Tom - other Big Mo slices to come early in New Year

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BIG MISSOURI PRECIOUS-BASE METAL DEPOSIT, NORTHWEST BRITISH COLUMBIA

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TABLE OF CONTENTS

PAGE

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 fine disseminated to semi-massive sulphide lenses, are recognized. Gold and silver minerals electrum, argentite, native silver and tetrahedrite occur as small grains on grain boundaries and fractures in the sulphides and within quartz gangue. Wallrock alteration, sulphide mineralogy, precious-base metal ratios and style or habit of mineralization are variable for deposits at the three stratigraphic levels.

Precious-base metal cherty tuff mineralization 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 resulted in local more sulphide-rich accumulations of chemical sediment. Both of these features are possibly related to synvolcanic faults that controlled

distribution of lithologies lower in the volcanic sequence. Further exploration utilizes stratigraphic and structural control of the mineralization and the variations that may occur within mineral deposits formed on or near the seafloor.

INTRODUCTION

The Big Missouri property is located in northwestern British Columbia, 25 kilometers north of the town of Stewart (Figure 1). Several other important mineral properties can be found in the immediate vicinity, including the Granduc copper-iron deposit, Scottie Gold Mine and the British Silbak Premier gold-silver-zinc-lead-copper deposit. The Granduc mine road provides access to the property from the town of Stewart. Elevations range from 760 m (2,500 feet) to 1,060 m (3,500 feet).

Discovered by prospectors in 1904, the Big Missouri property was put into production between 1938 and 1942 by the Buena Vista Mining Company, a subsidiary of Cominco Ltd. During this period 822,000 tons of ore grading 0.0775 oz/T gold (746,000 tonnes at 2.66 g Au/tonne) with minor amounts of silver, lead and zinc were produced 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 have been several attempts by various mining companies to re-evaluate mineral potential of the area. However, this was 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 now currently stand at 1,900,000 metric tons grading 2.46 gms/tonne Au and 27.7 gms/tonne Ag with minor zinc, lead and copper.

REGIONAL GEOLOGIC SETTING

The Big Missouri precious-base metal deposit is 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 Complex extending from Alice Arm at its southern end to the Iskut River at its northern end is one of the major mineral belts in British Columbia (Figure 2).

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 generally strike southeast and dip steeply to moderately 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 probable Middle Jurassic age intrudes the Hazelton Group and their metamorphic derivatives. Probable Tertiary granodiorite, quartz monzonite and lamprophyre dykes cut rocks of the Hazelton Group and the Texas Creek granodiorite pluton.

Recent Age Dates from USGS papers?

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

GEOLOGY OF THE BIG MISSOURI PROPERTY

The stratigraphy of the Big Missouri Property has been subdivided into 10 units; Units 1 to 7 belong to the Hazelton Group with 1 to 4 comprising the lower sequence or cycle of volcanism and units 5 to 7 the Upper, Unit 8 is the Bowser Group which unconformably overlies rocks of the Hazelton Group, and units 9 and 10 are late intrusive rocks, (Figure 3, Table 1). Rocks of the Hazelton Group form a southwest facing, moderately dipping homoclinal sequence whereas those of the Bowser Group have a variable attitude. No base to the Hazelton Group is recognized within the property area. All significant metal occurrences are within Unit 5 of the Upper Sequence. An east-west section through the southern part of the property is shown in Figure 4.

Basal units consist of dark grey heterolithic andesitic to dacitic flows, tuff and agglomerate which exhibit weak to moderate welding (Unit 1). Northwest along strike, the unit interfingers with a dark grey, heterogenous ash tuff sequence containing glass shards, rhyolitic welded tuff and pumice fragments (Unit 2). The tuff matrix grades from strongly carbonaceous at the south to weakly carbonaceous further north nearer the Dilsworth rhyolite unit. Gradational to and overlying this sequence is the Dilsworth rhyolite (Unit 3) consisting of coarse rhyolite fragmental that fines and becomes thinner to the southeast. Matrix to the rhyolite agglomerate is commonly limey, and locally thin beds of fossiliferous limestone are present. Matrix to the fragments is quartz-sericite rich in the north and grades south into highly carbonaceous tuff, (Plates 1A and 1B).

e. Cherty Tuff, Andesite and Rhyolite; silica rich beds with bleached or unbleached andesite fragments, occasional chert fragments, may be calcareous or carbonaceous, disseminated to semi-massive sulphides.

f. Rhyolite Lapillistone and Agglomerate; grey to tan, sericitic, variable pyrite.

g. Andesite - Rhyolite Lapillistone, Agglomerate and Tuff; green, mainly andesite.

h. Basaltic Andesite Lapillistone, Agglomerate and Tuff.

4 MAROON ANDESITE VOLCANICLASTIC UNIT

a. Agglomerate, Volcanic Conglomerate and Tuff; mixed maroon and green.

b. Siltstone and Volcanic Wacke; maroon.

c. Andesite-Cherty Tuff; green, minor chert and/or Jasper fragments.

d. Andesite Volcanic Breccia and Volcaniclastic; mixed green and maroon.

3 DILSWORTH 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 siltstone of Unit 2.

c. Rhyolite-Andesite Mixed Lapilli Tuff; feldspar detritus, minor carbon and limonite spots.

2 LOWER SILTSTONE UNIT

a. Carbonaceous Tuffaceous Siltstone; black, siliceous, poorly stratified, rhyolitic (unit 3) welded tuff and pumice fragments.

b. Carbonate Marker Horizon in Siltstone.

c. Carbonaceous Tuffaceous Siltstone and Wacke; dark grey, heterolithic andesite and rhyolite detritus.

1 LOWER ANDESITE UNIT

Andesite Flows, Lapilli Tuff and Agglomerate; dark grey, heterolithic, coarse feldspar phenocrysts.

Following the Dilsworth rhyolite are heterolithic maroon and green andesite breccia, conglomerate and epiclastic units (Unit 4). They outcrop on the north and south ends of the property (Figure 3). Between the areas of maroon volcanics at this stratigraphic interval are dark to medium green basaltic andesite flows, tuff and agglomerate (Unit 5c). Maroon andesitic rocks in the southeast are more epiclastic, with well defined sedimentary structures, than those further northwest near Mt. Dilsworth (Plates IC and 1D).

Maroon and green volcanic rocks are gradational to and interfinger with green andesite flows, tuff and agglomerate (Unit 5a) that form a thick (approximately 500 meters) relatively homogenous sequence that hosts the mineralized horizons. They are generally feldspar and amphibole porphyritic and have a weak to moderate foliation (Plates 1E and 1F). Within the sequence, separating the individual flows, tuff and agglomerate layers, are thin (up to 5 m) cherty tuff horizons. These cherty tuff horizons are silica rich beds containing sericitized and silicified (bleached) andesite fragments, occasional rounded chert fragments, variable amounts of carbonate and sulphide minerals (Plate 2A). The footwall andesite is commonly brecciated and filled with quartz and/or carbonate, while the hangingwall andesite is generally light grey, silicified and sericitic due to alteration (Unit 5b). In the lowermost of the three mineralized horizons, cherty tuff bands are carbonaceous and generally 8 to 10 m apart; bands in the Middle Horizon are generally 20 to 25 m apart and have abundant carbonate; while those in the uppermost horizon are the thickest and contain minor amounts of carbon and/or carbonate.

Overlying the andesites is a thin mafic volcanic unit consisting of dark green to black calcareous basaltic(?) tuff and breccia (Unit 6). The uppermost unit, a siltstone Unit (Unit 7) consists of black, carbonaceous, tuffaceous siltstone, argillaceous limestone and volcanic wacke that is gradational to volcanic rocks of Unit 6. These are exposed along the Granduc Road. (where exactly?)

Siltstone, sandstone and chert pebble conglomerate of the Middle to Late Jurassic Bowser Group (Unit 8) unconformably overlie rocks of the Hazelton Group and crop out on the east side of the property (Figure 3). The contact between rocks of the Hazelton and Bowser Groups is commonly a fault. Fig. 3 shows contact as an unconformity.

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

Faulting is the main form of structural deformation on the property. The dominant fault systems trend north and northeast and control the orientation of creek valleys and smaller ridges throughout the area. These faults have near vertical displacements and locally juxtapose the mineralized cherty tuff-bleached andesite horizons. Some of the larger faults such as the one along Silver Creek (Figure 4) appear to dip moderately west and to have reverse movement. Locally, very open folds have been developed by a slight warping of the strata. Drag folding is also common in the vicinity of the major faults.

A dominant northwest foliation, characteristic of Mesozoic rocks in western British Columbia and parallel to the general trend of the Coast Plutonic Complex is present. It is most prevalent in altered rocks and thin bedded units. Metamorphic grade is lower greenschist. No cataclastic rocks as reported by Grove (1971), are recognized.

DEPOSITIONAL HISTORY

Facies relationships of many of the lithologies within the volcanic rocks suggest that syn-depositional faulting controlled distribution. The heterolithic nature and maroon colouring of much of the volcanic material within Unit 4 suggests a transported origin of this debris from emergent volcanic areas into the shallow water flanking basin. Lack of heterolithic and maroon fragments in overlying andesites of Unit 5 suggests that the basin then subsided rapidly, the subsidence coinciding with a renewed cycle of volcanism.

Expand upon this basin concept eg. fault bounded?

The maroon and green volcanic and epiclastic rock facies boundary in the south, also corresponds with a facies boundary deeper in the stratigraphy where dark grey carbonaceous and argillaceous rhyolitic tuff of Unit 2 interfingers with ashflow units of Unit 1. The fine-grained, argillaceous and carbonaceous nature of the rhyolitic tuff near Fetter Lake grades northwest along strike into less argillaceous, pumiceous and sericitic tuff. These variations reflect small basins that ~~were~~ may have been present at the time of deposition. It is suggested that similar structural and topographic features may also have controlled distribution of sulphide-bearing cherty tuff in the overlying andesites of Unit 5.

REGIONAL STRATIGRAPHIC CORRELATION

Comparison of the stratigraphy of the Big Missouri property with that of Grove (1971) is difficult. In general, his rocks mapped as Unit H2 (Hazelton Group) are underlain by andesites of Unit 5. His Units M1, M2 and M3 (mylonitic rocks) include rocks of Units 1 through 4 and altered and mineralized rocks of Unit 5. His Unit B4 (Betty Creek Epiclastic member) consisting of maroon and green volcanic sandstone and conglomerate correlates with Unit 4. His Unit B1 (siltstone of the Bowser Group) located on the west side of the Big Missouri Ridge west of Hog Lake, correlates with siltstone of Unit 7 that conformably overlies volcanic rocks of Units 5 and 6 and is not a part of the Bowser Group which unconformably overlies the Hazelton Group.

The Monitor Lake Rhyolite unit (Grove, 1971) has not been visited but it is suggested that it may be correlated with the Dilsworth Rhyolite of Unit 3 and therefore part of the Hazelton Group. Both have associated carbonate rocks and show a spatial distribution of the maroon and green volcanic rocks of Unit 4 of this report; Unit B4 after Grove (1971).

Rocks of the Bowser Group are characterized by a basal chert pebble conglomerate in the Bowser Basin further east. Chert pebble conglomerate is observed on the Big Missouri property, however, an unconformable relationship is not directly observed. The contact with the volcanic rocks is usually covered by overburden or is a fault. It is suggested that the widespread discordance of the Bowser Group with rocks of the Hazelton Group may indicate a zone of detachment along the unconformity.

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 (Plate 2C). 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 (Plate 2E). Close to the cherty tuff, the footwall consists of altered andesite fragments in a quartz-sulphide matrix (Plate 2D). These quartz stringer and silicified breccia are discordant in detail, but grossly stratabound. Andesite units overlying the cherty tuff beds are more intensely sericitized and silicified (bleached). In the immediate hangingwall, abundant sphalerite and galena are commonly present in well developed quartz stringer zones. Further in the hangingwall, the relative amount of alteration and disseminated pyrite are less intense and only minor amounts of quartz-sulphide veins are present. Plate 3 shows a typical section through a cherty tuff bed.

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 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 horizon is greatest in the centre of the mineralized zones, 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. It should be noted that the cherty tuff beds occur throughout the andesite sequence as interflow units with only three horizons containing significant mineralization.

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

Any polybasite?

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. These relationships appear to be determined more by chemistry than paragenesis (Holbek, 1983).

In addition to stratabound mineralization, there are numerous late crosscutting quartz veins containing coarse-grained pyrite, sphalerite and galena. Figure 3 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 in the various rock types. The Dago zone is the most significant mineralized area within the Lower Horizon. (Symbol DA Figure 3).

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 fragmental and cherty tuff. The three cherty tuff beds that make up the Dago zone are 1-5 m thick and separated by 6 - 8 m of andesite commonly with quartz-sulphide stringers. Bleaching of the andesite resulting from pervasive sericitization and silicification varies from weak to intense, the latter with both agglomerate fragments and tuff matrix altered. Pyrite commonly psuedomorphs amphibole. Quartz and/or carbonate veining is intense with several different types and ages, with most containing little or no precious metal values.

Expand upon? ie. textures? calcite vs other carbonate

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

Correlation of the lithologies between drill holes, 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 (Figure 5). These consist of crudely laminated carbonaceous cherty tuff beds, grey mottled quartz stringer zones and/or carbonaceous, siliceous and sercitic andesite. Base of the mineralized stratigraphy is identified by a coarse feldspar amphibole porphyritic andesite containing up to 5 mm long, subhedral feldspar and up to 10 mm subhedral amphibole crystals.

The "D" bed is the thickest, most extensive and 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 consisting of what? (qtz-carb)

discrete grains of electrum, along fractures and grain boundaries of sulphides and in the gangue matrix. Relatively coarse grained electrum is found in both pyrite and sphalerite (Plates 4A and 4B). Silver minerals where present consist of argentite, 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 (what?) (Plate 4E), (Holbeck, 1983).

Figures 6A and 6B show a postfault and prefault topographic contour plan of the base of the lower cherty tuff bed of "D" zone. The overall shallow dip and plunge of the bed is evident (Figure 6A). Contoured assay values indicate a linear southwest trending zone prior to deformation (Figure 6B). This distribution is believed to reflect syn-depositional basin features.

Located approximately 10 m stratigraphically above the top of "D" bed is the "E" bed. It consists of weakly developed cherty tuff intercalated with well silicified carbonaceous bleached andesite. The zone is generally thin (1 - 2 m), discontinuous and of low grade (<0.05 oz. Au equiv./t.)

The uppermost mineralized bed, "F", is located approximately 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 4 - 5 m thick and is characterized by high silver to gold ratios. Microscopic studies (Holbeck, 1983) reveal that the silver minerals consist of native silver and argentite that is intergrown with galena, chalcopyrite and siderite along fracture fillings. Electrum is present as coarse grains along sphalerite-galena grain boundaries.

Preliminary geological reserve estimates indicate the presence of 740,000 short tons grading 0.103 oz. Au equivalent/ton[1] within the Dago zone (671,000 tonnes @ 3.53 g Au equivalent/tonne).

[1] Au equivalent based on 1 oz/t Au = 42 oz/t Ag

MIDDLE HORIZON

Best exemplified by the S1 zone (Letter S1, Figure 3), the horizon is characterized by the presence of abundant carbonate in the various rock types. A total of six mineralized zones (identified by a solid circle in Figure 3) are recognized over a distance of 2.5 km. It is this horizon which hosts the mineralization which was mined underground (Figure 4).

S1 Zone

Three distinct, southwest dipping cherty tuff beds approximately 20 m apart make up the Middle Horizon (Figure 7). These beds separate individual green plagioclase-amphibole porphyritic andesite fragmental units. Sericite and silica alteration is only weakly developed resulting in the matrix being more altered than the fragments. Cherty tuff beds are generally 1 - 2 m thick and contain carbonate, andesite fragments, laminated chert fragments and sulphide mineralization. An intense footwall breccia is developed beneath each of the cherty tuff beds. This consists of medium green, silicified andesite fragments suspended in a quartz-sulphide matrix. The breccia grades upward into cherty tuff and downward into a well developed stringer zone which decreases in intensity with depth.

The sequence strikes southeast and dips 20 - 30 degrees southwest. Preliminary work completed to date 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 hangingwall stringer zones. Locally at the base of the cherty tuff bed, weakly laminated, semi-massive to massive sulphide may be found. There is a general decrease in sulphide content of the cherty tuff-footwall breccia zone upward within the Middle Horizon.

Gold and silver occur only as electrum which is strongly associated with sphalerite. It also occurs within galena and along sulphide grain boundaries (Plate 4B). All of the sulphides are closely associated, often intergrown in polycrystalline aggregates along veinlets. Multiple phase crystallization is demonstrated by overgrowth textures (Plate 4G). Occlusion of large amounts of gangue within the sulphides is common (Holbek, 1983). Sphalerite often contains up to 12% exsolved chalcopyrite.

Preliminary geological reserve estimates indicate 200,000 short tons grading 0.093 oz Au equivalent/ton within the S1 zone (181,000 tonnes @ 3.2 g Au equiv./tonne).

UPPER HORIZON

Best illustrated by the Province zone, the Upper Horizon zone is characterized by a general lack of carbon or carbonate and a well developed chlorite footwall (Letters PA; Figure 3).

Province Zone

Located at the south end of the property, the Province zone consists of thick (up to 7 m) 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 hangingwall 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 (Figure 8). North trending faults are steep 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 20 cm thick quartz veins). In addition to the indicated vertical zoning in mineral content, 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. Assays from the east side give values of 1.0 g Au/t and 10 g Ag/t per each 1% Pb+Zn while those on the west side give values of 0.1 g Au/t and 13.6 g Ag/t per each 1% Pb+Zn.

Gold is present in the Province zone as discrete grains of electrum along sulphide grain boundaries and as variable sized grains within the gangue (Plate 4D). 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 (Plate 4F). Preliminary geological reserve estimates for the Province zone indicate 310,000 tonnes grading 2.5 g Au equivalent/tonne.

ALTERATION AND GEOCHEMICAL FEATURES

Alteration of the andesite wallrocks is centered about the sulphide-bearing cherty tuff horizons. It consists mainly of the development of chlorite, sericite, quartz, carbonate and sulphide minerals. Beneath the cherty tuff horizons sericite-carbonate-albite alteration of plagioclase and chloritization of amphibole grades up into more intense sericitization, chloritization and silicification of the andesite. Chloritization is the dominant footwall alteration. The immediate footwall of the cherty tuff horizons is extensively veined with irregular quartz ± carbonate ± sulphide stringers.

Alteration of the hangingwall to the cherty tuff horizons is dominated by silicification and sericitization which varies from pervasive to patchy. Quartz-pyrite-carbon veinlets are numerous, as are blue-grey mottled quartz-carbonate veins. Where hangingwall alteration is less intense quartz-chlorite-carbonate veins are present and may have envelopes of chlorite-sericite alteration.

Intensity of wallrock alteration about the zones is variable. Intense sericitization and silicification is best developed in the Dago and Province zones and least well developed in the S-1 zone. The S-1 zone contains the most carbonate and the alteration is predominantly chlorite-quartz. These differences are thought to reflect the duration of the quiescence and degree of seawater interaction.

Galley (1981) analyzed 20 rock samples from the andesite (Unit 5) sequence including rocks from the mineralized zones. A large range in major element compositions was found. The unaltered andesites contain 53 to 56% SiO_2, with altered andesite having up to 80% SiO_2. A plot of the major elements against % SiO_2 (Figure 9) illustrates the effects of alteration. In the silica-rich rocks all the major elements are decreased in abundance reflecting the lack of silicate minerals.

In general, with increasing alteration, as indicated by increasing SiO_2 content, CaO, MgO, TiO_2, MnO and FeO total decrease in abundance. Alumina averages 15 to 18% for andesites with up to 60% SiO_2 and decreases in rocks having more than 60% SiO_2. The % K_2O increases for SiO_2 contents up to 57% then decreases as the rocks become more siliceous. The % Na_2O is relatively small and shows variable depletion at moderate to high SiO_2 contents.

A comparison of alteration at Big Missouri to that of stratabound base-precious metal deposits in younger rocks suggests some similarites. Payne et al (1980) describe alteration and deformation of Lower Cretaceous andesitic rocks at the Britannia mine to quartz-sericite-chlorite schists with an increase in SiO_2, K_2O and H_2O, a loss of CaO, FeO total and MnO, and relatively constant Al_2O_3 and TiO_2 contents. Those rocks showing the greatest chemical change have developed the strongest schistosity. Similarily at Big Missouri the more sericitic altered andesites in Province and Dago zones have the strongest schistosity.

In the Miocene Green Tuff region of Japan, Shirozu (1974) has developed a zonal model of alteration about Kuroko polymetallic massive sulphide deposits (Figure 10). Alteration about these deposits is characterized by an increase in MgO due to addition of Fe-Mg chlorite. This feature is well illustrated in an Al_2O_3-MgO-CaO+Na_2O+K_2O diagram (Figure 11). The alteration trend for Big Missouri is also plotted and illustrates a lack of MgO enrichment and the trend towards sericite as the predominant silicate mineral. Both Big Missouri and the Kuroko deposits show a loss of Na_2O and CaO with increasing intensity of alteration and a general increase in SiO_2 and K_2O. The lack of MgO enrichment at Big Missouri suggests significant differences between these deposits and the young polymetallic massive sulphide deposits, perhaps reflecting the degree in which $MgSO_4$ bearing seawater is included in the alteration process.

GENESIS OF THE PRECIOUS-BASE METAL DEPOSITS

The 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 deposit 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. The 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 precipitated 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.

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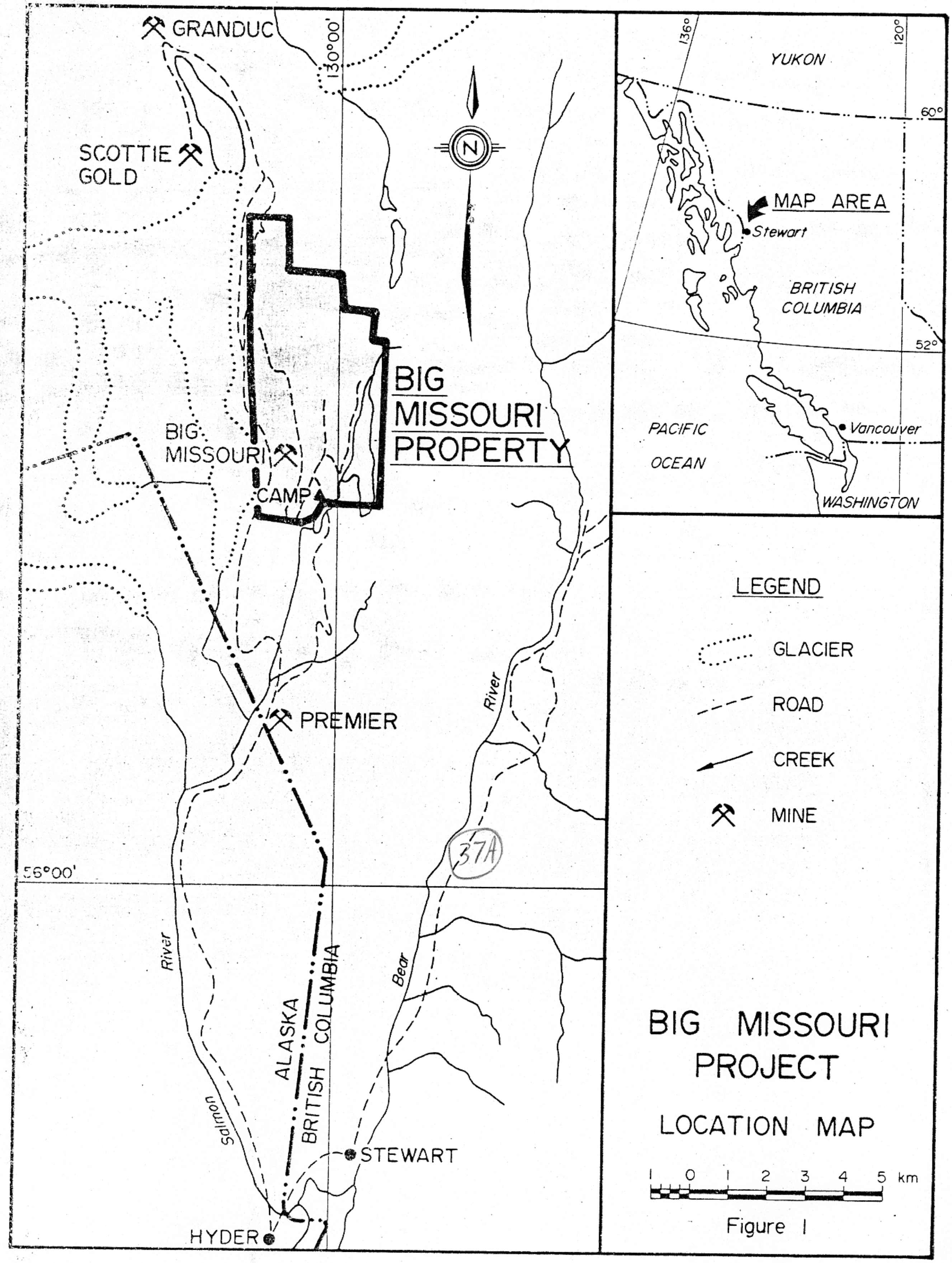
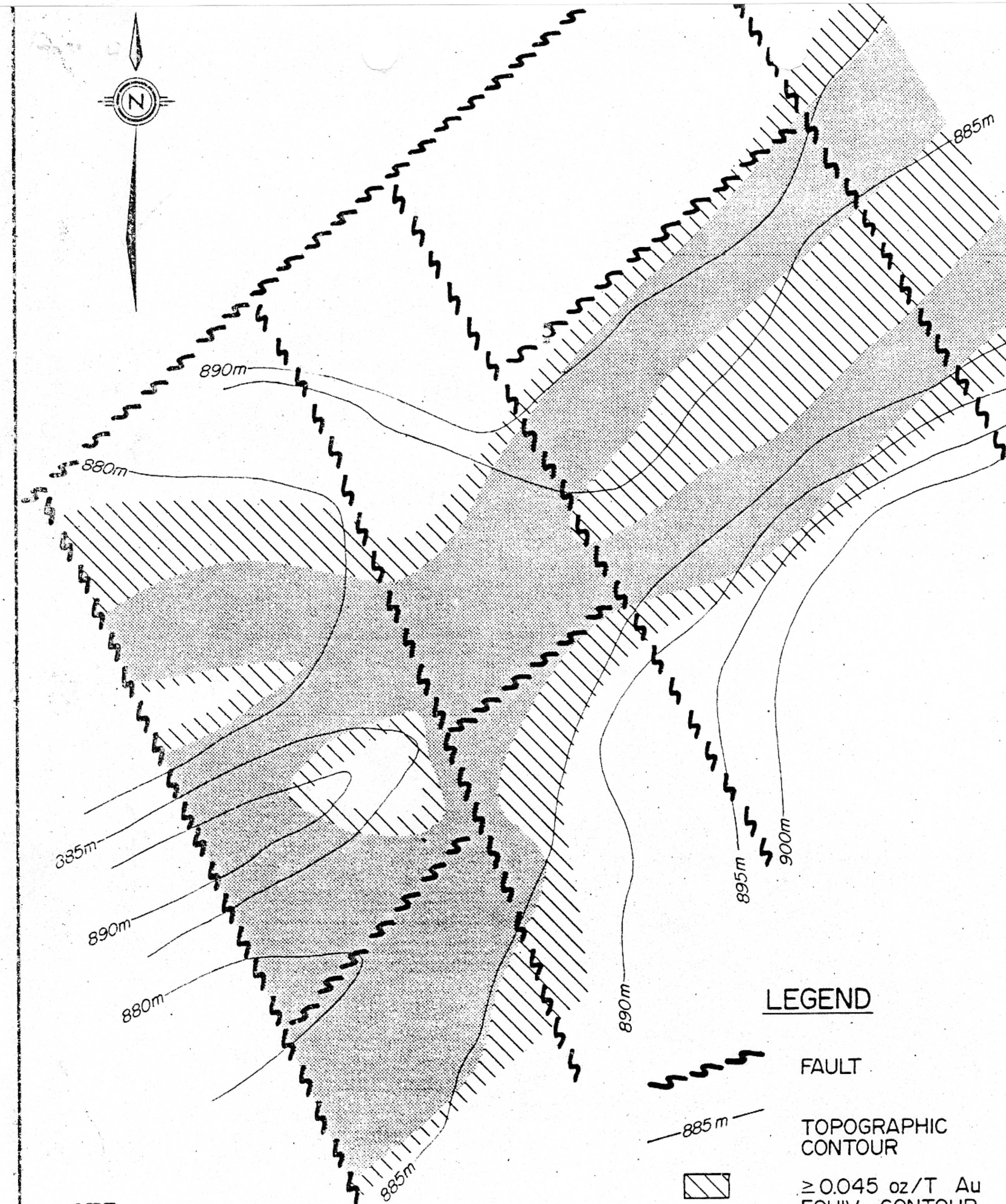

GRANDUC
130°00'
SCOTTIE GOLD
BIG MISSOURI PROPERTY
BIG MISSOURI
CAMP
PREMIER
River
56°00'
River
Bear
ALASKA
BRITISH COLUMBIA
Salmon
STEWART
HYDER
37A
136°
120°
YUKON
60°
MAP AREA
Stewart
BRITISH COLUMBIA
52°
PACIFIC OCEAN
Vancouver
WASHINGTON
LEGEND
GLACIER
ROAD
CREEK
MINE
BIG MISSOURI PROJECT
LOCATION MAP
1 0 1 2 3 4 5 km
Figure 1



LEGEND

FAULT

TOPOGRAPHIC CONTOUR (885 m)

≥ 0.045 oz/T Au EQUIV. CONTOUR

≥ 0.090 oz/T Au EQUIV. CONTOUR

NOTE:

Au EQUIVALENT BASED ON
1oz/T Au = 42 oz/T Ag

INFORMATION BASED ON ESTIMATED FAULT AND FOLD DISPLACEMENTS OF UNIT.

BIG MISSOURI PROJECT

PRE-DEFORMATION GRADE AND TOPOGRAPHIC CONTOUR MAP FOR THE BASE OF D-ZONE DAGO ZONE

20 10 0 20 40 60 metres

Figure 6b

SCHEMATIC SECTION

ANDESITE ± QTZ - CHL ALTERATION

- FLOW
- FRAGMENTAL

- QTZ-SER-CARB ALTERATION

CHERTY TUFF

- MINOR SULPHIDES
- SEMI-MASSIVE SULPHIDES