believed to have developed at a high elevation in the porphyry system. Potassium-argon age dating indicates a main pulse of mineralization and hydrothermal alteration around 58 m.y. and a younger post mineral event at around 49 m.y.

Mining of the Southern Tail orebody commenced in April 1980 with a mill feed rate of 5400 tonnes/day. Production to April, 1983 totalled 7 million tonnes of ore at 119.4g/t Ag; 1.29g/t Au and 0.433%Cu at a 50gAg eq cut-off. Antimony and arsenic were leached from the concentrate and recovered as by-products. The Main zone orebody, with reserves of 21.6 million tonnes grading 109g/t Ag; 0.85g/t Au and 0.35% Cu commenced production in late 1983. North of the Main zone is a smaller zone of mineralization called the Waterline zone which has mining reserves of 2.295mt at 89g/t Ag; 1.32g/tAu and 0.329%Cu based on a 70g/t Ageq cut-off. Elsewhere,

* From Economic Geology, Vol. 79, 1984, pp. 947-968, updated May 1988

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weak copper-molybdenum sulfides are associated with the quartz monzonite stock. Intense, irregularly distributed brecciation and tourmalinization with minor chalcopyrite, tetrahedrite, galena, and sphalerite occur in the northern part of the property, indicating that a mineralizing hydrothermal system was present in the proximity of known sulfide deposits.

Alteration and mineralization are compatible with an advanced argillic alteration, possibly related to base leaching associated with fluid circulation at a high level in a developing porphyry system.

Introduction

The Equity Silver mine, located 38km southeast of Houston, B.C. (Fig. 1), is a volcanic-hosted sulfide deposit associated with intrusive activity. The original prospect (locally referred to as the Sam Goosly prospect) was a new discovery (1967) found as a result of regional silt geochemical surveys conducted by Kennco Exploration (Western) Ltd. Further investigations until 1979 confirmed the existence of two distict mineralized zones, the Main zone and the Southern Tail zone.

Mining of the Southern Tail orebody commenced in April 1980 and the first unleached concentrate was produced in September 1980. Mill feed rate averaged 5400t/d.

Production from the Southern Tail orebody totalled 7 million tonnes of ore at 119.4g/t Ag; 1.29g/t Au and 0.433%Cu at a 50gAgeq cut-off. Mining of the Southern Tail ceased in March, 1983. Antimony and arsenic were removed through a chemical leaching process and were recovered as by-products in the form of calcium arsenate, sodium antimonate, and sodium sulfate.

Production from the Main zone orebody commenced in late 1983. Preproduction ore reserves were 21.6 mt grading 109g/tAg; 0.85g/t Au and 0.35%Cu and 0.07%Sb. A narrow zone of sulfides with similar grades is defined as a northerly extension of the Main zone and has been named the Waterline zone. Mining reserves of the Waterline zone as of June, 1987 are: 2.295mt at 89g/t Ag; 1.32g/t Au and 0.329%Cu based on a 70g/t Ageq cut-off.

Regional Geology

The regional geologic setting of the Equity Silver mine is illustrated in Figure 2 and is based largely on the map published by Carter (1981). The area is underlain by an incomplete succession of volcanic and sedimentary rocks ranging in age from Lower Jurassic to Miocene. Although formations of Lower

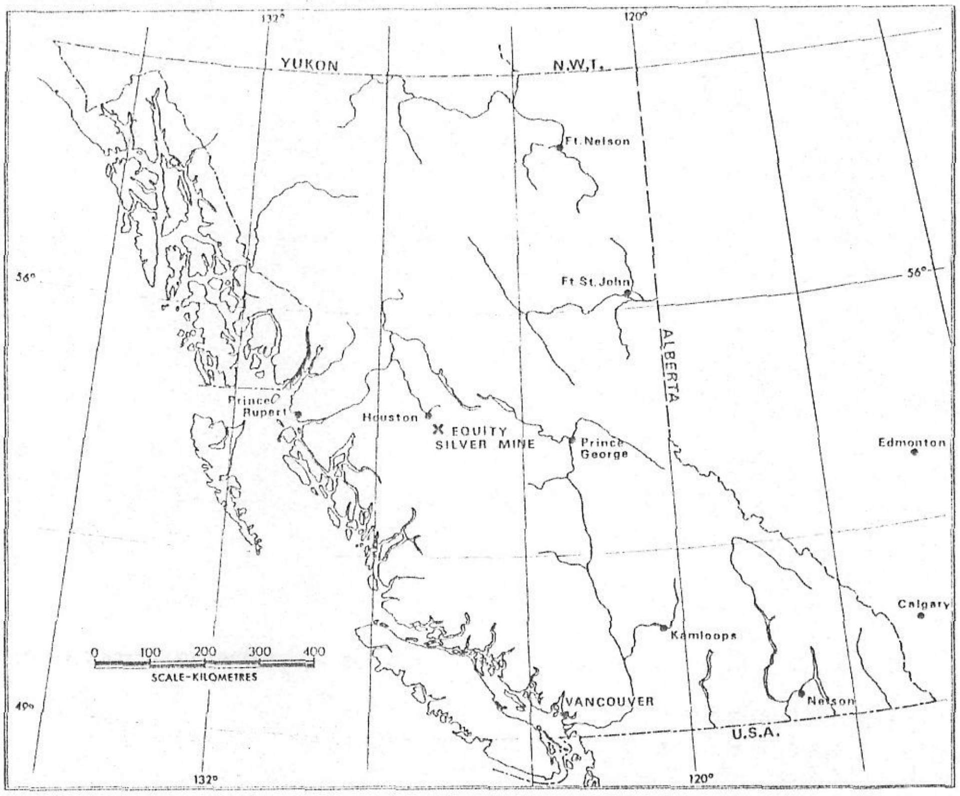

FIG. 1. Location map of the Equity Silver mine.

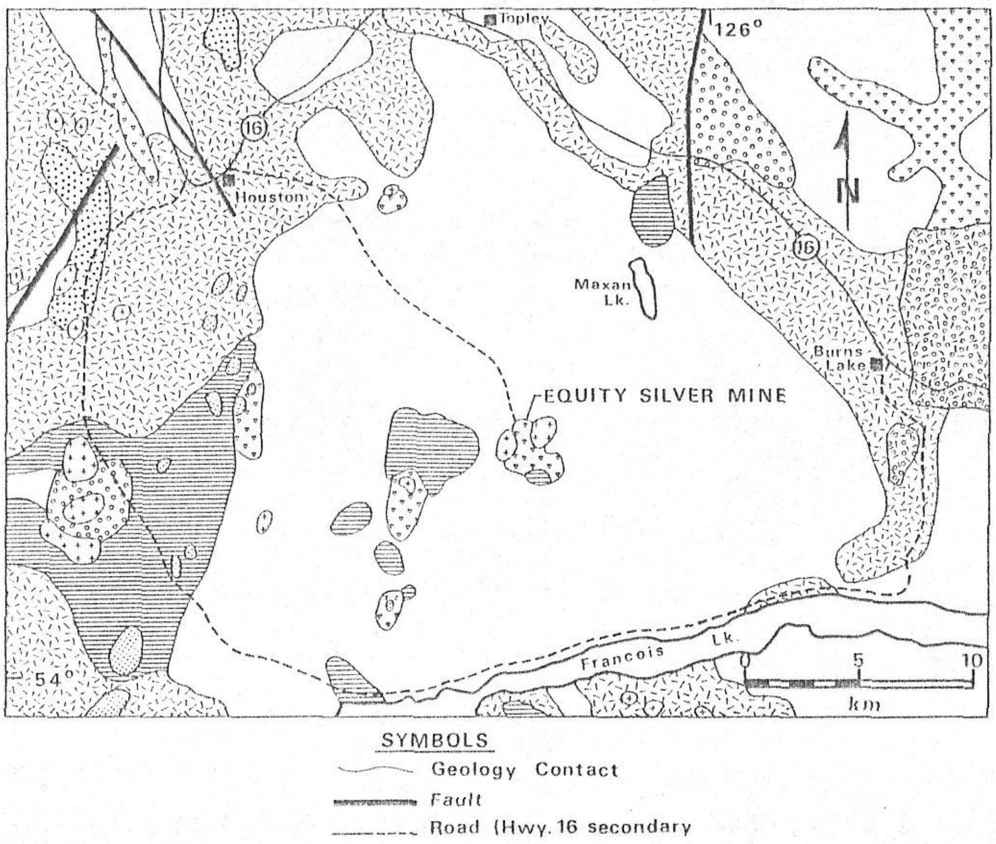

FIG. 2. Regional geology map (after Carter, 1981).

139

to Middle Jurassic age are most extensive regionally, much of the local area is covered by younger (Eocene to Miocene) volcanic rocks, mainly plateau basalts and andesite flows. Intrusive rocks of Upper Jurassic to middle Miocene age intrude these strata, but only Cretaceous and Tertiary intrusions appear to host significant mineral occurrences (Carter, 1981).

Stratigraphy

Hazelton Group: The oldest rocks in the area, the Hazelton Group, range from Lower Jurassic to Middle Jurassic (Callovian) in age (Tipper and Richards, 1976) and form the most widespread stratigraphic unit within west-central British Columbia.

Lower Jurassic rocks within the Hazelton Group are predominantly submarine and subaerial, bedded andesitic to basaltic, pyroclastic rocks with minor intercalated lava flows (Tipper, 1972).

Middle Jurassic rocks of the Hazelton Group comprise a mainly marine sequence of tuffs, volcanic breccias, shales and graywackes. The sedimentary rocks are locally noteably fossiliferous and reach thicknesses of more than 100m.

Rocks of late Middle Jurassic and Upper Jurassic age, part of the Bowser Lake Group (Tipper and Richards, 1976), comprise a marine and continental sequence of shales, siltstones, sandstones, and conglomerates and a volcanic assemblage of andesitic breccias, tuffs, and minor flows. This unit comprises most of the Jurassic sedimentary rocks of the Bowser basin (Fig.3), as well as rocks of similar age within the map area, and rests with angular unconformity on older rocks within the map area.

Skeena Group: The Skeena Group is Lower Cretaceous (Albian) in age and unconformably overlies Upper Jurassic rocks (Carter, 1981). The Skeena Group has been divided by MacIntyre (1976) into a lower sedimentary unit (Red Rose Formation) and an upper volcanic unit (Brian Boru Formation). Marine arkosic sandstones and fossiliferous shales are overlain conformably by a volcanic unit consisting of acidic pyroclastic rocks, amygdaloidal basaltic flows, and andesitic flows, tuffs, and breccias.

Kasalka Group: MacIntyre (1976) has defined the Kasalka Group as an assemblage of volcanic rocks which overlies unconformably the marine sediments of the Skeena Group. The type locality of the Kasalka Group is between the Tahtsa and Troitsa Lakes, located approximately 70km southwest of the map area. MacIntyre (1976) has identified four major subdivisions within the Kasalka Group, each with conformable contacts: a basal conglomerate; the Mt. Baptiste Formation consisting of subaerial layered pyroclastic rocks (rhyolitic to dacitic in composition) with minor interbedded flows and breccias; the Swing Peak Formation consisting of volcanic flow members and a laharic member; and the Bergette Formation consisting of rhyodacitic to rhyolitic flows and fine-grained siliceous tuffs. The top of the Bergette Formation has not been observed and thus the contact relationship between the Kasalka Group and younger rocks is uncertain (Wodsworth, 1979).

Sustut Group: The Sustut Group is a continental clastic sequence consisting of conglomerate, sandstone, shale, and bands of tuff. The age is believed to be Late Cretaceous (Cenomanian) to Tertiary (Eocene). Strata were deposited during the final stages of deformation in the north-central Canadian

LEGEND

SEDIMENTARY AND VOLCANIC ROCKS

ERA	PERIOD	EPOCH	FORMATION	LITHOLOGY
CENOZOIC	TERTIARY	EOCENE AND MIOCENE	ENDAKO GROUP, GOOSLY LAKE AND BUCK CREEK VOLCANIC ROCKS	BASALT AND ANDESITE FLOWS AND BRECCIAS; SOME RHYOLITE AND DACITE
			UNCONFORMITY	
MESOZOIC AND CENOZOIC	CRETACEOUS AND TERTIARY	UPPER CRETACEOUS	OOTSA LAKE GROUP, TIP TOP HILL VOLCANIC ROCKS	BASALT, ANDESITE, DACITE, AND RELATED TUFFS AND BRECCIAS; SOME RHYOLITE FLOWS AND BRECCIAS
			SUSTUT GROUP (IN PART)	SANDSTONE, CONGLOMERATE, AND SHALE
			UNCONFORMITY	
MESOZOIC	CRETACEOUS	LOWER CRETACEOUS	SKEENA GROUP, BRIAN BORU AND RED ROSE FORMATIONS	SILTSTONE, SANDSTONE, SHALE; PORPHYRITIC ANDESITE FLOWS; BRECCIAS AND TUFFS
			UNCONFORMITY	
	JURASSIC AND CRETACEOUS	MIDDLE JURASSIC UPPER CRETACEOUS	HAZELTON GROUP (IN PART)	SILTSTONE, GREYWACKE, SANDSTONE, CONGLOMERATE, ARGILLITE
			KASALKA GROUP (IN PART)	PEBBLE CONGLOMERATE, RHYOLITE AND ANDESITIC PHYROCLASTIC AND FLOW ROCKS
			LOCAL UNCONFORMITY	
	JURASSIC	MIDDLE JURASSIC	HAZELTON GROUP	ANDESITE, BASALT, DACITE TUFFS AND BRECCIAS; VOLCANIC SANDSTONE AND CONGLOMERATE; SILTSTONE AND GREYWACKE
			UNCONFORMITY	
		LOWER JURASSIC	HAZELTON GROUP	GREEN, RED, AND PURPLE ANDESITE AND BASALT TUFFS AND BRECCIAS; VOLCANIC SANDSTONE AND CONGLOMERATE; ARGILLITE AND GREYWACKE

INTRUSIVE ROCKS

ERA	PERIOD	EPOCH	FORMATION	LITHOLOGY
CENOZOIC	TERTIARY	EOCENE	GOOSLY LAKE INTRUSIONS NANIKA INTRUSIONS	GABBRO, SYENOMONZONITE QUARTZ MONZONITE PORPHYRY, FELDSPAR PORPHYRY, AND FELSITE
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	BULKLEY INTRUSIONS	PORPHYRITIC QUARTZ MONZONITE AND GRANODIORITE
	JURASSIC	UPPER JURASSIC	FRANCOIS LAKE INTRUSIONS	PORPHYRITIC QUARTZ MONZONITE, GRANODIORITE, AND QUARTZ DIORITE

FIG. 2. (*Continued*).

Cordillera.

Tip Top Hill volcanic rocks: Volcanic rocks of the middle Upper Cretaceous age occur near the center of the area shown in Figure 2. Church (1973) divides them into a lower acidic unit and an upper mafic unit. The lower unit is overlain by Tip Top Hill volcanic rocks which have an average age of 75.8 plus or minus 2.7m.y. (Church, 1973) and are described by Church (1970) as andesitic to dacitic breccias and flows.

Ootsa Lake Group: The Ootsa Lake Group ranges in age from late Upper Cretaceous to Oligocene (Duffell, 1959). Rocks are predominantly acidic flows and pyroclastic rocks with lesser amounts of andesitic and basaltic volcanic rocks. Rocks of the Ootsa Lake Group lie with angular unconformity on older Mesozoic rocks.

Endako Group: Rocks of the Endako Group unconformably overlie the Ootsa Lake Group and range from Oligocene to early Miocene in age (Duffell, 1959). The Endako Group is subdivided into a lower unit consisting of reddish brown vesicular breccias and flows of andesitic to basaltic composition (Goosly Lake volcanic rocks), and an upper unit consisting of vitreous, thick-bedded basalt flows and breccias (Buck Creek volcanic rocks).

Intrusive rocks

Francois Lake intrusions: Carter (1981) grouped the intrusive rocks of the area with an average K-Ar age of 138m.y. plus-or-minus 3m.y. into the Francois Lake intrusions which consist of granite, granodiorite, diorite and minor syenite. They form a belt which extends southeasterly from the northern part of the map area and are host to numerous molybdenum prospects, including the Endako Molybdenum mine.

Bulkley intrusions: Carter (1981) reports K-Ar isotope ages of 70 to 84 m.y. for the Bulkley intrusions (i.e., Upper Cretaceous). They occur as stocks and small batholiths of porphyritic granodiorite and quartz monzonite and are host to several copper and molybdenum and molybdenum-tungsten deposits, including Huckleberry and Glacier Gulch (Carter, 1981).

Nanika intrusions: Carter (1981) reports K-Ar isotope ages of 47 to 56 m.y. for the Nanika intrusions (i.e., middle Eocene). They occur as stocks, plugs, and dyke swarms and predominantly consist of porphyritic quartz monzonite and minor granite (Carter,1981). The Nanika intrusions are host to several copper-molybdenum porphyry deposits and prospects including The Berg and Lucky Ship (Carter, 1981). A quartz monzonite intrusion which contains weak copper-molybdenum mineralization crops out in the western portion of the Equity Silver property (Fig.4).

Goosly Lake intrusions: Church (1973) has identified coarse porphyritic dikes and stocks of Eocene age (K-Ar age of 48.3 3m.y.) at the northeastern portion of the Equity Silver property and elsewhere in the map area. The Goosly Lake intrusions vary from gabbro to syenomonzonite in composition (Church, 1970). No occurrences of economic minerals are known to be related to the Goosly Lake intrusions.

Regional Tectonic Setting

The major tectonic elements of west-central British Columbia are shown in Figure 3.

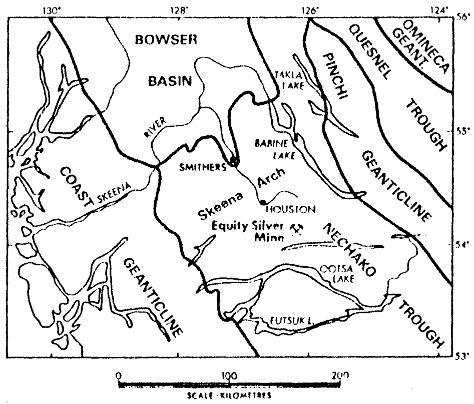

FIG. 3. Regional tectonic setting of the Equity Silver mine, north-central British Columbia (after Wheeler et al., 1972).

The Intermontane belt which includes the Nechako trough is underlain principally by Mesozoic volcanic and sedimentary rocks. Skeena arch, a prominent northeasterly trending transverse structure of early Mesozoic time, marks the approximate boundary between the Bowser Successor basin to the north and a broad area to the southeast covered by a veneer of early to late Tertiary volcanic rocks (Carter, 1981). Skeena arch provided one of the controls for emplacement of the Upper Triassic and Lower Jurassic granitic pluton (Carter, 1981). Granitic intrusions of Late Cretaceous and Early Tertiary age intrude Mesozoic volcanic and sedimentary rocks throughout the Intermontane belt and show no apparent relationship to the Skeena arch as now defined.

Local Geology

Equity Silver mine occurs in an inlier of sedimentary, pyroclastic, and volcanic rocks termed the Goosly sequence (Fig. 4), believed to be correlative with the Kasalka Group as defined by MacIntyre (1976). Strata within this inlier strike 010°, dip 45° to 80° west, and form a simple homocline with tops facing west. This is suggested by fining upward and graded bedding as seen in the clastic division. The true thickness of the Goosly sequence is estimated to be a minimum of 2,400m and a maximum of 4300m depending on the true thickness of the clastic division, the base of which is unknown.

The Goosly sequence is highly altered, but the bulk compositions from a suite of 15 analyzed specimens span a narrow range from dacitic to rhyodacitic (Church, 1970). A brief description of the detailed local geology as portrayed in Figures 4 and 5 is presented below.

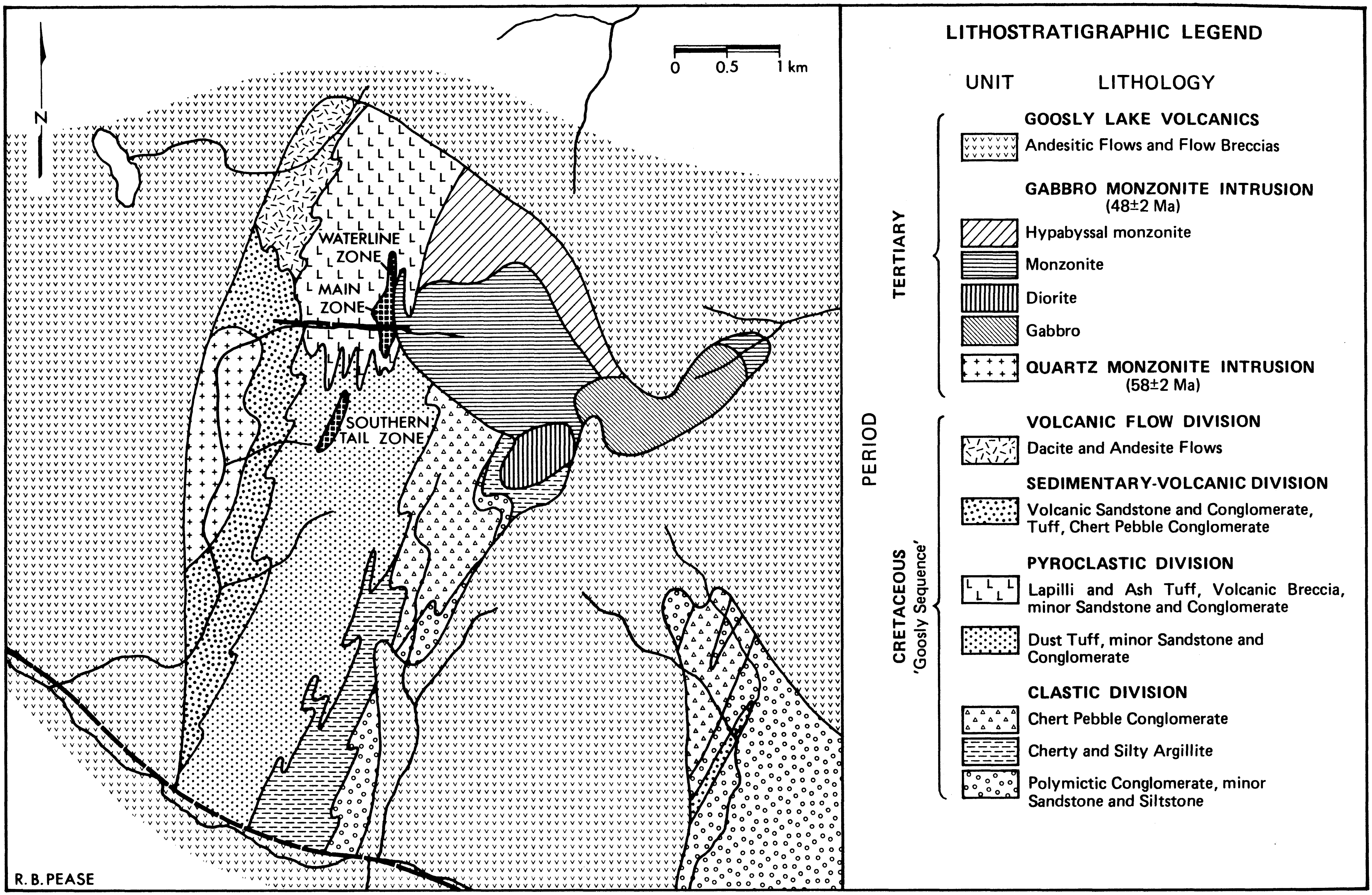

Figure 4 : Geologic Setting of the Equity Silver Mine

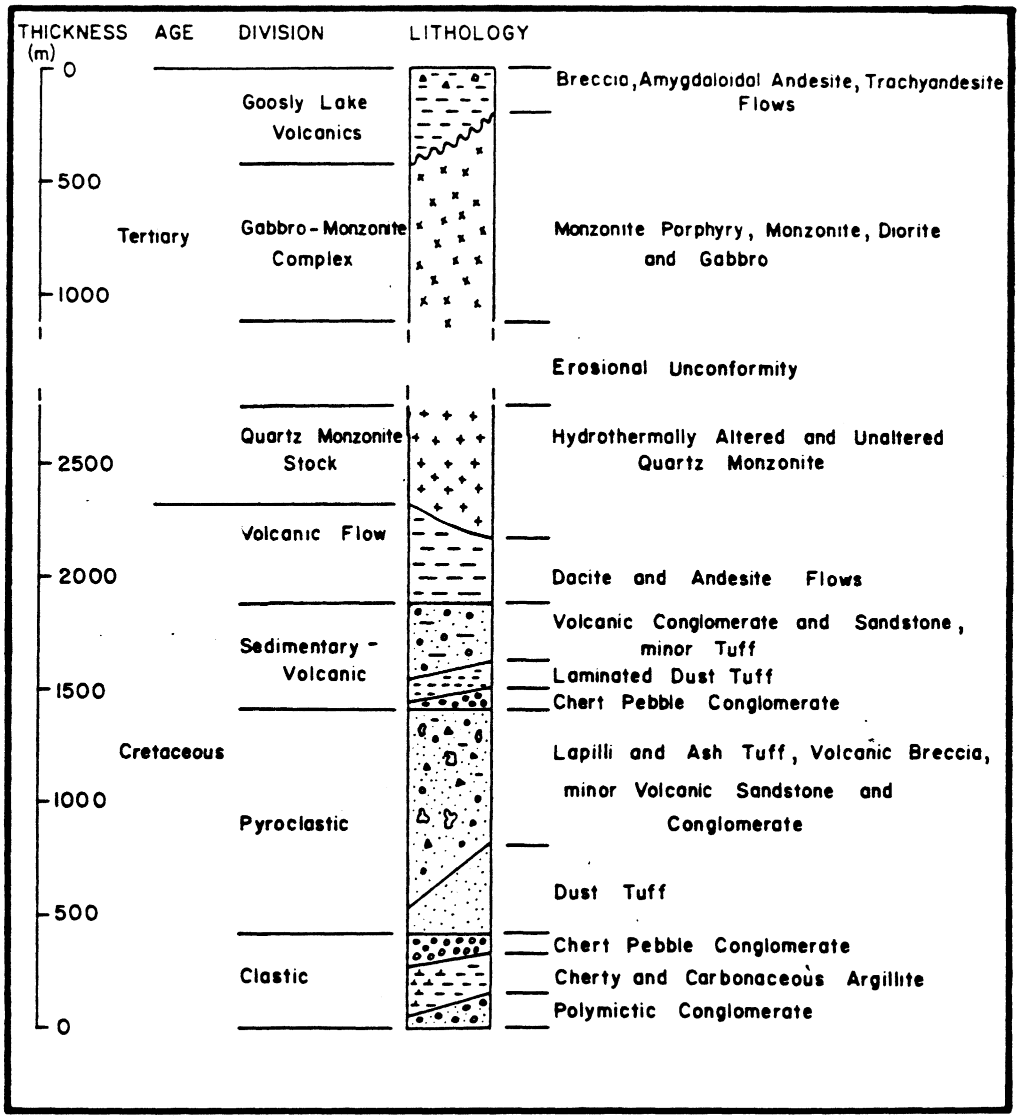

FIG. 5. Stratigraphic column, Equity Silver mine.

Clastic division (unit 1)

This division, with a possible maximum thickness of 2,400m (Ney et al.,1972), is the oldest exposed unit of the Goosly sequence. The unit is composed of polymictic conglomerate, with minor interbedded lithic sandstone and siltstone, and is overlain by cherty and silty argillite. A facies change from a hard, fine-grained black siliceous rock to a fissile, thinly laminated carbonaceous argillite occurs in a southerly direction. Uppermost in this unit is a chert pebble conglomerate containing clasts up to 25mm in diameter cemented in a white siliceous matrix. The conglomerates are texturally mature and are most likely indicative of a shoreline facies. Elsewhere in central British Columbia, mature conglomerates are known to have been deposited in Albian (late Lower Cretaceous) time (H.W.Tipper, pers.comm.).

Pyroclastic division (unit 2)

This division, consisting dominantly of intercalated subaerial tuffs, breccias, and reworked pyroclastic debris with wide ranges in grain size, conformably overlies the clastic division and has a maximum thickness of 975m. Coarse-grained lapilli and ash tuffs, volcanic breccia and minor intercalated very fine-grained tuff (locally called dust tuff), and volcanic conglomerate predominate in the northern and central portions of the property, whereas massive or poorly bedded, very fine-grained tuff with minor intercalated ash and lapilli tuffs and chert pebble conglomerate predominate in southern portions of the property. The transition is considered to represent a facies change between proximal and distal tuffs with a vent source to the north. A pronounced selvage or onion-skin texture around some fragments suggests that they were still hot and wet at the time of deposition. Volcanic conglomerate and volcanic sandstone consist of reworked pyroclastic debris and occur as irregular distributed lenses interbedded within the pyroclastic unit. Volcanic conglomerate with rare graded beds is characterized by quartz and minor volcanic clasts in a white siliceous matrix and resembles a poorly sorted equivalent to the chert pebble conglomerate of the clastic division. The uppermost part of the pyroclastic division contains distinctive minor welded tuff units in a general sequence of coarse pyroclastics and graded-bedded volcanic conglomerate.

Sedimentary-volcanic division (unit 3)

This division consists of interbedded waterlain volcanic conglomerate, sandstone, and tuff with an estimated thickness of 330m. Volcanic conglomerates and sandstones are well bedded and composed almost entirely of locally derived tuffaceous material. The chert pebble conglomerate is white, forms a distinctive bed at the base of this division, appears to thicken to the south, and is distinctly different in character from the chert pebble conglomerate in the clastic division in that it consists predominantly of rounded tuffaceous fragments supported in a sandy matrix. Carbonaceous filaments resembling plant roots or reeds occur rarely in volcanic sandstone (Schroeter,1979).

Volcanic flow division (unit 4)

This division, which conformably overlies and is in part interbedded with unit 2 and unit 3, represents the uppermost exposed unit of the Goosly sequence and has a known thickness of at least 550m. The volcanic flow division is composed of bedded, dark greenish-gray andesitic, and yellowish-gray fine-grained dacitic flows. Locally this unit has been pervasively tourmalinized, possibly as a result of hydrothermal activity or late-stage volcanism. Potassium-argon dating of a quartz-sericite-tourmaline alteration assemblage within this unit yielded an age of 58.5m.y. plus-or-minus 2.0 m.y. (Wetherell, 1979).

Quartz monzonite stock (unit 5)

A porphyritic quartz monzonite stock intrudes the Goosly sequence on the west side of the property and is overlain unconformably by upper Tertiary Goosly Lake volcanic rocks. The stock is poorly exposed and has been intersected by one diamond drillhole. It is locally kaolinized, sericitized, and chloritized, with alteration being most intense near its eastern contact with the Goosly sequence nearest the ore zones. Disseminated pyrite is ubiquitous, and minor quartz-pyrite-chalcopyrite-molybdenite veinlets have been observed near the eastern contact. A potassium-argon age of 60.0m.y. plus-or-minus 3.2m.y. has been obtained. This agrees with Wetherell's (1979) recalculated age of 57.2m.y. plus-or-minus 2.3m.y. All previously reported K-Ar ages and new ages determined for rocks in the inlier are documented in Table 2. Carter (1981) has suggested that the stock belongs to the Nanika Group intrusions, based primarily on its K-Ar age and its spatial and compositional relationships to known Nanika Group intrusions

Gabbro-monzonite complex (unit 6)

The multiphase gabbro-monzonite complex intrudes the Goosly sequence in the eastern and northeastern portions of the property. Ney et al. (1972) recognized six intrusive phases, although only four appear distinct in the field (Fig. 4). One of these other phases is now recognized as a cross-cutting quartz latite dyke and the other is transitional between monzonite and gabbro. Gabbro and monzonite phases, characterized by bladed phagioclase phenocrysts up to 25mm long and containing scattered apatite grains about 2 percent by volume, are generally coarse-grained; dioritic phases are finer grained. The hypabyssal monzonite is a dark gray, equigranular rock containing subhedral laths of plagioclase up to 5mm long. Contact relationships of phases are sharp, but a decrease in grain size toward a contact plus a tendency to an allotriomorphic-granular texture has also been noted. Tertiary trachyandesite flows are chemically and mineralogically similar to the plutonic rocks (Church, 1970). The complex is therefore believed to be a feeder system to the overlying flows and thus a remnant of a Tertiary volcanic neck. Potassium-argon dates of Tertiary flows (K-Ar=48.0m.y. plus-or-minus 1.8m.y.;Church, 1973) and of the gabbro-monzonite complex (K-Ar=49.7m.y. plus-or-minus 1.9m.y.,to 52.5m.y.) support this conclusion.

TABLE 1. Comparative Mineralogy of the Ore Deposits and Other Mineralized Areas at Equity Silver Mine (modified after Wetherell, 1979)

Mineral[1]	Relative abundance				
	Main zone	Southern tail	Waterline zone	Cu-Mo Porphyry zone	Tourmaline zone
Pyrite	XXXXX	XXXXX	XXXXX	XXXX	XXXXX
Rutile	X	X	X	X	
Ilmenite	X	X			
Magnetite	XXXX	XXX	XXX	X	XX
Pyrrhotite	XXXX		XX		
Molybdenite		X	X	XXX	X
Specular hematite	XXXX	XX	XXX		X
Arsenopyrite	XX	XXXXX	X		
Sphalerite	XXX	XXX	XXX		XX
Chalcopyrite	XXXXX	XXXX	XXXX	XX	XX
Tetrahedrite	XXXX	XXXXX	XX	X	X
Gold	XX	X	XX		
Galena	XX	XX	XX		XX
Sulfosalts	XX	XX	X		
Marcasite	XXX		X		
Chalcocite	X	X		X	
Covellite	X	X			
Scheelite			X		
Wolframite		X			
Stibnite	X				
Corundum	XX				
Andalusite	XX	XX	XX		
Tourmaline	XXXX	X	XX	X	XXXXX
Dumortierite	XX				X
Scorzalite	XXX	X	XX		
Spinel	XX				
Chlorite	XXXX	XXXX	XXX	XX	XX

[1] Listed in approximate order or paragenesis; XXXXX = very abundant, XXXX = abundant, XXX = moderate, XX = minor, X = trace

Dykes and sills

Three main types of post mineral Tertiary dykes and sills have been noted: quartz latite, aphanitic andesite, and trachyandesite. Cream-colored, porphyritic quartz latite dykes containing abundant sericite are conspicuous in the Southern Tail pit (e.g.,east dyke,49.9m.y.plus-or-minus 2.0m.y.; and west dyke, 48.3m.y. plus-or-minus 2.0m.y.). Locally, sulfides have been remobilized and reconcentrated adjacent to dyke contacts. Trace amounts of galena and sphalerite occur as rare fracture fillings and fine disseminations in quartz latite dykes, usually within a few centimeters of the contacts. Late-stage quartz latite dykes intrude the gabbro-monzonite complex and appear to be texturally and mineralogically similar to quartz latite dykes observed in the Southern Tail and Main zone orebodies. Greenish-gray, dark gray, and black trachyandesite dykes and andesite dykes (50.7m.y. plus-or-minus 1.8m.y.) cut the Goosly sequence and also quartz latite dykes. Trachyandesite dykes contain up to 15 percent bladed plagioclase phenocrysts and resemble plutonic rocks of the gabbro-monzonite complex in field observations. Some aphanitic andesite dykes contain up to 3 percent vesicles with calcite and/or quartz fillings. Chlorite, calcite, and sericite are common alteration products of these basic dykes. Quartz latite dykes cut andesite dykes and vice versa.

Tertiary-age volcanic rocks (unit 7)

Flat-lying Goosly Lake volcanic rocks (Church, 1970) lie with angular unconformity on Mesozoic rocks and consist of trachyandesite and andesite flows and flow breccias. Church (1970) estimates a thickness of at least 460m. Trachyandesite flows, characterized by bladed plagioclase phenocrysts at the base, are overlain by reddish-purple amygdaloidal andesitic flows and have been moderately saussuritized with calcite as a common product. Church (1973) states that the Goosly Lake volcanic rocks are Eocene, based on a K-Ar age of 48.0m.y. plus-or-minus 1.8m.y.

Flat-lying Buck Creek basalts of Eocene age (47.3m.y. plus-or-minus 1.6m.y.; Church, 1973) unconformably overlie Goosly Lake flows; they have an estimated thickness of 300m (Church, 1970) and form local caps to hilltops throughout the region.

Mineral Deposits

Introduction

Sulfide concentrations occur in two distinct zones designated the Southern Tail zone and the Main zone. A narrow zone of sulfides occurs as an extension of the Main zone and has been designated the Waterline zone (Fig.4). Also, the Tourmaline zone is a poorly understood zone of intense, irregularly distributed brecciation and tourmalinization located in the general area of the tailing pond and plant site (Fig.6). Quartz-sulfide veinlets occur as a poorly exposed stockwork within the quartz monzonite east of the silver-bearing ore zones. Table 1 depicts the comparative mineralogy of mineralized areas at the Equity Silver mine.

TABLE 2. K-Ar Ages from the Equity Silver Mine Area

Sample no.	Location	Rock type*	Mineral or concentrate	K (wt %)	Radiogenic ^{40}Sr ($\times 10^{-10}$ mole/g)	$\frac{100 \text{ rad } ^{40}\text{Ar}}{\text{Total } ^{40}\text{Ar}}$	Age (m.y.)
SG 28-254[2]	Main zone	Sericitized tuff	wr	3.75	3.183	91.4	48.3 ± 1.7
SC 1683	Southern Tail zone (west dike)	Quartz latite	wr	3.77 ± 0.01	3.202	92.7	48.3 ± 2.0
SC 1687	Gabbro-monzonite complex	Gabbro	plag	2.45 ± 0.01	2.097	79.9	48.7 ± 1.8
SC 1687[1]	Gabbro-monzonite complex		bi				48.8 ± 1.9
SC 1687[3]	Gabbro-monzonite complex		bi				49.7 ± 1.9[7]
SC 1689	Southern Tail zone (east dike)	Quartz latite	wr	2.25 ± 0.01	1.977	86.8	49.9 ± 2.0
SC 1686	Southern Tail zone (andesite dike)	Andesite	wr	1.26[6] 1.26[6]	1.124	82.8	50.7 ± 1.8
SC 1693	Southern Tail zone (east dike subzone)	Sericitized tuff	wr	4.33 ± 0.01	3.941	97.1	51.7 ± 1.9
SC 1693[4]	Gabbro-monzonite complex		bi				52.5
NC-69-6[1]	Quartz monzonite	Quartz monzonite	bi				56.2 ± 2.3
NC-69-6[3]	Quartz monzonite stock	Quartz monzonite	bi				57.2 ± 2.3**
SC 61-63[2]	Southern Tail zone	Sericitized tuff	wr	4.88[6] 4.71[6]	4.905	93.4	58.1 ± 2.0
SC 1681	Southern Tail zone	Sericitized tuff	wr	4.21[6] 4.15[6]	4.287	95.3	58.2 ± 2.0
SG 54-820[2]	Tourmaline Breccia zone	Sericitized dacite	wr	3.70[6] 3.62[6]	3.776	86.8	58.5 ± 2.0
SC 1692	Southern Tail zone	Sericitized tuff	wr	3.89 ± 0.07	4.029	96.2	58.7 ± 2.0
SC 1691	Quartz monzonite stock	Quartz monzonite	bi	3.95 ± 0.15	4.180	91.5	60.0 ± 3.2
SC 1691[4]	Quartz monzonite stock	Quartz monzonite	bi				61.1

Constants employed: $\lambda_\beta = 4.962 \times 10^{-10}$ yr^{-1}; $\lambda_e + \lambda_e' = 0.58 \times 10^{-10}$ yr^{-1}; ^{40}K/K = 1.167×10^{-4} mole/mole
Abbreviations: bi = biotite, wr = whole rock, plag = plagioclase, rad = radiogenic
[1] Data from Carter, 1981; [2] data from Wetherell, 1979; [3] data from Church, 1973; [4] data from Ney et al., 1972
[5] Sericitized tuff = very fine grained (dust) tuff
[6] Two analyses on this sample
[7] Recalculated model ages using presently accepted decay constants $Q_e + \lambda_e' = 0.581 \times 10^{-10}$ yr^{-1}; $\lambda_\beta = 4.962 \times 10^{-10}$ yr^{-1}; ^{40}K/K = 1.167×10^{-4} mole/mole
Previously reported ages are gabbro-monzonite, 48.3 ± 3.0 m.y., and quartz monzonite, 56.2 ± 3.0 m.y.

Southern Tail: The Southern Tail ore zone is 900m long, up to 70m wide and is open to depth in the central and southern portions (Fig.7). Relatively coarse-grained sulfides occur in shear, breccia, and crackle zones which randomly grade into lenses or pods of massive sulfides up to 50m long and 20mwide. The overall ore zone, which strikes northerly and dips 40° to 60° west, can be divided into three separate subzones based on mode of occurrence and style of sulfide concentration (Fig.7). The northernmost subzone has been termed the East Dyke ore zone because of its intimate spatial association with the east dyke of quartz latite composition (49.9m.y. plus-or-minus 2.0m.y.). This subzone is 150m long, up to 30m wide, and has an average down-dip extent of 90m. It occurs on the hanging wall and footwall of the 5- to 12-m-wide east dyke, dips 40°to 45° west, and is composed of pyrite, arsenopyrite, tetrahedrite, chalcopyrite, sphalerite, and minor galena in a stockwork of crackled to intensely brecciated, very fine-grained to aphanitic tuff. High concentrations of sulfides and intense brecciation are generally proximal to the east dyke, and for this reason it is thought the east dyke subzone represents remobilization and reconcentration of sulfides resulting from intrusion of the east dyke. Sulfide concentration is also reflected in high copper and silver grades. Chalcopyrite content increases relative to tetrahedrite in the down-dip direction. The east dyke subzone is characterized by abundant arsenopyrite, sphalerite and galena with respect to other ore zones on the property. An age of 51.7m.y. plus
or-minus 1.9m.y. (Table 2) was obtained for a sample of sericitized, very fine-grained to aphanitic tuff from the east dyke subzone and is interpreted to represent a reset age as a result of intrusion of the east dyke.

The Middle ore zone is in the central portion of the Southern Tail zone and is offset from the east dyke subzone 30m right laterally in an en echelon manner. It is 280m long, up to 70m wide and is open to depth along a dip ranging from 45° to 50° west. Additional information obtained from diamond drilling indicates that at depth it is lensoid in nature and plunges 34 degrees to the north. Sulfide minerals are tetrahedrite, pyrite, chalcopyrite, arsenopyrite and sphalerite in a crackled to intensely brecciated, aphanitic tuff (Fig.8C). Breccia matrix and fragments consist of quartz and sulfides in varying proportions. Irregular, random lenses and pods of massive sulfides are common; this has resulted in the best silver and copper grades coming from this zone. Small random pods of massive chalcopyrite have been documented in this zone which represents the heart of the Southern Tail orebody. Two intensely sericitized aphanitic tuffs from this zone have yielded K-Ar ages of 58.2m.y. plus-or-minus 2.0m.y. and 58.7m.y. plus-or-minus 2.0m.y. These agree with Wetherell's (1979) age of 58.1m.y. plus-or-minus 2.0m.y.

The South subzone is offset from the Middle subzone 50m right laterally in an en echelon manner. It is 80m long, up to 30m wide and is open to depth with a dip ranging from 50° to 55° west. It is composed of pyrite and tetrahedrite with minor chalcopyrite, arsenopyrite and sphalerite in a crackled to moderately brecciated fine-grained to aphanitic tuff (Fig.8C). The breccia matrix consists of quartz and sulfides in varying proportions. Chalcopyrite becomes dominant over tetrahedrite in a southerly direction along strike and in a down-dip direction. This subzone is defined only by assay limitations; sulfide concentrations continue along strike to the south, beyond open pit boundaries. Erratic silver and copper grades and abundant pyrite

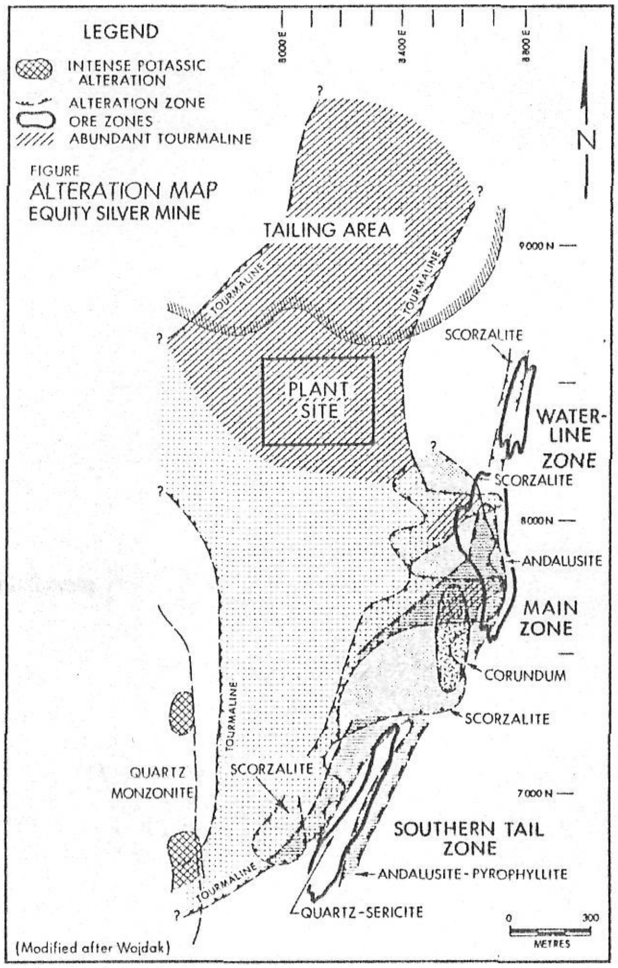

FIG. 6. Alteration map, Equity Silver mine.

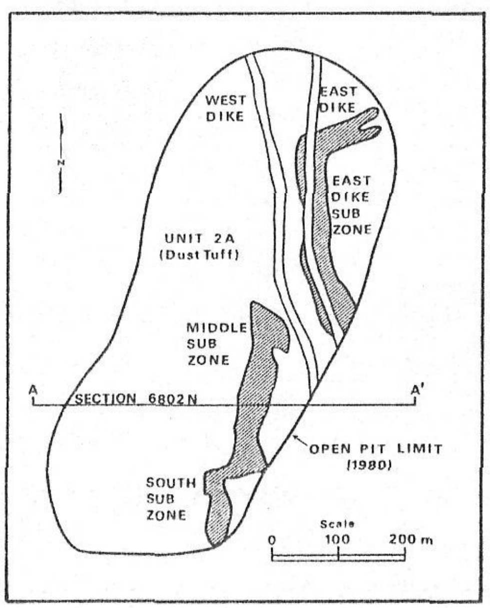

FIG. 7. Southern Tail pit and ore zones; plan view, 1300 bench.

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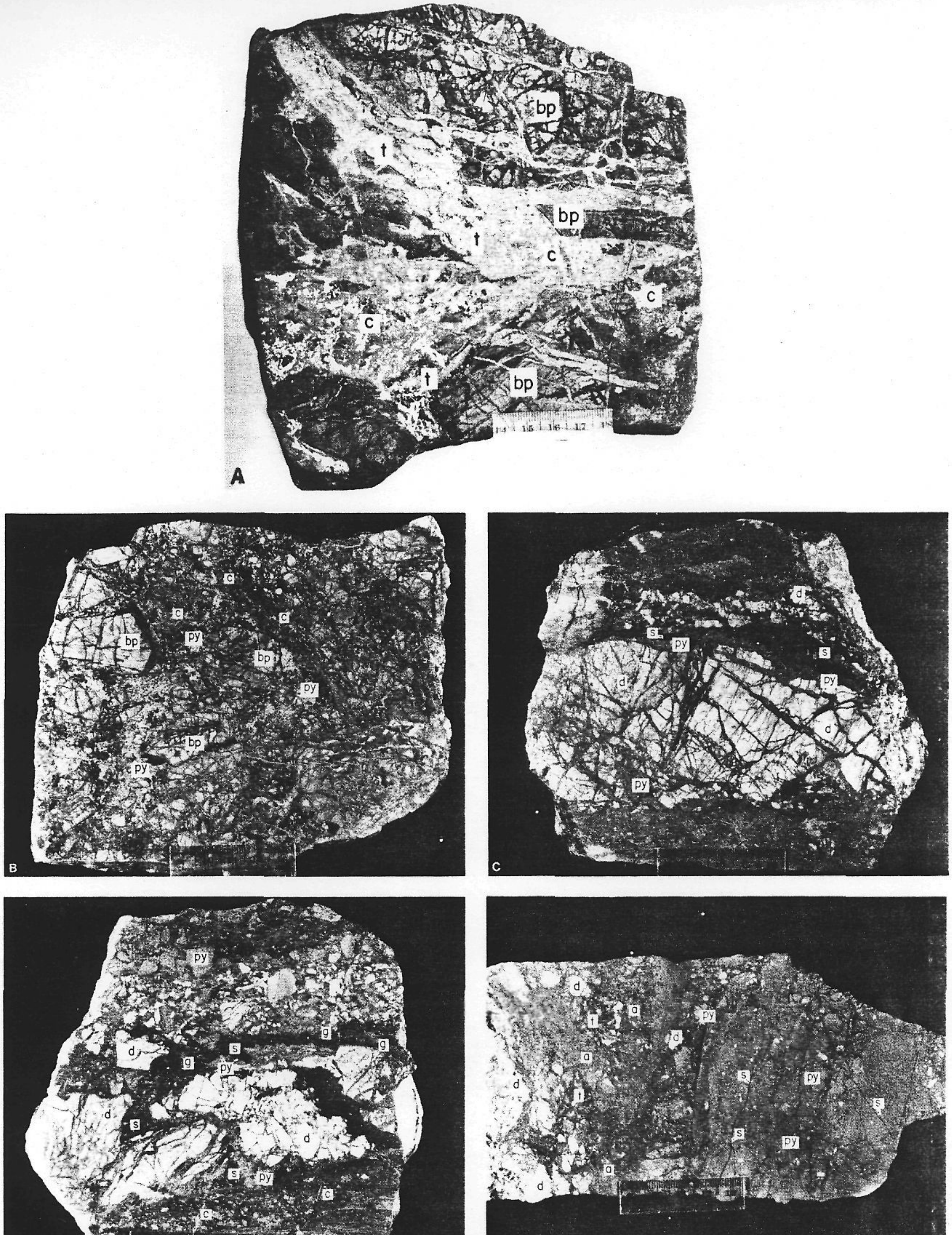

FIG. 8. Sulfide textures in ore zones. Abbreviations: a = arsenopyrite, bp = bleached pyroclastic tuff, c = chalcopyrite, cb = carbonate, d = very fine grained tuff fragments (dust tuff), g = galena, py = pyrite, s = sphalerite, t = tetrahedrite. Scale is in millimeters. A. Typical tuff breccia ore, Main zone; polished slab. B. Breccia ore, Main zone. C. Stockwork in very fine grained tuff (dust tuff), Southern Tail zone—moderately to intensely fractured specimen. D. Late-stage sphalerite-galena-pyrite breccia, Southern Tail zone. Note rimming by sphalerite and galena. E. Massive banded sulfide breccia, Southern Tail zone. Note coarse-grained recrystallized texture.

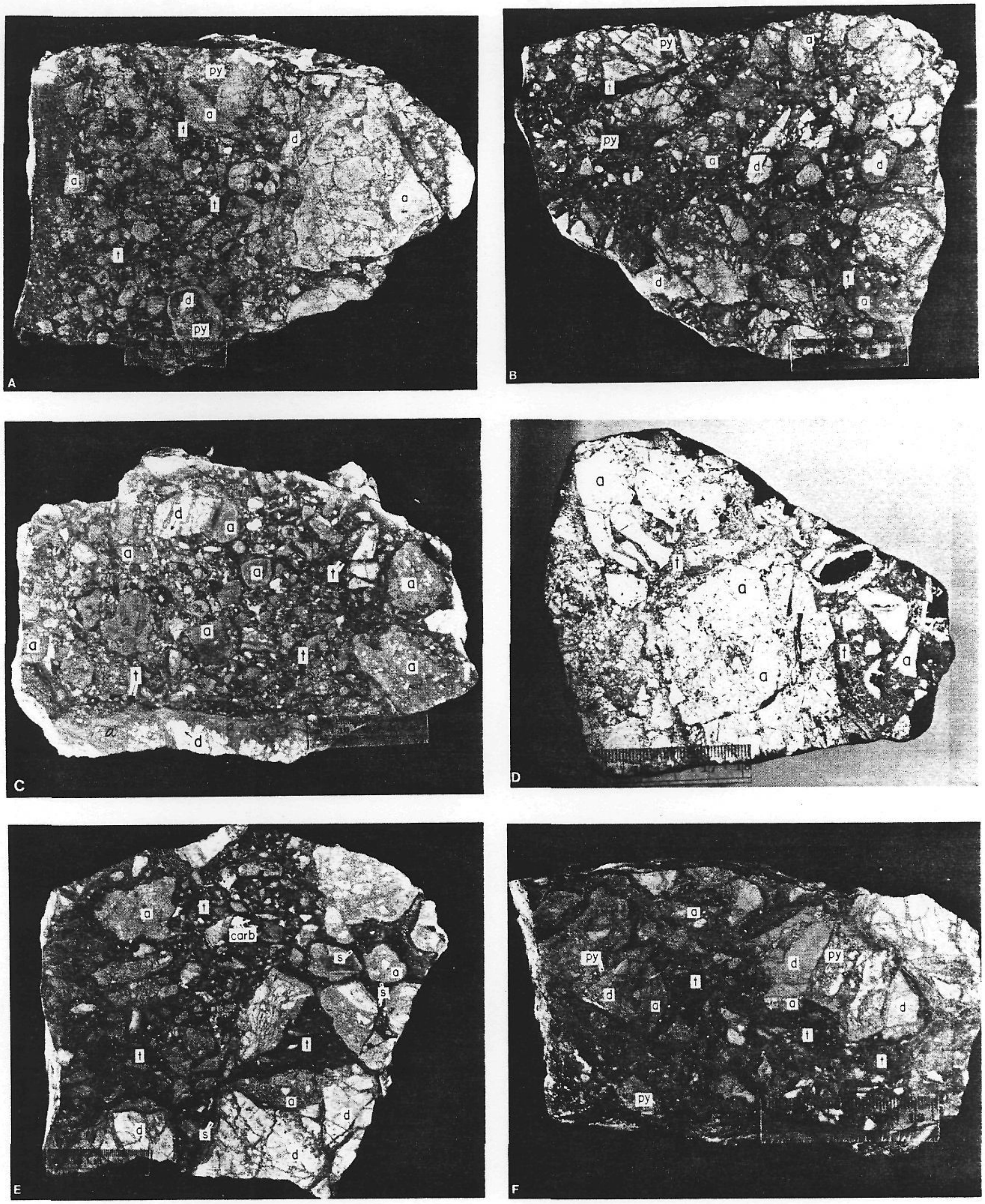

FIG. 10. Sulfide textures in ore zones; arsenopyrite = a, chalcopyrite = c, carbonate = cb, very fine grained tuff fragments (dust tuff) = d, galena = g, pyrite = py, sphalerite = s, tetrahedrite = t. Note: scale in millimeters. A. Arsenopyrite-rich replacement breccia, Southern Tail zone. Note rounding of fragments and inward growth of ore replacement by arsenopyrite. B. Arsenopyrite-rich replacement breccia, Southern Tail zone. Note rounding of fragments and replacement by arsenopyrite. C. Ar-

characterize this subzone, reflecting its structural and mineralogical discontinuity.

The Southern Tail zone is typified by an inner pervasive sericite-quartz-altered zone and an outer chlorite-magnetite zone with andalusite and pyrophyllite (Figs.9 and 6). Abrupt change from sericite-

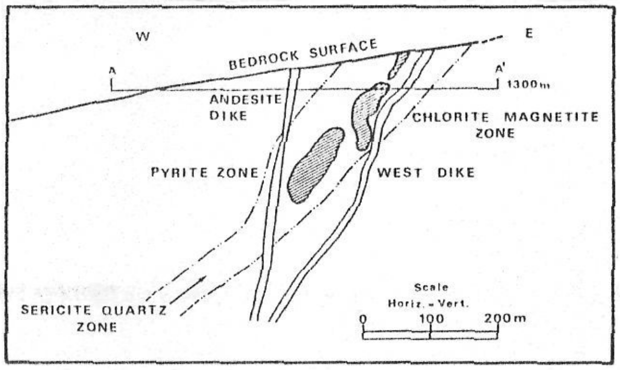

FIG. 9. Schematic presentation of the alteration of the Southern Tail ore zone, section 680N, viewing north.

quartz-altered tuffs to pervasive chloritic tuffs marks the change from the ore zone to the footwall. Chlorite development within footwall rocks has resulted in a dark green, dark gray or dark greenish-gray color and may be the result of hydrothermal alteration. Minor stringers and veinlets of chlorite-pyrite-chalcopyrite-magnetite-hematite are present in footwall rocks. Wojdak's (1974) andalusite-pyrophyllite zone generally coincides with the chlorite-magnetite zone. A pyrite subzone, defined as the zone in which pyrite is virtually the only sulfide present, even though it is an extension of the sericte-quartz-altered zone, bounds the ore on the hanging wall with a width of approximately 300m. A weakly to intensely crackled tan brown aphanitic to fine-grained tuff with fracture fillings of pyrite and/or quartz, designates this subzone, along with individual veins of coarse pyrite up to 3m wide. Sulfide and chlorite veins with sericite-quartz envelopes cut chlorite-andalusite rocks, and andalusite is totally replaced within the envelope. This texture and the common replacement ofandalusite grains by pervasive sericite (Wetherell, 1979) indicate that sericite-quartz alteration and associated sulfide mineralization post dates chlorite-andalusite alteration. This conclusion has also been stated by Wojdak (1974) and Wetherell (1979). Kaolinite occurs in the mineralized envelope as a late-stage alteration product. The pyrite subzone passes gradually upward into chloritic tuffs of the sedimentary-volcanic division (unit 3).

Sulfides have been introduced into breccia zones of host volcanic rocks in several paragenetically distinct but overlapping pulses which together compose one main mineralizing event (Figs.10 and 8C-E). Pyrite appears to be both authigenic (occurring as disseminations in brecciated host-rock and in fine-grained tuff fragments; Fig10A-C) and hydrothermally introduced, occurring throughout the entire period of mineralization. Pyrite and arsenopyrite were the first sulfides introduced during a period of initial brecciation of the host rocks (Fig.10). Arsenopyrite occurs as rims and, in some cases, pseudomorphically replaces host-rock fragments Fig.(10A and B) and irregular masses of interlocking pyrite grains (Fig.10). Pyrite and arsenopyrite crystallization were followed by chalcopyrite and tetrahedrite as indicated by fragments of pyrite and arsenopyrite in a tetrahedrite or tetrahedrite-chalcopyrite matrix (Fig.10). Zones of relatively massive chalcopyrite contain stringers and veinlets of tetrahedrite as well as interstitial patches of tetrahedrite. Introduction of sphalerite and galena marks the youngest phase of sulfide mineralization. Breccia fragments of pyrite, arsenopyrite, tetrahedrite and chalcopyrite are common in a matrix of sphalerite and galena. This is most obvious in the East Dyke ore zone. Virtually all sphalerite in the Southern Tail orebody contains stringers and blebs of chalcopyrite. This form of chalcopyrite occurrence has been termed chalcopyrite disease (Craig and Vaughn, 1981) and is thought to have resulted either by epitaxial growth during sphalerite formation or by replacement as copper-rich fluids reacted with the sphalerite after formation. Galena, which is associated with the youngest phase of sulfide precipitation, is essentially silver free.

Gold is present in the Southern Tail orebody and is associated intimately with arsenopyrite. Seventy-five percent of the gold occurs as native gold grains along ionic dislocations in arsenopyrite grains; the remainder forms blebs in tetrahedrite, chalcopyrite, bournonite and gangue (Wetherell, 1979). A single occurrence of gold within a pyrite grain has been documented by scanning electron microscope studies.

Bournonite (copper bearing) is the most common antimony sulfosalt observed, but boulangerite and jamesonite (both argentiferous) have also been noted. Lesser amounts of berthierite, pearceite, pyrargyrite, tetrahedrite-tennantite, and freibergite have also been identified (Mariano, 1971), as well as bismuthinite. These minerals occur rarely as patches and blebs within some tetrahedrite grains and commonly embay tetrahedrite, chalcopyrite, and sphalerite. Polished sections of massive tetrahedrite suggest that the bournonite-boulangerite content in individual grains can vary from 0 to 50 percent by volume.

Wetherell (1979) estimated that temperatures throughout much of the mineralizing event were probably between 350°C and 491° based on observed apparently stable sulfide assemblages.

Main Zone: The Main zone orebody is 700m long, up to 90m wide and open to depth in the south end only. Mineral assemblages are similar to those of the Southern Tail orebody; however, sulfide minerals occur as fine-grained disseminations, patches of grain aggregates and associated stringers and veinlets (Fig.8A and B) which apparently grade locally and randomly into patches of massive sulfide. The style of mineralization is dependent on the competency and permeability of the enclosing lapilli and ash tuffs. These rocks are less prone to fracturing and open-space filling than the very fine-grained tuffs of the Southern Tail; however, such favorable fracturing does exist (Wetherell, 1979). Pyrite, chalcopyrite and pyrrhotite are the most common sulfide minerals with accessory sphalerite, arsenopyrite, tetrahedrite and galena. Magnetite is commonly disseminated throughout the ore zone but was seen to occur as massive pods and lenses within a few meters of the gabbro contact. Locally, pervasive fine-grained apatite occurs as prismatic needles in the groundmass. Pyrrhotite appears to be confined to that part of the Main Zone within a 90m-wide zone around the contact with the gabbro-monzonite complex and is believed to be derived from the conversion of pyrite by contact metamorphic effects (Wetherell, 1979; Wojdak, 1974). Porphyroblasts of pyrite, 2mm to 10mm wide are seen in patches of massive pyrrhotite (Fig 11B).

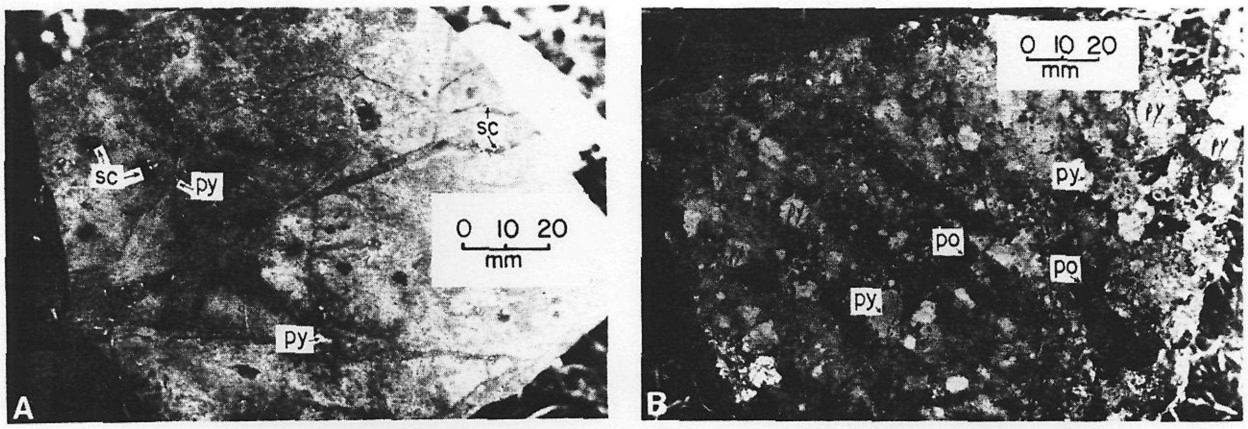

FIG. 11. Alteration and contact metamorphism textural examples. A. Alumina-rich altered tuff with blotches and veinlets of scorzalite (sc). B. Massive pyrrhotite (po)-pyrite (py) sulfide specimen exhibiting coarse recrystallized pyrite porphyroblasts in a matrix of pyrrhotite; from the contact metamorphic aureole, Main zone. Lighter colored grains are pyrite; darker colored ones are pyrrhotite.

Pervasive sericite, quartz and chlorite alteration is most common in the Main zone, resulting in nondescript grayish-green or blackish-green-colored rocks. An episode of aluminous mineral-rich alteration has resulted in the formation of coincident zones of disseminated and vein-filling andalusite, most of which has been altered to sericite, scorzalite and corundum (Wojdak, 1974; Fig. 6). Scorzalite occurs as patches, aggregates and veins with pyrite, tourmaline and corundum in the hanging wall in a broad zone 900m long and 360m wide (Wojdak, 1974). A distinct zone of corundum alteration with associated spinel and sulfides, lying stratigraphically above the ore zone has also been noted by Wojdak (1974). Rare dumortierite also occurs stratigraphically above the ore zone in the upper part of the pyroclastic division. Contact metamorphic effects associated with intrusion of gabbro-monzonite complex have converted andalusite to sillimanite within 90m of the contact (Wetherell, 1979). A recalculated K-Ar age of 49.7m.y. plus-or-minus 1.9 m.y. (Wetherell, 1979) has been obtained for the gabbro-monzonite complex. Wetherell (1979) also obtained a date of 48.3m.y. plus-or-minus 1.7 m.y. for a sample of sericitized, very fine-grained tuff from the Main zone. This date is interpreted as an older date reset by contact metamorphic effects of the gabbro-monzonite complex. The gabbro-monzonite complex bounds the ore zone on the footwall.

Silica alteration, variable in intensity and occuring in irregular patches, has produced medium to dark gray hard, extremely competent rocks (Fig. 8A and B). The combination of silicification and aluminization has resulted in the extremely rare juxtaposition of quartz and corundum which occur together in small veinlets.

Gold is present in the Main zone and is seen to occur as less than 10-micron-wide patches in chalcopyrite and as individual grains in gangue in contact with chalcopyrite and tetrahedrite. These grains were seen to be up to 100 microns in size. Bournonite, boulangerite and jamesonite occur as patches and blebs in tetrahedrite, galena, sphalerite, pyrite and gangue. Mariano (1971) reports boulangerite needles cross-cutting calcite grains, probably representing a late-stage crystallization feature. Tungsten in the form of wolframite was identified in Main zone polished sections as subrounded and subhedral grains up to several hundred microns long in gangue.

These grains are sometimes invaded by tetrahedrite and chalcopyrite and also occur in pyrrhotite.

Waterline Zone: The Waterline zone was discovered in the spring of 1979 during mill construction and is so named due to its proximity to the water tanks and mill waterlines (Fig. 6). Subsequent diamond drilling has outined a sulfide-bearing zone 450m long and up to 12m wide striking 010° and dipping 85° west through vertical to 80° east. The zone is interpreted as the northerly extension of the Main zone. Chalcopyrite, pyrite, sphalerite, tetrahedrite and arsenopyrite with traces of pearceite (Mariano, 1971), molybdenite and scheelite, occur as massive, brecciated and stringer sulfides within the pyroclastic division (unit 2). Gold content is slightly higher than in either the Main zone or the Southern Tail zone orebodies. Copper-silver-antimony grades are similar to the Main zone.

Tourmaline zone: A vaguely defined zone of intense, in part erratically distributed brecciation and tourmalinization approximately 1000m by 600m in surface area underlies the mill site and tailings pond areas (Fig 6). Host rocks include the upper part of the pyroclastic division (unit 2) and the volcanic flow division (unit 4). Tourmaline content ranges from less than 1 percent to over 90 percent. Tourmaline plus-or-minus pyrite occurs mainly in the matrix of breccias and as fracture fillings as well as disseminations and with pervasive alteration products, mainly quartz and sericite (Fig. 12A and B). Variable amounts of quartz, sericite and potassium feldspar are associated with the tourmaline which suggests a high-temperature depositional environment. Minor amounts of chalcopyrite, sphalerite, galena, tetrahedrite, magnetite and hematite occur in veinlets and veins up to 1.5m wide. Copper and silver grades are uneconomic. Wetherell (1979) obtained a K-Ar age of 58.5m.y. plus-or-minus 2 m.y. for a sample of sericitized dacite from the tourmaline breccia zone. This is similar to the K-Ar ages for sericitized, fine-grained tuffs from the Southern Tail zone which range from 58.1m.y. plus-or-minus 2.0 m.y. to 58.7m.y. plus-or-minus 2.0 m.y.

The origin and significance of the Tourmaline zone is not well understood and requires further investigation.

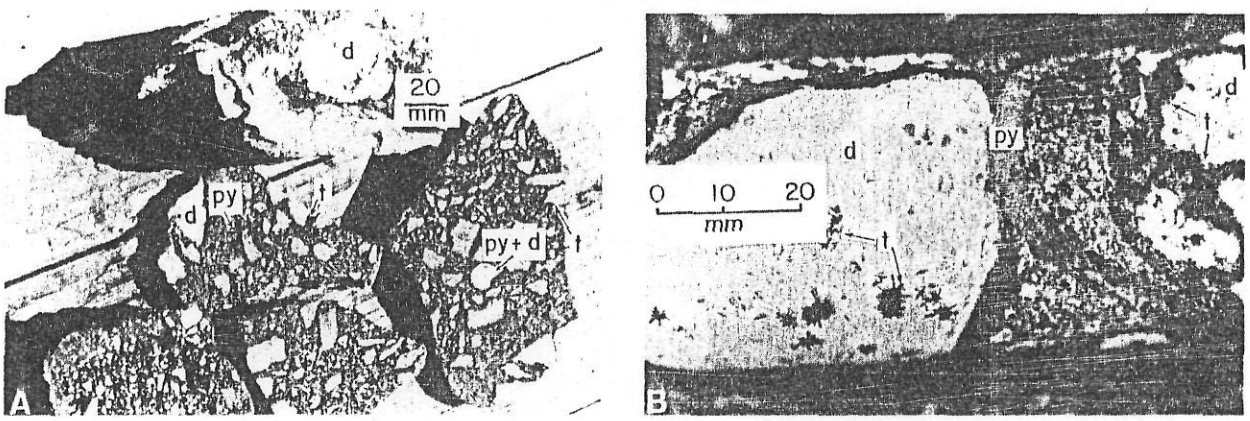

FIG. 12. Textures of tourmaline breccias, Tourmaline Breccia zone, tourmaline = t, pyrite = py, very fine grained tuff fragments (dust tuff) = d. A. Pervasive replacement of matrix and fragments by tourmaline and pyrite. B. Two styles of tourmalinization: veins and disseminations.

Quartz monzonite stock: Veinlets of quartz plus or minus pyrite-chalcopyrite-molybdenite form a poorly exposed stockwork within the quartz monzonite. To date, two diamond drillholes have intersected the quartz

58

monzonite, however a definite orientation of the stock could not be determined. Mapping of a previously exposed area indicates a zone of intense hydrothermal alteration in the southeastern part of the intrusion (Fig.6). Plagioclase has been altered to kaolin and sericite; biotite to chlorite. The intensity of stockwork veining appears to have increased in this zone. Ney et al. (1972) reported a tetrahedrite-bearing veinlet within the southern part of the stock, but it has not been observed by the writers. The alteration zone is generally confined to the eastern portion of the stock.

The quartz monzonite stock is believed to be correlative with other Nanika Group intrusions, which include a number of small plutons of quartz monzonite to granite composition (Carter,1981). Several of these intrusions contain significant deposits of copper and molybdenum in west-central British Columbia (e.g., The Berg, Lucky Ship, and Red Bird). Potassium-argon ages for these intrusions range from 47 to 56 m.y. (Carter,1981).

Alteration

Alteration assemblages in the Goosly sequence are characterized by minerals rich in alumina, boron and phosphorous (Table 3). The distribution of various alteration zones is shown in Figure 6 and is based largely on the work of Wojdak (1974) and Wetherell (1979). Four types of alteration are recognized:

1. Aluminous alteration is characterized by a suite of aluminous minerals including andalusite, corundum, pyrophyllite and scorzalite. These alteration zones show a systematic spatial relationship to areas of mineral deposits (Fig.6).

2. Boron-bearing minerals consisting of tourmaline and dumortierite occur within the ore zone and in the hanging wall section of the Goosly sequence (Fig. 6).

3. Phosphorous-bearing minerals incuding scorzalite, apatite, augelite and svanbergite (Table 3) occur in the hanging wall immediately above and intimately associated with sulfide minerals--particularly in the Main zone (Fig.6).

TABLE 3. Alteration Minerals (Wetherell 1979)

	Mineral	Chemical formula
Aluminous minerals	Andalusite	Al_2SiO_5
	Sillimanite	Al_2SiO_5
	Corundum	Al_2O_3

	Pyrophyllite	$Al_2Si_4O_{10}(OH)_2$
	Spinel	$(Fe,Mg)Al_2O_4$
	Chlorite	$(Mg,Fe,Al)_6(Al,Si)_4O_{10}(OH)_8$
	Muscovite (sericite)	$KAl_2(AlSi_3)O_{10}(OH)_2$
Boron minerals	Tourmaline	$Na(Mg,Fe)_3Al_6(BO_3)_3(Si_6O_{18})(OH)_4$
	Dumortierite	$(Al,Fe)_7BSi_3O_{18}$
Phosphorus minerals	Scorzalite	$(Fe,Mg)Al_2(PO_4)_2(OH)_2$
	Apatite	$Ca_5(PO_4)_3F$
	Augelite	$Al_2(PO_4)(OH)_3$
	Svanbergite	$SrAl_3(PO_4)(SO_4(OH)_6$

4. The sericite-quartz zone is a zone of abundant sericite-quartz alteration at least 600m long and 80m wide; it appears to coincide with development of very coarse-grained tetrahedrite and pyrite veining in intensely brecciated and fractured aphanitic tuffs in the Southern Tail zone.

Alteration at Equity Silver is described in detail by Wojdak and Sinclair (1984) and will not be considered further here.

Metamorphism

Contact metamophism

Gabbro-monzonite: The gabbro-monzonite complex has formed a contact alteration assemblage which post dates aluminous alteration of the Goosly sequence rocks. A sillimanite-bearing zone 90m wide extends outward from the pluton. Locally, sillimanite appears to be pseudomorphic after andalusite and is commonly associated with quartz (Wetherell,1979). Biotite is present in a hornfels zone as much as 90m from the pluton but is most abundant within 9m of the contact. (Wodjak, 1974). Porphyroblasts of pyrite in pyrrhotite have formed as far as 60m from the contact. Another possible contact metamorphic effect is the dewatering and conversion of some pyrophyllite to andalusite plus quartz (especially in the Main zone) as described by Wodjak (1974).

Quartz monzonite: The margins of the quartz monzonite stock have been intensely hydrothermally altered to potassium feldspar, kaolinite and sericite. Primary biotite has been altered to chlorite and secondary biotite. A zone of quartz stockwork corresponds to the intensly altered rocks. The contact zone between the stock and Goosly sequence has been observed in core from two diamond drillholes and in a road cut west of the Southern Tail zone.

Retrograde alteration

A late-stage alteration assemblage consisting of sericite-kaolinite-chlorite-carbonate plus or minus albite and epidote has overprinted the aluminosilicate alteration. Corundum is altered to brown micaceous fragments and andalusite is replaced by kaolinite. In the Main zone, carbonate formed as a retrograde product.

Retrograde alteration probably occurred during a period of high heat flow with associated circulating ground water, possibly during emplacement of post mineral dykes related to the gabbro-monzonite complex. K-Ar ages suggest that the retrograde event occurred around 48 m.y. ago.

Radiometric Dates

Previous (9) and recently determined (8) potassium-argon radiometric dates from the Equity Silver mine are presented in Table 2. All samples were analyzed at the geochronology laboratory operated jointly by the Department of Geological Sciences and Department of Geophysics, University of British Columbia. In view of the close proximity of the quartz monzonite, the gabbro-monzonite complex, and several post mineral dykes to the mineral deposits as well as the apparent contemporaneity of alteration and mineralization, we decided to determine their ages by using the potassium-argon method on biotite, hornblende and plagioclase separates and whole rocks. We believe that K-Ar dating of sericites offers a potential means of determining directly the age of sulfide mineralization, even with present limitations.

Quartz monzonite stock

Four biotite ages have been determined from samples of the quartz monzonite stock (Table 2). Two of the dates are in good agreement at approximately 56 m.y. The other two dates are approximately 60 and 62.7 m.y.

Tourmaline breccia

One whole-rock age of 58.5 plus-or-minus 2.0 m.y. has been determined for a sample of sericitized dacite from within the volcanic flow division from the tourmaline breccia zone (Table 2). The date is in close agreement with the ages determined on altered host rocks from the Southern Tail zone (i.e. approximately 58.2 m.y.) and suggests that the two events may be genetically related.

Sericitized Dust Tuff

Five whole-rock ages have been determined for samples of altered aphanitic tuff which forms the host rock of the ore zones, especially the Southern Tail zone. Analyses of these rocks were expected to reveal the age of the mineralizing event. Three of the four samples from the Southern Tail zone are in good agreement at approximately 58 m.y. and the fourth is interpreted to have been reset by metamorphic effects associated with the intrusion of the east dyke (49.9 plus-or-minus 2.0 m.y.). The one sample from the Main zone is much younger at approximately 48 m.y. (Table 2). This date is similar to the age of the gabbro-monzonite complex and therefore, because of its proximity to the gabbro complex, is interpreted to have been reset by contact metamorphism associated with the intrusion of the complex. The close association of dates from the quartz monzonite stock, altered dacite from the Tourmaline zone and altered aphanitic tuff host rock suggests a genetic relationship between intrusion, alteration and mineralization.

Dykes

Three whole-rock ages have been determined for dyke samples from the Southern Tail pit--two for quartz latites of the east and west dykes and one for andesite. The ages fall into a range of approximatey 48 to 51 m.y. (Table 2). Quartz latite dykes cross-cut andesite dykes and vice versa. The dykes cross-cut mineral zones and locally have caused remobilization of sufides adjacent to dyke contacts (i.e. east dyke subzone). One quartz latite dyke has been observed to cross-cut the gabbro-monzonite complex. Trachyandesitic (bladed plagioclase porphyry) dykes may be in part late phases of the gabbro-monzonite complex.

Gabbro-monzonite complex

Three biotite ages and one feldspar age have been determined for samples of the gabbro-monzonite complex. Three of the ages are in close agreement at approximately 49 m.y. (Table 2). The other date at 52.5 m.y. (Table 2) appears to be erroneous.

Paragenesis

On the basis of macroscopic vein relations and mineralographic study, a paragenetic sequence of opaque minerals for the Southern Tail zone, Main zone and Waterline zone (Fig.13) can be divided into seven main stages.

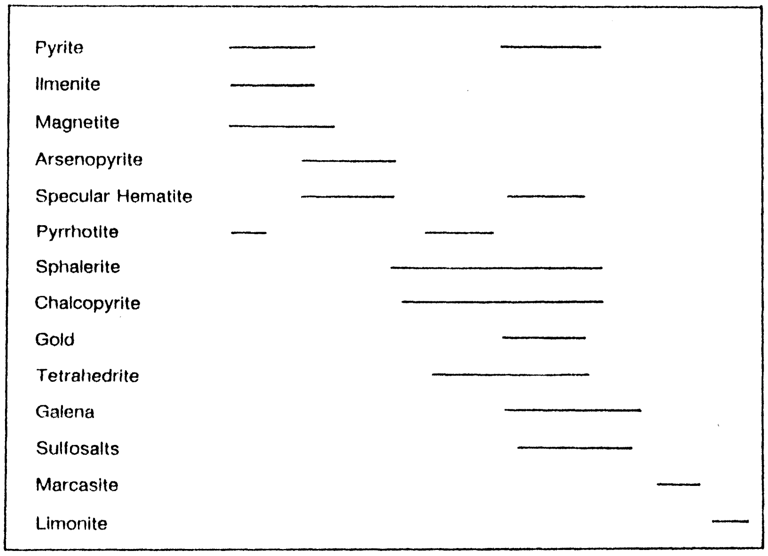

FIG. 13. Sulfide paragenesis for the Main zone and Southern Tail zone. Variations in the paragenetic sequence caused by metamorphism have not been differentiated, although much of the younger pyrrhotite is probably of metamorphic origin. Marcasite has replaced pyrrhotite and therefore postdates metamorphism (see text for discussion).

Listed in deposition with the earliest formed minerals cited first, they are: (1) pyrite, rutile, wolframite, magnetite, arsenopyrite, and specular hematite; (2) pyrrhotite; (3) sphalerite, chalcopyrite, tetrahedrite, sulfosalt minerals (including bournonite, boulangerite, jamesonite, berthierite, pearceite, pyrargyrite and bismuthinite), and gold; (4) galena and various sulfosalt minerals (mainly boulangerite and bournonite); (5) veins and veinlets of galena, sphalerite, pyrite and stibnite, with or without calcite; (6) marcasite; and (7) limonite. Both stages (1) and (2) were accompanied by brecciation of the host rock (Figs.10 and 8).

Stage 1

Pyrite is the oldest opaque mineral, but locally it is nearly contemporaneous with chalcopyrite and forms a sulfide cement interstitial to gangue. A second generation pyrite occurs as fine-grained rims or overgrowths on pyrite aggregates and locally on sphalerite patches. Veins of pyrite and chalcopyrite cross-cut the more abundant pyritiferous quartz or tourmaline veins. Pyrite also occurs as disseminations and fracture filling in some post mineral dykes (especially in the Southern Tail zone), but it does not cross dyke contacts. The grain size and idiomorphic nature of pyrite increase adjacent to the gabbro-monzonite complex (Nielsen, 1969; Wojdak, 1974) and adjacent to post mineral dykes. This porphyroblastic texture probably is the result of contact metamorphism.

Arsenopyrite is commonly the dominant sulfide in mineralized breccias of the Southern Tail zone where it is seen to replace host-rock fragments (mainly aphanitic tuff with disseminated pyrite; Fig.10A and B). Rock fragments are rimmed by arsenopyrite and commonly are suspended in fragments of arsenopyrite (Fig. 10A, B and C). This relationship suggests that the country rock was brecciated during the early stages of the mineralizing event and was cemented by arsenopyrite. The rock was brecciated again during a later deposition of tetrahedrite. Veinlets of arsenopyrite cross pyrite aggregates and pyrite commonly is corroded and replaced by arsenopyrite along grain boundaries and fractures. (Fig.10). In the Main zone, arsenopyrite occurs as scattered remnant grains in chalcopyrite and gangue.

Magnetite (especially in the Main zone) and specular hematite (especially in the Southern Tail zone) commonly occur together and commonly are associated with pyrite. The iron oxides have an antipathetic relationship with pyrrhotite which is most noticeable in the Main zone. In some Main zone polished sections, pyrite is interstitial to magnetite and the latter appears to be older. Specular hematite is common as an oxidation product of magnetite. It forms grains interstitial to magnetite and pyrite and has replaced them locally. Replacement of specular hematite by magnetite was seen to occur locally in some Main zone polished sections.

Wolframite occurs as subhedral to anhedral grains in pyrrhotite and gangue of the Main zone. It is extremely erratic, being most common in the southern portions of the Main zone. individual grains are usually corrorded and fractured and are sometimes invaded by chalcopyrite and tetrahedrite.

Stage 2

Pyrrhotite occurs as minor amounts in most rocks, although it is not seen to occur in the Southern Tail zone. It occurs as inclusions in pyrite or as minute blebs in chalcopyrite and sphalerite. Locally pyrrhotite has replaced pyrite along grain boundaries and fractures. Within about 90m of the gabbro-monzonite complex, pyrrhotite is abundant and occurs in lenses of massive sulfide. Some pyrrhotite forms an interlocking mosaic interstitial to pyrite, gangue and rarely magnetite (Fig.11B). Pyrrhotite was also seen to occur as grain fragments in chalcopyrite, having been invaded and brecciated by this younger sulfide.

Stage 3

Tetrahedrite, chalcopyrite and sphalerite are commonly intergrown with one another (Fig.10A, B and E). Tetrahedrite and chalcopyrite commonly cement brecciated masses of arsenopyrite and pyrite, as does sphalerite locally (Fig.10). Replacement of pyrite and arsenopyrite by tetrahedrite and chalcopyrite occurs along grain boundaries and fractures. Wetherell (1979) reports that tetrahedrite pseudomorphs of arsenopyrite are common and that chalcopyrite pseudomorphs of pyrite are present locally. Both tetrahedrite and chalcopyrite form local rims around pyrite grains (Fig.10). Chalcopyrite rims on subhedral and euhedral pyrite metacrysts in pyrrhotite are common in massive sulfide areas of the Main zone. Tetrahedrite forms blebs, patches and veins in chalcopyrite. Wherever tetrahedrite is the dominant copper mineral, it predates chalcopyrite and is corroded by and cut by microveinlets of chalcopyrite. Similarly, wherever chalcopyrite is the dominant copper mineral, it predates tetrahedrite. When present in near equal concentrations, mutual cross-cutting relationships are observed.

Chalcopyrite is generally interstitial to gangue (Fig.8A and B), and locally replaces pyrite, pyrrhotite and magnetite along fractures and grain boundaries. It also, however, invades and brecciates these minerals. Some arsenopyrite grains are rimmed by chalcopyrite (Wetherell, 1979). Chalcopyrite corrodes and embays sphalerite and local patches of tetrahedrite. Chalcopyrite rims sphalerite blebs in tetrahedrite and rare rims are present around tetrahedrite grains. Chalcopyrite also occurs in veins with pyrite and specular hematite. Rare blebs of chalcopyite are present in quartz amygdules within some dykes.

Sphalerite occurs in veins and in massive sulfide lenses and is commonly associated with chalcopyrite. It forms irregular patches in chalcopyrite and rounded inclusions in pyrite and pyrrhotite. In brecciated zones, sphalerite rims arsenopyrite and is interstitial to the sulfide matrix (tetrahedrite plus-or-minus chalcopyrite) and gangue (Fig.10). Replacement of pyrite occurs locally along grain boundaries at fractures. Rare sphalerite microveinlets cut chalcopyrite. Stars of sphalerite are present in chalcopyrite and almost all sphalerite contains chalcopyrite either as an emulsion or as blebs along crystallographic planes (i.e. chalcopyrite disease; Wetherell, 1979). Thus, sphalerite is considered to be both contemporaneous with and in part slightly older than chalcopyrite. In the Main zone, however, brecciated chalcopyrite and pyrite fragments were seen to occur in a matrix of medium-to coarse-grained sphalerite.

Gold occurs in trace amounts as rounded inclusions and blebs in chalcopyrite, tetrahedrite, bournonite and gangue, although individual grains up to 100 microns have been noted in polished section samples of massive sulphide from the Main zone.

Stage 4

Galena is present in minor amounts in veins and interstitial to gangue (Fig.8D) and locally fills interstices in pyrite and arsenopyrite. It commonly corrodes and embays sphalerite and chalcopyrite. Wetherell (1979) reported rare selvages of galena along some bournonite veins as well as corrosion and embayment by the galena. Microveinlets of galena cross pyrite locally.

Sulfosalts, including bournonite, jamesonite, boulangerite, berthierite, pearceite, pyargyrite and other unidentified varieties occur as veins and scattered grains in gangue and as blebs and patches in tetrahedrite, chalcopyrite, galena and locally sphalerite, and commonly embay these minerals (Wetherell, 1979). Argentite has been identified as five-to fifty-micron-wide scattered grains in gangue and in pyrite from Main zone polished section samples.

Stage 5

Late-stage veinlets of galena, sphalerite and pyrite in a quartz gangue cross-cut all other veins and sulfide concentrations. Locally galena and sphalerite form coarse-grained veins up to 1m wide and clearly cross-cut stratigraphy. In the Main zone, acicular radiating crystals of stibnite in quartz-calcite veins and patches have been identified.

Stage 6

Marcasite occurs as a replacement of pyrrhotite with concentric fractures and colloform textures well developed locally. Marcasite was also identified in a 1m wide marcasite-pyrite-galena-tetrahedrite vein east of the coarse ore stockpile and now buried under the tailings pond road.

Stage 7

Limonite occurs locally as replacement rims about pyrite and pyrrhotite. Limonite also forms minute grains and patches in rock fragments and has probably replaced disseminated pyrite.

Although contact metamorphism has probably affected much of the Main zone, no attempt to describe variations in the paragenetic sequence caused by metamorphism, other than that of pyrrhotite, has been made.

The consistency of paragenesis suggests that the three ore zones are related genetically. Furthermore, a similar paragenetic sequence exists in general for other mineralized zones at Equity Silver.

Geologic History

The geologic history of the area including the Equity Silver mine is portrayed schematically in Figure 14. In Early to Middle Jurassic time, uplift of the northeast-southwest-trending Skeena arch separated the Bowser basin (to the north) from the Nechako trough (to the south) (Fig.3). The formation of Skeena arch is thought to have been related to the emplacement of the Topley intrusions (Fig.14A), a group of subvolcanic granitic stocks which form the axis of the arch (Carter, 1981), and roughly coincident with the projection of a major magnetic discontinuity extending southeasterly from the Great Slave Lake fault (Morley et al., 1967). In late Lower Cretaceous (Albian) time (Fig.14B), deposition of the Goosly sequence commenced in the Nechako trough along the eastern margin of the eastward-transgressing sea. The marine clastic division was the first unit to be deposited in this period. Basal polymictic conglomerates, formed in a period of transgression, are poorly sorted and are typical of a near-shore, shallow-marine environment. The argillaceous units were deposited in much deeper water as the sea further transgressed. The upper chert pebble conglomerate represents a shoreline facies as the sea regressed and land emerged.

In Middle to Late Cretaceous time (Fig.14B), volcanism was widespread in the district as the Albian sea retreated. Initial violent eruption from a local source resulted in the formation of the pyroclastic division, a thick sequence of welded and nonwelded tuffs thought to be correlative with the Kasalka Group. Reworking of the debris in a subaerial environment during breaks in volcanic activity resulted in the formation of interbedded lenses of volcaniclastic rocks. Venting of fluids and gases caused the formation of pyroclastic breccias.

The sea transgressed over the region again during for formation of the sedimentary-volcanic division. The basal white chert pebble conglomerate was deposited in a near-shore, shallow-marine environment. The subsequent sandstones and conglomerates, of local provenance, were deposited in a shallow-marine environment.

Regression of the sea and episodes of less violent lava eruption account for formation of the andesitic and dacitic flows of the volcanic flow division. It is not clear how much material subsequently formed on top of the Goosly sequence, which has since been eroded or is unexposed.

During Early Tertiary times (Fig.14C), tectonism related to the emplacement of the Coast plutonic complex resulted in folding and faulting of the Goosly sequence. Intrusion of the quartz monzonite stock followed shortly after the folding and is believed to be correlative with emplacement of the Nanika intrusions (Carter, 1981). These include a number of small plutons of quartz monzonite to granite composition within the region. Carter (1981) reported potassium-argon ages for these intrusions ranging from 47 to 56 m.y. Several of the Nanika intrusions contain significant deposits of copper and molybdenum, such as The Berg, Lucky Ship, Red Bird, and Mount Thomlinson. Minor copper-molybdenum porphyry-type mineralization occurs within the quartz monzonite stock.

The gabbro-monzonite complex intruded the Goosly sequence approximately 10m.y. after the emplacement of the quartz monzonite stock and is believed to be correlative with the Goosly Lake intrusions in the region south of Houston. Church (1970) suggests that the Goosly Lake intrusions are centers of Eocene volcanism. Therefore, the Goosly Lake volcanic rocks, which unconformably overlie the Goosly sequence and are widespread within the region, may be genetically related to the gabbro-monzonite complex. Andesite and quartz latite dykes, observed cross-cutting the Goosly sequence and the gabbro-monzonite complex, are believed to be late stage phases of the complex.

Some time between intrusion of the quartz monzonite stock and that of the gabbro-monzonite complex, open-space and replacement sulfide mineralization occurred within the pyroclastic division. Recent potassium-argon age determinations for alteration minerals associated with the mineralization indicate the ore is more closely related to the quartz monzonite stock in age than to the gabbro-monzonite complex.

During late Eocene time, basalts of the Buck Creek volcanic unit covered the Goosly Lake volcanic rocks. Pleistocene glaciation removed much of the volcanic cover and exposed the Equity Silver deposit.

Ore Genesis

Based on the combination of mineralogy, style, and geologic setting, the Equity orebodies are not easily assigned to a known type of ore deposit. Several modes of ore genesis have been postulated (Cyr et al., 1983; Wetherell, 1979; Ney et al., 1972).

Sulfides were deposited as disseminations and veins and in open-space fractures as well as in crackle and breccia zones subconcordant with host-rock stratigraphy. The orebodies are contained within a well-developed, advanced

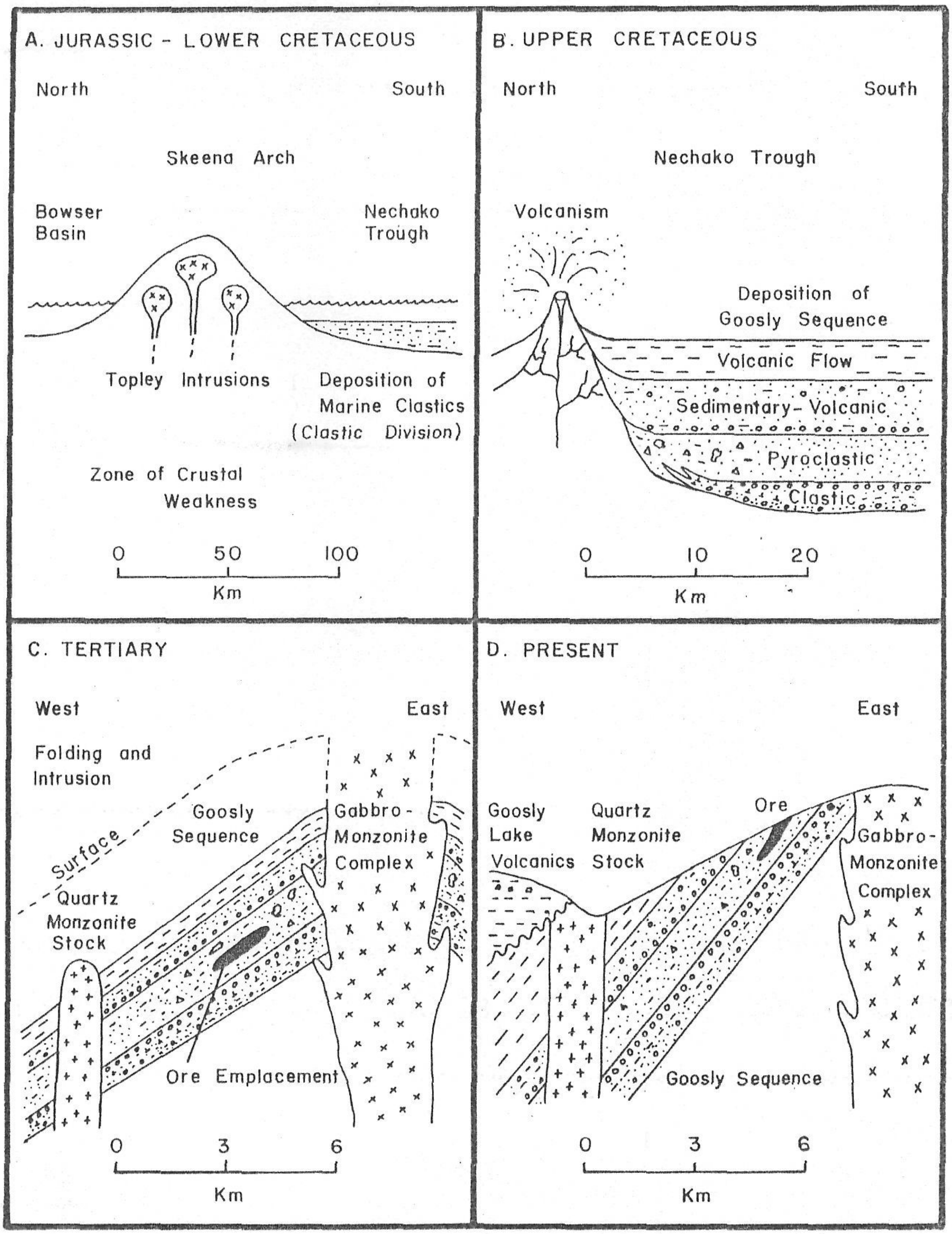

FIG. 14. Schematic presentation of the geologic history of the Equity Silver mine.

argillic alteration assemblage, possibly related to base leaching associated with fluid circulation at a high level in a developing porphyry system, i.e. quartz monzonite intrusion or unexposed intrusion of similar age.

Intrusive activity resulted in the shattering of the massive, brittle aphanitic tuff, as evidenced by common breccia and crackle textures, and the introduction of hydrothermal metal-rich solutions, presumably enriched in boron and sulfur. Sulfides introduced into more competent and permeable ash and lapilli tuffs of the Main and Waterline zones formed as disseminations, veinlets, patches and stringers which grade randomly into zones of more or less massive sulfide. In the Southern Tail, veins and zones of massive sulfides developed in the aphanitic dust tuff as open space fillings. Emplacement of post mineral quartz latite and andesite dykes into all types of sulfide-rich pyroclastic rocks resulted in remobilization and concentration of sulfides adjacent to intrusive contacts. Remobilization, concentration and contact metamorphism of sulfides occurred in ash and lapilli tuffs of the Main zone at the contact with the gabbro-monzonite complex.

Meteoric water descending into open-space fracture fillings and percolating through more permeable pyroclastic rocks could have been responsible for sulfide concentration (Shen and Sinclair, 1981). The preliminary evaluation of fluid inclusion data (Shen and sinclair, 1981) suggests that all of the principal mineralized zones formed during a single episode of mineralization. They suggest that the hydrothermal system was apparently centered on and driven by the quartz monzonite stock. High salinity fluid inclusions that contain halite as a daughter product suggest that a very small proportion of the ore fluid had an igneous origin. Most of the ore fluid was of relatively low cut variable salinity indicating that meteoric water was the dominant component in the hydrothermal system (Shen and Sinclair, 1981). Wetherell (1979) suggested formation temperatures between 300° and 491°C for sulfide and altered minerals.

The close age association of sericitized, aphanitic tuffs and dacite (K-Ar ages approximately 58 m.y.) and the quartz monzonite (K-Ar ages 56-61 m.y.;Table 2) suggests a genetic association related to a contemporaneous episode of mineralization and alteration. Ages of 48m.y. for the gabbro-monzonite complex and 50m.y. for quartz latite and andesite dykes indicate that these intrusive events were clearly younger than the sulfide-mineralizing event. Field relationships also support this conclusion. Trace amounts of disseminated pyrite exist within both the gabbro-monzonite complex and the quartz latite dykes however the significance of this is unknown at this time. Sericite-altered rock and a quartz-sulfide-bearing stockwork exist in the quartz monzonite intrusion.

Acknowledgments

The excellent contributions over several years on the Equity Silver Mines Ltd. property by Kennecott Copper Corporation, Equity Mining Corporation, and Placer Development Ltd. (now Placer Dome Inc.) geologists and from the theses by Wojdak (1974) and Wetherell (1979) have led to a continually better understanding of the property geology and are duly acknowledged. Geologic mapping at Equity Silver Mine by Daryl Hanson is also acknowledged.

Appreciation is extended to Sue Campbell of Placer Dome Inc. for her assistance with radiometric age dating and electron microscopic determination.

March 20, 1984

Revised May, 1988

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PROPERTY TOUR - EQUITY SILVER MINE

by J. Cyr and T.G. Schroeter Sept. 26/88

Stop #1 **South Wall Lookout** - 1350m. elevation

To the north - Main Zone open pit and tailings ponds.

To the southwest - Nadina Mountain, as well as the area of the next Pit stop.

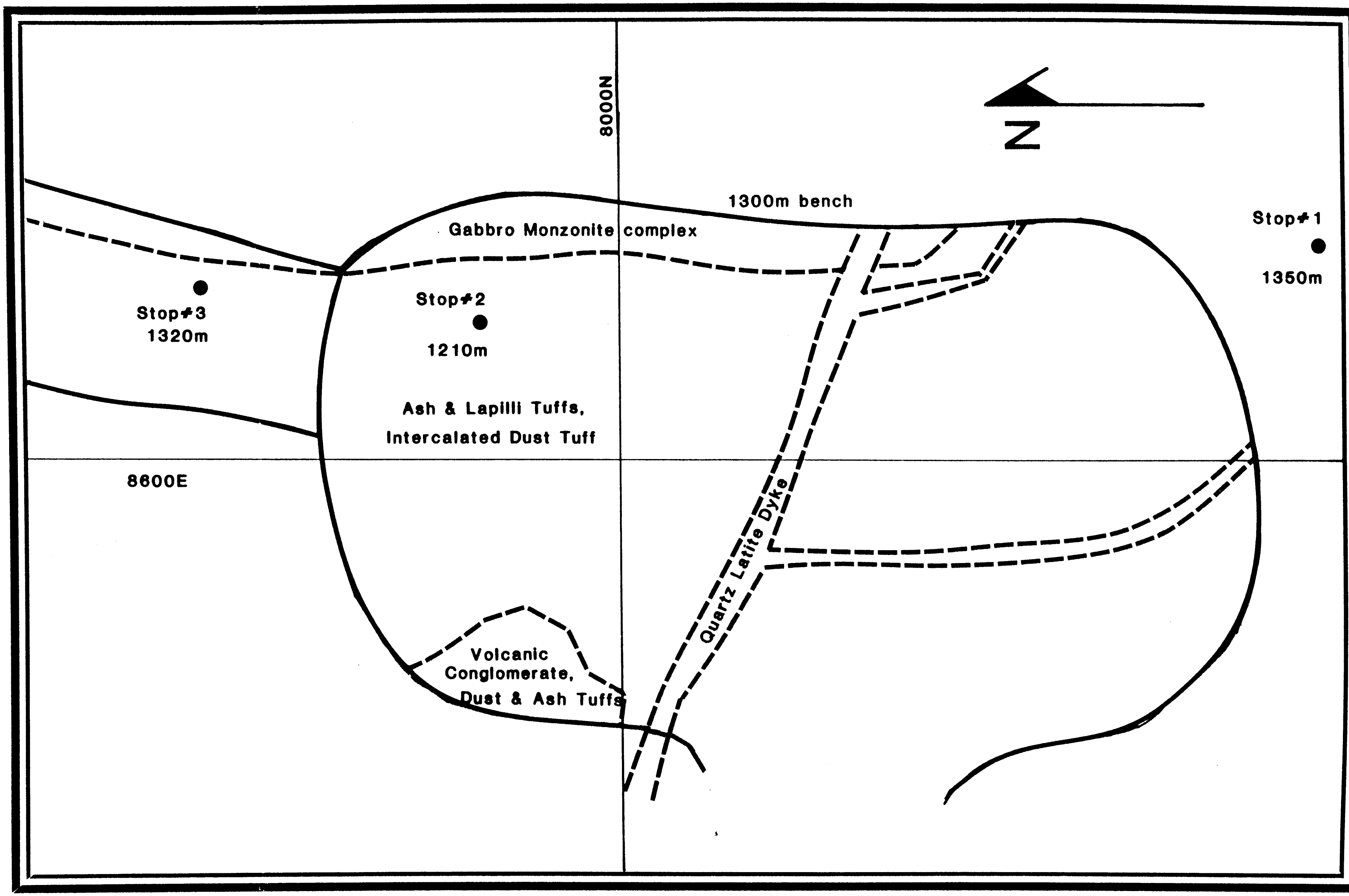
Stop #2 **Bench 1210m., Main Zone Pit**

Ore bearing ash and lapilli tuffs of the Goosly sequence intruded by post mineral quartz latite and andesitic dykes. Exposures of Gabbro-Monzonite complex will be examined, if accessible.

Stop #3 **Waterline Zone** - 1320m. elevation

Mineralized exposures of ash and lapilli tuff will be examined, as well as exposures of the Gabbro - Monzonite complex.

NOTES :



Main Zone Pit Equity Silver Mine

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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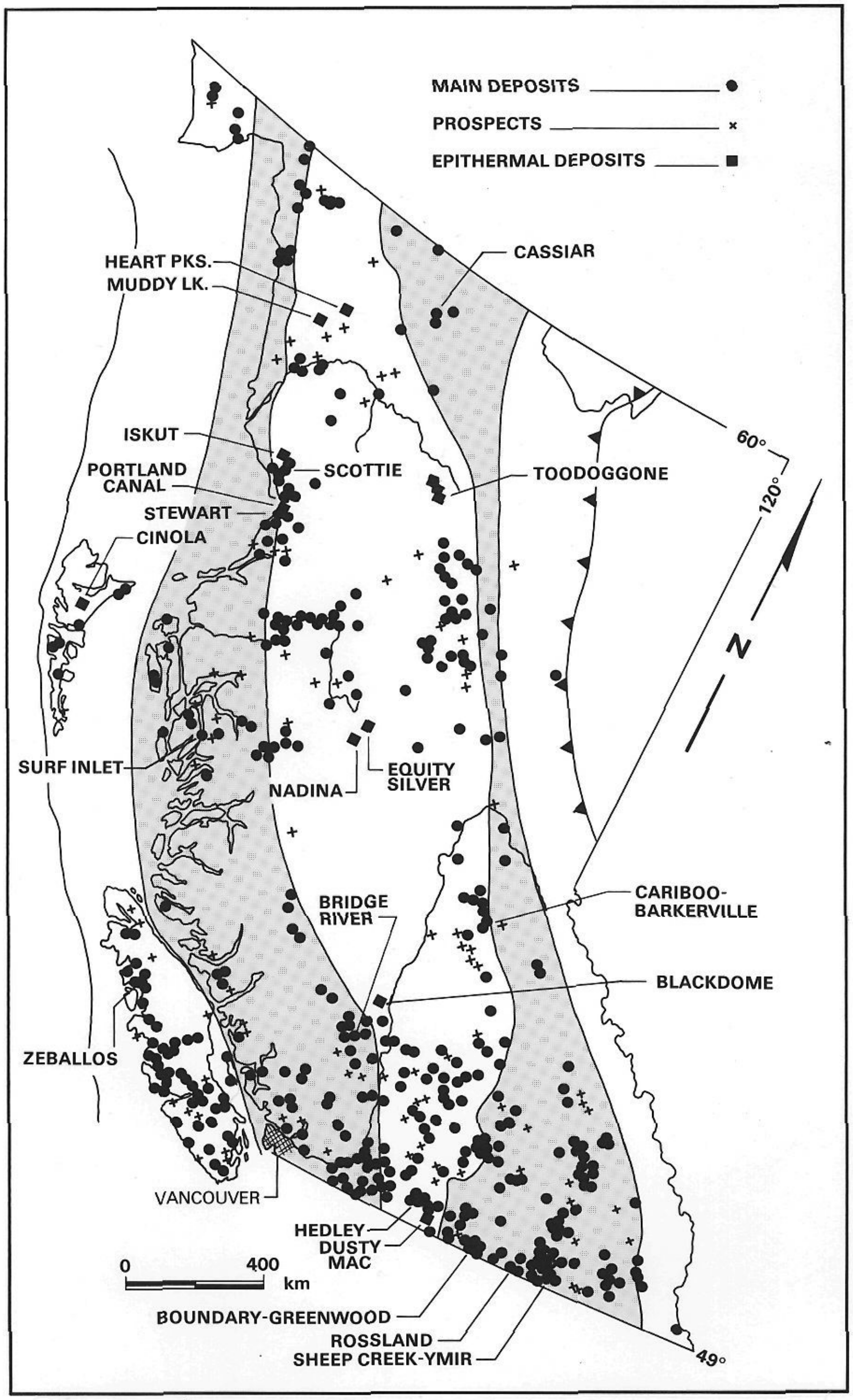


Distribution of gold deposits in British Columbia showing major camps, individual deposits and areas of recent exploration activity. Lines indicate major tectono - physiographic boundaries. Crystalline - metamorphic terranes of the Coast Plutonic Belt in the west and Omineca Belt in the east are shown by the hachured pattern.

The earliest major gold production in northwestern British Columbia began in 1861 following discovery of placer gold along the Stikine River. Placer deposits discovered in the Omineca (Germanson River), 1869-1871, Stikine (Dease Lake-Cassiar), 1873-1874, and Atlin, 1898, Mining Divisions resulted in recorded production of nearly 1 million ounces of gold (Holland, 1950).

Interest in lode gold-silver deposits increased at the beginning of this century as returns from the rich placer fields diminished and the miners and prospectors turned their attention to the bedrock sources of the placer gold. The first mining venture to ship more than 100 tons of ore was the Imperial mine near Atlin, where quartz veins yielded nearly 100 ounces of gold from 290 tons of ore in 1899-1900. The first undertaking leading to major lode gold production began in 1902 at the Princess Royal Group, later Surf Inlet Mines (Plate 1). This north coast vein mining operation continued until 1943 and became the fourth largest precious metal producer in northwestern British Columbia; production was almost 390,000 ounces of gold and 200,000 ounces of silver from approximately 1 million tons of ore.

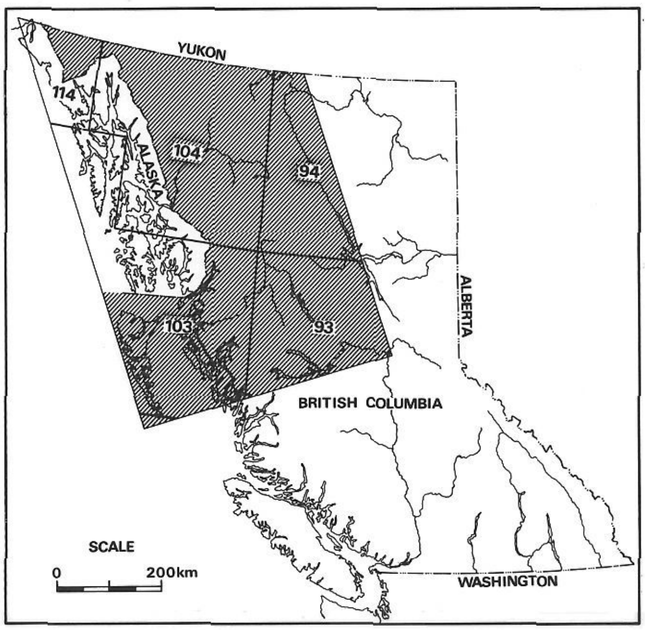


Figure 1: Location of northwestern British Columbia lode gold-silver deposits

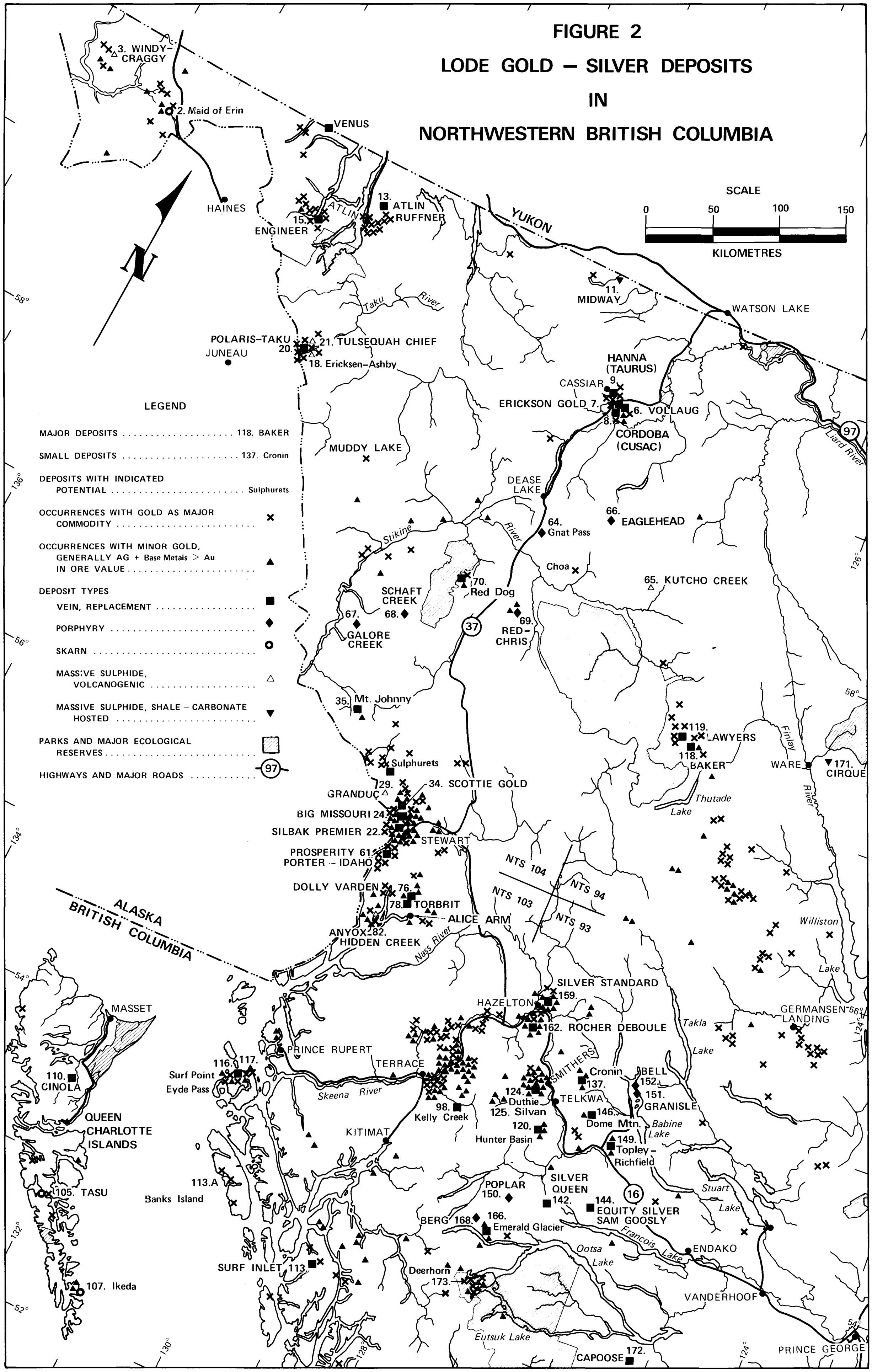


FIGURE 2

LODE GOLD – SILVER DEPOSITS IN NORTHWESTERN BRITISH COLUMBIA

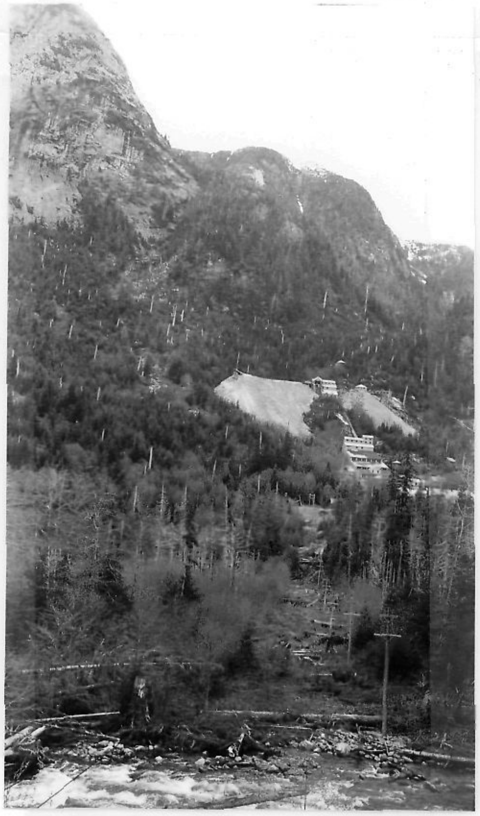
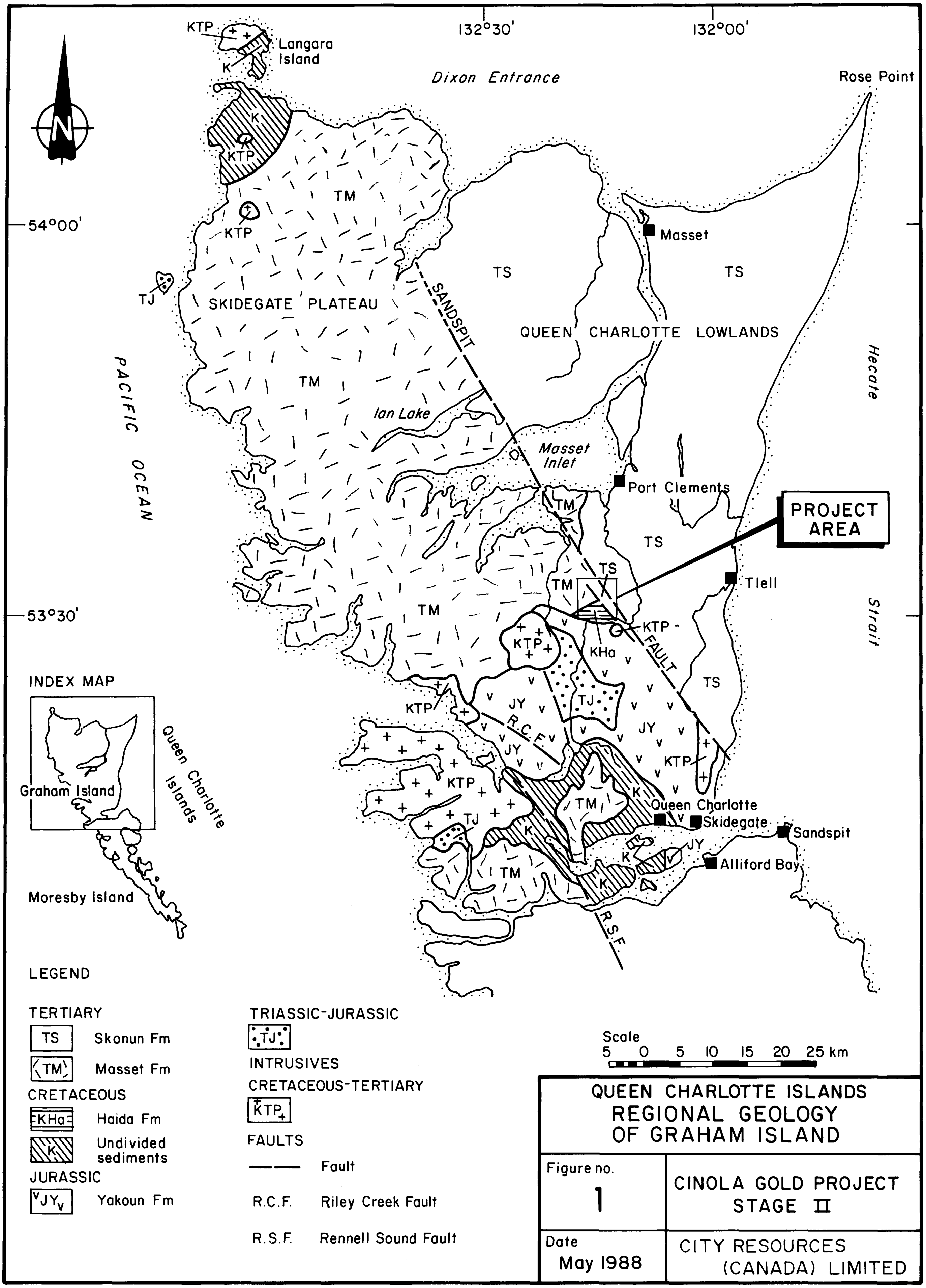
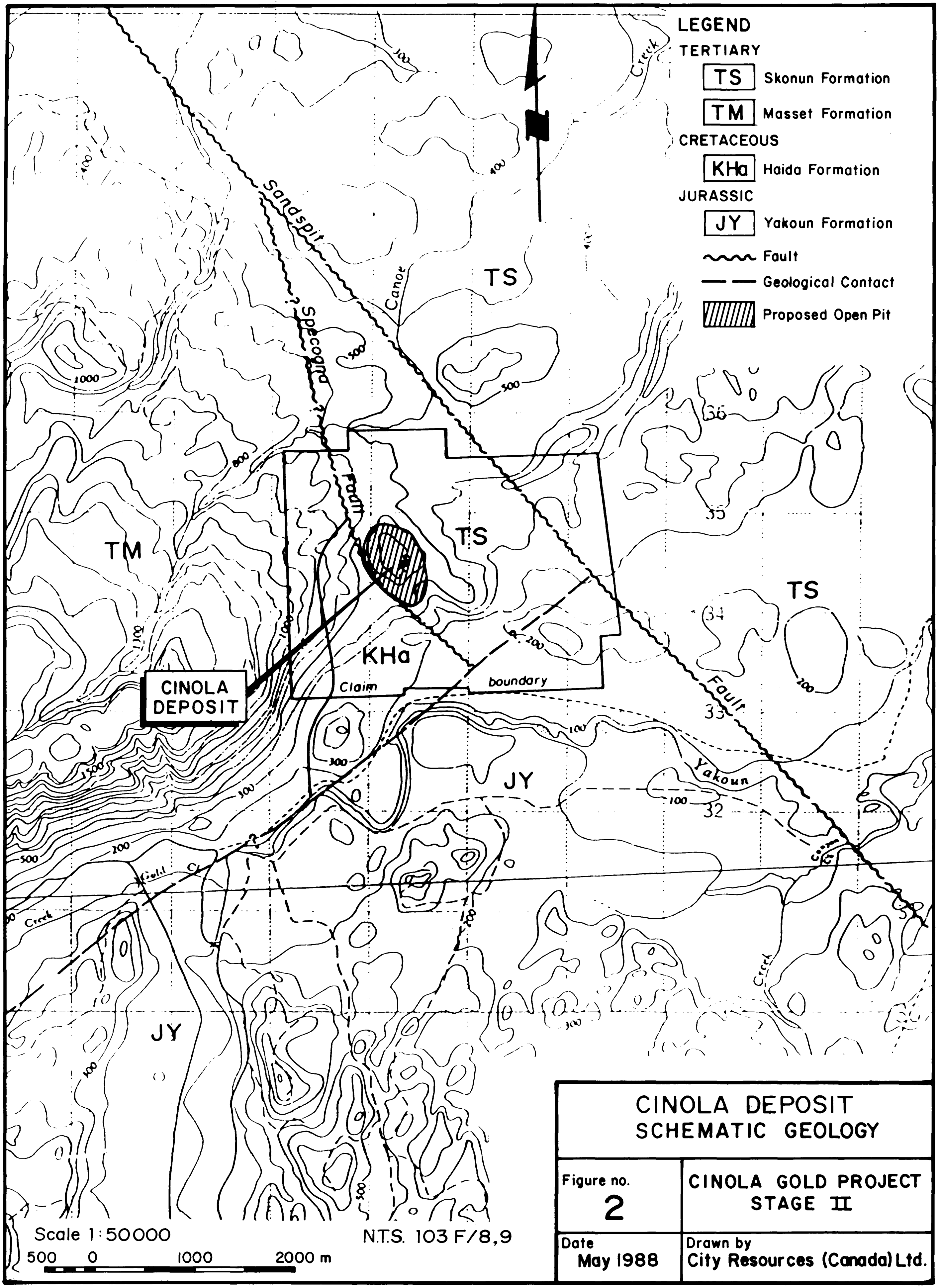
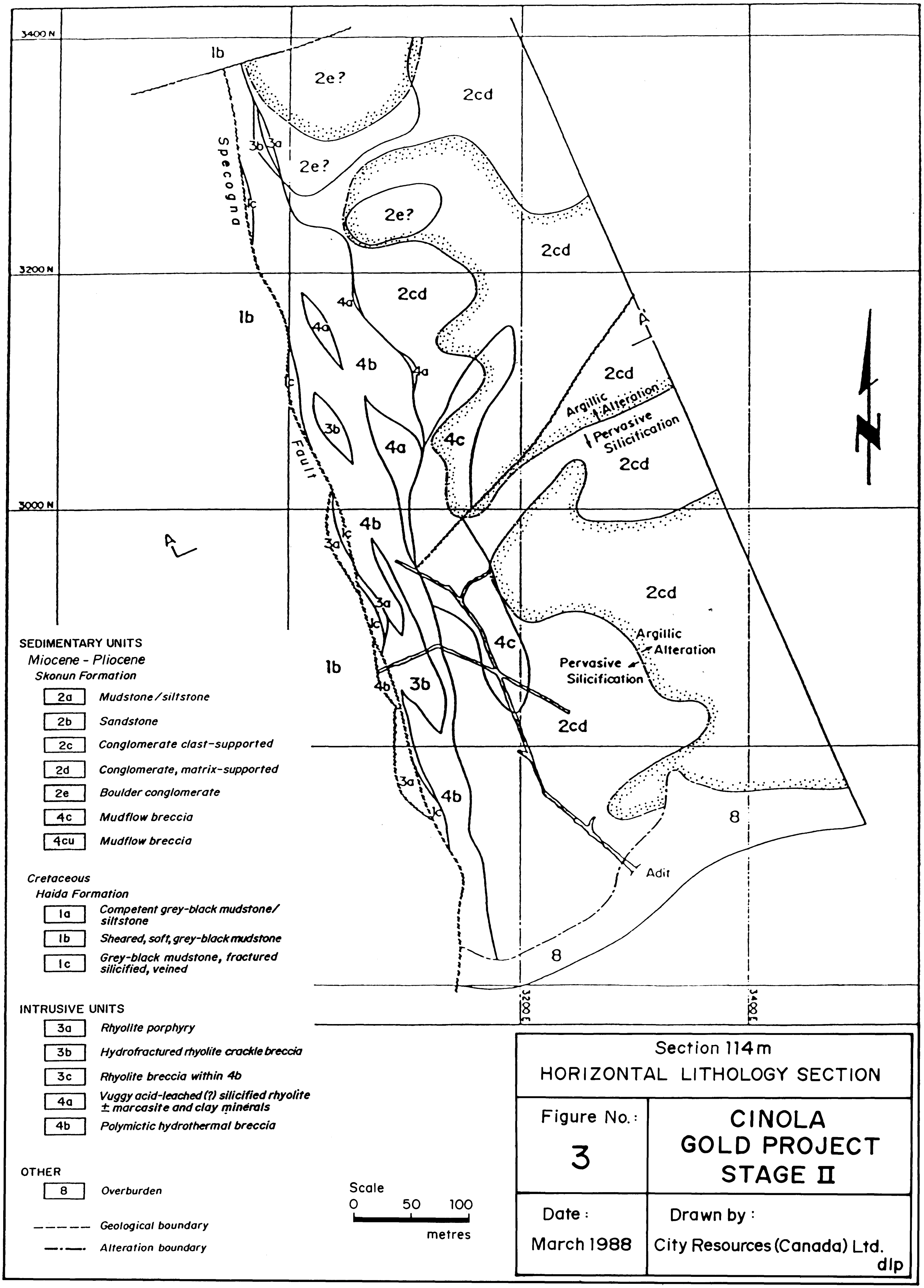


Plate 1: Surf Inlet Consolidated Gold Mine Limited, 1935; production from 1902 to 1943, 1 million tons, 389,000 ounces. A typical north coast mining operation. Quartz veins within sheared zones in gneissic quartz diorite.

Plate 2: Equity Silver Mine (Sam Goosley Deposit), July 1984, View looking Easterly


Langara Island
KTP
K
132°30'
132°00'
Dixon Entrance
Rose Point
54°00'
53°30'
TM
TS
Masset
SKIDEGATE PLATEAU
SANDSPIT
QUEEN CHARLOTTE LOWLANDS
PACIFIC OCEAN
Hecate Strait
TJ
Ian Lake
Masset Inlet
Port Clements
PROJECT AREA
Tlell
KHa
FAULT
JY
R.C.F.
R.S.F.
Queen Charlotte
Skidegate
Sandspit
Alliford Bay
INDEX MAP
Graham Island
Queen Charlotte Islands
Moresby Island
LEGEND
TERTIARY
TS Skonun Fm
TM Masset Fm
CRETACEOUS
KHa Haida Fm
K Undivided sediments
JURASSIC
JY Yakoun Fm
TRIASSIC-JURASSIC
TJ
INTRUSIVES
CRETACEOUS-TERTIARY
KTP
FAULTS
Fault
R.C.F. Riley Creek Fault
R.S.F. Rennell Sound Fault
Scale
5 0 5 10 15 20 25 km
QUEEN CHARLOTTE ISLANDS
REGIONAL GEOLOGY
OF GRAHAM ISLAND
Figure no.
1
CINOLA GOLD PROJECT
STAGE II
Date
May 1988
CITY RESOURCES
(CANADA) LIMITED


LEGEND
TERTIARY
TS Skonun Formation
TM Masset Formation
CRETACEOUS
KHa Haida Formation
JURASSIC
JY Yakoun Formation
Fault
Geological Contact
Proposed Open Pit
Sandspit
Specogna
Fault
Canoe
Creek
Claim boundary
CINOLA DEPOSIT
Yakoun
Gold Cr.
TS
TM
KHa
JY
Scale 1:50000
500 0 1000 2000 m
N.T.S. 103 F/8,9
CINOLA DEPOSIT
SCHEMATIC GEOLOGY
Figure no.
2
CINOLA GOLD PROJECT
STAGE II
Date
May 1988
Drawn by
City Resources (Canada) Ltd.


3400 N
3200 N
3000 N
3200 E
3400 E
1b
2e?
2cd
3b
3a
Specogna
Fault
1c
4a
4b
4c
8
Adit
A
A'
Argillic Alteration
Pervasive Silicification
SEDIMENTARY UNITS
Miocene - Pliocene
Skonun Formation
2a Mudstone/siltstone
2b Sandstone
2c Conglomerate clast-supported
2d Conglomerate, matrix-supported
2e Boulder conglomerate
4c Mudflow breccia
4cu Mudflow breccia
Cretaceous
Haida Formation
1a Competent grey-black mudstone/ siltstone
1b Sheared, soft, grey-black mudstone
1c Grey-black mudstone, fractured silicified, veined
INTRUSIVE UNITS
3a Rhyolite porphyry
3b Hydrofractured rhyolite crackle breccia
3c Rhyolite breccia within 4b
4a Vuggy acid-leached(?) silicified rhyolite ± marcasite and clay minerals
4b Polymictic hydrothermal breccia
OTHER
8 Overburden
Geological boundary
Alteration boundary
Scale
0 50 100
metres
Section 114m
HORIZONTAL LITHOLOGY SECTION
Figure No.:
3
CINOLA
GOLD PROJECT
STAGE II
Date:
March 1988
Drawn by:
City Resources (Canada) Ltd.
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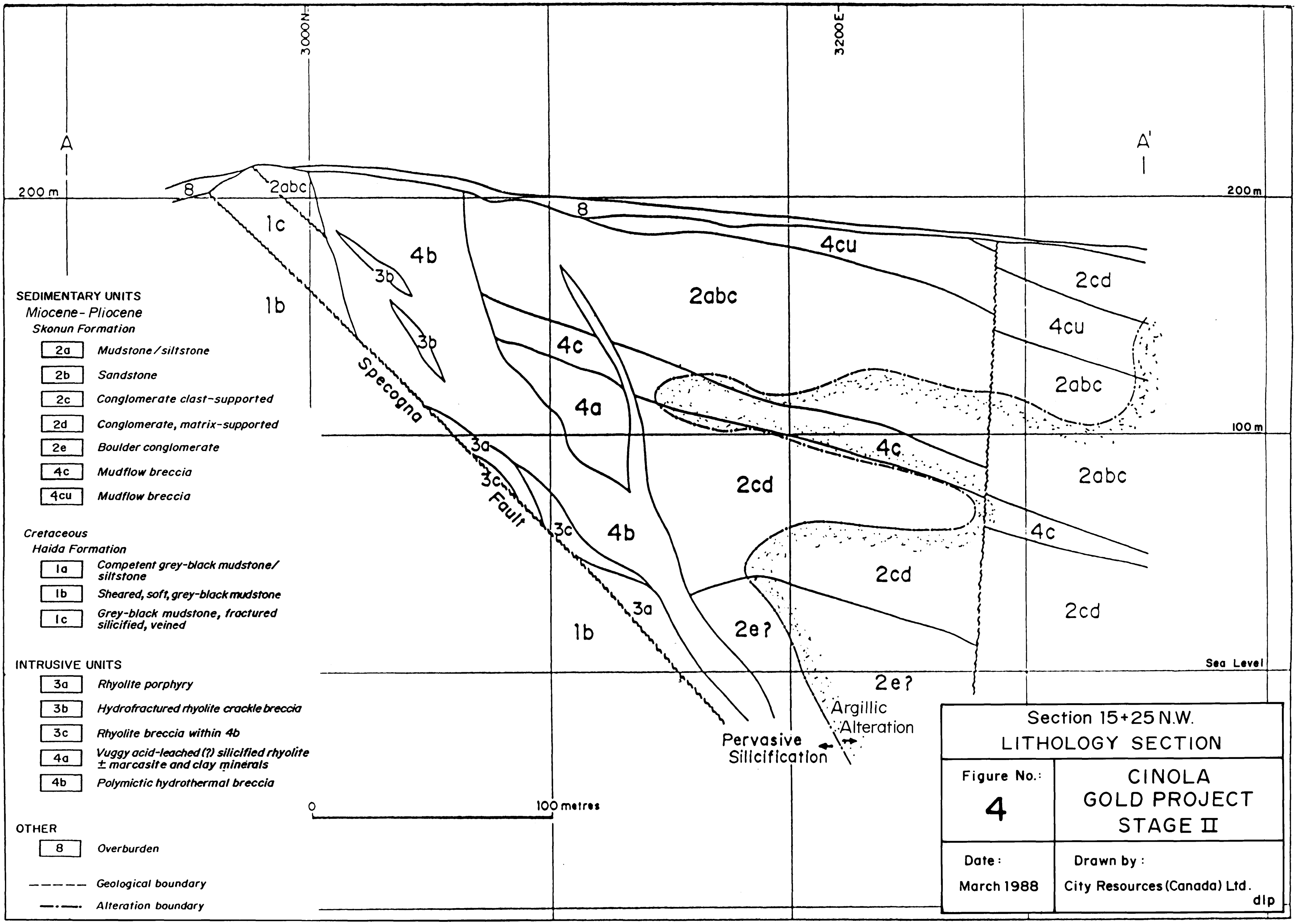
3000N
3200E
A
A'
200 m
200 m
100 m
Sea Level
8
2abc
1c
1b
3b
3b
4b
4cu
2abc
4c
4a
2cd
4c
3a
3c
3c
4b
3a
1b
2e ?
2cd
2e ?
2cd
4cu
2abc
2abc
4c
2cd
Specogna Fault
Argillic Alteration
Pervasive Silicification
SEDIMENTARY UNITS
Miocene - Pliocene
Skonun Formation
2a Mudstone/siltstone
2b Sandstone
2c Conglomerate clast-supported
2d Conglomerate, matrix-supported
2e Boulder conglomerate
4c Mudflow breccia
4cu Mudflow breccia
Cretaceous
Haida Formation
1a Competent grey-black mudstone/ siltstone
1b Sheared, soft, grey-black mudstone
1c Grey-black mudstone, fractured silicified, veined
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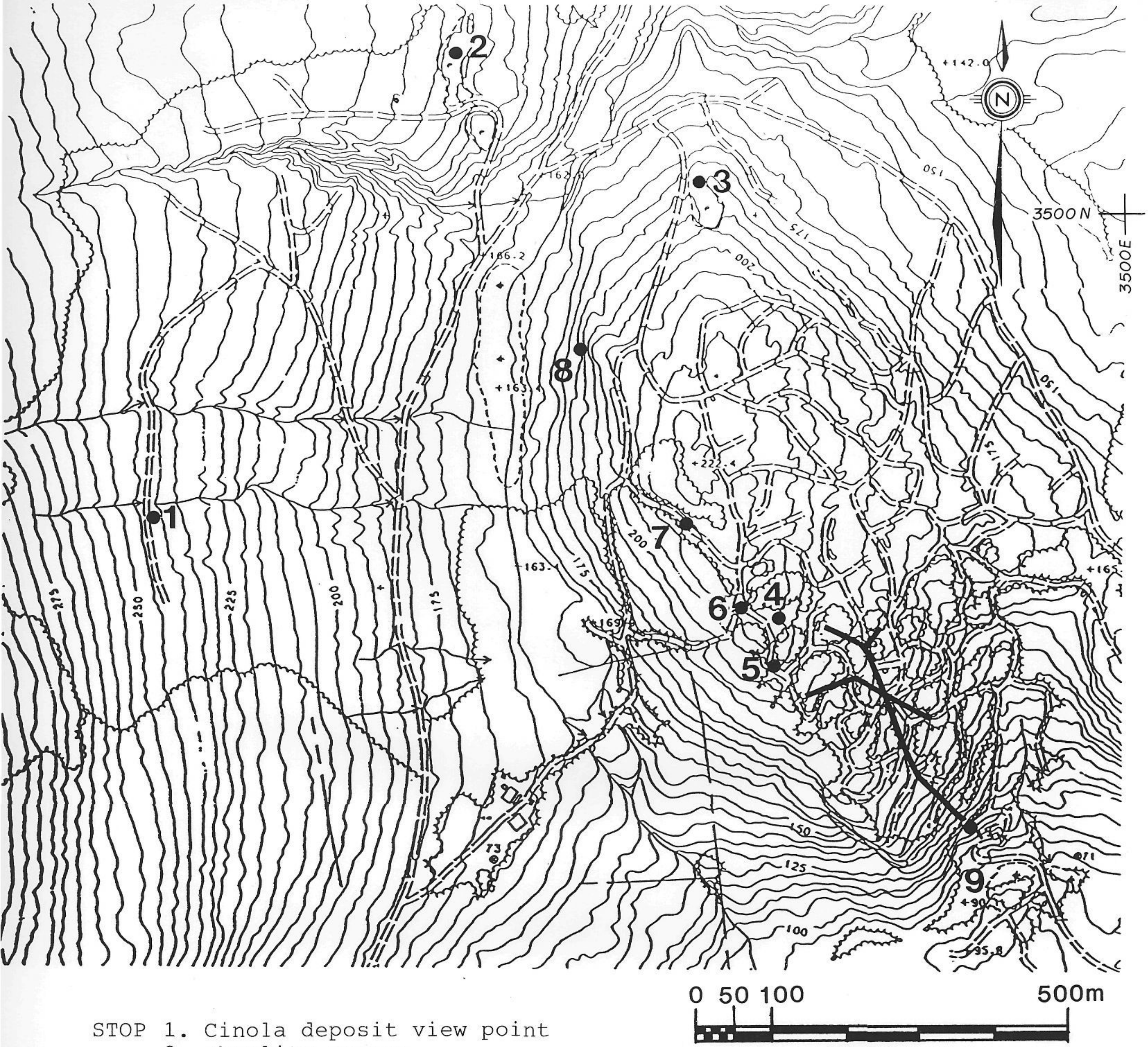
3a Rhyolite porphyry
3b Hydrofractured rhyolite crackle breccia
3c Rhyolite breccia within 4b
4a Vuggy acid-leached (?) silicified rhyolite ± marcasite and clay minerals
4b Polymictic hydrothermal breccia
OTHER
8 Overburden
Geological boundary
Alteration boundary
0
100 metres
Section 15+25 N.W.
LITHOLOGY SECTION
Figure No.:
4
CINOLA GOLD PROJECT STAGE II
Date:
March 1988
Drawn by:
City Resources (Canada) Ltd.
dlp



STOP 1. Cinola deposit view point
2. Rhyolite quarry
3. Silicified Skonun Formation sediments
4. Multiphase breccia and intense veining
5. Multiphase breccia and hydrofractured rhyolite
6. Silicified Haida Formation mudstone breccia
7. Specogna Fault
8. Marino Showing
9. Adit

Fig.1 Selected tour stop locations

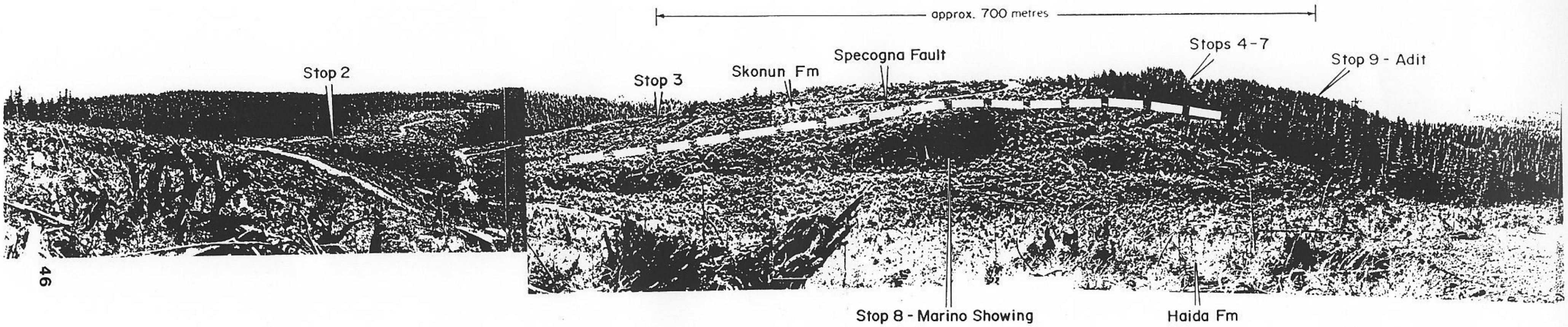
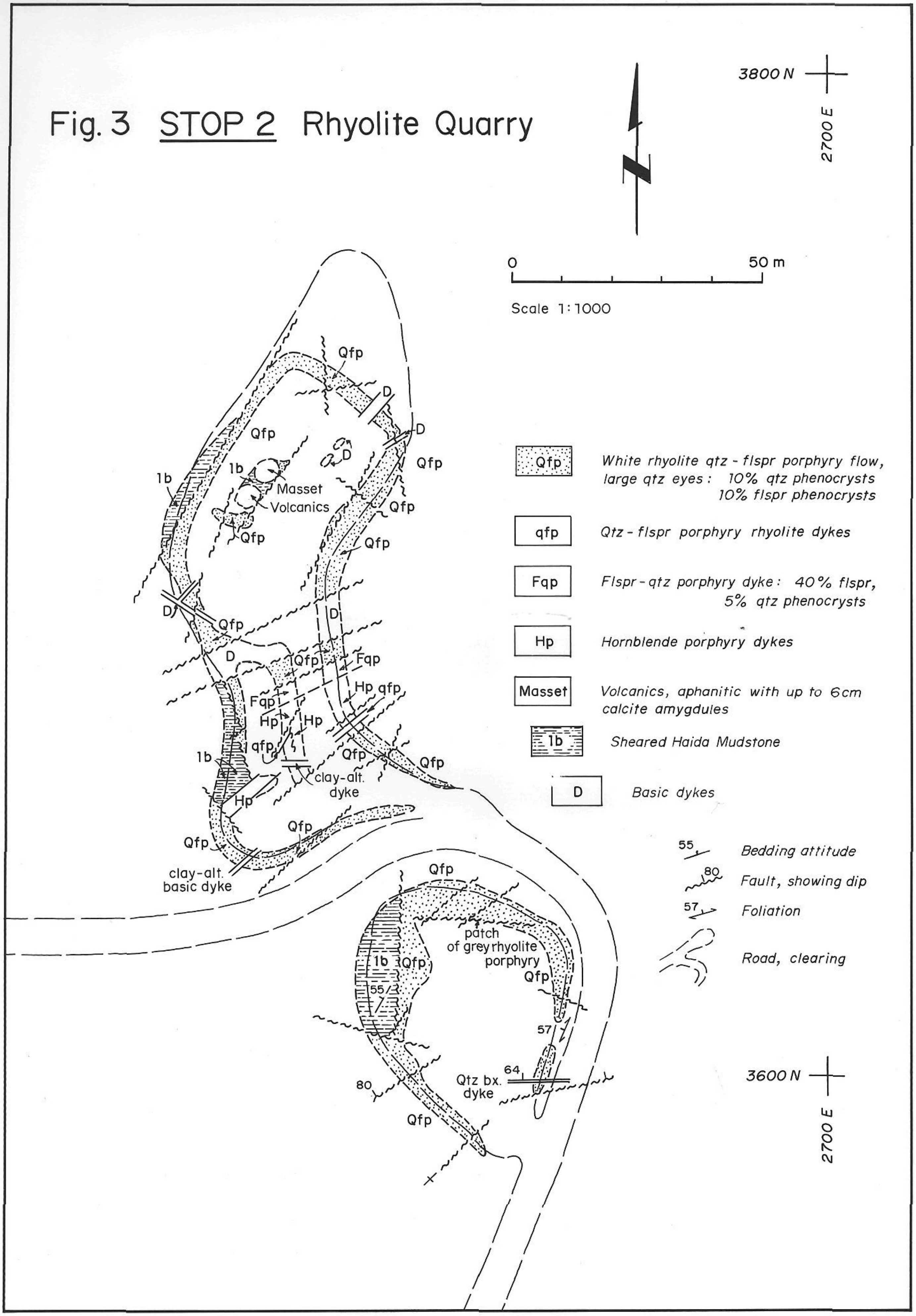


Fig. 2 STOP 1: View of silicified knoll containing the Cinola deposit (East)

Fig. 3 STOP 2 Rhyolite Quarry



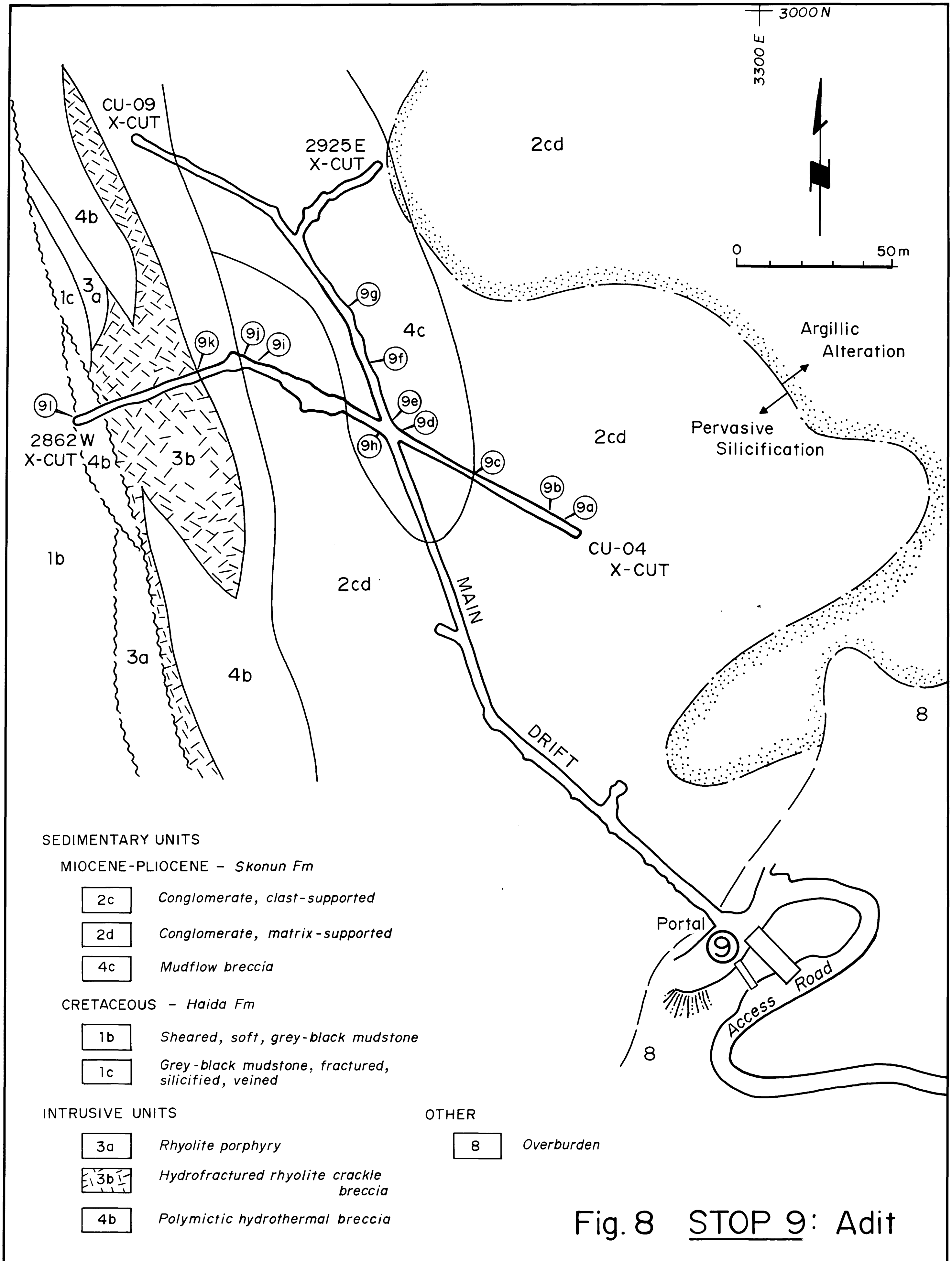


Fig. 8 STOP 9: Adit

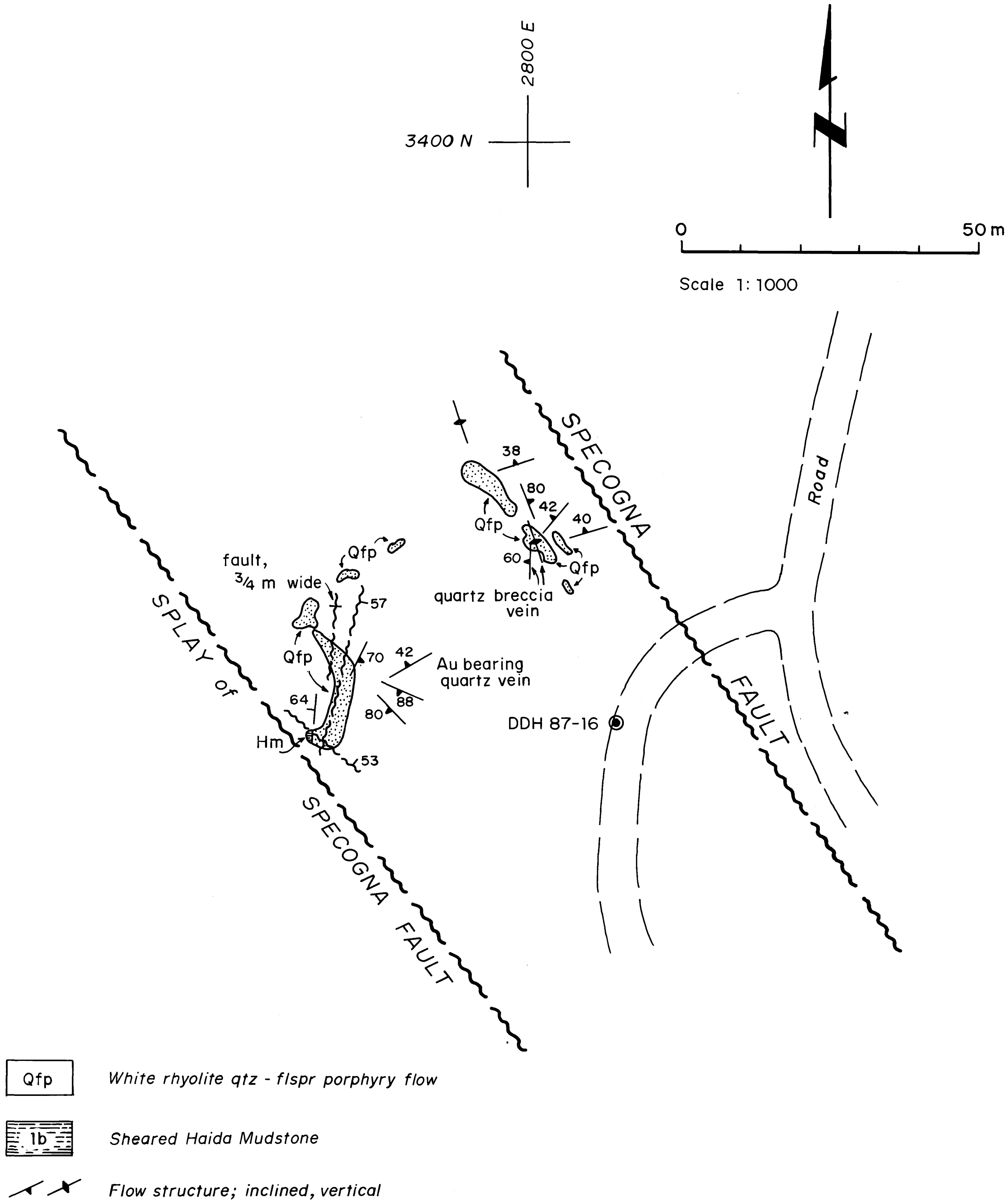


Fig. 7 STOP 8: Marino Showing

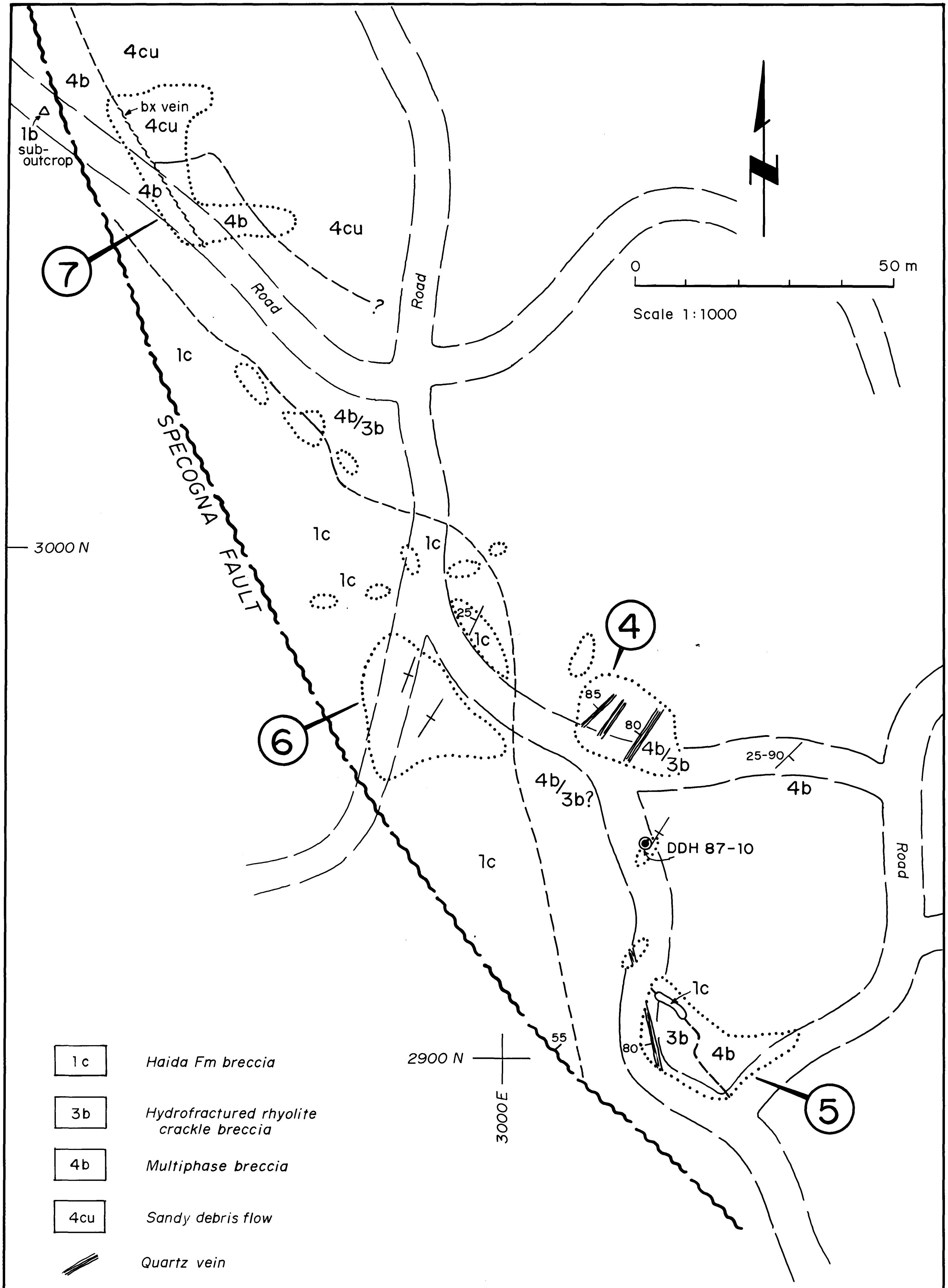
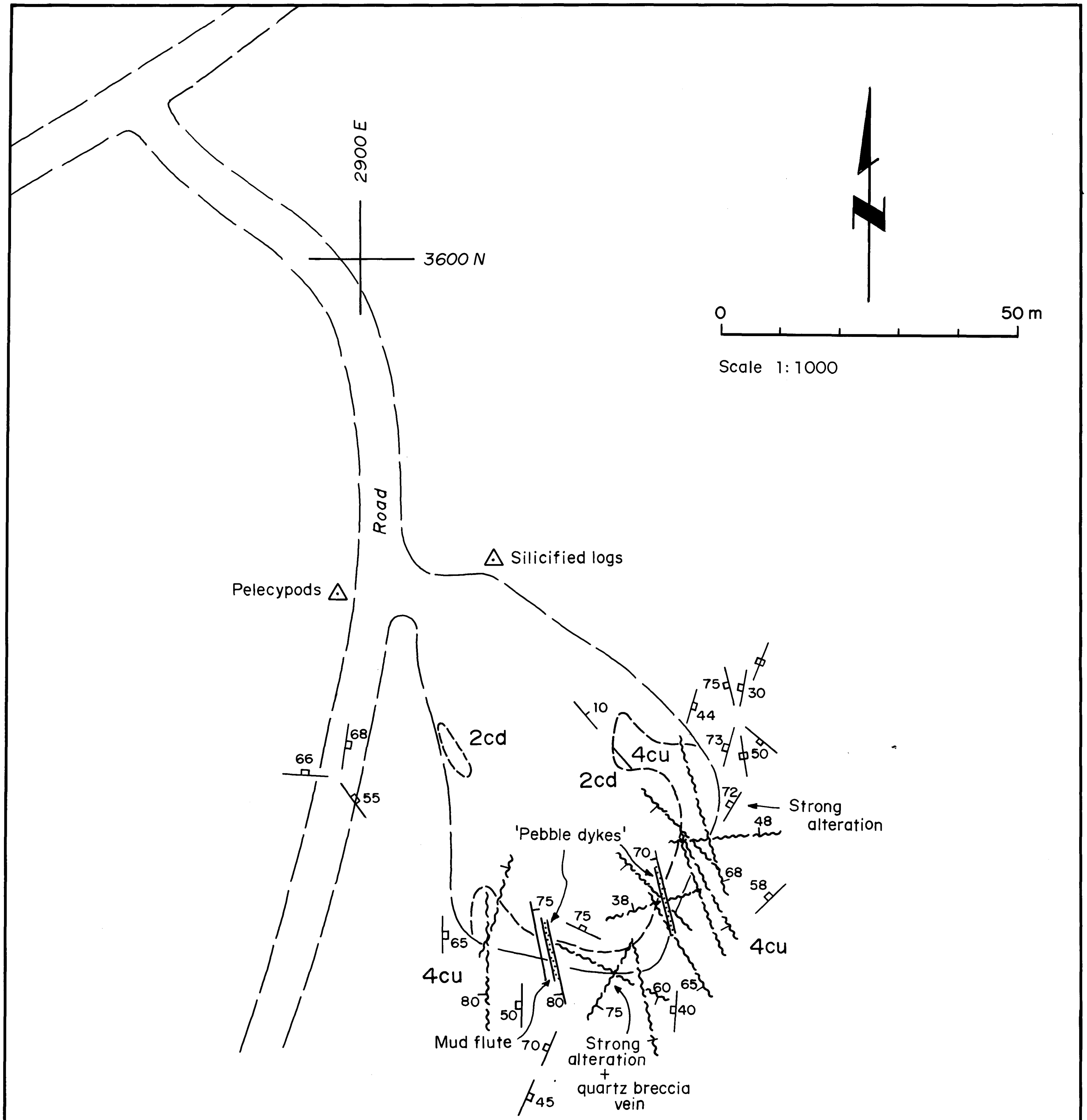


Fig. 6 STOPS 4,5,6,7



SEDIMENTARY UNITS

MIOCENE - PLIOCENE: *Skonun Formation*

2cd	*Conglomerate, clast- and matrix-supported*
4cu	*Sandy debris flow*

Fig. 5 STOP 3: Skonun Fm. sediments quarry

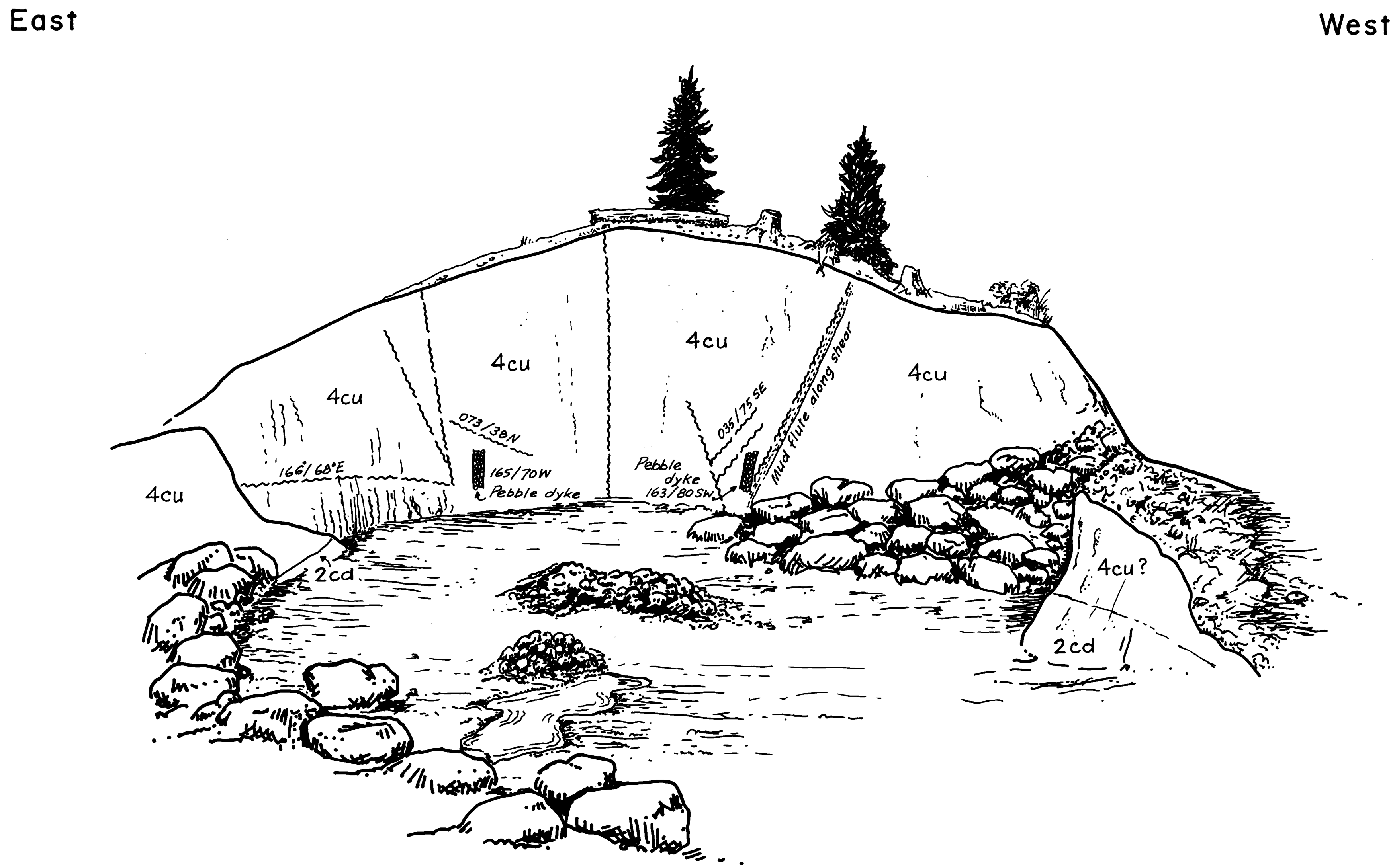


Fig. 4 STOP 3: Skonun Fm. sediments quarry (South)

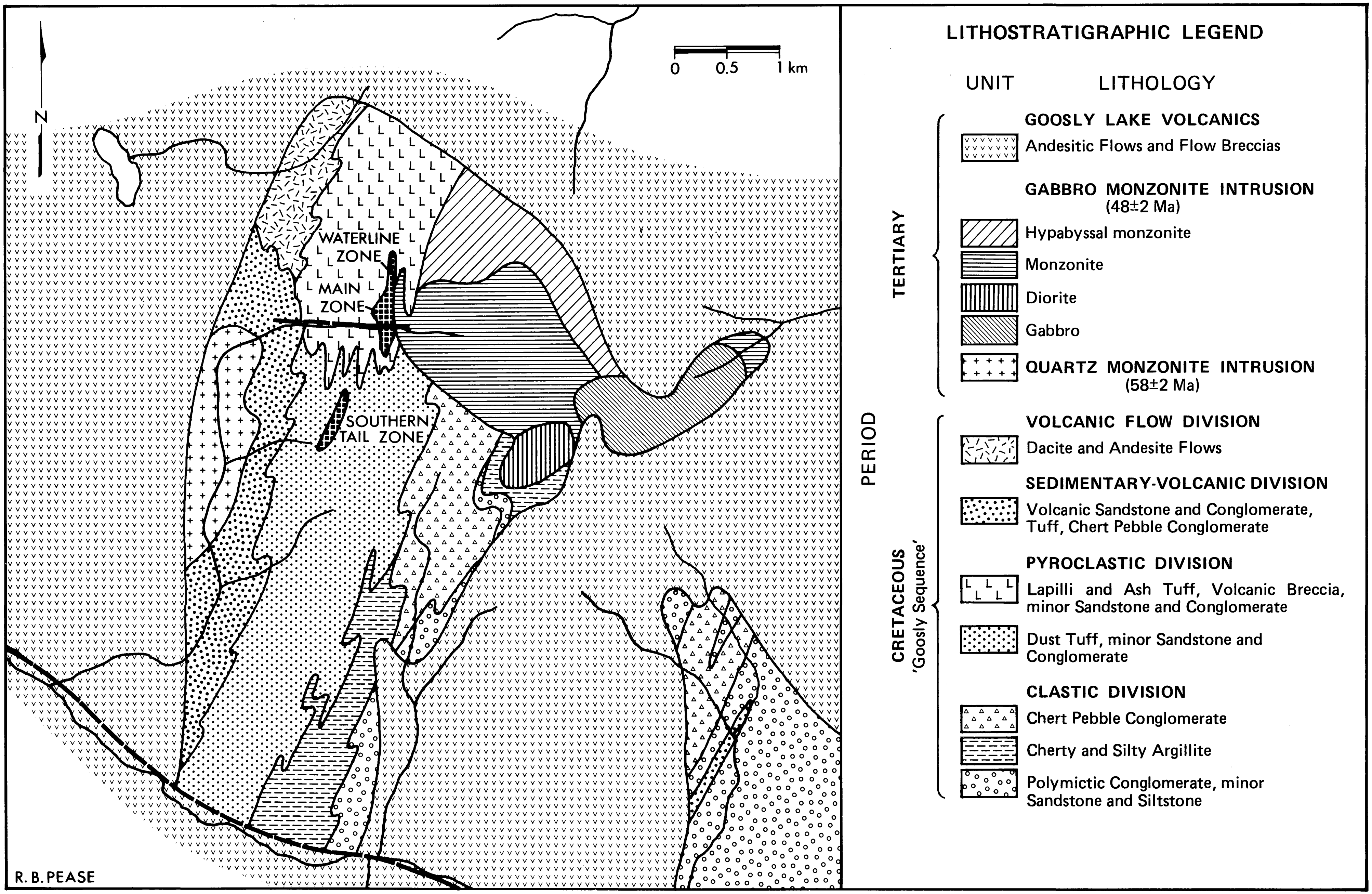


Figure 4 : Geologic Setting of the Equity Silver Mine

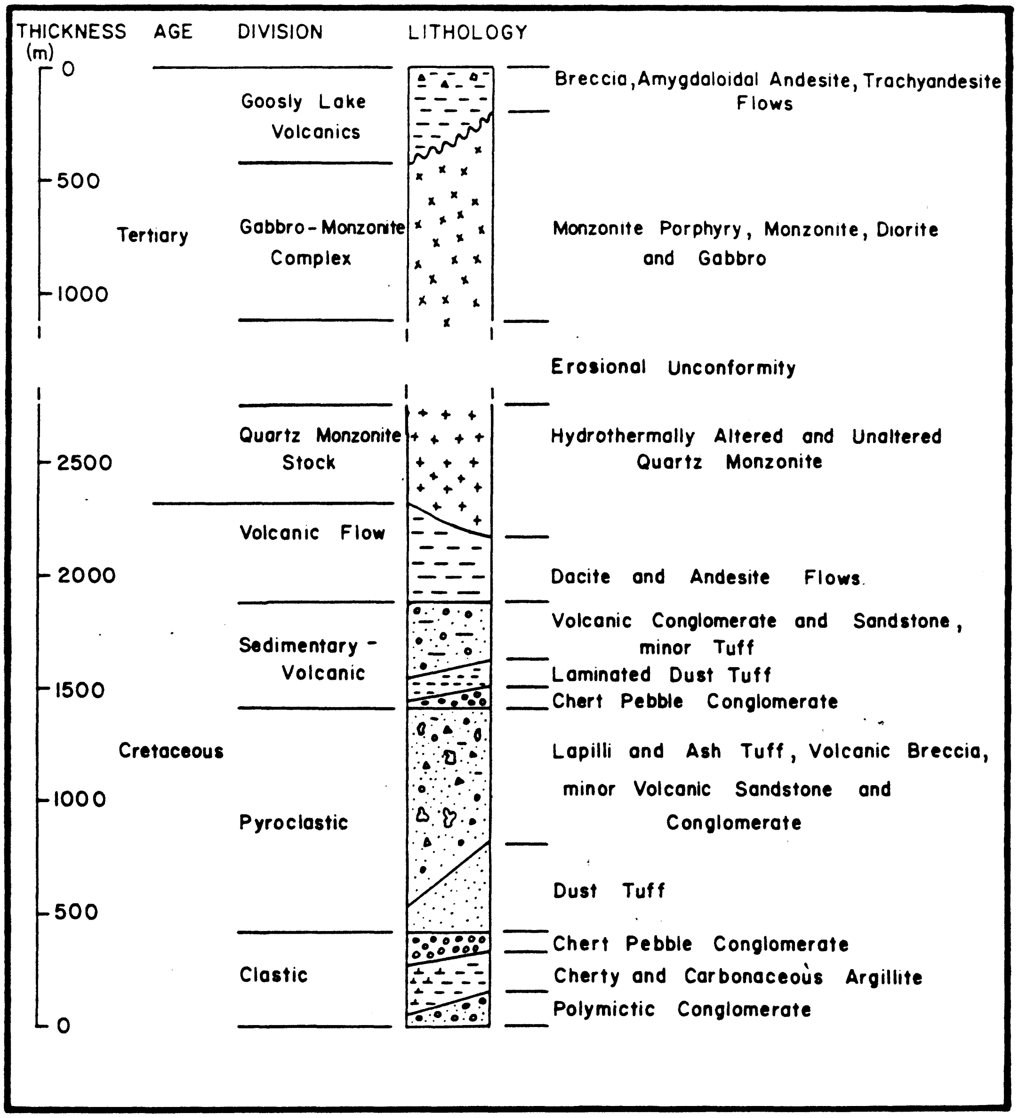


FIG. 5. Stratigraphic column, Equity Silver mine.

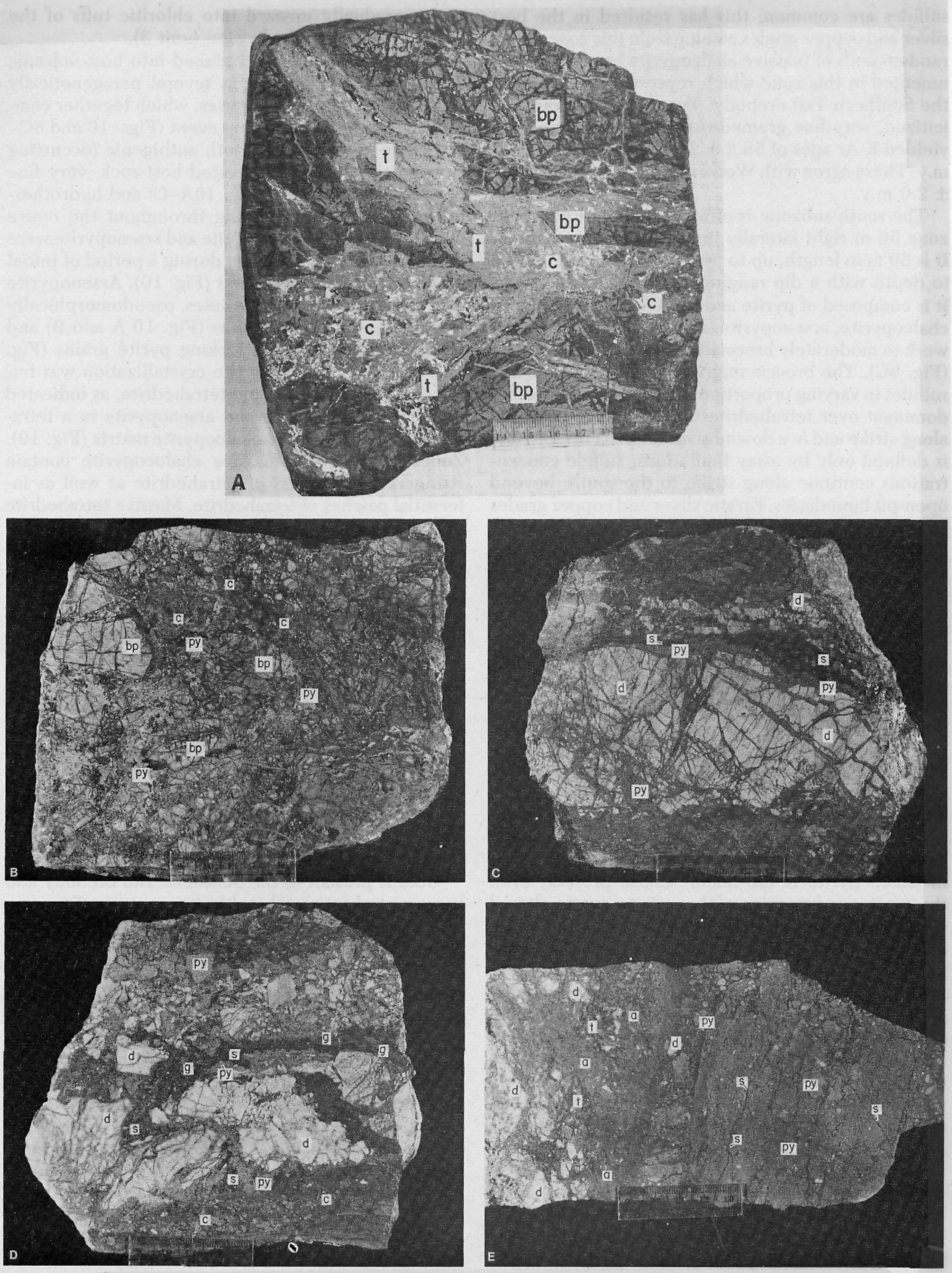


FIG. 8. Sulfide textures in ore zones. Abbreviations: a = arsenopyrite, bp = bleached pyroclastic tuff, c = chalcopyrite, cb = carbonate, d = very fine grained tuff fragments (dust tuff), g = galena, py = pyrite, s = sphalerite, t = tetrahedrite. Scale is in millimeters. A. Typical tuff breccia ore, Main zone; polished slab. B. Breccia ore, Main zone. C. Stockwork in very fine grained tuff (dust tuff), Southern Tail zone—moderately to intensely fractured specimen. D. Late-stage sphalerite-galena-pyrite breccia, Southern Tail zone. Note rimming by sphalerite and galena. E. Massive banded sulfide breccia, Southern Tail zone. Note coarse-grained recrystallized texture.

53

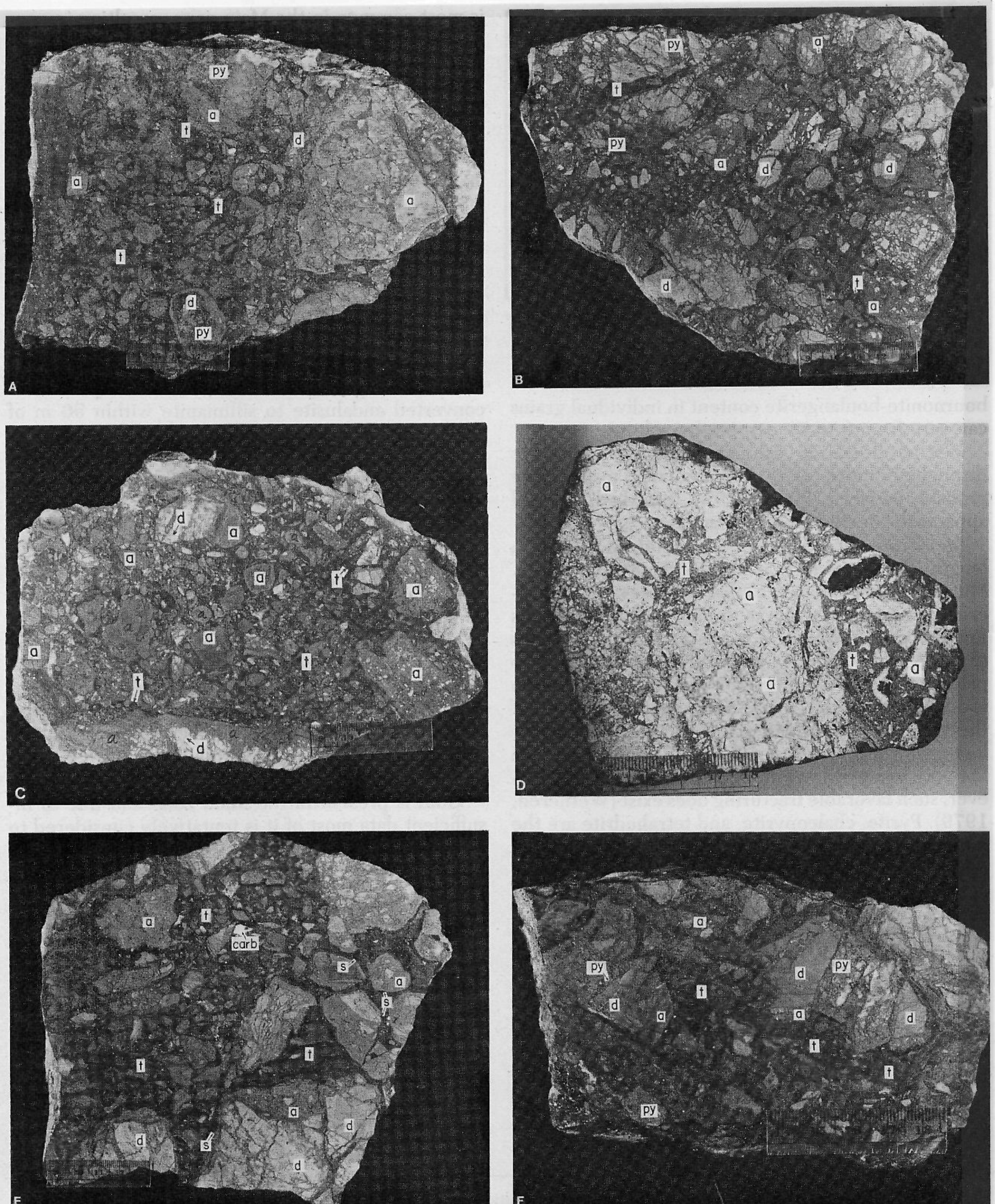


FIG. 10. Sulfide textures in ore zones; arsenopyrite = a, chalcopyrite = c, carbonate = cb, very fine grained tuff fragments (dust tuff) = d, galena = g, pyrite = py, sphalerite = s, tetrahedrite = t. Note: scale in millimeters. A. Arsenopyrite-rich replacement breccia, Southern Tail zone. Note rounding of fragments and inward growth of ore replacement by arsenopyrite. B. Arsenopyrite-rich replacement breccia, Southern Tail zone. Note rounding of fragments and replacement by arsenopyrite. C. Ar-

154

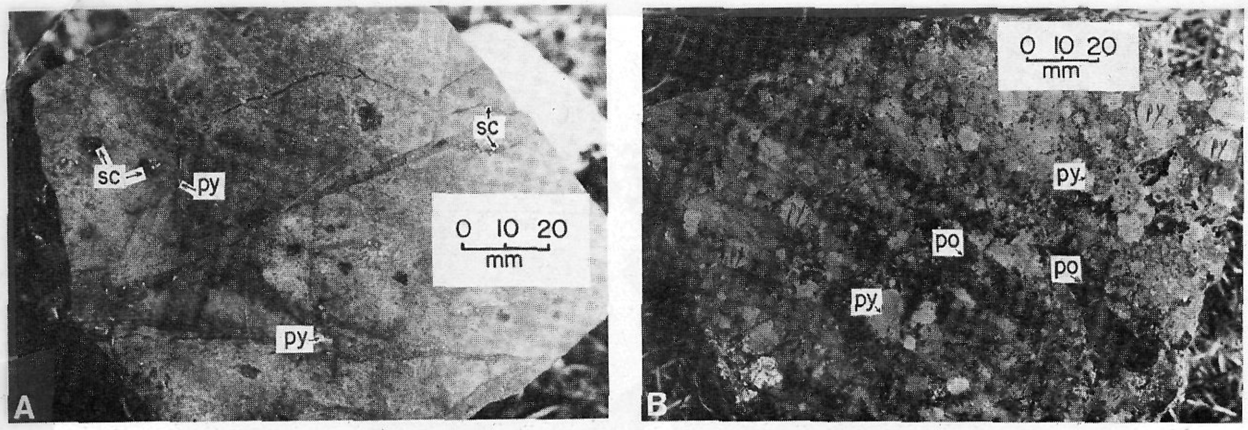


FIG. 11. Alteration and contact metamorphism textural examples. A. Alumina-rich altered tuff with blotches and veinlets of scorzalite (sc). B. Massive pyrrhotite (po)-pyrite (py) sulfide specimen exhibiting coarse recrystallized pyrite porphyroblasts in a matrix of pyrrhotite; from the contact metamorphic aureole, Main zone. Lighter colored grains are pyrite; darker colored ones are pyrrhotite.

Pervasive sericite, quartz and chlorite alteration is most common in the Main zone, resulting in nondescript grayish-green or blackish-green-colored rocks. An episode of aluminous mineral-rich alteration has resulted in the formation of coincident zones of disseminated and vein-filling andalusite, most of which has been altered to sericite, scorzalite and corundum (Wojdak, 1974; Fig. 6). Scorzalite occurs as patches, aggregates and veins with pyrite, tourmaline and corundum in the hanging wall in a broad zone 900m long and 360m wide (Wojdak, 1974). A distinct zone of corundum alteration with associated spinel and sulfides, lying stratigraphically above the ore zone has also been noted by Wojdak (1974). Rare dumortierite also occurs stratigraphically above the ore zone in the upper part of the pyroclastic division. Contact metamorphic effects associated with intrusion of gabbro-monzonite complex have converted andalusite to sillimanite within 90m of the contact (Wetherell, 1979). A recalculated K-Ar age of 49.7m.y. plus-or-minus 1.9 m.y. (Wetherell, 1979) has been obtained for the gabbro-monzonite complex. Wetherell (1979) also obtained a date of 48.3m.y. plus-or-minus 1.7 m.y. for a sample of sericitized, very fine-grained tuff from the Main zone. This date is interpreted as an older date reset by contact metamorphic effects of the gabbro-monzonite complex. The gabbro-monzonite complex bounds the ore zone on the footwall.

Silica alteration, variable in intensity and occuring in irregular patches, has produced medium to dark gray hard, extremely competent rocks (Fig. 8A and B). The combination of silicification and aluminization has resulted in the extremely rare juxtaposition of quartz and corundum which occur together in small veinlets.

Gold is present in the Main zone and is seen to occur as less than 10-micron-wide patches in chalcopyrite and as individual grains in gangue in contact with chalcopyrite and tetrahedrite. These grains were seen to be up to 100 microns in size. Bournonite, boulangerite and jamesonite occur as patches and blebs in tetrahedrite, galena, sphalerite, pyrite and gangue. Mariano (1971) reports boulangerite needles cross-cutting calcite grains, probably representing a late-stage crystallization feature. Tungsten in the form of wolframite was identified in Main zone polished sections as subrounded and subhedral grains up to several hundred microns long in gangue.

57