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STRUCTURAL GEOLOGY AND GOLD MINERALIZATION OF THE GOLDEN BEAR MINE PROPERTY

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The gold deposits of the Golden Bear Mine property lie within silicified dilatant zones along steeply dipping fault surfaces of the Ophir Break fault zone, a north trending, subvertical anastomosing fault system that has experienced more than one episode of faulting. Along the Ophir Break there are three deposits which appear to be regularly spaced, occurring at approximately 250 m intervals. These are the Kodiak A, B and C deposits (see Figure 1). A fourth deposit called the Ursa Zone occurs approximately 1000 m north of the Kodiak A deposit, along a splay of the Ophir Break called the Ursa Fault. The apparent regular spacing of the deposits may be an important clue for discovering additional mineralized zones if the deposits lie within a predictive geologic structure.

The main focus of this study was to determine if this apparent periodicity was structurally controlled by fold interference patterns cut by the Ophir Break, a possibility suggested by Lehrman and Caddey (1989). This study was accomplished by detailed remapping along the Ophir Break and mapping of new areas to elucidate the stratigraphy and structures and ultimately achieve a property-wide understanding of the deformation history in the rocks. This led to the completion of a property-wide compilation map, the determination of wavelengths and locations of fold hinges and the construction of cross sections through the mineralized zones.

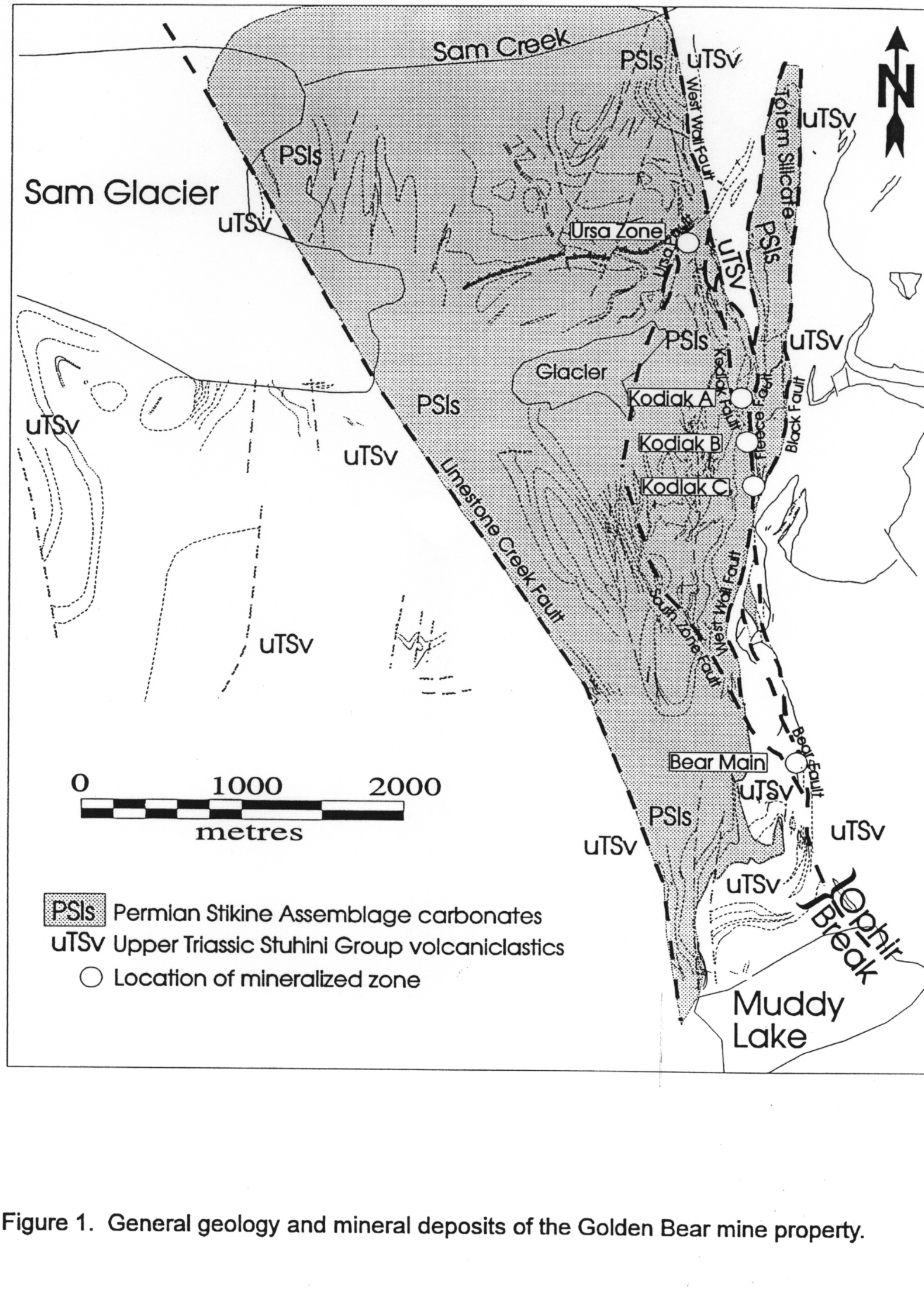


Figure 1. General geology and mineral deposits of the Golden Bear mine property.

REGIONAL GEOLOGIC SUMMARY

The general regional geology of the study area is outlined in Figure 1. Permian carbonates of the Stikine Assemblage are the oldest stratigraphic units in the map area. These occupy the central portion of the field area and on the map they encompass a south-tapering wedge bounded to the east and west by faults, to the north by a regional thrust fault (Oliver, 1996) and to the south by an unconformable contact with an overlying tuff-dominated unit. The Permian age of the carbonates has been constrained by correlation with regional Stikine Assemblage lithology and is supported by a biostratigraphy of rugosan corals and poorly preserved fusilinids (Souther, 1971). Rugosan corals are locally abundant in many of the units in the field area but fusilinids were not observed by this study. Most fine scale bedding features of the Permian rocks have been wiped out by a regional metamorphic event which recrystallized the calcitic and dolomitic carbonates to low-grade marbles.

Upper Triassic Stuhini Group rocks overlie the Permian carbonates across a distinct contact. Oliver (1996) suggested that this contact is a regional thrust fault which placed Stikine Assemblage volcanic rocks that stratigraphically underlie the carbonates up and over the carbonates. A thrust fault is unlikely as the overlying lithology most closely resembles the Stuhini Group, a stratigraphic package composed primarily of tuff with lesser tuffaceous carbonate, dolomite, argillite and quartzite. The tuffs have not undergone the greenschist-grade metamorphism or the structural deformation that is characteristic of the volcanic units which underlie the Permian carbonates. Stuhini Group rocks of the field area have experienced only minor alteration and deformation and do not appear to be significantly folded, much less thrusted. They unconformably overlie the Permian carbonates along an erosional surface. Contact relations of the unconformity are obscured by faulting of the Ophir Break along the eastern boundary and by overburden along the western boundary of the carbonate wedge but are well exposed on the south margin, just north of Muddy Lake.

STRATIGRAPHY

PERMIAN CARBONATE STRATIGRAPHY, STIKINE ASSEMBLAGE

The stratigraphy of the Stikine Assemblage carbonates has been reinterpreted by this study. A previous stratigraphic column and the one derived from this study are exhibited in figure 2. The main change from Pigage's 1995 stratigraphy resulted from the identification of two distinct LMGT units. LMGT(1) underlies the lowermost LMST(1) unit and forms the host rock for gold mineralization in the Ursa zone. The uppermost unit of the Permian package is LMGT(2). The two LMGT's are very similar and would be impossible to distinguish if not for the excellent exposure of these two units along the north-facing slope of Sam Creek, immediately north of the Ursa zone. The entire property-wide Permian stratigraphy is visible along this slope.

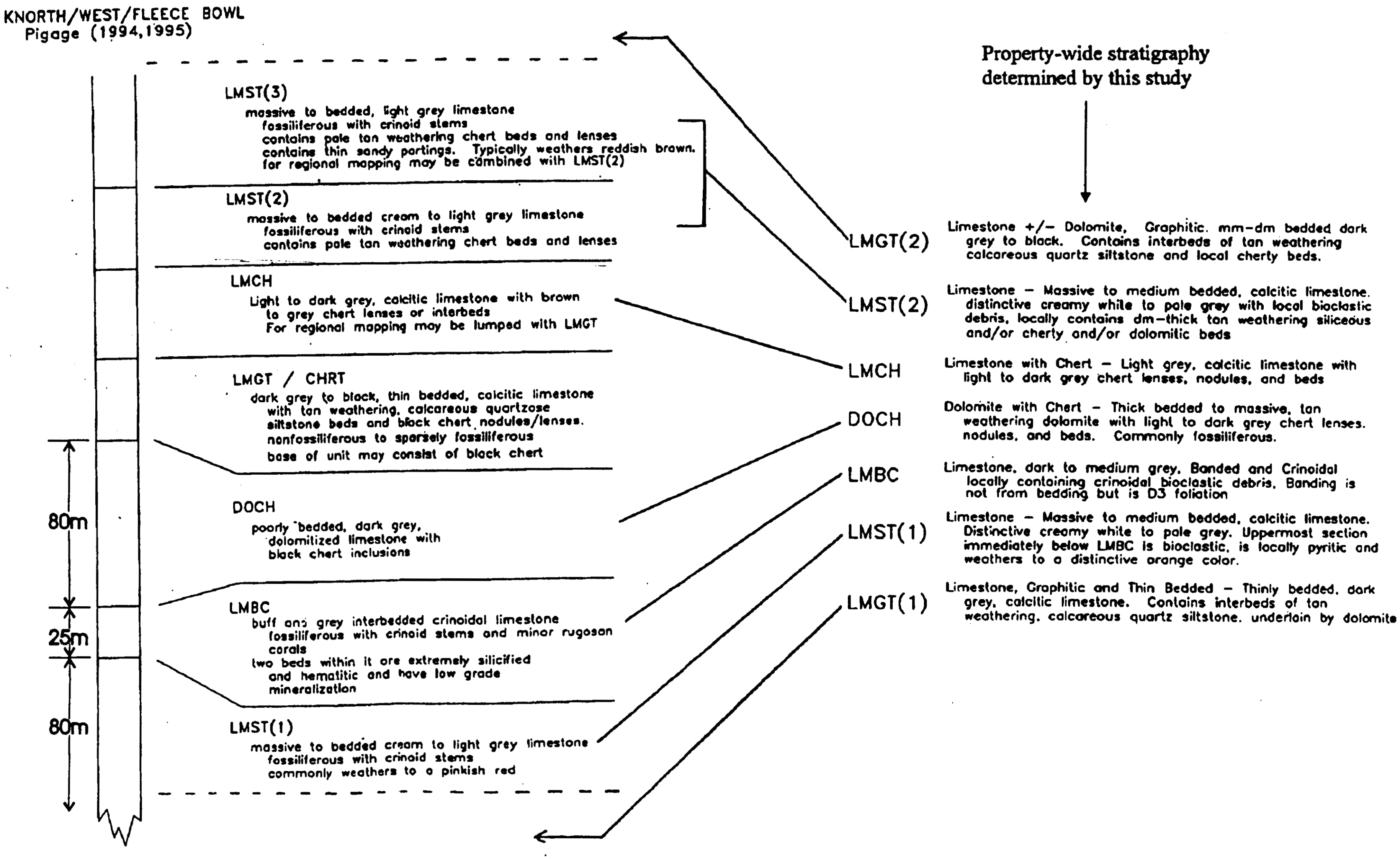


Figure 2. Permian Stikine Assemblage, carbonate stratigraphy of the Golden Bear Mine area.

From oldest to youngest the Permian units are described as follows:

LMGT(1) -Thinly bedded, medium-dark to dark grey, non-fossiliferous graphitic limestone. Graphite is finely disseminated within the limestone but is concentrated along millimetre-thick laminations which are parallel to bedding and cleave easily. Exposed surfaces weather to a ribbed appearance with recessive dark grey limestone bands and calcareous quartz siltstone layers forming resistive buff weathering ribs. Any soil which has formed from the weathering of this rock type is black and graphite-rich. Bedding is cm- to dm-thick and in the Ursa Area may actually be a foliation related to high temperature shearing during D2 deformation. Southwest of the Ursa Area this unit contains two limestone interbeds which are 1-2 metres thick. Immediately beneath this unit is a dolomitic limestone.

LMST(1) -Thick-bedded, cream to pale grey, locally fossiliferous calcitic limestone. The uppermost few metres of this unit has distinctive orange weathering beds from oxidized disseminated pyrite. LMST(1) generally contains abundant crinoid ossicles and weathers to hackley shards of felsenmere. Most beds are massive cream calcite but a few contain dm-thick layers of buff weathering siliceous or cherty, possibly dolomitic beds. Silicified examples of this unit are white with an almost bleached sugary appearance.

LMBC -Thick-bedded, light grey to dark grey, Banded and locally Crinoidal calcitic limestone. Contains dm-thick tan weathering siliceous beds, locally abundant crinoid ossicles and sparse rugose corals. The mm-cm wide faded or indistinct banding which is characteristic of this unit is not relict bedding but is actually D2 foliation. Silicified varieties of this unit are commonly a translucent pinkish-grey.

DOCH -Massive to thick-bedded, buff to medium grey dolomitic limestone. Usually contains black chert which ranges in occurrence from unbedded irregular pods to continuous dm-thick beds. The chert may also be light grey and is commonly fossiliferous with abundant crinoid ossicles. In the fault zones DOCH is invariably crackled and may be silicified or calcite-welded.

LMCH -Thick-bedded, light to medium grey, locally crinoidal calcitic limestone. This forms a discontinuous unit between the underlying DOCH and overlying LMST(2) and is mapped as LMST(2) where convenient. LMCH sometimes contains chert layers that are similar to those in the DOCH unit.

LMST(2) -Thick-bedded, cream to pale grey calcitic limestone. Most beds are massive cream coloured calcite and often contain dm-thick layers of buff weathering siliceous or cherty, possibly dolomitic beds. LMCH and LMST(1) are absent between DOCH and LMGT(2) at the toe of Sam Glacier. This can be explained simply as a lateral facies change where the LMCH and LMST(2) units taper out to the west.

LMGT(2) -Thinly bedded, medium-dark to dark grey, non-fossiliferous graphitic limestone.

with rare dolomitic beds and some cherty beds. Graphite is finely disseminated within the limestone and is usually concentrated along bedding plane contacts. Bedding is cm- to dm-thick and exposed surfaces weather to a ribbed appearance with recessive dark grey limestone bands and calcareous quartz siltstone layers forming resistive buff weathering ribs. Any soil which has formed from the weathering of this rock type is black and graphite-rich. Faults which cut this unit (and LMGT(1)) have a distinctive black graphitic fault gouge.

Other stratigraphic observations and implications of the Stikine Assemblage carbonates.

LMBC and LMST(1) become complexly mixed along a ductile fault zone which extends west of Ursa zone. Few clearly defined boundaries between these two units could be mapped in this area. Most of this area has been mapped as LMST(1).

Silicified LMGT identified on the margins of Totem Silicate supports previous studies identifying it as an anticlinal structure. This study interprets Totem Silicate as a silicified DOCH-LMCH-LMST(2)-LMGT(2) sequence. The apparently continuous stratigraphic sequence from the bottom of Fleece Bowl northwards into Totem Silicate indicates relatively minor horizontal offset along Fleece and Kodiak faults.

UPPER TRIASSIC STUHINI GROUP VOLCANICLASTICS, SILICLASTICS AND CARBONATES

The Stuhini Group does not have a defined stratigraphic sequence that is consistent across the field area. This is likely due to the effects of lateral facies changes and faulting along the Ophir Break and Limestone Creek Fault. Rock types do remain consistent across the property however and the following descriptions are in order of abundance from most abundant to least:

Stuhini Group Lithologic descriptions:

MFTF -Variably bedded, medium to dark green ash tuff. Bedding varies from massive unbedded very fine grained to dm-bedded and massive very coarse grained crystal-detrital tuff. Coarser varieties rarely exhibit graded bedding and scour surfaces at their bases suggesting a high energy, possibly turbiditic depositional environment for some beds. MFCA is a faulted and hydrothermally altered variety of this unit. MFCA weathers orange and fresh surfaces are commonly pale grey/green from alteration. MFCA often contains disseminated fine grained euhedral pyrite.

MFEP -Thinly bedded, very fine grained, brown to light grey epiclastic tuff. Bedding is generally mm- to cm-thick. The very fine grained nature of this reworked tuff unit gives it an almost translucent greasy appearance. MFEP commonly contains discontinuous bedding-parallel pods or 'sweats' of quartz +/- feldspar that are less than 5cm thick. MFEP also alters to MFCA where it is faulted and hydrothermally altered.

ARGI -Finely laminated, dark grey to black argillite. Argillite is fissile, is mm- to cm-bedded and weathers easily. It is commonly interbedded with shaley siltstone and thin black chert layers and less commonly with MFTF.

DOLO -Massive to poorly bedded light grey to cream dolomite. Generally occurs in contact with MFEP or ARGI.

QTZT -Thinly bedded dark grey to black quartzite. Commonly has a sugary quartz texture from silicification. Locally has thin argillaceous or possibly graphitic interbeds. Is commonly interbedded with ARGI.

LMST -Cm- to dm-bedded white to light grey calcitic limestone. Locally interbedded with MFEP and MFTF.

Location and stratigraphy of Stuhini Group lithology:
On the south-facing slope north of Muddy Lake, above the unconformity, the base of the Stuhini Group consists of ARGI with some QTZT, grading up into fine grained finely laminated MFTF and then into a thick plagioclase +/- pyroxene-detrital MFTF along Muddy Lake. A few flow basalts and rare pillows are present within this succession. The beds dip steeply to the south and a few graded beds near the base of the plagioclase +/- pyroxene-detrital unit indicate tops to the south.

On the east side of the map area, just west of Totem Silicate, the Stuhini Assemblage stratigraphy starts at the West Wall Fault contact with the Permian carbonates and consists of a brownish grey, extremely fine grained and finely laminated tuff that is considered to be reworked or epiclastic tuff (MFEP). This is overlain by fine grained finely laminated MFTF with some thin dm- to m-scale discontinuous beds of plagioclase +/- pyroxene-detrital MFTF. Some well exposed outcrops along Totem Creek show evidence of basal scour of some of these beds with tops to the east. Bedding dips gently to the east.

On the west side of the map area the lowermost observed Stuhini Group rocks are epiclastic tuff (MFEP) overlain by a thin wedge of MFTF. These occur on the west side of Limestone Creek Fault where it is exposed in the toe of Sam Glacier. Stratigraphically above this outcrop and approximately one kilometre southwest (immediately southwest of Sam Glacier) begins a thick package of interbedded LMST and MFEP overlain by DOLO interbedded with MFCA, then a wide zone of QTZT and then calcareous tuff, thinly bedded LMST, DOLO and ARGI. Above all this is more of the fine grained MFTF. The entire western tuffaceous package appears to dip uniformly and gently to the southeast.

STRUCTURAL HISTORY

The deformation history of the property is summarized in figure 3. The first three episodes of deformation (D1, D2, D3) outlined below only affected the Stikine Assemblage

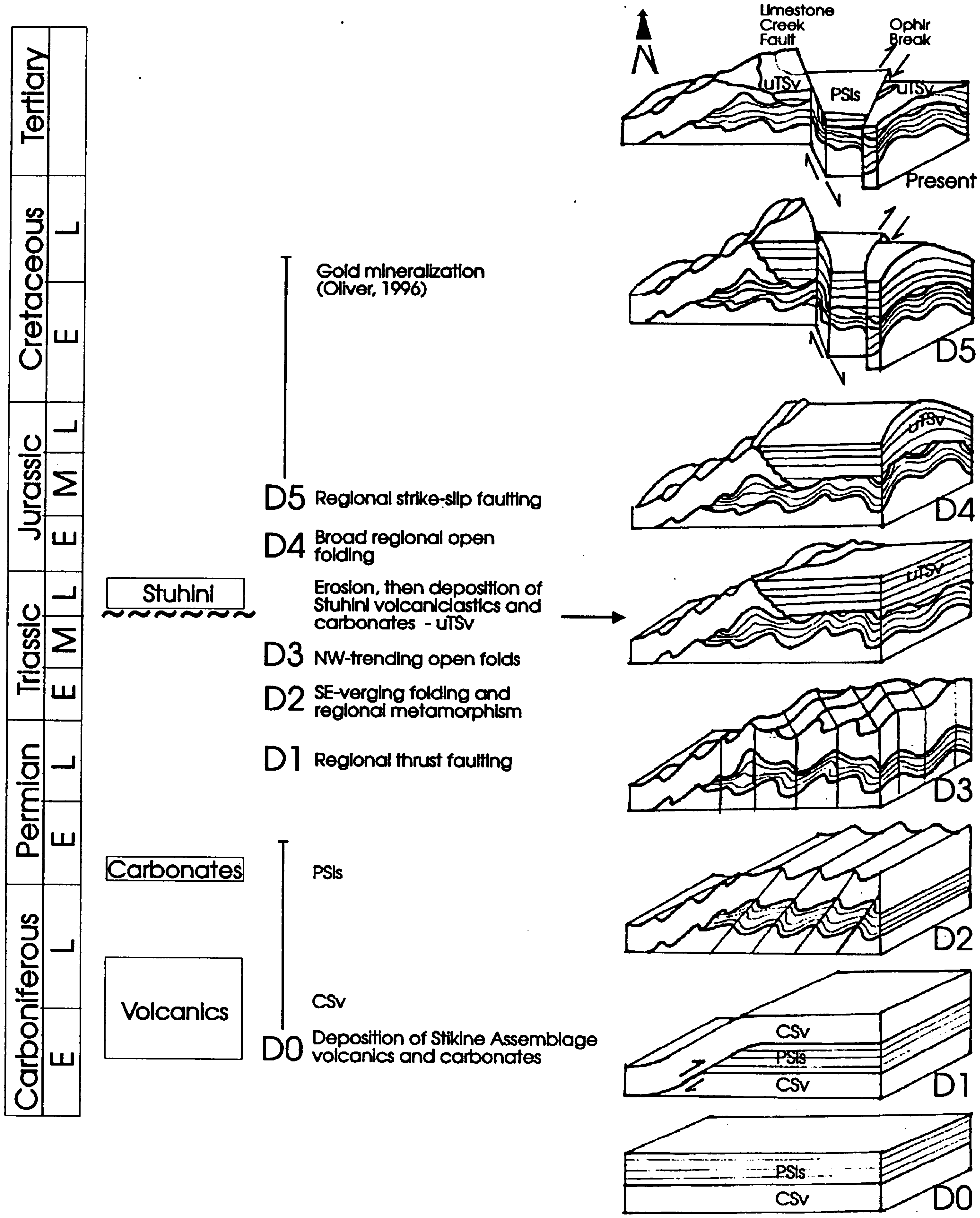


Figure 3. Age relations of stratigraphy, deformation and mineralization of the Golden Bear Property.

carbonates.

D0 Deposition and compaction of the Stikine Assemblage sediments.

D1 The first phase of deformation was a period of major thrust faulting that resulted in both the stacking of Paleozoic stratigraphy of the Stikine Assemblage and the formation of bedding-parallel metre-scale rootless isoclines (Bradford and Brown, 1993, Oliver, 1996) that were possibly related to flexural slip along bedding planes. No D1 structures were measured, mapped or directly observed by this study, however, subsequent deformation in the carbonates might have overprinted any earlier D1 structures. D1 thrust faulting may be related to the ensuing D2 deformation because of the strong vergence and apparent high temperatures associated with D2 structures. Thickening of the crust and continued contraction during late stages of thrusting would result in regional metamorphism and folding with a pronounced vergence. The SE-vergence of D2 structures does not necessarily mean that D1 thrusting was SE-vergent as well.

Thrust faulting might also explain the westward tapering of the LMCH and LMST(2) units observed in the field area but this can be simply explained as a lateral facies change.

Timing for this event has been constrained to late Permian and may be correlated with the Tahltan Orogeny (Oliver, 1996), a regional event with a similar deformation style.

D2 The second phase of deformation was a contractional event that was concurrent with regional metamorphism. The Permian carbonates of the property are low grade marbles, and most fine scale bedding features have been wiped out by recrystallization. This event produced tight north- to northeast-trending E- to SE-verging overturned folds with locally well developed foliation. Crinoid ossicles and rugose corals are elliptical parallel to the foliation that is strongly developed in D2 fold hinges. Stereoplots of D2 foliations from the Kodiak deposits area (Fleece Bowl) have a mean orientation of 219/55 (Figure 4-C). Foliation is defined by transposition of bedding and recrystallization and is visible as faint to distinct mm to cm bands or layers in the calcitic carbonates but not in the dolomitic DOCH unit. Felsenmere of foliated carbonates weathers into flat shards.

Wavelengths of most D2 folds range from 25 to 150 metres. However, there are two zones of large scale D2 structures that are separated by about 1.5 kilometres. These correspond to the Ursa Zone and Kodiak deposits area. A large scale SE-verging overturned anticline-syncline pair is present at the Kodiak area and a D2 ductile detachment exists at the Ursa zone (Figure 5).

West of the Ursa Zone D2 deformation is associated with boudins, stretching lineations and strongly transposed bedding that is parallel to D2 foliation. These observations suggest that during D2 a SE-verging zone of ductile delamination propagated from a large-scale D2 anticline. The Permian carbonates may have been the root of a thrust structure with faults propagating from the large overturned folds. The ductile thrust fault at Ursa likely resulted from the more competent DOCH unit buckling and failing by delamination while underlying limestones folded easily and smeared beneath the DOCH. The graphite-rich LMGT(2) forms the core of the anticline which failed by delamination.

From a regional perspective, D2 of Oliver (1996) forms the dominant north-south structural grain of the region. D2 is associated with a strongly developed foliation and north-to northeast- trending fold axes and axial planes which dip an average of 65° to the west. Bradford and Brown (1993) describe a D2 that is associated in some areas with tight north- to northeast-trending chevron folds which have an eastward-verging asymmetry. Other D2 folds observed by Bradford and Brown trend east-northeast. Their D2 includes the formation of mullions, mineral lineations and stretched clasts, features which could have developed during regional metamorphism.

The similar descriptions of D2 structures reported by Oliver (1996), Bradford and Brown (1993) and this study indicate that D2 represents the same event for all authors.

D3 The third phase of deformation observed in the Permian carbonates was a second compressional event which produced upright open folds with northwest trends and shallow plunges. Wavelengths of these folds range from 50 to 250 metres, with no wider spaced larger scale folding evident. Stereoplots of poles to D2 foliations indicate folding about NW-trending D3 fold axes (Figure 4-A, C, E). The D3 fold axis in the Kodiak Deposits area is approximately 55--->290. The interaction between D3 and D2 folds produces outcrop scale interference patterns in some exposures. The shapes of some mapped lithologic contacts in the Kodiak Deposits area roughly resemble the idealized type 1-2 dome and saddle interference patterns depicted in figure 6. The actual pattern will vary depending on the thickness of bedding, degree of overturning, fold wavelength and amplitude, and angle at which the erosion surface cuts through the structures.

NW-trending folds have not been documented by other authors, but perhaps the regional NW-trending Tatsamenie Antiform of Oliver (1996) is related to this phase of deformation.

Between D3 and D4 the area experienced erosion, then deposition of the overlying Upper Triassic Stuhini Group tuff, quartzite and carbonate.

D4 D4 deformation is only obvious in the Stuhini Group rocks and includes a broad open fold which formed steep south-dipping bedding orientations on the south slope facing Muddy Lake and gentle SE- and E-dipping attitudes of tuff west of Limestone Creek Fault and east of Ophir Break respectively. Stereoplots of all Stuhini Group bedding measurements suggest an approximate ESE-trending D4 fold axis of 38 -->107 (Figure 4-I, K, M). This is not parallel to a strongly developed intersection lineation which trends SSE, but they may have developed during the same event. There are no visible small scale folds parallel to the lineation.

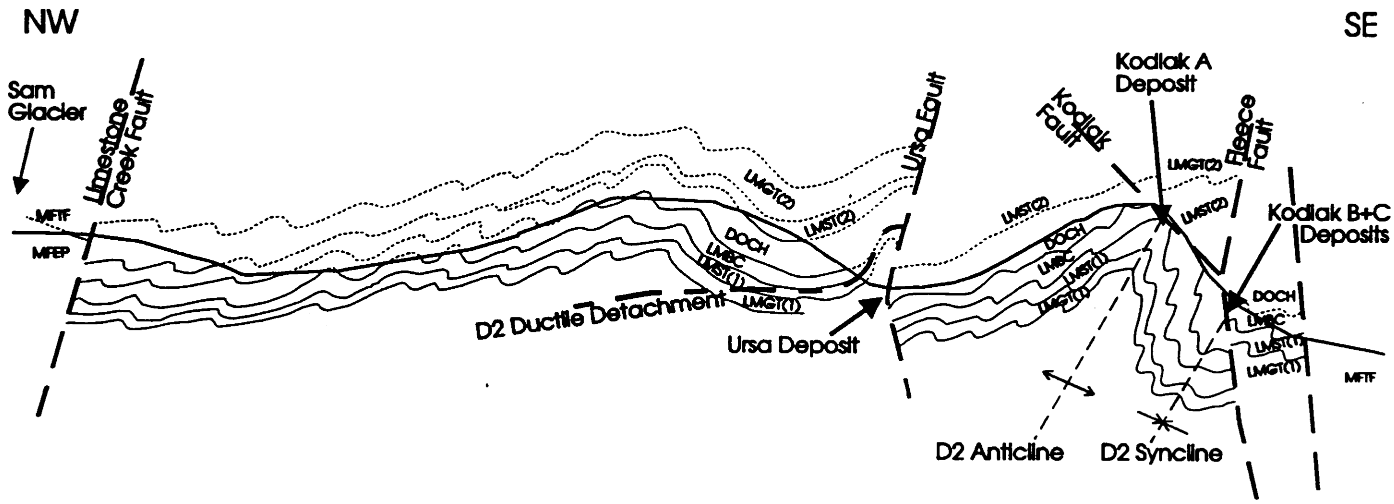


FIGURE 5 Schematic cross section through the property. Gold deposits occur where faults cut the large D2 structures. The Kodiak deposits occur where faults (D5) cut the large scale D2 overturned folds. The Ursa deposit occurs where the Ursa Fault cuts the D2 ductile detachment.

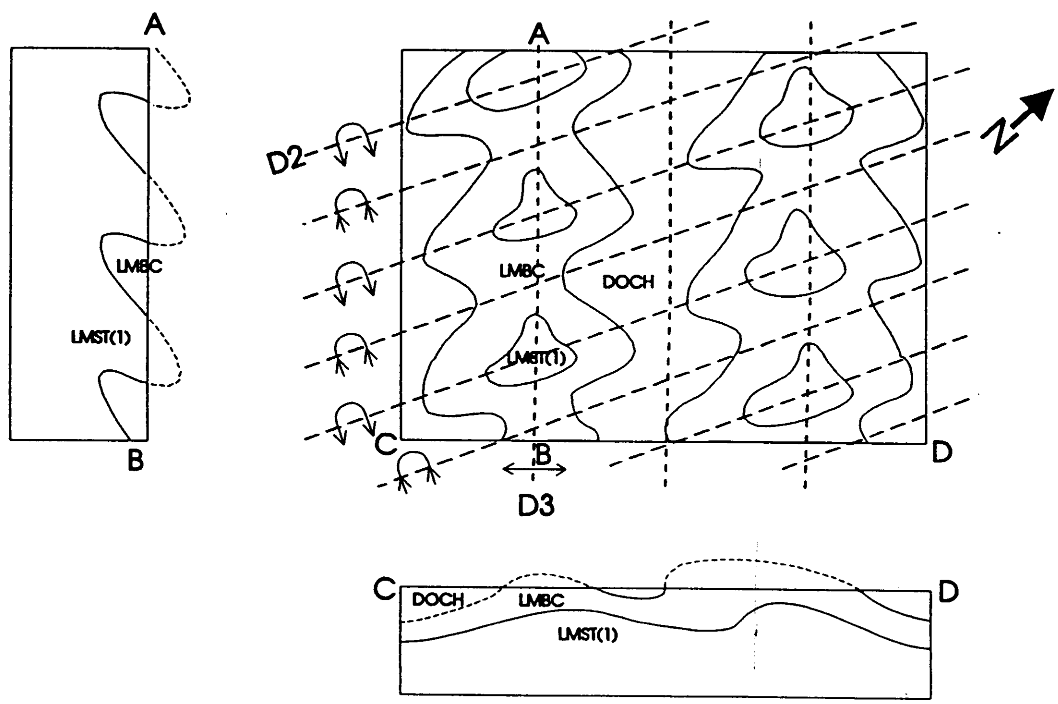


FIGURE 6 Idealized outcrop pattern that results from D3/D2 fold interference. Lithologic contacts with patterns similar to to this diagram were mapped on the slope above the Kodiak Deposits area.

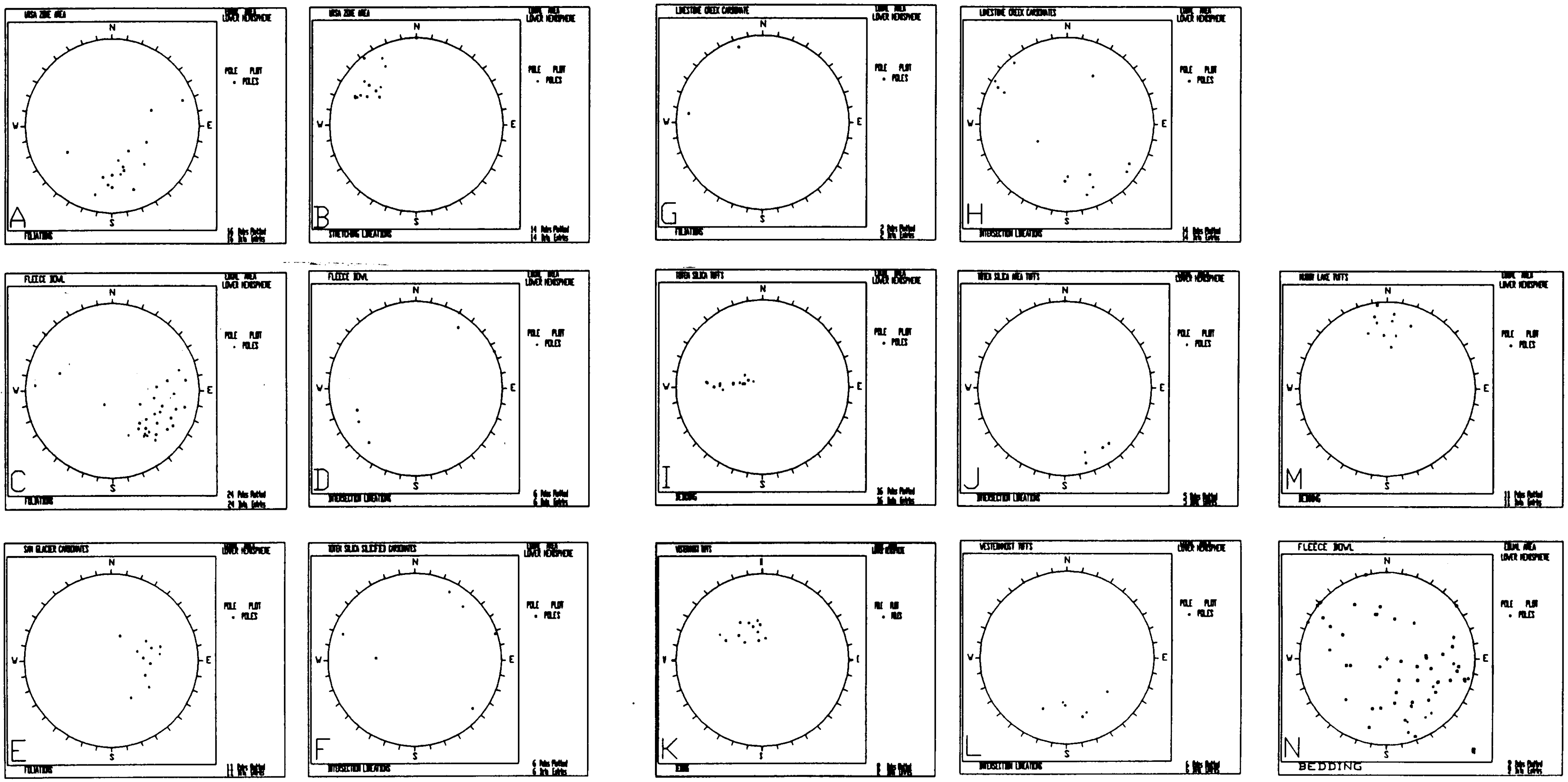


Figure 4   Stereoplots of Golden Bear Property Structural Data
Bedding and foliation plotted as poles to planes

D4 deformation was not directly observed in the Stikine Assemblage carbonates due to the complex deformation prior to D4. Stereoplots of poles to D2 foliations in the Stikine Assemblage (Figure 4-A, C, E) do show some scatter which might be interpreted as D4 folding but this is not conclusive.

D4 deformation of this study may correlate with D3 of Oliver (1996). However, folds identified as D3 by Oliver (1996) are NE-trending open folds instead of SE-trending as indicated by this study. D3 of Oliver includes the Sam Creek Antiform, a broad open fold that deforms the Permian carbonates, the overlying thrust faulted Stikine Assemblage volcanics as well as the Stuhini Group rocks. Oliver (1996) gives D3 deformation a lower Jurassic to upper Cretaceous age.

The stereoplot of poles to bedding for the Stuhini Group in the Totem Silicate area (Figure 4-I) does suggest subtle open folding about a north-trending fold axis, but this may be local deformation related to faulting along the Ophir Break (D5).

D5 This phase of deformation is a regional faulting event which in the Golden Bear Mine area involves the development of the Ophir break and Limestone Creek Fault systems.

The Ophir Break in the vicinity of the deposits occurs as a steeply dipping anastomosing fault network where it cuts through the carbonates. The fault exhibits brittle deformation and typically involves brecciation which does not preserve kinematics well. Of the few fault surfaces that do retain slickensides, most have two sets of prominent slickensides, one set which is subhorizontal and a second set that is steeply plunging. The steeply plunging set usually cuts across the horizontal slickensides indicating strike-slip followed by dip slip-motion. The strike-slip slickensides are generally associated with silicification along the fault planes. The dip-slip slickensides are often associated with calcite shear steps and calcite-welded breccia, although faults with sinistral offset also occur associated with calcite shear steps and brecciation. Calcite-welded breccias sometimes contain clasts of silica-welded breccia fragments, confirming that at least two periods of faulting have occurred and that silicification occurred before calcite-welding.

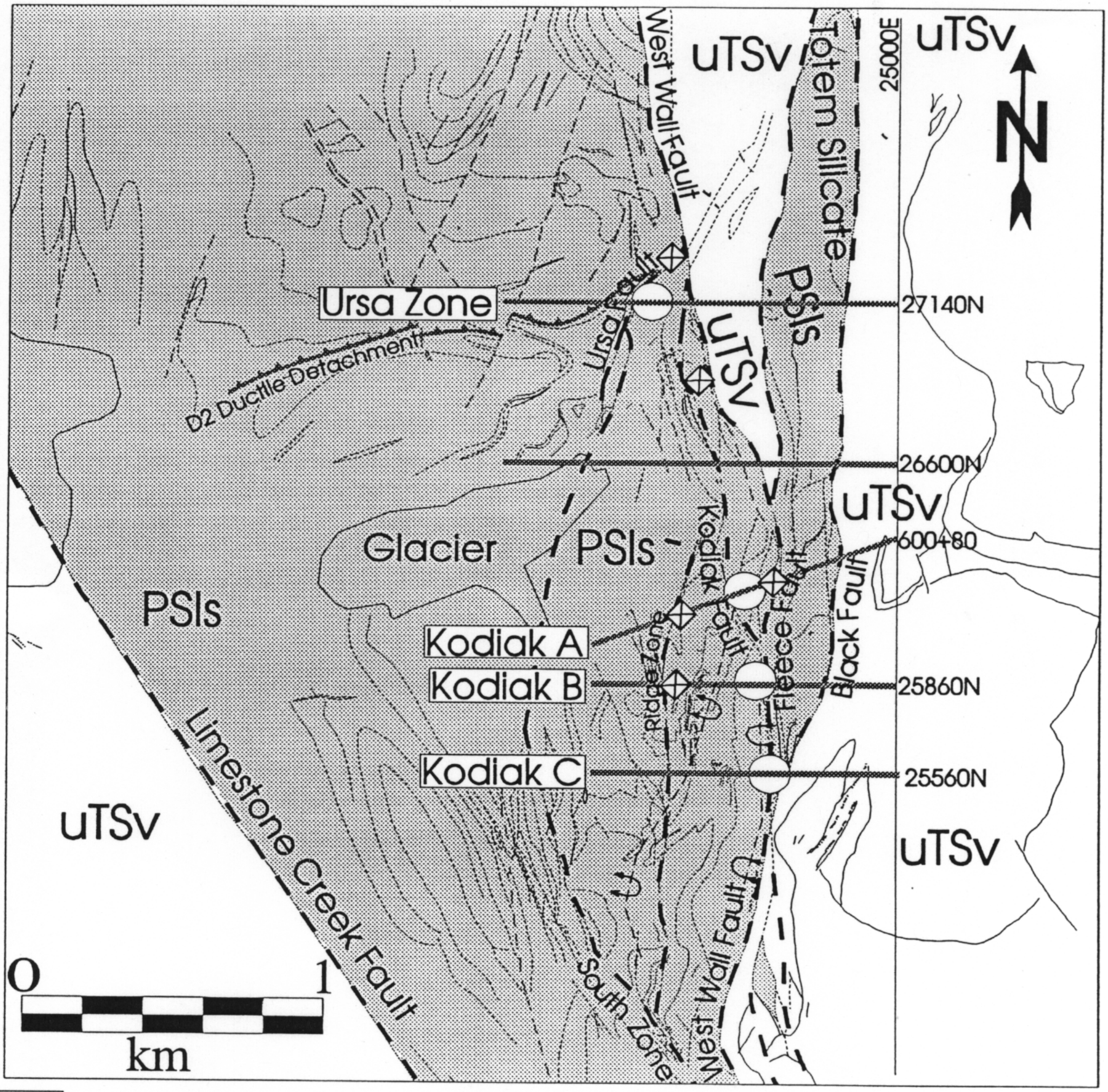
Cross sections through the deposits (Figures 8-12) show the along-strike variation in fault geometries and stratigraphic offsets (see figure 7 for location of cross sections). The main sense of offset is apparently reverse or east side up as suggested by offsets across the Fleece Fault. This apparent displacement could be the result of dextral oblique motion or pure strike-slip followed by dip-slip. Net slip along the Fleece Fault is probably less than 500 metres since the same stratigraphy is present on both sides of the fault. Some evidence of dextral movement is present by the approximately 50 metres of offset of an LMGT bed on the south end of the South Zone fault.

Limestone Creek Fault is a NW-trending structure that is defined by the contact between Permian Stikine Assemblage carbonates to the east and Stuhini Group volcaniclastics, carbonates and siliciclastics to the west. Strike-slip faulting of dextral sense is indicated by stratigraphic offsets and drag folds along fault splays in the Stuhini Group rocks. Fault splays appear to be N- to NNE-trending, steeply dipping structures that become rarer farther west of the main fault. One fault plane has well developed slickenside lineations which plunge 38 degrees NNE, indicating dextral-oblique displacement. Some silicification along these fault planes is evident by silica-welded limestone breccia and drusy quartz in voids.

The Limestone Creek Fault appears to have experienced more displacement than Ophir Break. The fault contact at the break in slope where it goes down to the south to Muddy Lake has the DOCH unit in contact with a tuff unit that is at least 1km up-section from the visible base of the tuff unit (assuming an average dip of 25 degrees for the bedding attitude in the tuff and assuming that the tuff outcrop at the toe of Sam Glacier is in fact the base). Offset along this fault is likely much greater.

A phase of folding visible in the tuffs is a rarely developed centimetre-spaced crenulation or kink banding of irregular orientation which may have formed during D5 strike-slip deformation or during later normal faulting along E-W trending normal faults. D5 folds in the carbonates were seen only as weakly developed kink folds in LMBC immediately west of Kodiak pit in Fleece Bowl.

Silicification of the Totem Silica zone may be related to the influx of siliceous fluids along D5 fault surfaces. The shape of the Totem Silica outcrop may reflect the original topography prior to deposition of Stuhini Group tuff. The tuff may have blanketed the Totem Silica and caused the carbonates to stew in the siliceous fluids, resulting in intense silicification.



PSls Permian Stikine Assemblage carbonates
uTSv Upper Triassic Stuhini Group volcaniclastics
Location of Deposit
Cross Section Location
Location of Exploration Target

FIGURE 7 Location of cross sections and potential targets for further exploration.

FIGURE 8. Cross Section Ursa 27140N

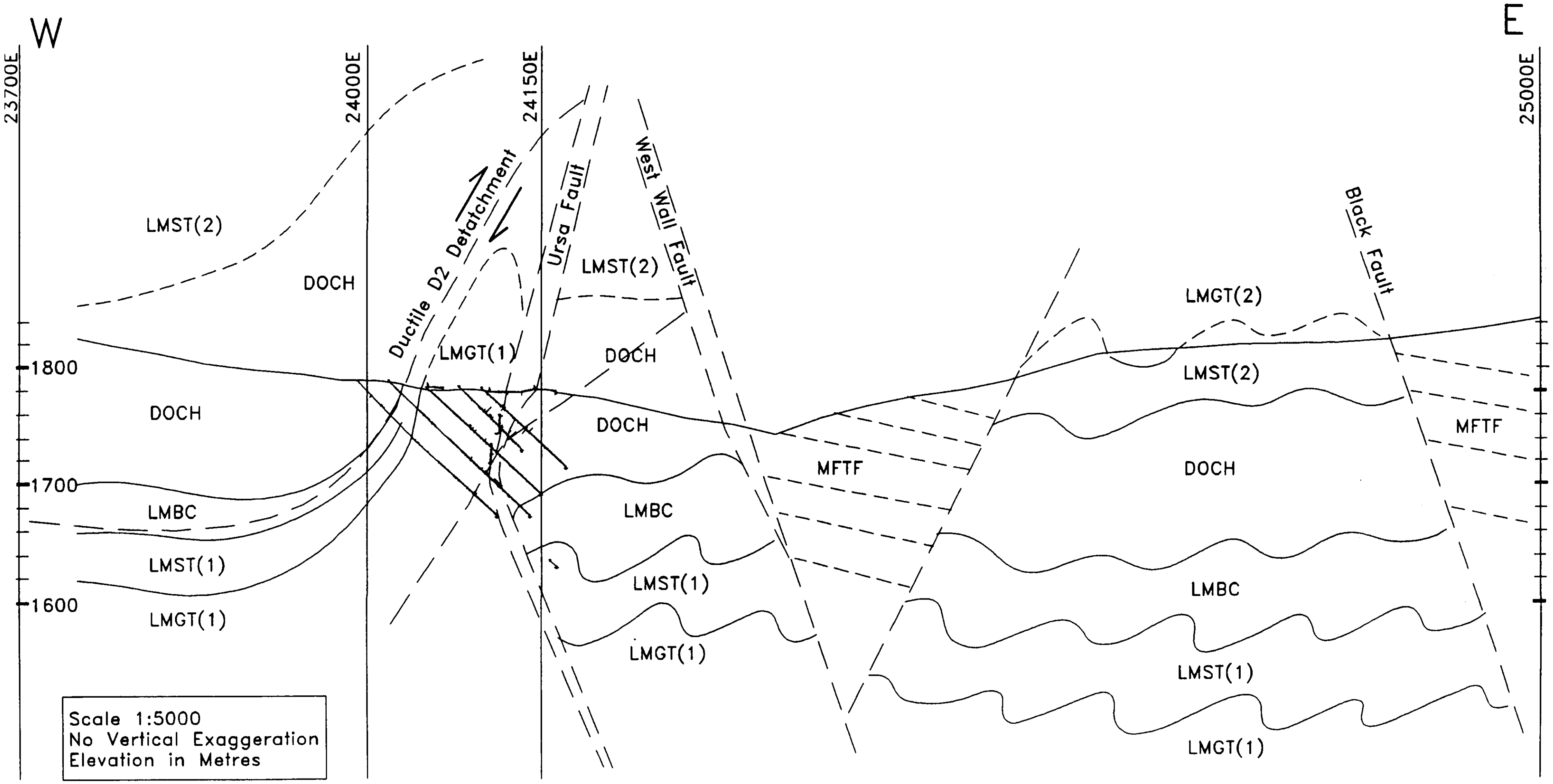


FIGURE 9. Cross Section at 26600N

(See Figure 7 for section location)

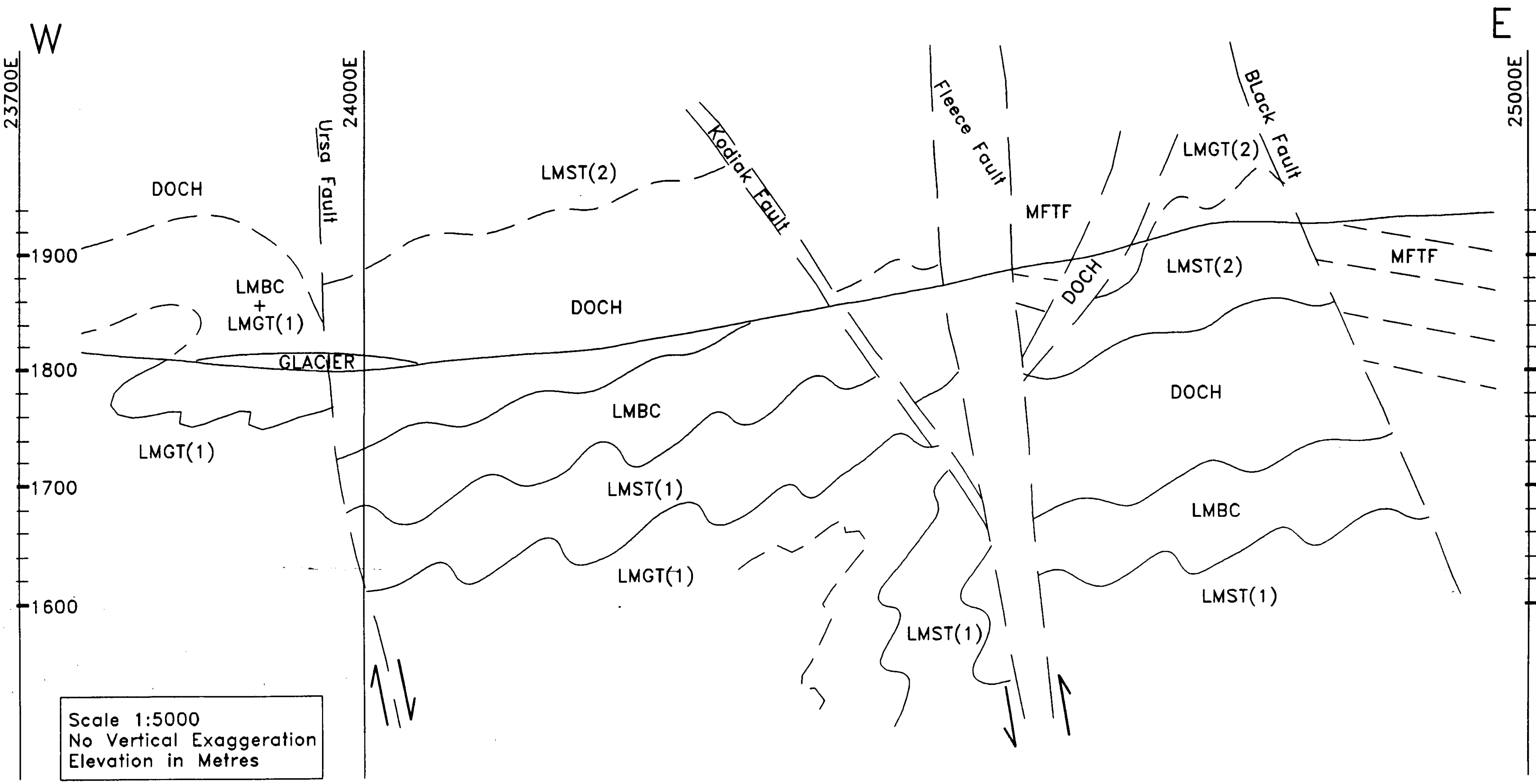


FIGURE 10. Cross Section Kodiak A 600+80

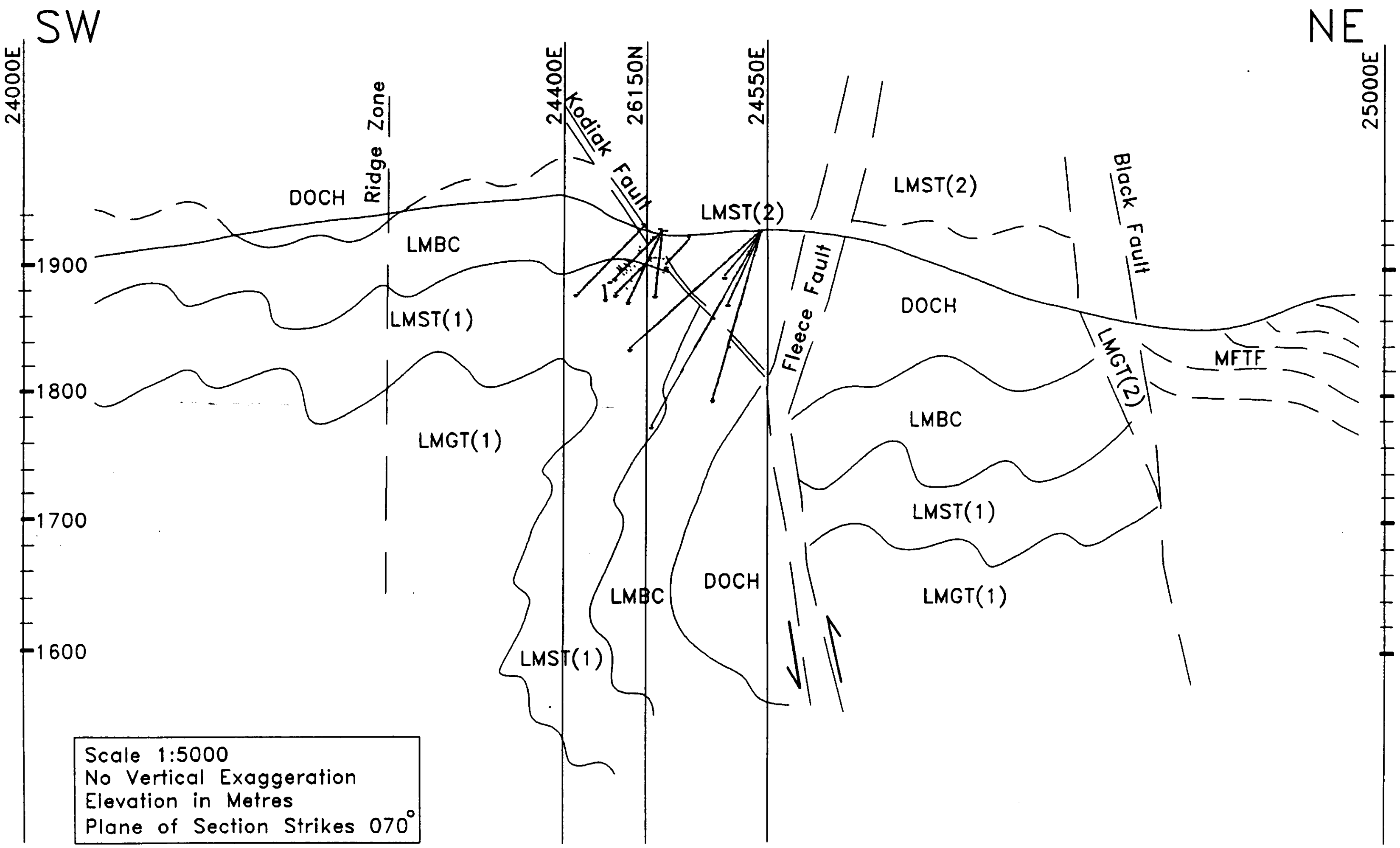


FIGURE 11. Cross Section Kodiak B 25860N

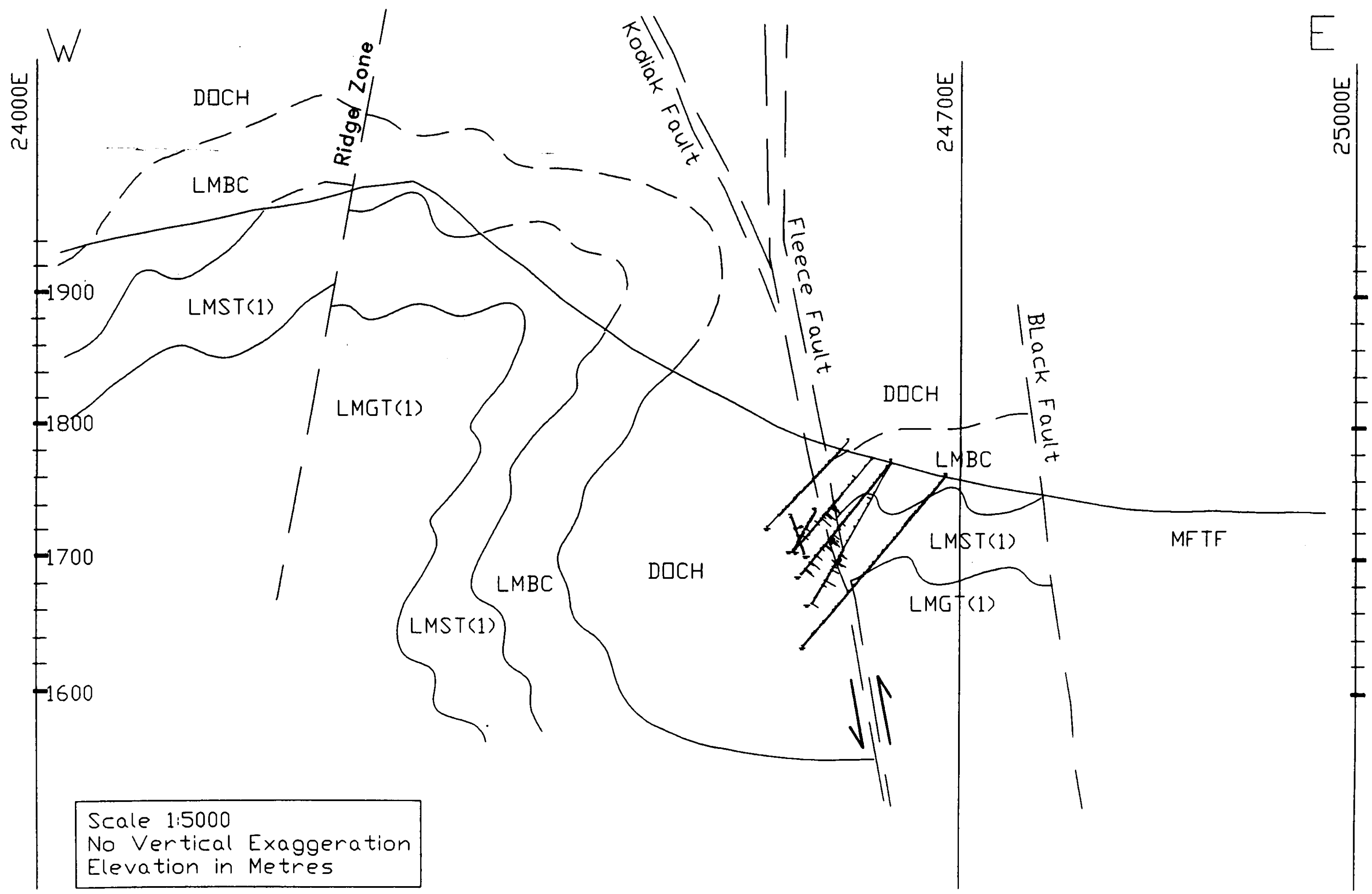
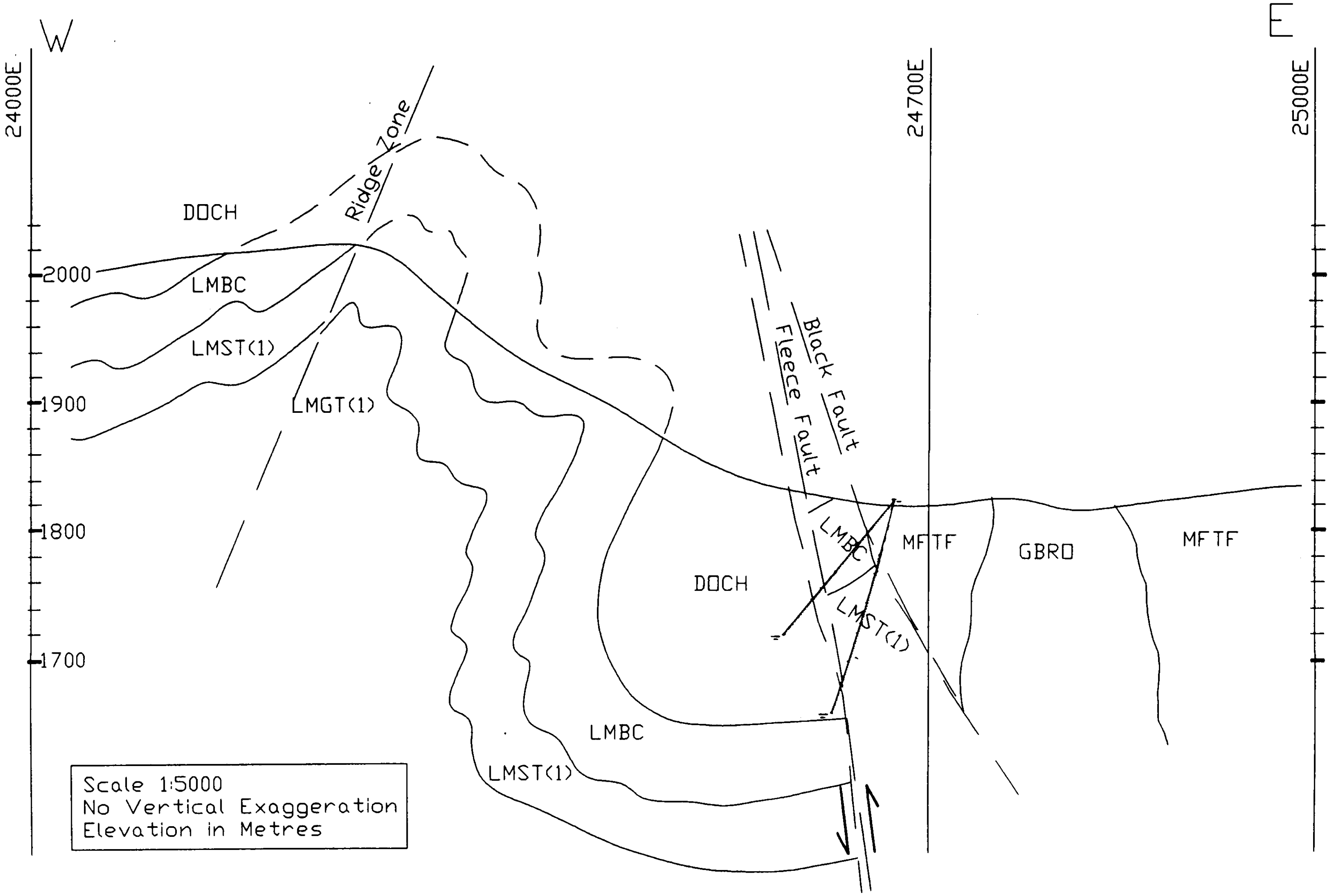


FIGURE 12. Cross Section Kodiak C 25560N



CONCLUSIONS

INTERPRETATION OF STRUCTURES IN TERMS OF GOLD MINERALIZATION

Transport of the gold-bearing fluids of the Golden Bear property occurred along the D5 brittle fault surfaces. Mineralization occurred where the fluids encountered the proper structural and chemical conditions. From a structural perspective the Ursa, Kodiak A, Kodiak B and Kodiak C deposits appear to exist where faults intersect the large D2 structures (Figure 5).

The Ursa deposit occurs where the Ursa Fault cuts the D2 ductile delamination zone. The Ursa fault is spoon shaped where the high grade zone occurs. This shape would form a dilatant zone regardless of sense of slip. However, a SE-side down sense of displacement may be inferred from the shape of the high grade zone which is concentrated near the top of the 'spoon' (Figure 8).

The Kodiak A deposit occurs where the Kodiak Fault cuts the large scale D2 anticline. The high grade zone seems to be mainly in the footwall and coincides with the core of the fold, possibly where there is a change in rock type between LMBC and LMST(1) (Figure 10).

The Kodiak B and C deposits are virtually identical, occurring where the Fleece Fault cuts along the D2 syncline. This zone lies completely within the DOCH and mineralization may be related to appropriate ground preparation in the tight synclinal core (Figures 11 and 12). If this simple explanation were valid then the entire core of the syncline should be mineralized as the Fleece Fault appears to cut subparallel to the fold axis. Since mineralization is discontinuous between Kodiak C and B there must be some other control of mineralization. One possibility is the effects of polyphase folding. The spacing of Kodiak B and C could be related to D2/D3 interference patterns being cut by the fault.

RECOMMENDATIONS FOR FURTHER EXPLORATION

Further exploration should concentrate along faults which cut the large D2 fold axes. Potential targets that meet these requirements are as follows:

One target for further exploration is where the Fleece Fault cuts the large D2 syncline beneath the Kodiak A deposit (Figure 10). The syncline core continues to the north from the Kodiak B deposit and intersects the fault at approximately 1700m elevation. The distance to this target from Kodiak B is approximately the same as the distance between Kodiak B and C, so this should be in the right spot if there is a second structural control of mineralization that is periodic.

A second zone of potential mineralization is where the Fleece and Kodiak faults appear to intersect near the core of the D2 anticline approximately 500 metres north of the Kodiak A deposit (Figure 9). This may cut the LMGT(1) unit in the core of the anticline, the same unit that is the host for mineralization in the Ursa Deposit.

A third target exists where the Ridge Zone Fault cuts the large D2 anticline at depth as seen on Figures 10, 11 and 12. This target may not be as lucrative because the Ridge Zone fault is not as large a structure as the Kodiak and Fleece Faults and involves relatively minor displacement.

It is interesting to note that the mineralization associated with the South Zone Fault occurs approximately where the large D2 anticline of the Kodiak A deposit intersects the South Zone fault. There could be more mineralization at depth where the fault cuts across the anticlinal core (Figure 7). This target might also be less desirable as this fault appears to involve minor offset and is quite narrow.

As dextral offsets are indicated for the faulting event preceding or synchronous with mineralization, further exploration along the Ophir Break should concentrate on likely dilatant zone areas that form on appropriately oriented fault deviations. One likely area is the Ursa Fault where it curves to the northeast and joins the West Wall Fault. Another fault deviation occurs where the northern extent of the Kodiak Fault takes a jog to the east where it's surface trace rejoins the Fleece Fault (Figure 7).

The Limestone Creek Fault and its splay faults with drag folds and brittle deformation features represents a potential target area for further exploration. Preliminary trenching and drilling has outlined gold occurrences along the Limestone Creek Fault and associated splays, however, the source for the strong geochemical anomaly in the area has yet to be found.

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3.2 GOLD MINERALIZATION

3.2.1 STRUCTURE

Gold mineralization on the Golden Bear property is hosted in dilatant zones that occur along brittle failure fault structures. The Ophir Break, the anastomosing fault system which hosts the Bear Main, Grizzly, Kodiak C and Kodiak B deposits, is the primary mineralized structure, however major splays from this multi-strand fault system also host gold mineralization, including the Kodiak and Ursa faults which host the Kodiak A and Ursa deposits, respectively. In addition, recent exploration work has identified several other gold bearing fault structures. Two of these, the Ridge and South faults, are sub-parallel to, and lie a few hundred metres to the west of the Ophir Break. The Limestone Creek Fault, which bounds the western edge of the Permian carbonate and forms a mirror image of the Ophir Break, was discovered to host gold mineralization in 1996. The location of these fault structures is shown on Figure 3.2-1 and the Ophir Break zones are shown on a grade times thickness long section (Figure 3.2-2).

Several theories have been advanced to explain the development and location of mineralized dilatant zones along the Ophir Break fault system. Lehrman and Caddey (1989) have proposed that there is a spatial periodicity to mineralization based on the presence of a regularly spaced fold interference pattern, that has one set of axial planes that is parallel to the Ophir Break. Movement on the fault system would then create dilatant zones on the flanks of the interference domes. Cooley (1996) has suggested that a number of the known mineralized zones occur where the largest of the northeast trending D2 folds in the Permian carbonates intersect the Ophir Break, implying that fold cores provided structurally receptive areas for mineralizing fluids. It is the opinion of the author (Hamilton) that it is unlikely that either of these structural elements provided primary control for development of mineralized dilatant zones.

Firstly, detailed mapping of the Permian carbonate package in 1995 and 1996 did not reveal the presence of a regular fold interference pattern, although such interference patterns or domes are present on the property. Furthermore, it is improbable that a fold interference dome or pattern would be preserved in an anastomosing fault system such as the Ophir Break. This is particularly the case with the Bear Main and Grizzly carbonate lenses where faulting has not only detached a lens of carbonate from the main carbonate wedge, thereby destroying any periodicity, but the lenses have also been internally faulted, with displacements of enough sufficient magnitude to emplace volcanic wedges of significant size within the carbonate lens.

Similarly, the geometry and orientation of the mineralized zones does not

SCALE 1 : 5000
0
200
metres
BEAR MAIN
GRIZZLY
KODIAK C
KODIAK B
KODIAK A
URSA
23000 N
23500 N
24000 N
24500 N
25000 N
25500 N
26000 N
26500 N
27000 N
1900 M
1800 M
1700 M
1600 M
1500 M
1400 M
1300 M
1200 M
1100 M
1000 M
900 M
800 M
700 M
GRADE TIMES THICKNESS
VALUE
> 100
50 – 100
25 – 50
10 – 25
5 – 10
NORTH AMERICAN METALS CORP
GOLDEN BEAR MINE
VERTICAL LONGSECTION
OPHIR BREAK
LONGSECTION
Grade X Thickness
Drawn By:APH
Date: DEC 1996
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FILE:g:\data\andrew\propgeol\pw-ls96b

appear to concur with the orientation of D2 folds. All of the mineralized zones are basically tabular or lozenge shaped and lie parallel to generally north-south trending faults, while the D2 fold axes trend 030°. The Kodiak A, Kodiak B and Ursa deposits do occur where D2 structures intersect fault structures of the Ophir Break, but diamond drilling on these zones does not indicate that gold mineralization extends to the southwest along the cores of these folds, which would be expected if they are providing structural control for mineralization. Their location with respect to mineralization may be coincidental.

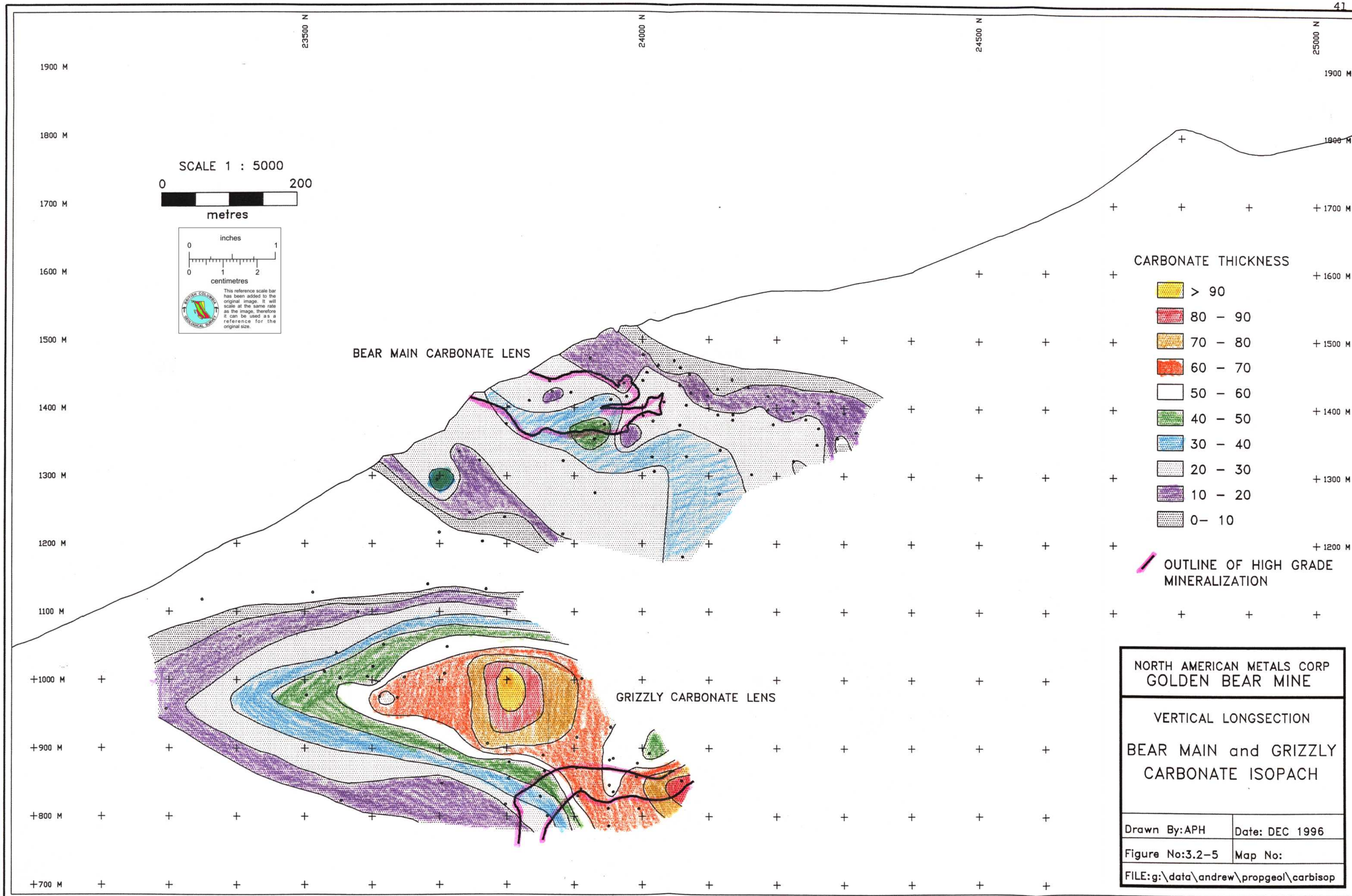
The development of dilatant zones on the Golden Bear property is most likely due to a number of movements along brittle failure fault surfaces. Dilatancies would occur wherever strike and dip irregularities or flexures are present on major fault planes, or where rheological differences exist between rock units that come into fault contact with one another. Fault movement would then cause intense fracturing and breccia development in the vicinity of flexures or irregularities, or in the least competent unit, thereby providing dilatant, open space for mineralizing fluids. Examples would include the rheological differences between the DOCH (massive, hard) and the LMGT (bedded, fissile) in the Ursa deposit, and the differences between the volcanic (plastic) and carbonate (brittle) rocks in the Bear Main and Grizzly deposits.

most competent unit would fracture

silicified

There is also evidence to suggest that fault movements have produced several series of closely spaced Reidel shears that have acted as receptive zones for mineralization. This appears to be the case in both the Kodiak A and Kodiak B deposits. When level plans of these deposits are contoured by gold grade, areas of higher grade corresponding to low angle Reidel shears can be noted to extend into the footwall areas of the Kodiak and Fleece faults, which would be considered principle shears (see Figure 3.2-3). Fluid infiltration would have been greatest along the Reidel shears so they are the most strongly mineralized, with lower fluid flow along fractures into intervening rock producing a mineralized, but lower grade envelope. A schematic level plan is shown in Figure 3.2-4.

It is likely that there have been several tectonic events that have caused movement on the fault structures of the Ophir Break, but the direction and magnitude of these movements is unclear. Both Lehrman and Caddey (1989) and Oliver (1995) suggest that the most recent movement is right-lateral reverse oblique slip. This explains the location of the Bear Main deposit which lies on the upper, east side of the Bear Main carbonate lens (see carbonate isopach long section, Figure 3.2-5). A change in the dip of the hanging wall contact of the carbonate lens created a dilatant zone for mineralization when the hanging wall volcanics were moved upwards. In the vicinity of the Kodiak B deposit mapping by Cooley (1996), indicates a right-


23500 N
24000 N
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1900 M
1800 M
1700 M
1600 M
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SCALE 1 : 5000
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centimetres
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.
BRITISH COLUMBIA GEOLOGICAL SURVEY
BEAR MAIN CARBONATE LENS
GRIZZLY CARBONATE LENS
CARBONATE THICKNESS
> 90
80 – 90
70 – 80
60 – 70
50 – 60
40 – 50
30 – 40
20 – 30
10 – 20
0– 10
OUTLINE OF HIGH GRADE MINERALIZATION
NORTH AMERICAN METALS CORP
GOLDEN BEAR MINE
VERTICAL LONGSECTION
BEAR MAIN and GRIZZLY CARBONATE ISOPACH
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lateral strike slip movement of 500 metres. These senses of movement however, are apparent and in all probability only represent the the final product of a number of fault movements. Evidence to date suggests substantially smaller fault movements on the Ridge and South faults.

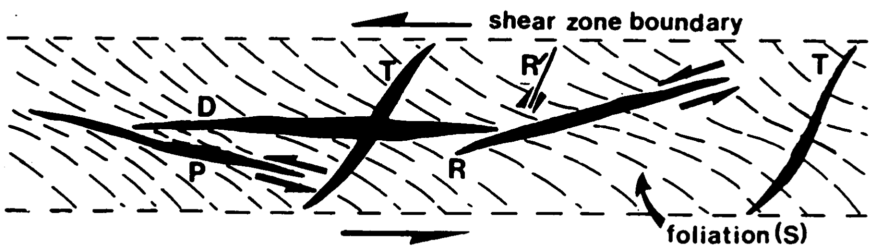

Figure 5 *The orientation of shear fractures and extension fractures in a brittle-ductile shear zone. The fractures are shown occupied by veins.* **R**, *low-angle Riedel shear fractures, 15 degrees to shear zone boundary;* **R'**, *high-angle Riedel shear fractures, 75 degrees to SZB;* **P**, *shear fractures or reverse fractures, 15 degrees to SZB;* **D**, *principal shear fractures, parallel to SZB;* **T**, *extension fractures, form in YZ plane of the strain ellipse, perpendicular to the S foliation.*

Figure 3.2-3: Reidel Shear Fracture System

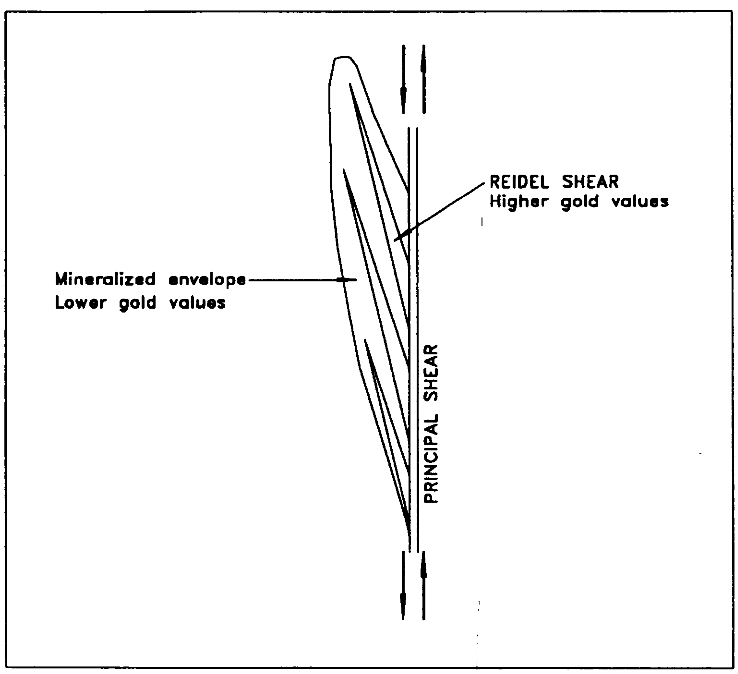

Figure 3.2-4: Schematic Level Plan of the Kodiak A & B Deposits

3.3.2 ALTERATION

Alteration on the Golden Bear property occurs as two distinct assemblages. One is associated with the Stuhini group volcanics and is similar to alteration most commonly associated with mesothermal deposits. The other is associated with the Permian carbonate rocks and is similar, if not identical, to that found associated with Carlin style disseminated gold deposits.

Alteration of Stuhini Group rocks occurs in envelopes around fault structures of the Ophir Break where they cut through the volcanics on the southern portions of the property, and in the wedges of volcanic rocks that are fault bound within carbonate on northern portions of the property. The altered rocks, which may extend for 30 to 40 metres away from major faults, vary in colour from light green to light tan in colour depending on alteration intensity. A prograde alteration assemblage is dominated by sericite and chlorite with minor quartz and k-feldspar (Oliver, 1995). An apple green mica, similar to fuchsite but chromium deficient, is also present locally. Opaque minerals present include pyrite, which occurs as disseminations and irregular microveinlets, and hematite. This assemblage has been overprinted by late stage, anastomosing calcite-ankerite veinlets and very coarse grained euhedral pyrite. These carbonate veinlets may comprise up to 30 or 40% of rock volume (Oliver, 1995).

Alteration in the carbonate rocks is characterized by removal of carbonate, addition of silica and alteration of non-carbonate mineral grains to sericite, illite and lesser chlorite. Of these, silicification is most closely related to gold mineralization and seems to be a necessary condition for it's presence. Silicification may be pervasive, resulting in a jasperiod, or silica may occur as microveinlets. The removal of carbonate, which manifests itself either as a "sanded" texture or a porous, vuggy texture, is not noted in all mineralized zones but where present is often associated with illite and high grade gold values. The extent of alteration in the carbonate rocks is much more limited than in the volcanic rocks, rarely extending beyond the limit of anomalous gold values (0.5 g/t Au).

3.2.3 MINERALIZATION

On the Golden Bear property gold mineralization occurs in two distinct styles. Refractory gold mineralization occurs in the Bear Main and Grizzly deposits and also in portions of the Kodiak B deposit. The Kodiak A and Ursa deposits, the Ridge, South and Kodiak C Zones, and much of the Kodiak B deposit all contain oxide gold mineralization.

The refractory mineralization is characterized by the presence of up to 7 or 8% fine grained dark gray pyrite, with much lesser amounts of sphalerite, tetrahedrite, chalcopyrite and arsenopyrite. A few grains of electrum, from 5 to 20 microns in size, have been detected by SEM analysis in a sample of Grizzly Zone mineralization (Cannon, 1996), but none has been noted in work performed on samples of Bear Main material. Trace amounts of a mercury telluride, coloradoite, has also been detected by microprobe work (Oliver, 1995).

At least two populations of pyrite have been identified: an early framboidal pyrite, and a slightly later euhedral pyrite. Both of these pyrite populations may be zoned, with zonation correlating strongly to arsenic content. Arsenic content increases toward the edges of the framboids or euhedral grains, reaching concentrations of 4 to 7% (Cannon, 1996). Microprobe analysis by Oliver (1995) of these arsenian pyrite grains indicates that many, but not all, contain significant amounts of gold and in quantities that increase with arsenic content. The rims of several grains that were probed contained greater than 100 grams per tonne, and up to 200 grams per tonne.

The refractory mineralization occurs in both volcanic and carbonate rocks. Most of the economic gold mineralization mined from the Bear Main deposit was hosted in sheared pyritic tuffs and in volcanic derived pyritic gouge along the hanging wall contact of the Bear Main carbonate lens. Similar refractory mineralization has been encountered in a fault bound wedge of volcanic rocks in the Kodiak B deposit.

Within carbonate rocks, refractory, pyritic mineralization occurs as fine disseminations in the siliceous matrix of tectonic breccias, and as microveinlets and fracture coatings. *It is only developed in close proximity to volcanic rocks.* Gold mineralization hosted in carbonate rocks more than 10 metres from volcanic rocks is generally of the oxide variety, as discussed below.

Oxide gold mineralization is developed in silicified crackle and breccia zones that occur wholly within carbonate rocks. It is characterized by the presence of variable quantities of hematite, goethite and iron hydroxides which generally occur with quartz, sericite and illite as breccia matrix. In the Kodiak A deposit hematite is also present as a pervasive flooding in very strongly silicified limestones. In both the Kodiak A and Ursa deposits Cannon (1996) has detected gold grains of a high fineness. Those from the Kodiak A deposit are from 5 to 20 microns in size, while gold grains have been observed in samples from the Ursa deposit ranging from 5 microns to 2.0 millimetres in size. Other metallic phases that have been identified include arsenopyrite, stibnite and bismuth and silver tellurides (Cannon, 1996), however the oxide zones are very poor in these minerals, and they are so fine grained that SEM analysis is required to identify them.

3.2.4 DEPOSIT MODEL

The classification of the Golden Bear gold mineralization has always been difficult as it does not fit cleanly onto any one ore deposits model. Lehrman and Caddey (1989) decribed the property as a shear-zone hosted, epithermal gold-silver telluride deposit, primarily based on an epithermal geochemical signature, as the multi-stage quartz veins and alteration assemblage characterisitc of epithermal deposits are absent. At the same time they did recognize, as did Wober and Shannon (1985) and Schroeter (1986), that the Golden Bear property has many characteristics, primarily alteration features, of a gold-silver mesothermal deposit. At the time of their reports however, they were unaware of the presence of the oxide deposits that have been discovered in the past three years.

The gold mineralization on the Golden Bear property can best be viewed as occurring in structurally hosted deposits that can be classified as belonging to one of two ore deposit models, depending on the host rocks, alteration and ore mineralogy. As noted by earlier authors, the alteration and refractory mineralization associated with the volcanic rocks closely resembles the features of mesothermal gold deposits. The Bear Main and Grizzly mineralization fall into this classification, the notable difference with type deposits being the presence of silicified carbonate rather than quartz veins. The oxide gold zones can be classified as Carlin style disseminated gold deposits. The structural control, silicification, de-calcification and occurrence of gold grains with iilite, are all well documented features of the gold deposits in the Carlin trend, Nevada.

3.3 AGE DATING

Between 1984 and 1996 a number of samples have been collected from the Golden Bear property for age dating by Ar/Ar, K/Ar and trace lead methods, in order to constrain the age of mineralization. The materials tested include one sample of a basaltic dyke from the Bear Main deposit, six samples of sericite altered volcanics from several locations on the property (on the assumption that the sericite analysed represents the age of alteration and mineralization), and three samples of gold bearing, pyritic mineralization from the Grizzly Zone. The results of this testwork and the constraints placed on age of mineralization are discussed below.

The basaltic dyke material was collected from the Bear Main deposit by Oliver (1996). Such dykes have been observed in both the Bear Main deposit and the Grizzly Zone sealing fault structures. They are unaltered and postdate mineralization, thereby setting an upper limit on the date of mineralization. Dated using the $^{40}Ar/^{39}Ar$ method, the sample returned an age of 14.9 ± 2.27 Ma, consistent with the age of the basalts of the Level Mountain Group.

Of the six samples collected for sericite analysis, 5 were subjected to the K/Ar method and one was subjected to the $^{40}Ar/^{39}Ar$ method. The five K/Ar samples, collected from several locations on the property including the Totem Silica Zone, the Black Fault and the Bear Main deposit. The samples returned results ranging from 177 to 205 Ma ± 7 Ma (Schroeter, 1986), indicating a Lower to Middle Jurassic date. This date suggests that the mineralizing event was synchronous with the development of large strike slip faults in the area (Ophir Break) and perhaps related to emplacement of Jurassic diorite intrusions.

The single $^{40}Ar/^{39}Ar$ sample collected by Oliver (1996) from intensely altered footwall volcanics in the Bear Main pit, returned a date of 83.88 Ma ± 1.2 Ma. This result indicates a Mid to Upper Cretaceous date that is some 110 Ma younger than the K/Ar dates. Oliver concluded that his younger date represents the mineralizing date on the basis that the earlier K/Ar dates were from samples that were not intimately associated with economic mineralization, and that the samples were screened to a fraction size that allowed grains of coarser metamorphic sericite to mix with very fine grained hydrothermal sericite.

In an effort to date gold mineralization more directly, three samples of pyritic, gold bearing material from the Grizzly Zone were submitted to the geochronology laboratory at the University of British Columbia for analysis using trace isotopic lead from sulphide. All samples were found to be extremely radiogenic, exhibited considerable scatter and could not be correlated with the substantial lead isotope database that has been compiled for the Iskut area further south. Interpretation of the results is difficult due to the paucity of lead isotope data in the immediate Golden Bear area, particularly with respect to igneous units.

In summary, the age of Golden Bear mineralization remains poorly constrained. Current data indicates the age of mineralization is between 205 Ma and 15 Ma, the lower limit being constrained by dating of presumed hydrothermal sericite and the upper limit being constrained by post mineral basalt dykes. A Lower to Mid Jurassic date seems to be the best fit with the structural and igneous framework, however this assumes that the sericite tested correlates directly with gold mineralization. In addition, the disparate sericites dates could indicate more than one alteration or mineralization episode. Further testwork, consisting of dating of hydrothermal sericite that is Known to be intimately related to gold mineralization could be undertaken in order to better constrain the age of the mineralizing event. Such work would probably not enhance exploration on the Golden Bear property, but if correlated to a specific igneous event could provide focus for regional exploration.

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