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Big Missouri precious-base metal deposit, northwest British Columbia

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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.

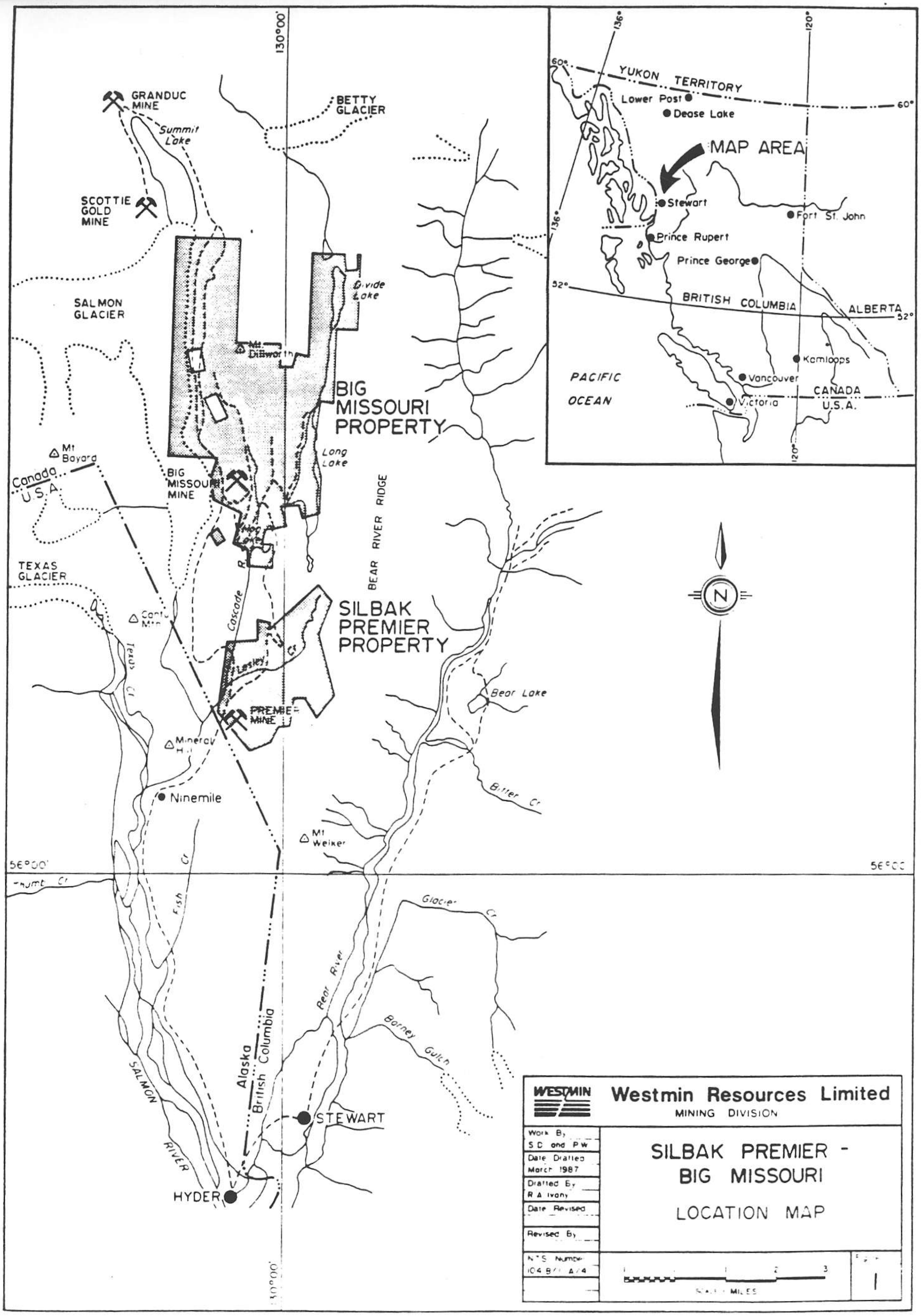
Precious-base metal mineralization in the cherty tuff and silica and sericite alteration of the andesite are interpreted to have formed on or near the seafloor as the result of submarine exhalative activity. Cherty layers and sulphide lenses were deposited during periods of quiescence. Distribution of 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
Mt. Dillworth
Divide Lake
BIG MISSOURI PROPERTY
Long Lake
Mt Bayard
Canada
U.S.A.
BIG MISSOURI MINE
BEAR RIVER RIDGE
TEXAS GLACIER
Cascade
SILBAK PREMIER PROPERTY
Lesley Cr
PREMIER MINE
Bear Lake
Mineral Hill
Ninemile
Bitter Cr
Mt Welker
56°00'
Fish Cr
Texas Cr
Glacier Cr
Bear River
Barney Gulch
SALMON RIVER
Alaska
British Columbia
STEWART
HYDER
YUKON TERRITORY
60°
136°
120°
Lower Post
Dease Lake
MAP AREA
Stewart
Fort St. John
Prince Rupert
Prince George
52°
BRITISH COLUMBIA
ALBERTA
PACIFIC OCEAN
Kamloops
Vancouver
Victoria
CANADA
U.S.A.
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
1

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.

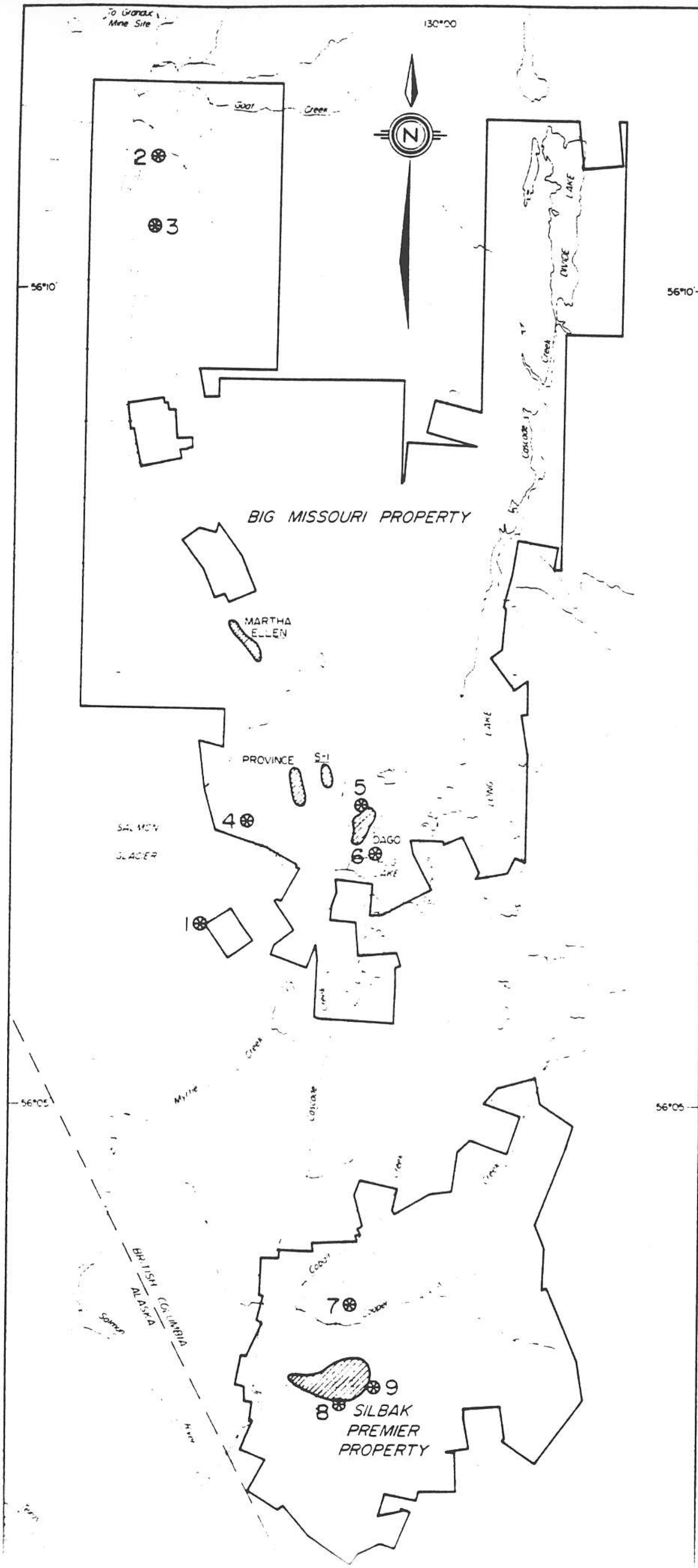
D. GEOLOGY OF THE BIG MISSOURI PROPERTY

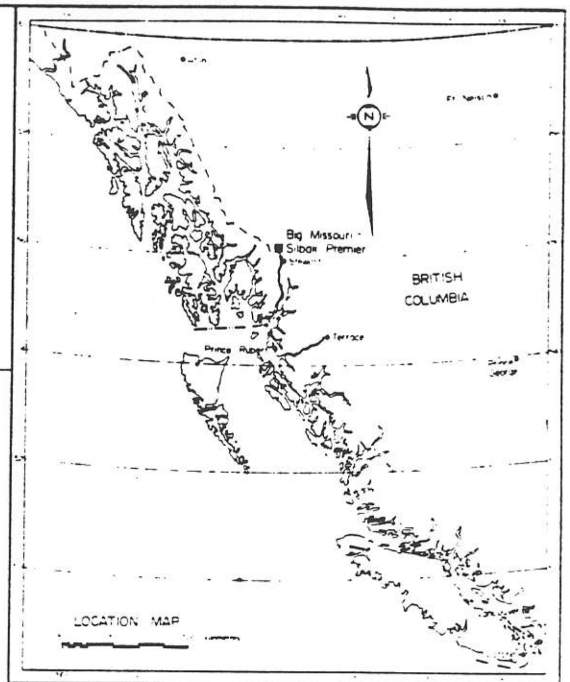
The Big Missouri property is underlain by a southwest facing, moderately dipping sequence of volcanic and volcaniclastic rocks belonging to the Hazelton Group (Figure 4, Table 1). Figures 5 and 6 show an east-west orientated stratigraphic sections of the Hazelton Group as it appears on the Big Missouri 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,

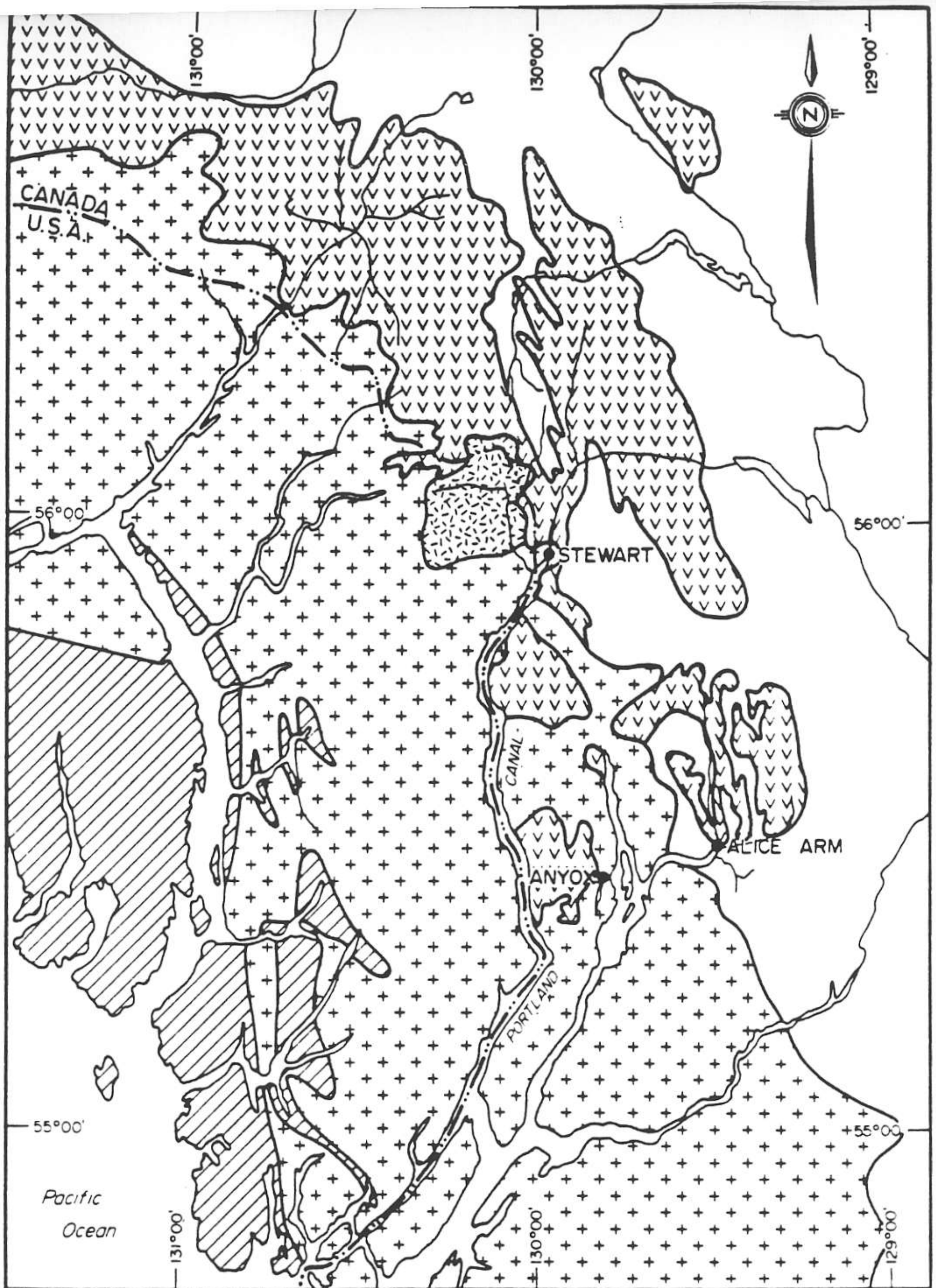




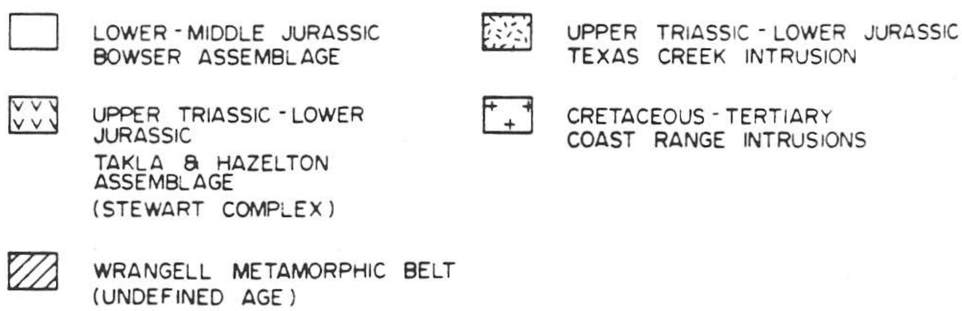
⊛ FIELD TRIP STOP

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	

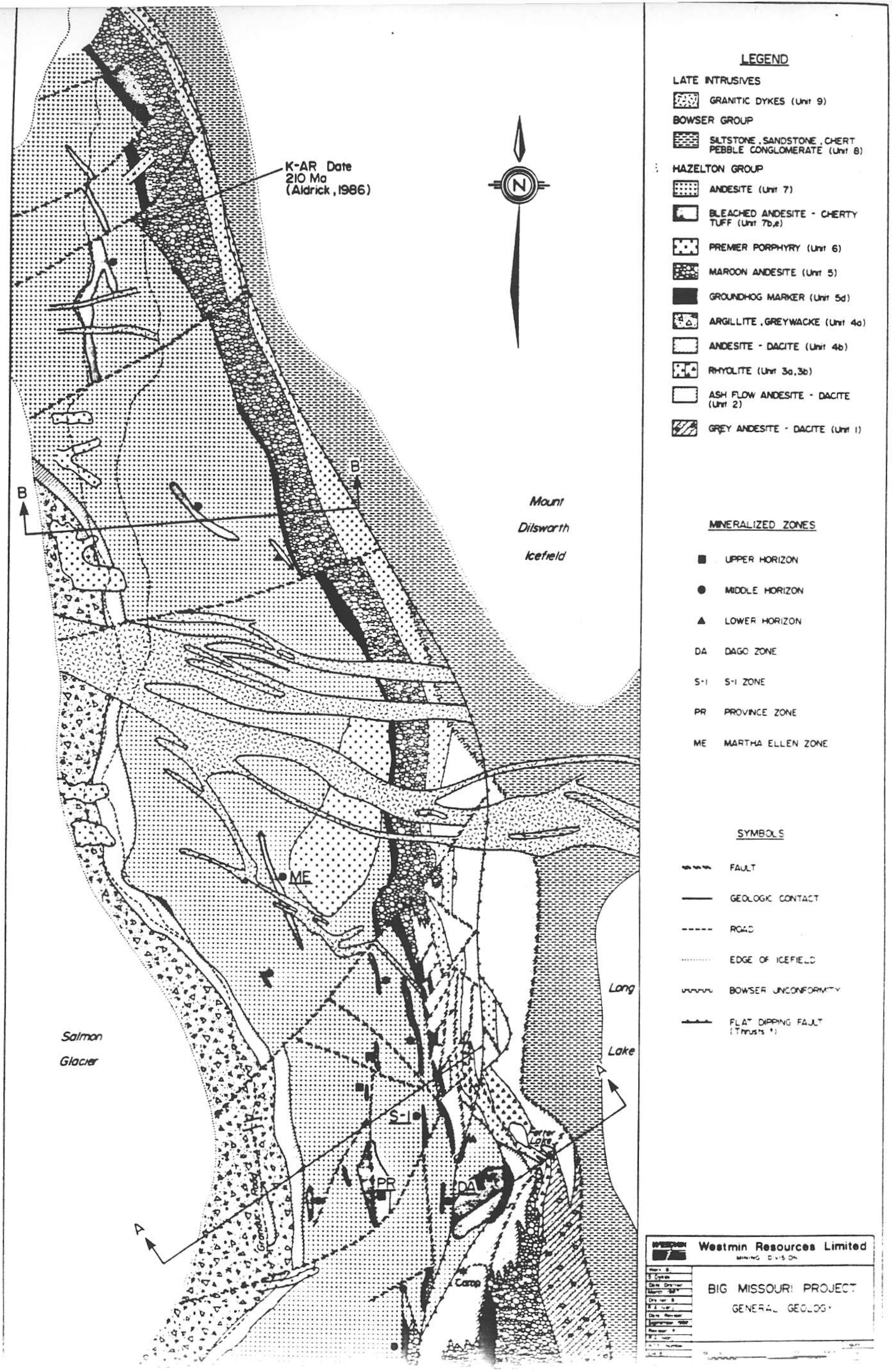


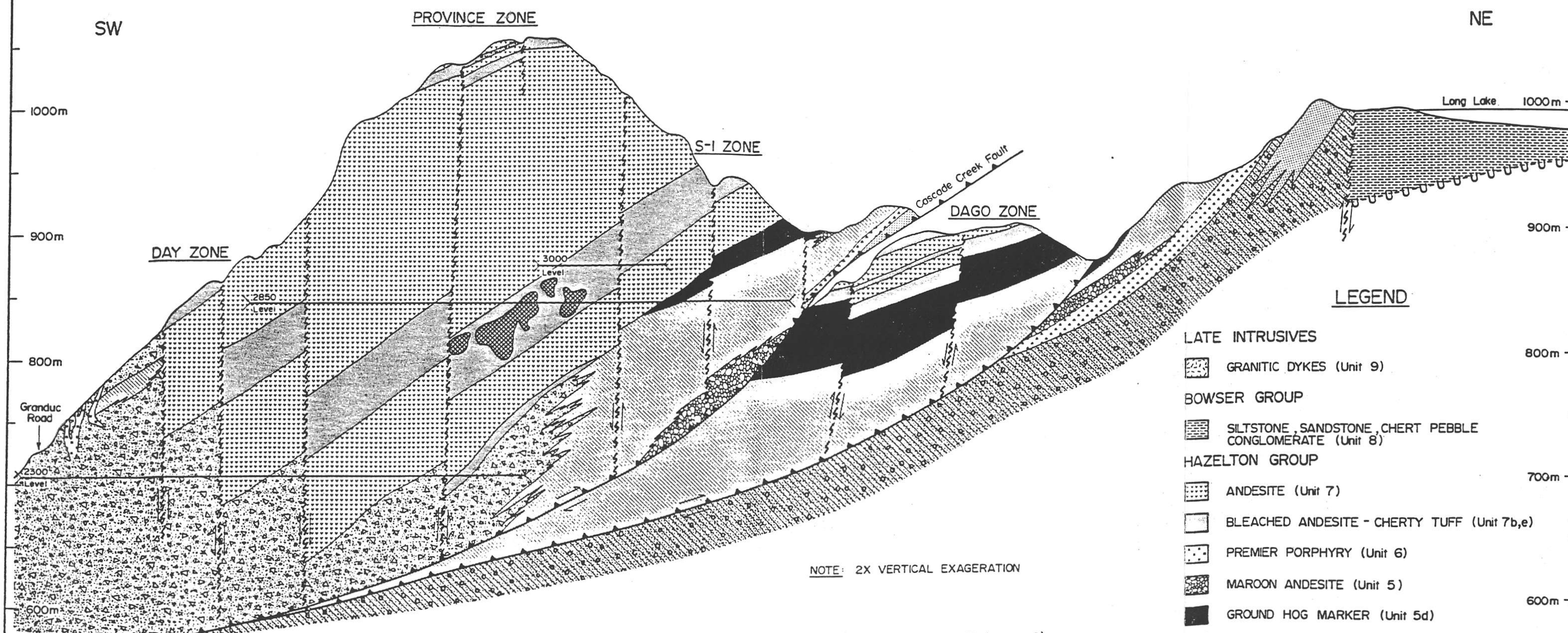
LEGEND



REGIONAL GEOLOGY OF THE STEWART - ANYOX AREA

Figure 3


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
BOWSER UNCONFORMITY
FLAT DIPPING FAULT (Thrusts ?)
K-AR Date
210 Ma
(Aldrick, 1986)
N
B
B
Mount
Dilsworth
Icefield
ME
Long
Lake
Salmon
Glacier
S-1
PR
DA
A
A
Camp
Westmin Resources Limited
MINING DIVISION
BIG MISSOURI PROJECT
GENERAL GEOLOGY



NOTE: 2X VERTICAL EXAGERATION

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)

GROUND HOG MARKER (Unit 5d)

ARGILLITE, GREYWACKE (Unit 4a)

ANDESITE - DACITE (Unit 4b)

RHYOLITE (Unit 3)

ASH FLOW ANDESITE - DACITE (Unit 2)

GREY ANDESITE - DACITE (Unit 1)

FLAT DIPPING FAULT (thrusts?)

FAULT (with displacement)

CONTACT

BOWSER UNCONFORMITY

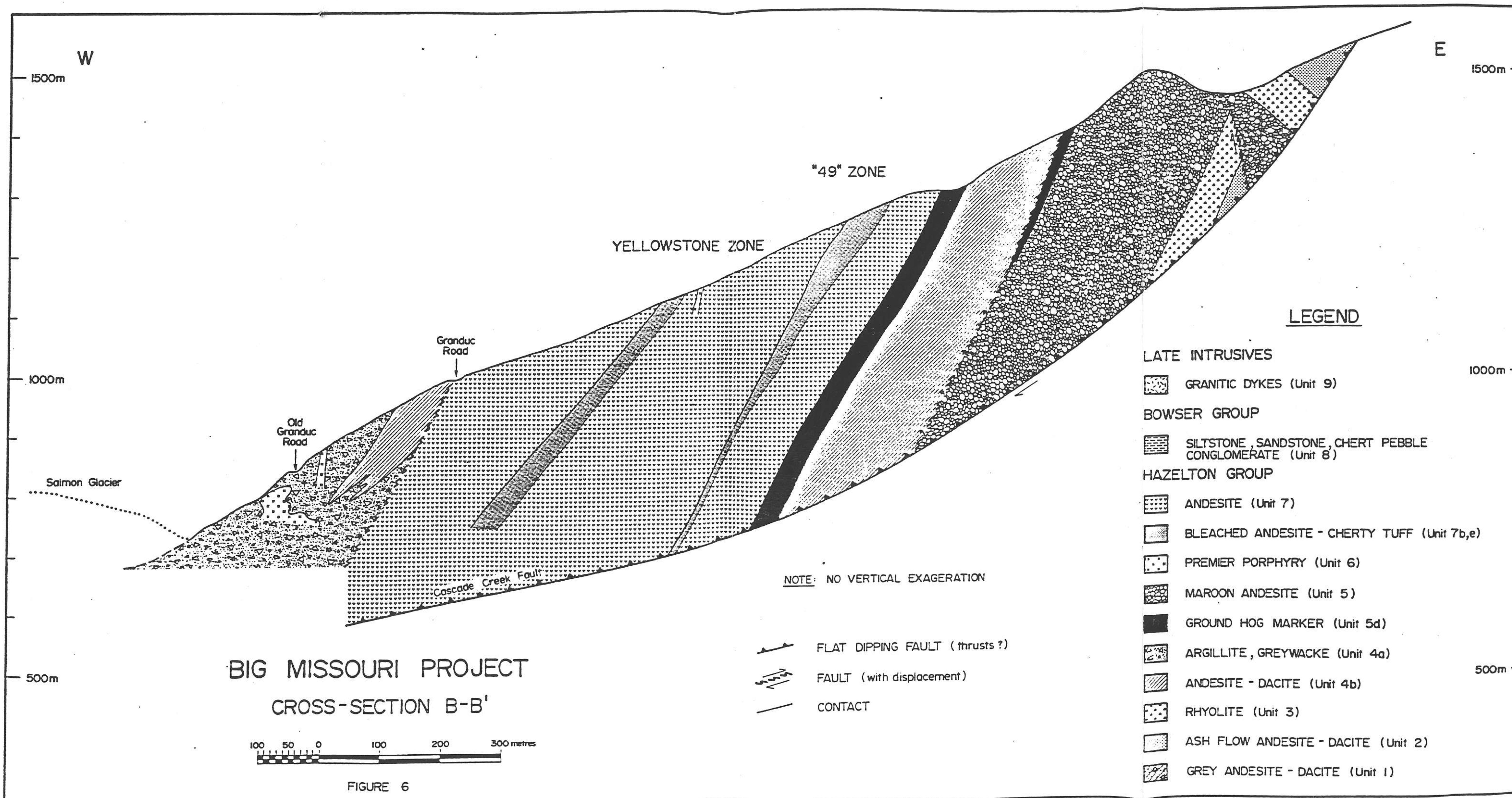
1938-42 UNDERGROUND MINING AREA

BIG MISSOURI PROJECT

CROSS-SECTION A-A'

100 50 0 100 200 300 metres

FIGURE 5



BIG MISSOURI PROJECT

CROSS-SECTION B-B'

FIGURE 6

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 sedimantary 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.

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

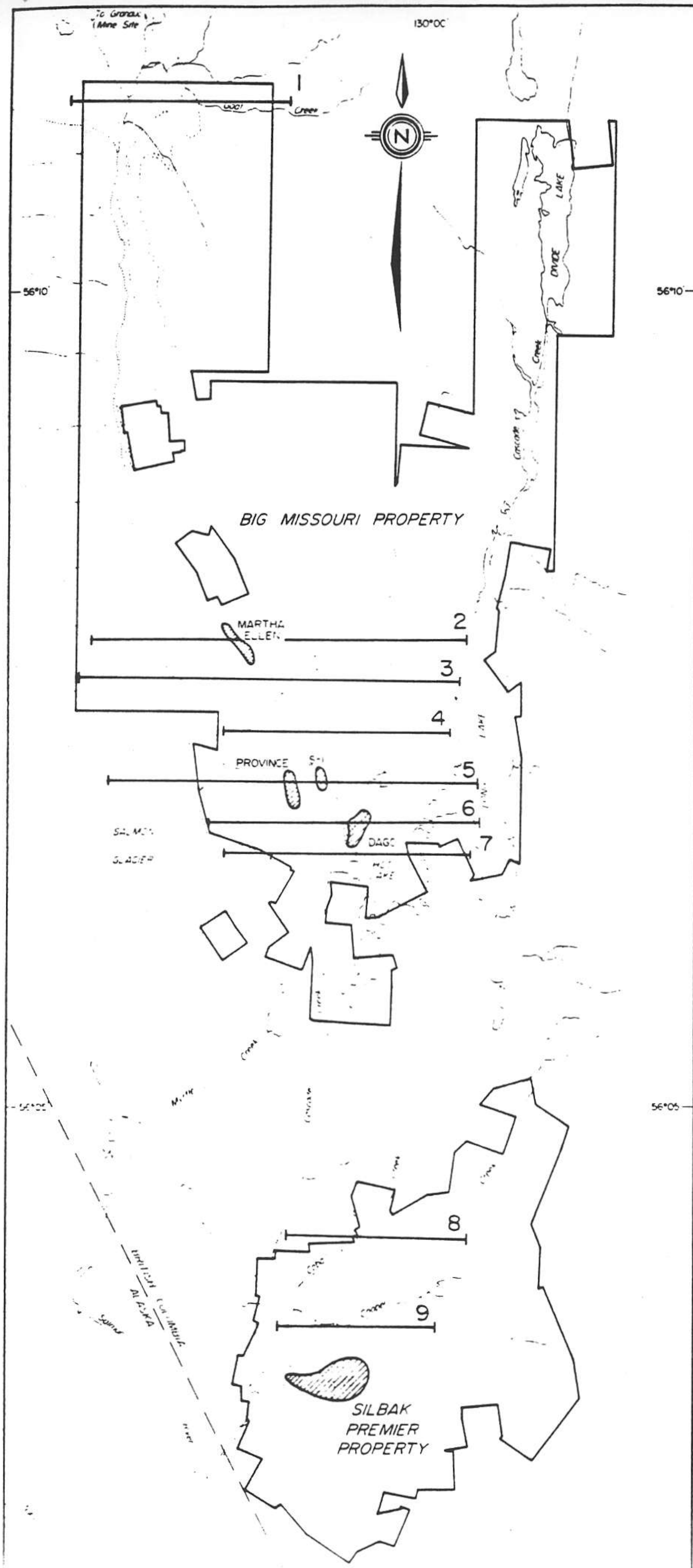
5. **Maroon Andesite Volcaniclastic Unit**
   a) Agglomerate, volcanic conglomerate and tuff; mixed maroon and green
   b) Volcanic wacke; maroon
   c) Dacite; lapillistone, tuff, agglomerate-quartz phenocrysts
   d) Ground Hog marker - extrusive equivalent of 6a

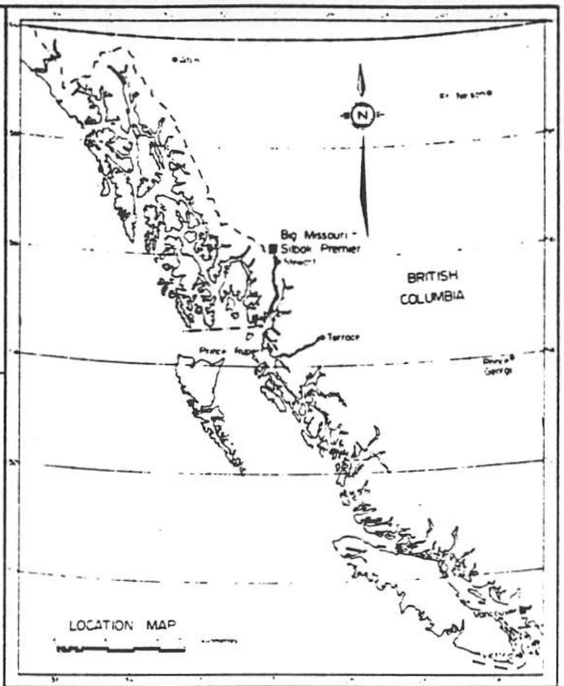
4. **Siltstone Unit** (Facies equivalent Unit 5)
   a) Black carbonaceous tuffaceous siltstone, argillaceous limestone and volcanic wacke
   b) Basaltic andesite to dacite flows, tuff and agglomerate

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

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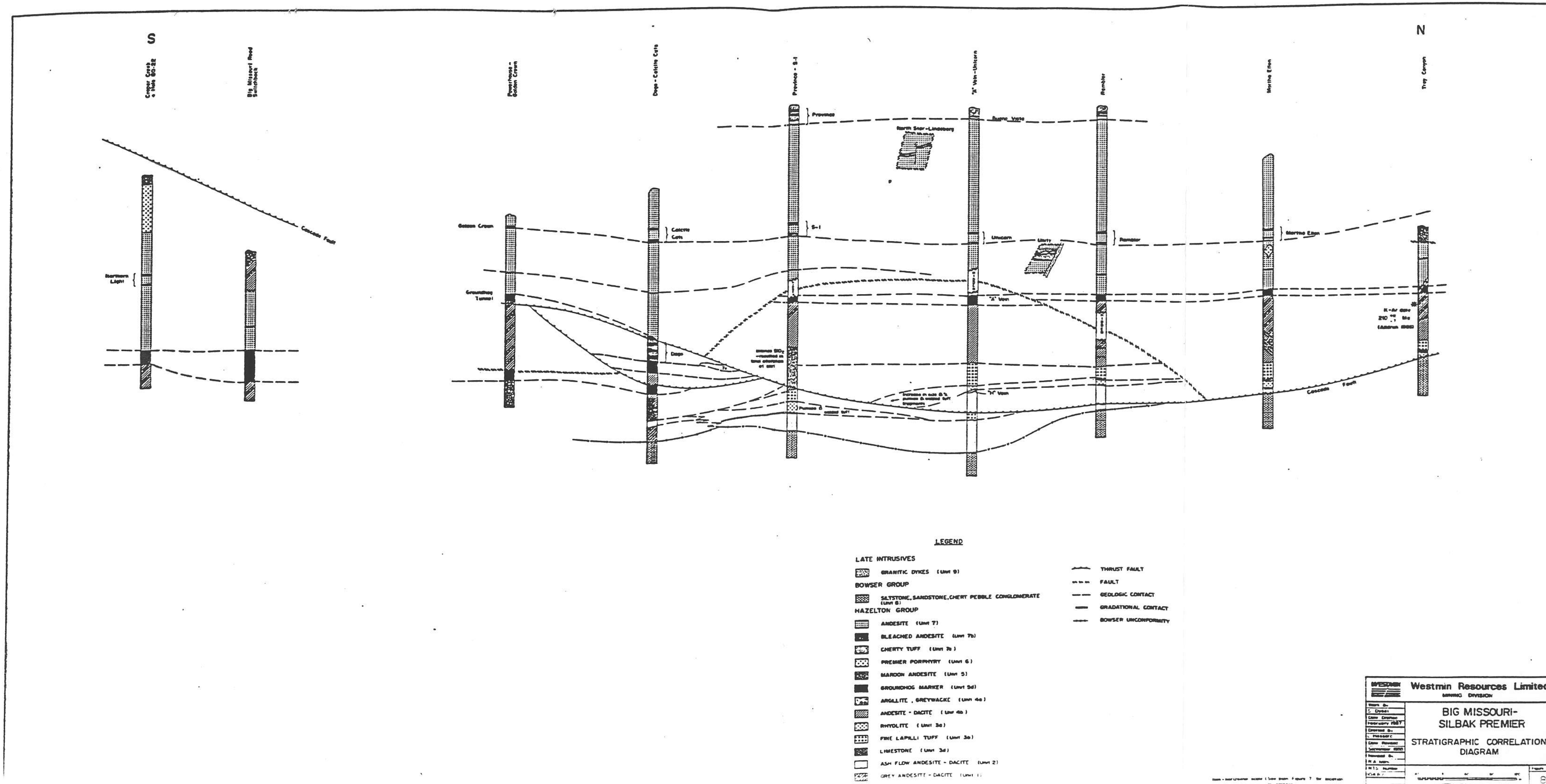
MINING DIVISION

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	Figure


S
N
Cascade Fault
Groundhog Tunnel
Golden Crown
LEGEND
LATE INTRUSIVES
GRANITIC DYKES (Unit 9)
BOWSER GROUP
SILTSTONE, SANDSTONE, CHERT PEBBLE CONGLOMERATE (Unit 8)
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ANDESITE - DACITE (Unit 4b)
RHYOLITE (Unit 3a)
FINE LAPILLI TUFF (Unit 3b)
LIMESTONE (Unit 3d)
ASH FLOW ANDESITE - DACITE (Unit 2)
GREY ANDESITE - DACITE (Unit 1)
THRUST FAULT
FAULT
GEOLOGIC CONTACT
GRADATIONAL CONTACT
BOWSER UNCONFORMITY
Westmin Resources Limited
MINING DIVISION
BIG MISSOURI-
SILBAK PREMIER
STRATIGRAPHIC CORRELATION
DIAGRAM
8

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 severel 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.

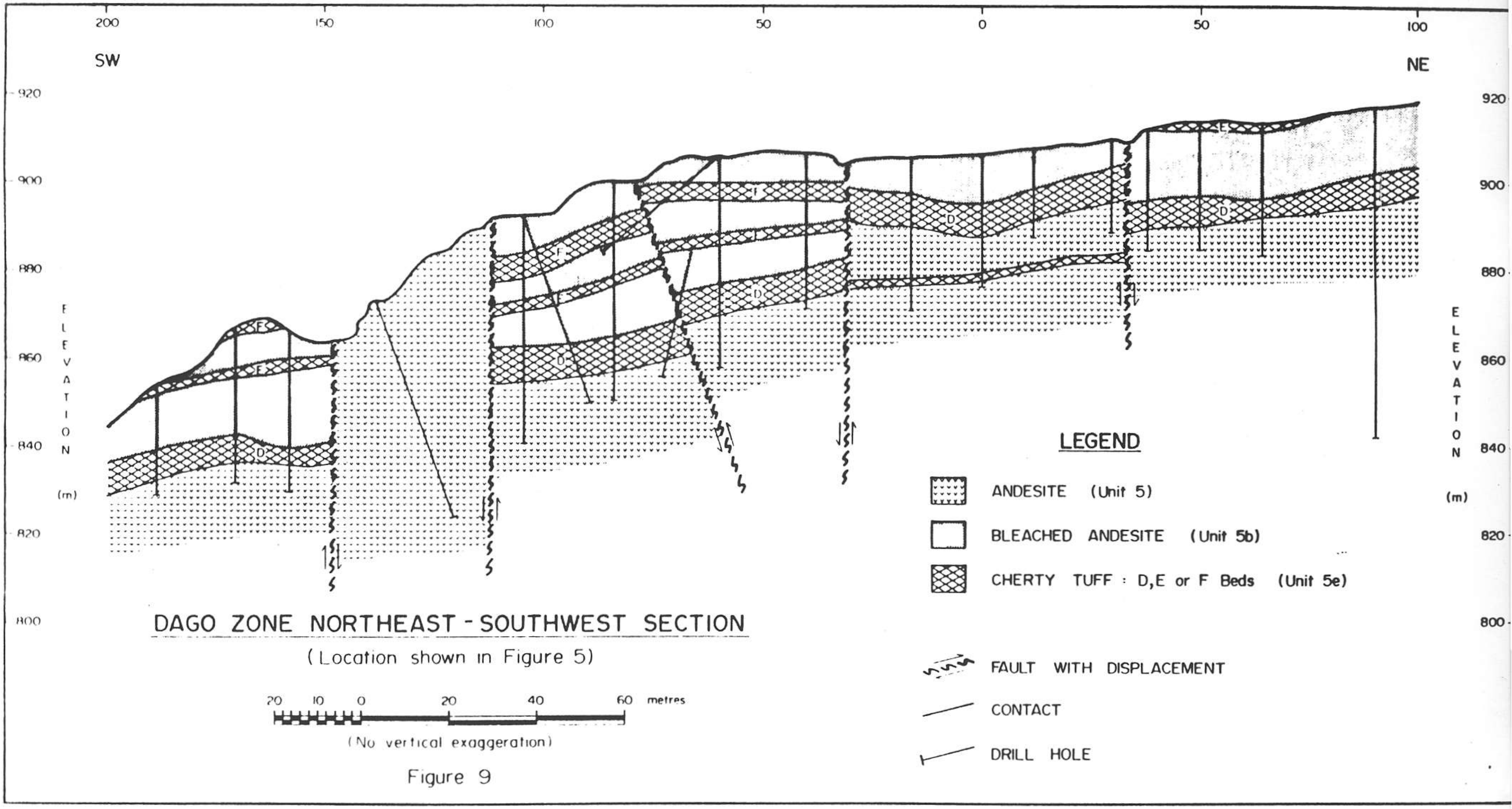
In addition to stratabound mineralization, there are numerous late crosscutting quartz veins containing coarse-grained pyrite, sphalerite and galena. Figure 4 shows the location of the various mineralized zones and showings on the property.

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

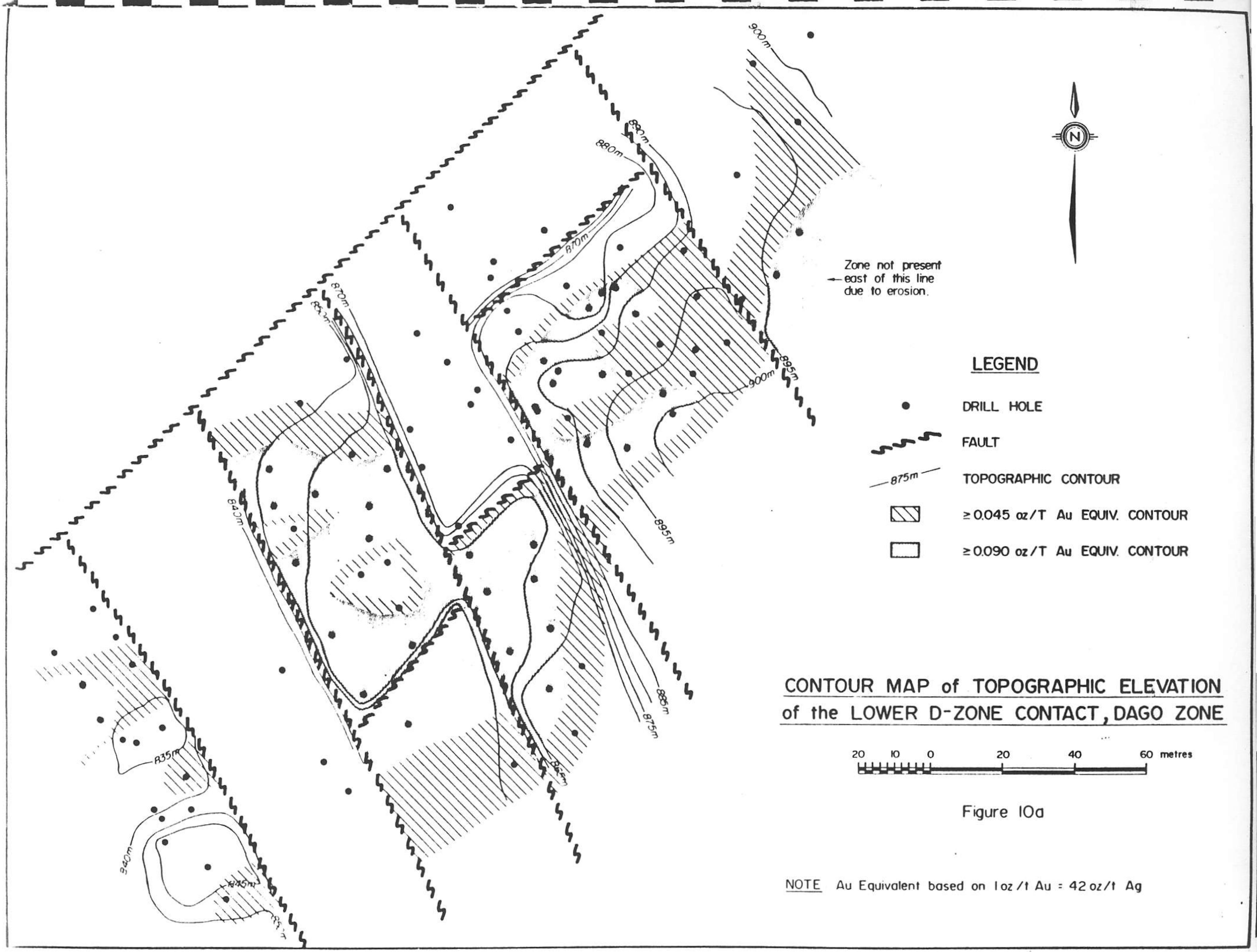
Located at the south end of the property, the Dago Zone is one of the main near-surface zones. Green plagioclase-amphibole andesite agglomerate and lapilli tuff predominate with lesser bleached andesite and cherty tuff. The three cherty tuff beds that make up the Dago Zone are 1 to 5m thick and separated 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.



DAGO ZONE NORTHEAST - SOUTHWEST SECTION

(Location shown in Figure 5)

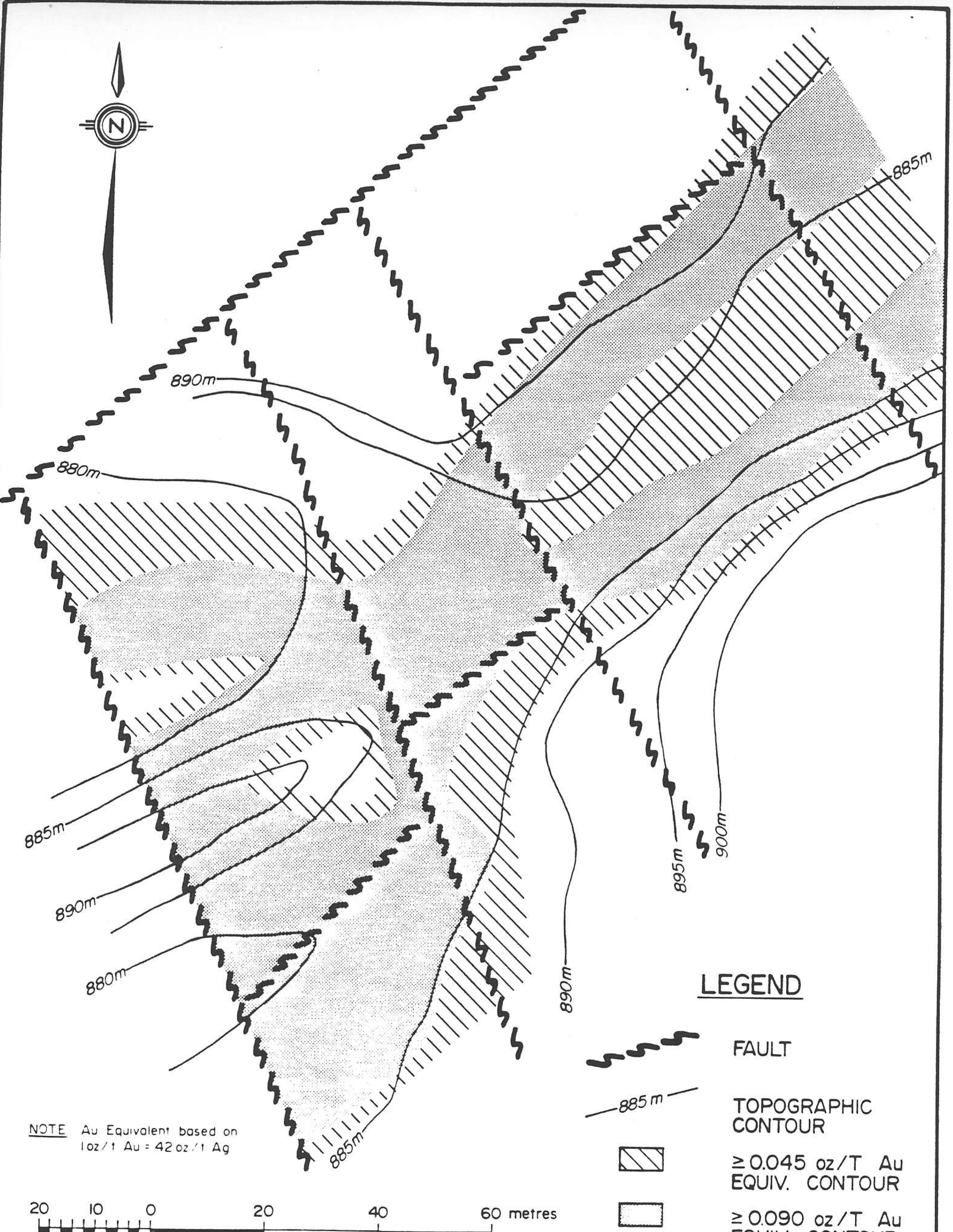
Figure 9



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

Figure 10a

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



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

Figure 10b

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 oonsists 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 oontaining up to 5 mm long, subhedral plagioclase feldspar snd 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 rn apart separated by anbesite 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.

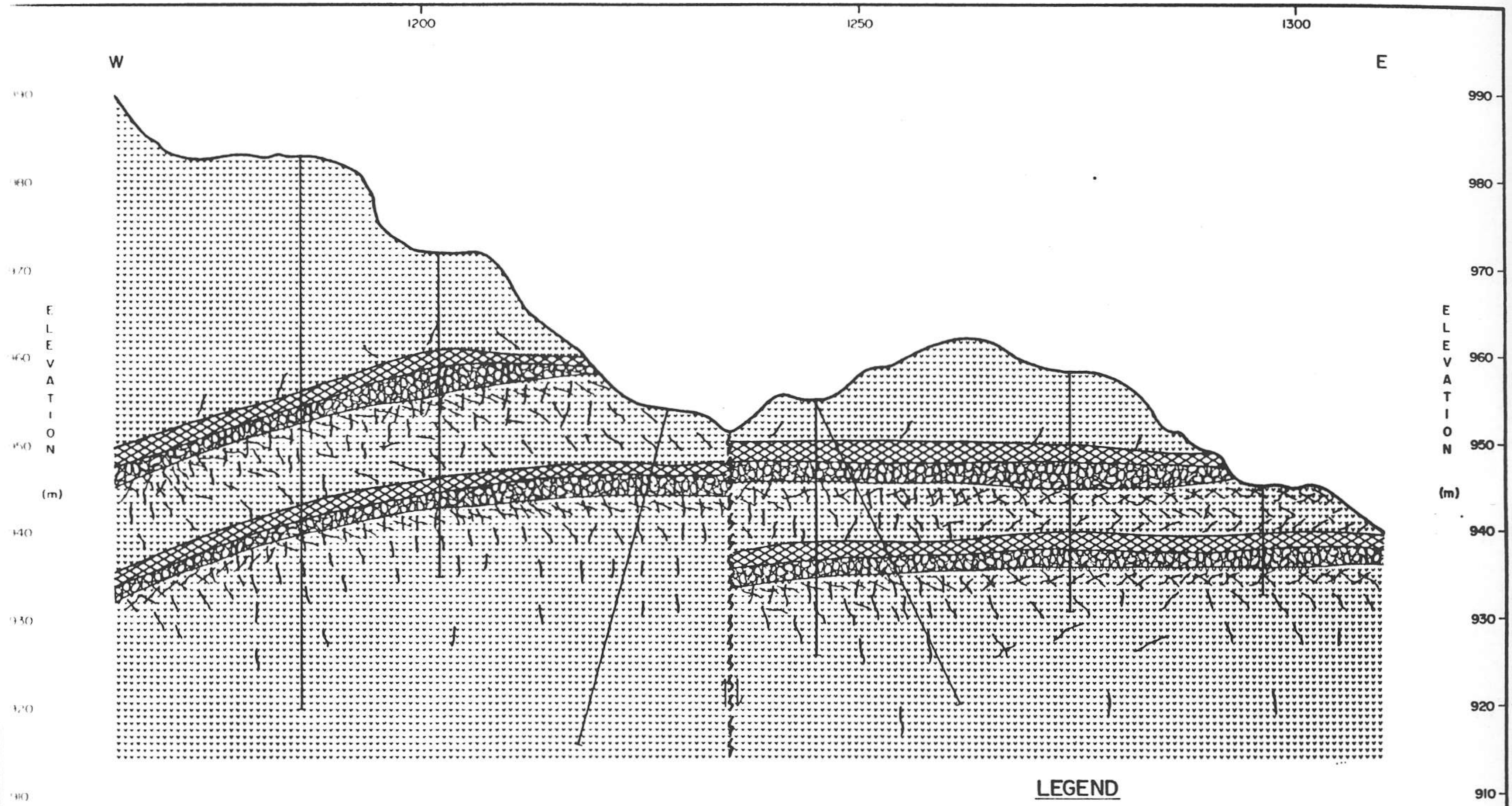
Geological reserve estimates indicate 557,000 tonnes grading 2.92 g/tonne Au equivalent (Au equivalent is based on 1 g/t Au = 100 g/t Ag) within the Dago Zone.

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



LEGEND

- ANDESITE (Unit 5)
- FOOTWALL STRINGER (Unit 5)
- FOOTWALL BRECCIA (Unit 5)
- CHERTY TUFF (Unit 5e)
- FAULT WITH DISPLACEMENT
- CONTACT
- DRILL HOLE

S-1 ZONE EAST-WEST SECTION

(Location shown in Figure 5)

10 5 0 10 20 30 metres

(No vertical exaggeration)

Figure 11

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.

Upper Horizon

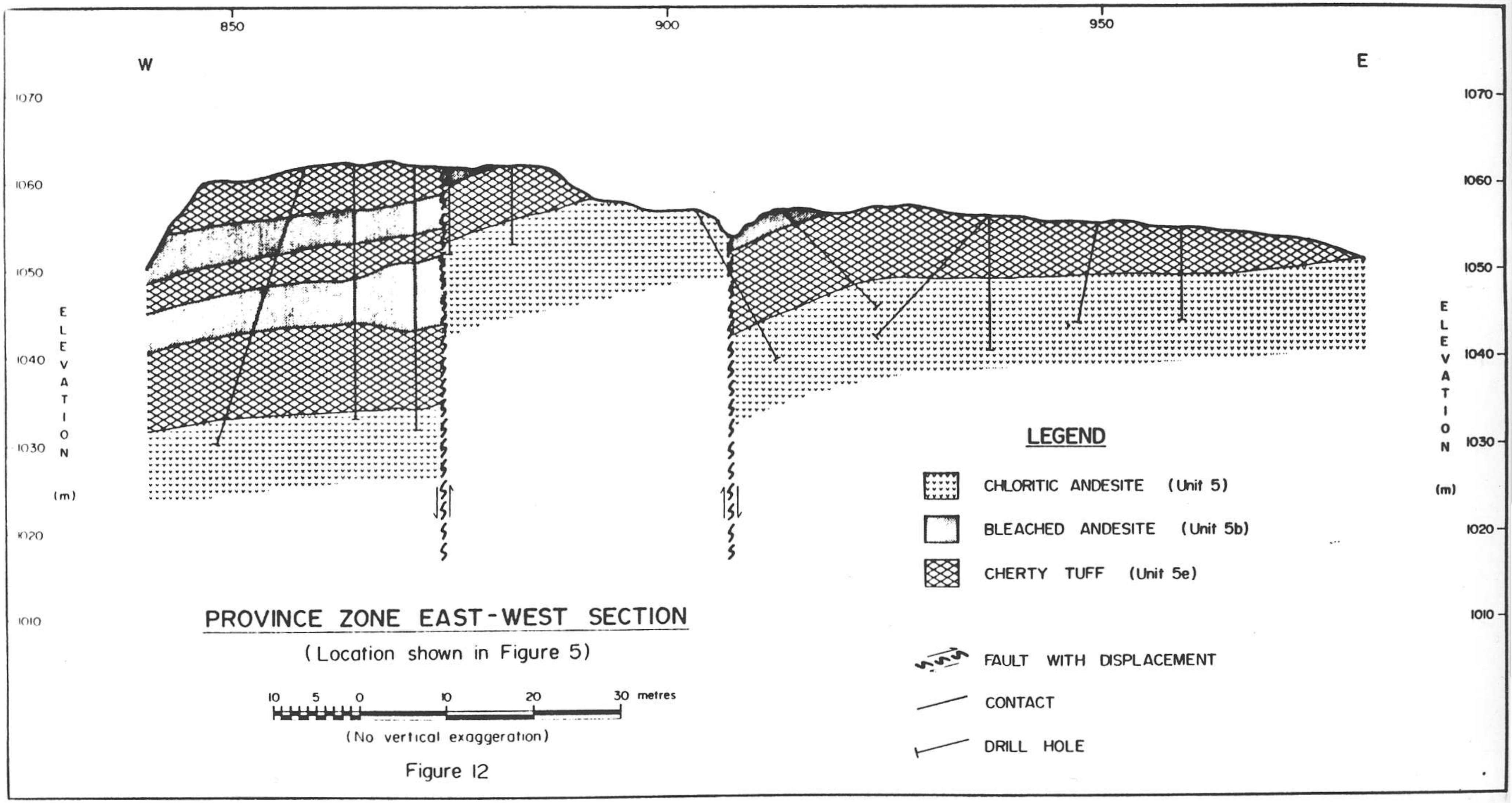
Best illustrated by the Province zone, the Upper Horizon is characterized by a general lack of carbon or carbonate and a well developed chlorite footwall.

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.



PROVINCE ZONE EAST-WEST SECTION

(Location shown in Figure 5)

Figure 12

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-beering 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 e 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.

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