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A Review of STRUCTURAL GEOLOGY and LOCAL CONTROLS ON MINERALIZATION at the GOLDEN BEAR PROPERTY

Bearskin (Muddy) Lake,

Northern British Columbia

for

North American Metals Corp.

by

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INTRODUCTION

The following report reviews the observations and inferences which were obtained during recent mapping on the Golden Bear property, northern British Columbia.

The principal mandates of this study were to re-consider the general structural setting of the deposits presently known or developed on the property, and to offer suggestions as to possible controls on mineralization, the results of which implicitly should inform and guide future exploration on the property.

Mapping was undertaken initially well outside the deposit areas to gain a sense of regional context, and was followed by traverses in selected areas of the property closer to the deposits: adjacent to or within the immediate Bear Main, Kodiak A&B (Fleece Bowl), and Ursa Pit settings. The study did not involve a full re-mapping of the entire property (although on present evidence some areas may warrant re-mapping), nor detailed mapping within past producing pits. The map of structural elements and lithologic trends which accompanies this report (Fig. 1) differs in some respects significantly from previous compilations (e.g., Cooley, 1996). However, it also contains significant gaps, and some of the inferences discussed herein should be considered as preliminary. The study is further informed by a review of available literature documenting past exploration efforts (including Cooley, 1996) and regional mapping (Souther, 1971; Bradford and Brown, 1993; Oliver, 1996; etc.).

The field study upon which this report is based was undertaken at the request of Mr. Dunham Craig, Vice President Exploration of Wheaton River Minerals Ltd. It was completed during the period Aug 5-Sept 5, 1999.

LITHOLOGIC AND STRATIGRAPHIC ISSUES

Most of the map units previously ascribed to Permian carbonate stratigraphy have been subdivided by past workers into several limestone/dolostone (marble) units. Historically, lithologic distinctions have been accorded on the basis of colour, foram content, interpreted stratigraphic position, etc. Especially prior to the compilation by Cooley (1996), mapping and core logging by several generations of company geologists has been marred, critically, by gross inconsistencies. During this current study, it proved impossible to correlate lithologic intersections in historic drill sections through the Kodiak and Bear Main deposit areas: a problem without easy resolution, since much of the archived core has been scavenged for metallurgical studies.

All of the units ascribed to the Permian on past and current maps have been designated as carbonates. Many are described in core logs and on maps of surface geology as being silicif<u>ied</u>, as opposed to silic<u>eous</u>, with the implicit genetic implications that arise from the too casual use of the former - rather than the latter - descriptive term. Historic petrographic analyses, especially those undertaken by J.F. Harris, Ph.D., indicate that many intervals previously logged as LMST or as LMBC(?) generally contain significant ($\leq$95%) quartz, much of which on textural evidence is detrital in origin. Textural observations from these thin-sections indicate that the carbonate occurs typically as intergranular matrix to quartz grains, or as bedded intercalations with quartz-rich beds and laminae: an observation confirmed under the binocular microscope and in the field during the current study. Samples previously mapped and logged as silicified (sic) limestone (LMST) crackle breccia are instead comprised of quartzite clasts cemented by granular quartz with accessory sericite and carbonate, or locally by carbonate alone, with minor limonitic staining[1].

These Permian carbonate units, then, generally are siliciclastic quartz-rich lithologies, and/or locally are intercalated with siliciclastic quartz-rich lithologies. They more properly should be considered in most instances to be derived from calcitic sandstones which have been metamorphosed to quartzite and marble. They likely result from deposition of terrigenous sediments within a limey environment. Oliver (1996, p.

[1] In the "Totem Silica" area, limonite staining preferentially occurs along bedding planes where quartz-rich beds are intercalated with relatively quartz-poor limestone beds, and along jig-saw fractures.

13) tentatively has suggested either toe of slope or reef foreslope facies, but the relative abundance of detrital quartz throughout may add some further complexity. The petrographic evidence, as well as field observations from this study, further suggest that silicification in this environment is limited to that normally expected through diagenesis and, locally but perhaps importantly, to a relatively minor and late overprint of fracture-controlled silica-rich fluids. There is little current petrographic evidence to suggest that the quartz-rich aggregates represent pristine carbonates which were pervasively silicified subsequent to diagenesis by externally derived fluids; Harris' petrography found no evidence of processes involving de-calcification and silica replacement (and at least one suite of samples examined by him was obtained immediately beneath the Kodiak A deposit setting). These inferences also particularly apply to the Totem Silica, which previously has been mapped as chert by Jim Oliver and as silicified LMST by Cooley, and which is considered by this author to constitute a thin veneer of quartzite (QTZT) which is intercalated with quartz-rich limestone (LMST) at its base. However, the inferences extend as well to much of the LMST and, likely, DOCH units mapped on the property.

A notable lithologic exception to the above comments occurs for the LMBC unit, as herein defined: a grey weathering, soft, generally strongly calcareous, weakly argillitic limestone that locally grades to dark grey strongly argillitic limestone and weakly calcareous argillite. LMBC is particularly well exposed west and southwest of the Ursa Pit, but also outcrops intermittently up-slope to the south of Ursa Pit and in Fleece Bowl. Southwest of Ursa Pit, LMBC incorporates what previously have been mapped there, inappropriately, by Cooley as separate LMGT, LMST, and LMBC units[2]. Although distinctions can be made among several facies (sub-units) within LMBC there (Table 1, Fig. 1), they collectively describe a lithology which can be distinguished from LMST and LMGT in that it is variably argillitic (marl), is generally crowded with bioclastic debris, and is relatively lacking in quartz except in silty intercalations. Although both Oliver and Cooley have tentatively associated the dark grey argillitic sub-unit (LMBC-c in this study) with LMGT, the LMBC-c sub-unit lacks the black chert and hematitic overprint of LMGT observed elsewhere on the property, and its stratigraphic position differs from LMGT observed elsewhere. It differs from LMGT, as well, in being fossiliferous. Resolution of that lithologic setting near Ursa Pit into

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[2] The lithologic distinctions incorporated into Cooley's compilation map seem unnecessarily complex, locally inconsistent, and to some extent obscure stratigraphic relations in the property area

Table 1: Lithologic Units

GBRO		Gabbro
GRDF		Granodiorite; foliated
		PERMIAN
LMGT		Graphitic to argillitic limestone±dolomite; generally interbedded with dark grey to black chert; weakly to moderately hematitic
QTZT		Quartzite: massive, but locally bedded to thinly laminated; transitional to, and locally intercalated at base with, highly siliceous LMST; white, and "cherty"
LMST		Limestone: moderately to very hard, massive to locally bedded, weakly to moderately calcareous quartz-rich limestone/quartzite; typically intercalated with QTZT near transitional contact where bedding planes are preferentially rusty orange in colour, imparting a buff orange colour to outcrop
DOCH		Dolomite: moderately to very hard, massive to thick-bedded, buff-weathering, pale grey to buff on fresh surface, quartz-rich dolomite; typically includes grey siliceous nodules and lenses, and less commonly continuous mid-grey siliceous beds
LMBC		Argillitic limestone: generally fossiliferous
	LMBC-a	Generally soft, weakly to strongly calcareous, pale grey, finely laminated, silty limestone; commonly interbedded with high weathering, thin, silty, buff carbonate beds, lenses & nodules (DOCH?); intermittent bioclastic debris (less commonly than for b, c); locally weathers with abundant dissolution pits
	LMBC-b	Soft, strongly calcareous, mid-grey weathering, finely laminated to thin-bedded limestone; commonly interbedded with high-weathering, thin, silty, buff to grey carbonate beds and nodules (DOCH?); generally crowded with abundant poorly sorted bioclastic debris including crinoids
	LMBC-c	Soft, strongly calcareous, mid- to dark grey, finely laminated to thin bedded argillitic limestone; commonly interbedded with high-weathering, thin, silty, buff to grey non-calcareous carbonate beds (DOCH?), and locally intercalated with LMBC-b; locally with bioclastic debris including crinoids; grades locally to dark grey-black strongly argillitic limestone and weakly to non-calcareous argillite, with concomitant diminishing of bioclastic debris
		METAVOLCANIC & METASEDIMENTARY ROCKS (Lower Carboniferous)
MFTF		Metavolcanic tuff ± flows - undifferentiated
	MFAS	Ash tuff
	MFLP	Lapilli tuff
	MFFL	Mafic flows: locally with weakly to moderately developed pillow selvedges
	MFCA	Carbonatized mafic metavolcanics
ARGI		Argillite: locally graphitic
PHYL		Phyllite

a single unit greatly clarifies stratigraphic relations on the north part of the Golden Bear property.

The implied stratigraphic sequence for carbonates (Table 1, Fig. 1) attached to the map which accompanies this report is based on field relations observed only within the areas selected for study during the current field project, and does not benefit from broader full-property or regional mapping; it may warrant further revision. It does conflict significantly with that inferred from the compilation by Cooley, and is instead fairly consistent with Oliver's (1996) Permian stratigraphic section. It properly should be viewed as preliminary, subject to further mapping and petrographic analyses. In addition, there is some evidence in outcrop that stratigraphy at Golden Bear, at least in the Permian carbonates if not as well in the metavolcanics, is overturned, possibly on the lower limb of a regional scale recumbent isoclinal nappe. Hence, the order of the map units should not necessarily be construed as defining chronological, rather than structural, succession.

No attempt has been made for this study to break out or reconsider stratigraphic order in the rocks which surround the Permian carbonates at Golden Bear. Oliver (1996) recognizes upper Carboniferous and lower Carboniferous suites, whereas Bradford and Brown (1993) assign an upper Triassic age (Stuhini Group) to the predominantly tuffaceous mafic metavolcanic rocks which occur on the west, south, and east flanks of the Permian carbonate exposures. The suite of strain fabric elements and the structural style of folding thus far observed on the property is consistent and correlative throughout all rock suites, allowing for rheological differences among them.

PROPERTY-SCALE STRUCTURAL GEOLOGY

Within the limits of the areas mapped for this study, two principal fold styles are discerned. Superposition of open to locally tight NNE-plunging folds (F2) on an earlier fold set which typically is recumbent and isoclinal (F1) suggests that the two styles can be ascribed to separate and distinct tectonic events. Although the orientations of fabrics derived from the earlier episode locally differ significantly between the Permian carbonate setting, and the flanking metavolcanic and metasedimentary rocks, both signatures are present and correlative in all areas and all rock suites observed during this study. Previous mapping and geochronology (Oliver and Hodgson, 1990; Oliver and Gabites, 1993; Bradford and Brown, 1993) suggest additional complexities to regional fold patterns that cannot be addressed by this study. However, these two principal episodes are the essential fold imprints which have affected the immediate Golden Bear setting, and account in large part for the presently understood map pattern of lithologies. Fault trajectories and displacements in the area may likely be more easily resolved by unravelling these fold patterns.

Recumbent Folding (D1)

Within Permian Carbonates

The LMBC argillitic limestones exposed southwest of the Ursa Pit are dramatically characterized by pervasive development of long-limbed asymmetric recumbent isoclinal folds, boudinage of relatively more competent thin silty layers within that unit, rootless isoclines defined by the silty boudins and by fine laminae within the limestone, and re-orientation of boudins sub-parallel to an axial planar foliation which occurs at a generally low angle to relict bedding attitudes (Pla. 4, 5). In this area, the axial planes of these recumbent isoclines generally dip northwesterly to northerly, at angles which typically are shallow but which steepen locally. Fold axes generally plunge shallowly from west-southwest to west-northwest. Fold vergence is broadly to the south. These are Z-shaped asymmetric folds which progressively rise in elevation to the south or south-southeast, suggesting that lithologies in this area may be overturned. The recumbent folds typically are stacked, separated by narrow displacement surfaces.

These outcrop-scale fold patterns are most spectacularly apparent within the strongly argillitic limestone and calcareous argillite sub-unit designated for this study as LMBC-c, and where it is interfolded with the more moderately argillitic limestone sub-unit designated LMBC-b. This is a relatively quartz-poor lithology, the rheology of which is preferentially amenable to strain partitioning compared with the overall, relatively quartz-rich, Permian carbonate sequence. The LMBC-c sub-unit in particular appears to have acted as locus of significant stratigraphic offset, as a result of both flexural flow transposition and related more discrete fault displacement. The results of this study tentatively suggest, for instance, that LMBC has been tectonically imbricated to overlie DOCH in the area immediately south of the Ursa Pit, and that the strongly argillitic LMBC-c sub-unit has preferentially focussed tectonic displacement there. The faulting may be thrust-related, but gravity sliding cannot be ruled out.

This mesoscopic style of recumbent folding is identical to that observed macroscopically at upper elevations in the Fleece Bowl, wherein asymmetric Z-shaped (looking west) recumbent folds verge to the south-southeast. The macroscopic fold pattern is strongly reminiscent of fold nappe geometries, and it is at least possible that the upper Fleece Bowl setting may lie on the overturned limb of a regional recumbent anticline. At Fleece Bowl, the fold pattern includes LMBC and LMST lithologic units, and possibly may include DOCH at lower elevations. The west wall of the Kodiak A Pit locally is characterized by a spectacular series of stacked recumbent isoclinal folds which progressively in turn have been refolded about shallowly north- and south-dipping axial planes (Pla. 6). Stacked folds there locally are separated by (thrust? slide?) fault displacement planes (≤1-2 cm wide) with preserved shear fabrics. The Totem Silica QTZT, which occurs at the uppermost levels of the Permian sequence, dips essentially sub-parallel to slope north of the height of land near 11.5K on the access road to Ursa Pit (Fig. 3), and hence extends in outcrop for hundreds of metres to the north at a shallow attitude (Fig. 1). Intercalations between the QTZT and immediately underlying orange-weathering LMST, and between LMGT and QTZT, are characterized by locally exposed recumbent isoclines and transposed rootless isoclines identical to those described above. The Totem Silica units likely underlie eroded thrust-emplaced lower Carboniferous metavolcanics here.

Southwest of the Ursa Pit, axial traces of the recumbent folds generally trend to the southwest and west, and axial planes generally are shallowly dipping. However it is apparent from the mapping compiled by Cooley (1996) and from this study, that the fold traces progressively fan moving from west of Ursa Pit to upper Fleece Bowl. Moreover, between the upper elevations at Fleece Bowl and the Black Fault, dips of bedding progressively steepen, as do the axial traces of asymmetric isoclinal folds observed there. Close to the Fleece and Black Faults, the folds are upright to inclined, and fold axes have been rotated to southerly trends. In the past, north-south trending isoclinal folds in the lower Fleece Bowl, as well as at Bear Main and at other settings on the Golden Bear property have been interpreted as part of a distinct fold event, postdating recumbent folding and predating a later overprint of NNE-plunging folds (herein D2). Nowhere

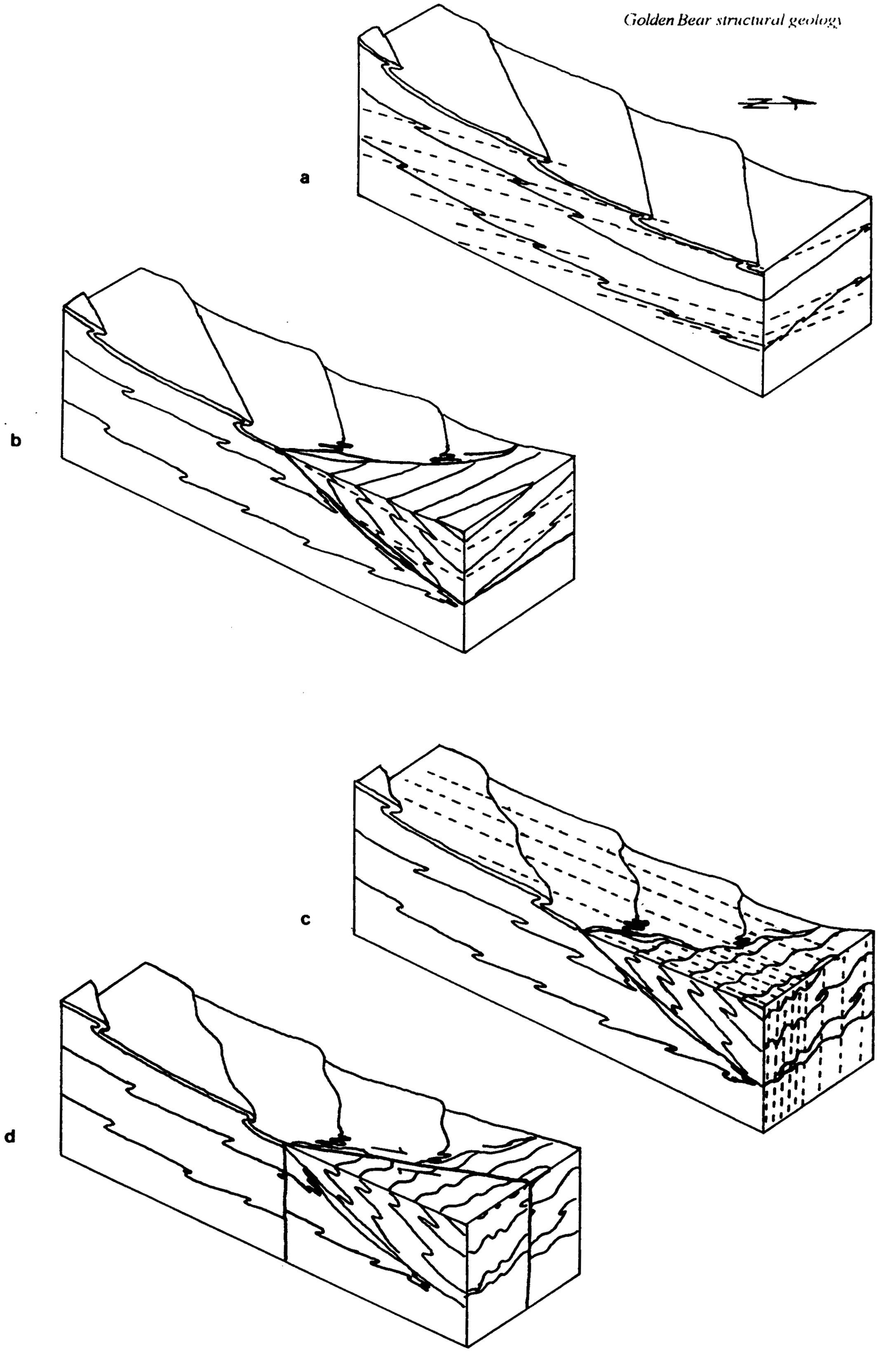

Fig. 5 Schematic illustration of principal deformations events: a) D1 asymmetric recumbent isoclinal folding, here shown in Permian carbonates. b) thrust emplacement of Carboniferous metavolcanics over carbonates, with associated splays and reorientation/tightening of D1 folds close to fault planes, c) D2 open folding with shallow NNE-trending axes (dip of axial planes approximate). and d) relatively minor late brittle fault displacement, shown here with an assumed dextral component of offset. The thrust fault is shown as curviplanar, trending WNW-ESE in the distant view, and closer to N-S in the foreground where its displacement would include a significant strike slip component.

during the current mapping, however, have such folds been observed overprinting the morphologically identical recumbent D1 folds. Observations for this study suggest instead that the more upright, south trending folds in these areas were initially shallowly dipping D1 folds which have been progressively rotated and reoriented. It also is apparent that the reorientation is most pronounced approaching the main thrust which places lower Carboniferous rocks over Permian carbonates, and approaching individual faults which splay from that thrust (e.g., Black Fault, Fleece Fault).

The mesoscopic observations so dramatically apparent in LMBC-c&b immediately southwest of the Ursa Pit hence appear to more broadly characterize the dominant early deformation imprint recorded within at least the structurally higher Permian units exposed on the Golden Bear property. This imprint likely resulted in significant tectonic transposition. D1 fabrics (bedding, foliation, fold axes and intersection lineations) locally are re-oriented to steeper dips near major fault zones in the area, and are additionally overprinted by F2.

Within Lower Carboniferous Rocks

Little account has been documented in previous regional studies regarding the presence of fabric relations, identical to those observed within the Permian stratigraphy, in the largely metavolcanic tuffs±phyllites±argillites which flank the Permian carbonates at Golden Bear. Current mapping as far east as the bridge across Samotua River consistently indicates the presence of i) a shallowly dipping early (S1) penetrative cleavage which is everywhere subparallel to bedding (S0) where the latter can be discerned, and ii) locally preserved shallowly to moderately plunging recumbent isoclinal folds, the limbs of which are subparallel to the penetrative cleavage. Facing directions in (generally) shallowly dipping metasedimentary rocks along the main access road east of camp locally are overturned. Shallowly plunging minor recumbent asymmetric S-folds have been observed in generally upright felsic tuffs and sedimentary rocks at Samotua River (Pla. 1, 2). The upper access road to Bear Main locally exposes recumbent subhorizontal asymmetric Z- and S-shaped folds within fold packets juxtaposed along imbricate fault slivers in variably serpentinized and sheared mafic metavolcanics and argillites. Similar packets of isoclinal folds and rootless isoclines occur in graphitic argillite and tuffs which flank the Bear Main Pit to the west but, there, the recumbent folds as well as S0-S1 and packet bounding shears have been rotated to steeper easterly dips closer in attitude to that of the Bear Fault. Isoclinal rootless isoclines occur locally within ash tuff along the Ursa Pit access road above Fleece Bowl (Pla. 7). In addition, the tongue of metavolcanics which extends northerly between the Totem Silica and Ursa Pit, although strongly overprinted by F2, locally exposes mesoscopic-scale recumbent isoclinal folds between interfolded ash tuff and lapilli tuff components. Many individual metavolcanic outcrops in that area show a crude generally Z-shaped asymmetry to bedding looking west, similar to that observed in DOCH between Kodiak Fault and Ursa Fault. Along the east flank of the Totem Silica, metavolcanics are isoclinally interfolded with LMGT and QTZT in uncommon contact exposures. Throughout the metavolcanics, D2 folds locally have re-oriented bedding, cleavage, and the recumbent isoclinal folds.

These observations in concert suggest that the lower Carboniferous metavolcanics may as well have been subjected to at least locally partitioned transposition, and that D1 fabrics are correlative between those rocks and the Permian units.

Superimposed Folding (D2)

Most lithologies in the areas mapped for this study record a second increment of folding that is superimposed on precursor fabric elements. D2 folding is characterized by generally upright to slightly overturned, gentle to open (but locally tight) folds, the axes (L2) of which plunge shallowly to the north-northeast. D2 locally reorients generally north to northeast dipping S0 and S1 to generally moderate east-southeast and west-northwest dips. Westerly plunging L1 folds axes and intersection lineations become doubly plunging, at shallow angles, to the west-northwest and east-southeast where affected by D2 cross-folding. Where the early plunge of L1 axes and lineations was more to the southwest, as in some areas near Ursa Pit and in the upper Fleece Bowl (as well as in lower Carboniferous metavolcanics), the rotation is less apparent and original plunges are relatively undisturbed. In the latter case, such fold axes commonly have been mapped in the past as part of a separate fold event; fabric relations confirm instead that they are preserved D1 isoclinal folds. An S2 cleavage axial planar to the superimposed folds is not strongly expressed, except locally, in the mapped areas. In general, D2 constitutes a broad warping of earlier fabrics, locally accompanied by cm- to m-scale second order minor buckle folds.

D2 folding, as envisaged herein, may be related to the Sam Creek Antiform as defined by Oliver (1996). The area where Oliver has traced that regional fold lies outside the area mapped for this current study.

In some areas of the property, superimposed D2 folding likely has resulted in a previously reported dome-and-basin (Ramsay Type I) non-coaxial fold interference pattern: i.e., where F2 cross-folds warp shallowly north dipping composite S0-S1. Elsewhere, where precursor S0-S1 trends were closer to north-south, the overprint is near coaxial, and the dome-and-basin interference pattern is absent.

North of the height of land above Kodiak A Pit, the Totem Silica and immediately contiguous metavolcanics define a synform-antiform-synform relation (Fig. 4); closely parallel contacts exhibit a linear north-south trend in plan view (Fig. 1). The map pattern superficially suggests isoclinal folding. However, gross lithology dips subparallel to topographic slope there, and has been only gently refolded about NNE-plunging axes whose plunge also is closely subparallel to slope. Hence, the resulting plan distribution of lithologies there greatly exaggerates the tightness of interlimb angles resulting from the superimposed D2 folding.

Faulting

Most plausibly, the regional inferred thrust fault which places lower Carboniferous metavolcanics on top of Permian carbonates in the Golden Bear setting can be ascribed to the same broad episode of regional strain responsible for D1 recumbent folding observed there. Oliver (1996) has documented supporting relations throughout the Muddy Lake/Tatsamenie Lake District. The thrust fault may represent the culmination of D1 strain, since presently it is not reported in the regional literature to have been recumbently folded.

The trace of the thrust fault cuts obliquely, generally at a low angle, across Permian stratigraphy on the Golden Bear property, such that the metavolcanics locally are emplaced discordantly against DOCH, LMST and QTZT. The thrust extends across the Golden Bear property most likely as far south as to include the Black Fault in Fleece Bowl, and it possibly (as inferred by Oliver), includes at least that part of the Bear Fault which bounds the carbonate/"chert" sliver at the Bear Main Pit. If the Black Fault and the West Wall Fault indeed represent a continuation of the main regional thrust, then most of the apparent displacement along them likely occurred during early thrusting rather than late reactivation (Fig. 5).

The attitudes of bedding and D1-related strain fabric elements differ on either side of the fault in the Golden Bear area. In the Permian carbonates, widely scattered bedding attitudes centre about a peak attitude of 225/32NW (Fig. 6), whereas composite S0-S1 from metavolcanics east of the fault cluster broadly about a 349/20NE (Fig. 7). Doubly plunging L1 fold axes and intersection lineations in the carbonates generally trend NW-SE (Fig. 8), whereas both shallow north-northeast-plunging and southeast-plunging L1 lineations dominate in the metavolcanics (Fig. 9, 10). These relations either can be attributed to low angle discordance in original attitudes of the carbonate and metavolcanic lithologies prior to faulting or, alternatively, may suggest that the fault trace and/or movement direction were curviplanar at regional scale. A further possibility is that the north-south trending, steeply dipping trace of the inferred thrust as it extends along the east flank of Totem Silica toward Fleece Bowl and Bear Main may represent an oblique or a lateral ramp, oriented at a high angle to the ≈east-west trending frontal ramp of the main regional thrust. In such a case, displacement along that part of the thrust (including the Black Fault) plausibly would include a significant strike-slip component: dextral in sense. The thrust fault appears to have been only moderately folded during subsequent D2 regional strain (Fig. 4).

Mapping for this study tentatively suggests that the Ursa Fault and others in that area initially formed during D1 recumbent folding. They may be truncated by the main regional thrust fault, or could also represent divergent splays that emanate from that structure (Fig. 4). Similarly, the Kodiak Fault, extending into the Fleece Fault at Fleece Bowl, could possibly represent a rejoining splay off the main thrust. Tight to isoclinal folds observed near the Fleece and Black Faults herein are inferred to be reoriented D1 recumbent folds, rather than manifestations of a distinct and separate tectonic event. More satisfying resolution of these possibilities requires greater stratigraphic constraints than are currently available on property geology maps, and additional structural analysis dependent on such constraints. The current observations do intimate, however, that much of the apparent displacement along these faults could have

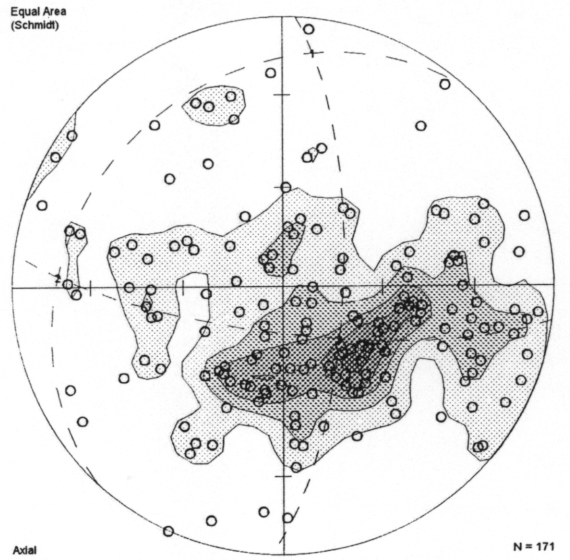

Fig. 6 Contoured poles to bedding in the Permian carbonate sequence, Golden Bear property. The peak trend and plunge of the contoured poles is 135→58 corresponding to a planar attitude of 225/32NW. The data are broadly scattered along a great circle girdle, the pole to which occurs at 007→14, roughly parallel to F2 fold axes in the area.

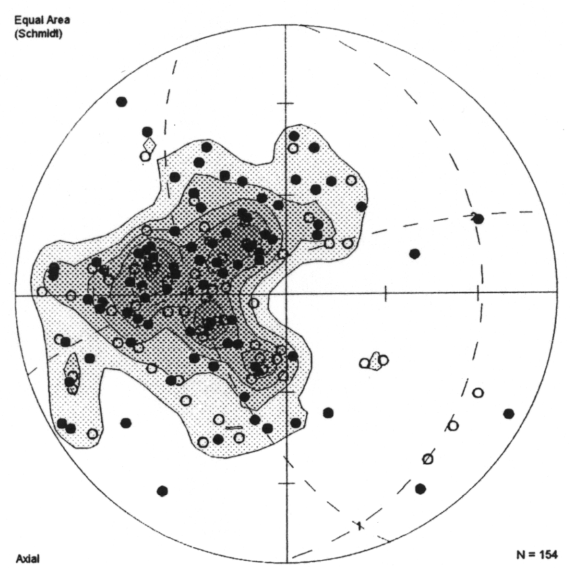

Fig. 7 Contoured poles to bedding (open circles) and S1 cleavage (filled circles) in Carboniferous metavolcanics and metasediments, Golden Bear property. Bedding and cleavage are generally subparallel. The peak trend and plunge of the contoured poles is 283→48 corresponding to an orientation of 013/42ESE. This attitude is discordant to bedding attitudes within the carbonates.

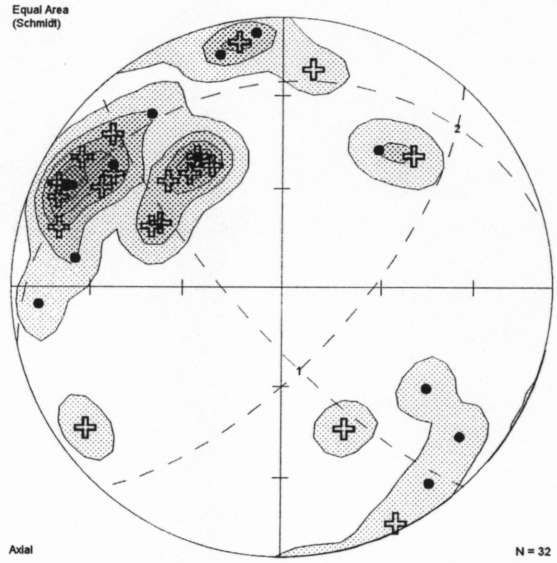

Fig. 8 Contoured L1 fold axes (filled circles) and S0-S1 intersection lineations (crosses) in Permian carbonates, Golden Bear property. The data exhibit a peak trend and plunge of 297→14, but indicate plunges generally to both NW and SE. L1 lineations have been refolded by NNE-trending D2 gentle to open folds.

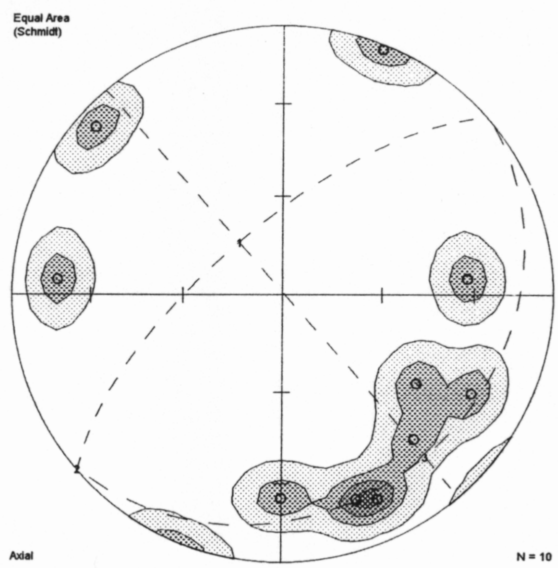

Fig. 9 Contoured L1 fold axes in Carboniferous metavolcanics and metasediments, Golden Bear property. Most axes plunge shallowly NW or SE, similar to L1 axes in e Permian carbonates.

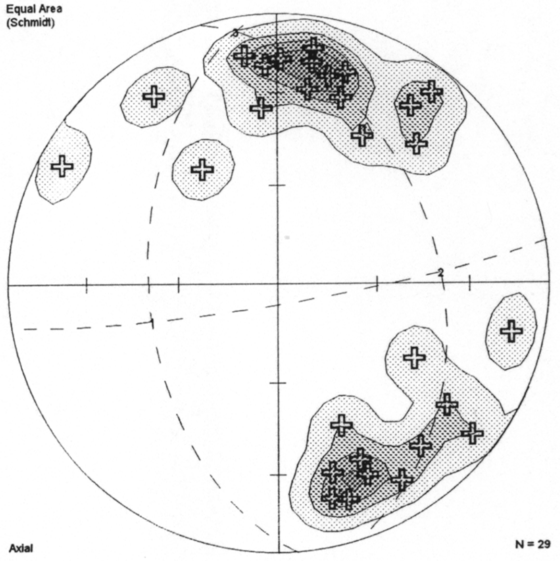

Fig. 10 Contoured intersection lineations in Carboniferous metavolcanics and metasediments, Golden Bear property. Two clusters of data are noted, centred about peak trends of 012→22 and 159→24. The latter group is closely subparallel to L1 recumbent fold axes. The NNE-plunging cluster of data reflects the D2 fold overprint.

taken place during D1 early folding and/or thrust events, rather than during a later episode of fault movement. Cross-sections of fault splays at Kodiak B&C, and at Bear Main, can be explained as easily and more plausibly by thrust imbrication rather than by relatively late fault adjustments, notwithstanding the steep dips to imbricate slivers preserved in those settings. The relatively late Ophir Break, which reportedly crosscuts the main thrust regionally and which is spatially related to mineralization in the area, might hence be envisaged as incorporating precursor thrust strands along which reactivated (extensional?) movement involved local and/or relatively minor displacements.

DEPOSIT-SCALE POSSIBLE CONTROLS ON MINERALIZATION

There is general consensus among all previous workers that the Ophir Break fault system has exerted a fundamental control on the migration of mineralizing fluids in the Golden Bear setting and, reasonably, that local dilatations (fault jogs, cymoid loops, etc) may have further contributed to local deposition of gold. Nothing has been observed during this study to refute such a broad concept. All of the known deposits occur along or adjacent to probable elements of this composite fault system, and most occur a short distance from fault splay junctions.

Lehrman and Caddey (1989) invoked a cymoid loop model involving reverse movement along the Bear Fault for mineralization in the Bear Main setting. Oliver (1996) too has suggested reverse movement[3] along that fault strand, and confirmed that mineralization appears to be partly controlled by a local flexure where the fault exhibits an anomalously shallow dip. Lehrman and Caddy, and Cooley (1996), have further suggested that local dilation and consequent mineralization may be influenced and perhaps controlled by the intersecting hinge regions resulting from interference of D1 and D2 cross-folds. Although some elements of these models may apply locally, surface mapping for this study suggests that none of them are universally applicable to all of the known deposit settings on the property, and some certainly are not relevant to the Kodiak A and Ursa Pits. They therefore are not uniformly useful as predictors of additional mineralization in the Golden Bear setting.

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3 Note that the inferred reverse (east-side-up) sense of displacement inferred by these authors is consistent with the dip-slip component of possible early thrust imbrication.

Mineralization thus far encountered on the Golden Bear property appears to be (very?) late, relative to regional deformation events. High grade and locally visible gold is contained within cataclastic fault gouge obtained from the floor of the Ursa Pit, along the Ursa Fault. On surface, the Fleece Fault is characterized by brittle gouge, and by intensively developed fluid-generated stockwork fractures in the metavolcanic sliver within it and in immediately contiguous carbonates. At Kodiak B&C, mineralization reportedly attains highest grade where the fault or adjacent units are most intensely brecciated. A significant proportion of mineralization at Bear Main is hosted within a broad zone of fault gouge (Oliver and Hodgson, 1989), and the Bear Fault has been described as a brittle reactivated fault system. Previous observations and those obtained during the current study hence suggest that mineralization resulted from relatively late fluid infiltration into a multi-stage fault system, syn- or post-late cataclasis, and that the path of mineralizing fluids was influenced by earlier fault-related fabrics.

Mineralization at Kodiak A Pit and at Ursa Pit flares outward from the locally controlling faults at those respective settings. At Kodiak A, mineralization extends into carbonates on the west side of the Kodiak Fault, crudely outlining an inverted tear-drop shape in profile. The west benches of that pit are uniquely characterized by stacked recumbently refolded isoclinal folds, separated by cm-wide ductile shear displacement zones which exhibit locally strong hematitic and limonitic staining. The structural elements (and lithology?) there differ from those at the north and south boundaries of the pit bulge. At Ursa Pit, current grade plots in plan indicate that mineralization extends west-southwest of the Ursa Fault within the lithologically distinct pale grey sub-unit herein defined as LMBC-a. Both settings suggest that mineralization has to some extent selectively exploited local variations in primary lithology, outboard of their controlling faults. The lithologic control may be secondary and merely incidental. More plausibly, however, both lithologic/structural settings may have been preferentially permeable within the overall carbonate stratigraphy, and thereby may have directly influenced gold precipitation along, as well as adjacent to, their respective controlling faults.

Selective infiltration of mineralizing fluids outboard of the faults likely reflects permeability contrasts within the carbonate stratigraphy which may be primary, or which could have resulted from regional strain: e.g., enhanced permeability along lithologic sub-units i) relatively deficient in detrital quartz, ii) characterized by continuous networks of intercrystalline fractures generated during regional D1 folding within relatively quartz-rich (primary or diagenetic) brittle elements of the carbonate sequence, or iii) marked by intense recumbent folding and a relatively abundance of closely spaced discrete shear/fault displacement zones. None of these or other extant possibilities can be precluded at present, and can best be evaluated with additional detailed and extensive petrographic studies.

Current mapping hence suggests that local controls on mineralization may be at least in part lithological, and that such controls cannot be properly evaluated without additional petrographic and stratigraphic constraints. Specific sites of gold deposition hence may reflect the combined influence of fault pathways for fluids, and locally enhanced fault brecciation, where the faults cut preferentially permeable lithology.

RECOMMENDATIONS FOR FURTHER WORK

Present and additional mapping on the Golden Bear property requires tighter lithologic and stratigraphic constraints.

As a first step, prior to next field season, detailed petrographic descriptions and analyses of representative samples from all presently recognized carbonate map units on the property, from various locations, should be undertaken. The modal abundance and composition both of detrital constituents and of secondary hydrothermal overprints hopefully should be resolved by such a study, as well as stain fabric overprints. This suggestion has two purposes: 1) to constrain broad lithologic distinctions among units that can be mapped in the field consistently, and to track detrital variations within such map units, and 2) to assess which unit(s) might preferentially offer a primary or secondary permeability for potentially mineralizing fluids.

Based on the above, and with field checking, an attempt should be made to resolve the current overly complex (Cooley, 1996) rock type codes for Permian lithologies into units and sub-units which are consistently distinguishable in the field and in core (e.g., DOCH, LMBC, LMST, QTZT, etc.). The carbonate legend incorporated into the current geologic compilation of Cooley by way of Pigage may be informed, but it includes some units (e.g., two LMST units and two LMGT units) which cannot be field-mapped consistently, and which obscure lithologic continuity and macroscopic stratigraphic correlation.

Results of the above should partly resolve some lithologic ambiguities which have also arisen during the current mapping. In addition, there are significant and critical gaps in coverage undertaken during this study: notably between Fleece Bowl and Ursa Pit, and up-slope of the Fleece Bowl toward the Totem Silica. Stratigraphic relations between those settings are presently unresolved (e.g., Fig. 2), and can be addressed best only after such a petrographic study, with subsequent field checking.

These recommendations deliberately emphasize the importance of lithology and stratigraphy within the carbonates at Golden Bear, since the results of the present study suggest that lithologic distinctions may critically influence mineralization there. Previous mapping and core logging on the property have been inconsistent at best, and contradictory at worst, throughout the historic exploration efforts, and consequently have hindered rather than properly advanced attempts to understand local and regional controls on mineralization there. It seems incumbent, as a result of this study, to get the fundamental lithology and stratigraphy in order, before attempting to fully resolve the structural setting and more specific controls on mineralization. Only then can predictive tools for additional exploration be rigorously constrained. And perhaps only then can regional-scale hypotheses (e.g., possibly analogues to Carlin-type mineralization) be properly assessed.

Mineralization at Ursa Pit appears to be focussed near the intersection of the Ursa Fault and a pale grey band of LMBC-a or LMBC-a±b. Based on the mapped strike and dip of these elements, their intersection projects at a plunge of approximately 45-55° to the north or north-northeast. A longitudinal section of the delineation drilling for the Ursa deposit confirms a steep to moderate northerly plunge. The closure of the deposit is very tightly constrained by several delineation drill intersections on roughly 25 m centres. However, broader spaced exploration drilling has not yet tested for a possible down-plunge extension of the mineralized zone to the north-northeast, along the Ursa Fault/LMBC-a intersection. Such drilling is warranted here. As well, additional mineralization may occur on the east flank of the Ursa Fault where it intersects the offset continuation of this particular LMBC-a sub-unit. Present observations suggest that displacement along the Ursa Fault is reverse (west-side-up) in its dip-slip component: strike-slip component unknown. Hence such a target likely would lie beneath the elevations of the Ursa Pit-defined setting.

Respectfully submitted

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REFERENCES

Bradford, J.A., and Brown, D.A., 1993. Geology of the Bearskin Lake and southern Tatsamenie Lake map areas, northwestern British Columbia; *in* Geological Field Work 1992, Paper 1993-1, British Columbia Geological Survey.

Cooley, M.A., 1996. Structural geology and gold mineralization of the Golden Bear mine property. Internal report (?) dated November 2, 1996; 47pp.

Lehrman, N.J., and Caddey, S.W., 1989. Golden Bear project Northern British Columbia Canada - geologic appraisal and exploration recommendations. Internal report for Homestake Mining Company, dated July 17, 1989.

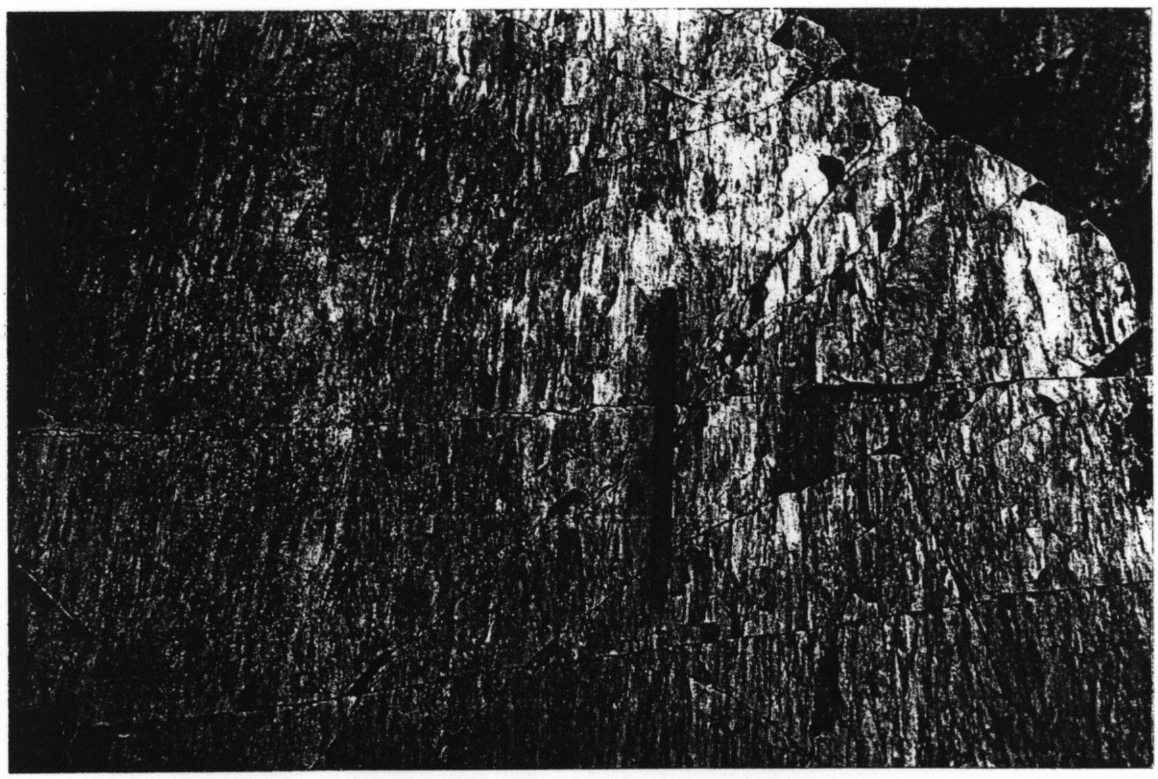
Oliver, J.L., 1996. Geology of Stikine Assemblage rocks in the Bearskin (Muddy) and Tatsamenie Lake district, 104K/1 and 104K/8, northwestern British Columbia, Canada, and characteristics of gold mineralization, Golden Bear mine, northwestern British Columbia. Unpublished Ph. D. thesis, Queen's University, Kingston, Ontario; 236pp.

Oliver, J.L., and Hodgson, C.J., 1990. Geology and mineralization, Tatsamenie Lake district, Northwestern British Columbia; p. 163-173 *in* Geological Field Work 1989, Paper 1990-1, British Columbia Geological Survey.

Oliver, J., and Gabites, J., 1993. Geochronology of rocks and polyphase deformation, Bearskin (Muddy) and Tatsamenie Lakes district, Northwestern British Columbia; p. 177-184 *in* Geological Field Work 1992, Paper 1993-1, British Columbia Geological Survey.

Souther, J.G., 1971. Geology and mineral deposits of Tulsequah map area. Geological Survey of Canada Memoir 362; 76pp.

Pla. 1 Recumbent isoclinal fold in metasediments, Samotua River bridge. The upper limb is upright, as defined by graded bedding. The axial plane is subparallel to bedding along the fold limbs.



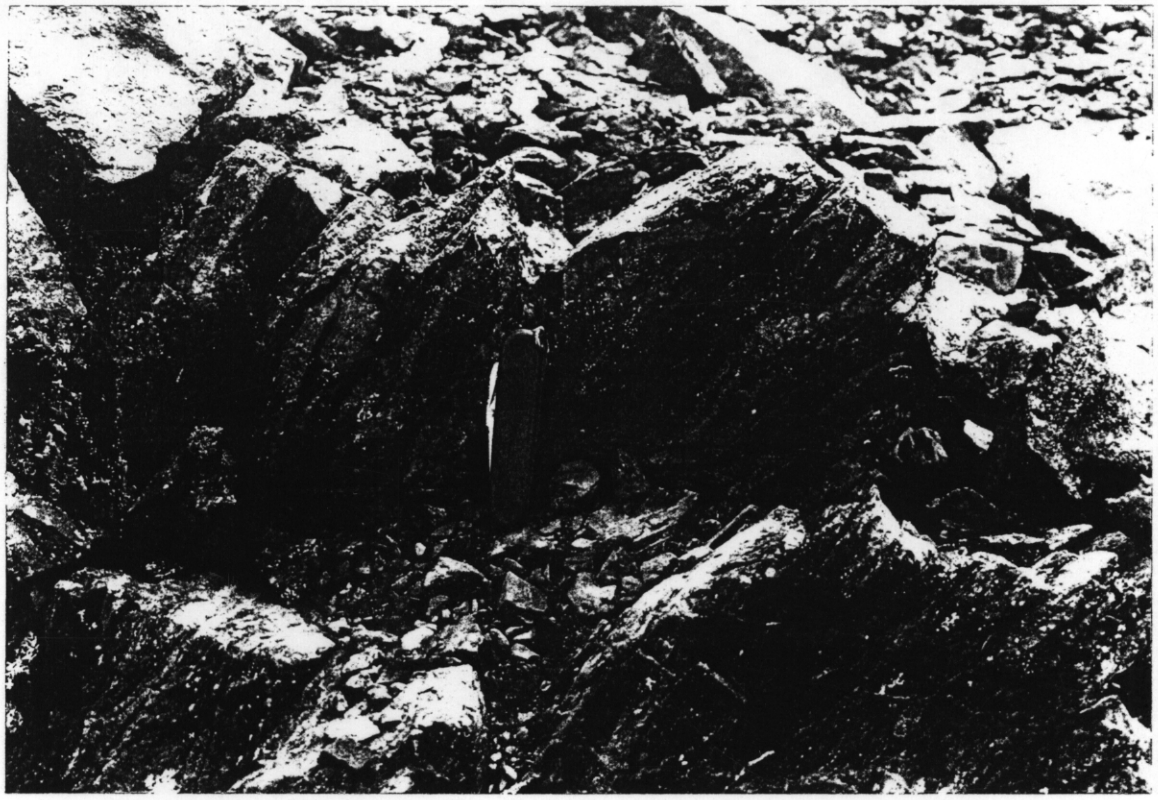
Pla. 2 The intersection of bedding (S0) and subparallel axial planar cleavage (S1) produces a generally strong intersection lineation throughout the Carboniferous metavolcanic and metasedimentary rocks. Photo location same as in Pla. 1. Here the lineation plunges shallowly NNE.

Pla. 3 Transposed bedding in LMBC, upper Fleece Bowl. Cusps of silty beds and forams define faint cleavage (foliation symbol in photo) in the recrystallized limestone unit, at a low angle to relict bedding (pencil, dashed marker line). Photo faces SSW.

Pla. 4 Bedding-cleavage relation in LMBC-b, west of Ursa Pit. Low angle between S0 and S1 is apparent above scale card. This unit is identical to that in Pla. 3 (upper Fleece Bowl).

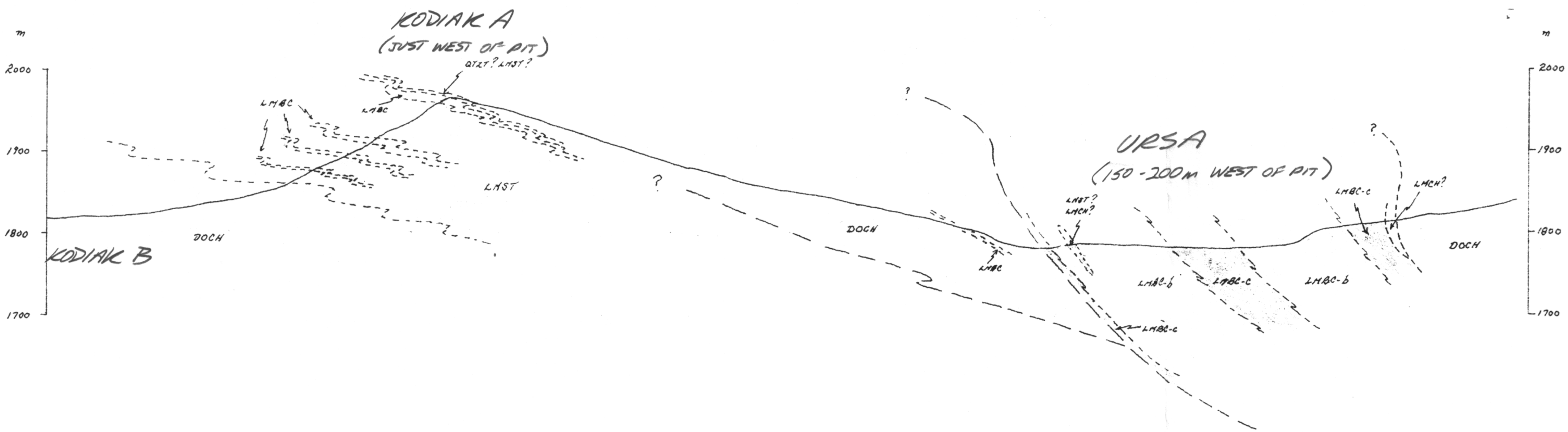
Pla. 5 Small-scale asymmetric recumbent isoclinal folds in dark grey LMBC-c, west of Ursa Pit. Fold axes here plunge WNW, parallel to a lineation defined by the intersection of bedding/laminae (S0) with a cleavage (S1) that is axial planar to the folds.

Pla. 6 Stacked recumbent isoclinal folds, west benches of Kodiak A Pit. The recumbent fold (buff, centre of photo) with shallowly SE-dipping (to left in photo) axial plane overlaps and truncates shallowly N-dipping grey beds immediately below hinge area (right centre), but bedding is continuous further down-dip on lower limb; view is to SW.



Pla. 7 Asymmetric rootless isoclines in mafic tuff, near 11K on Ursa Pit access road. The isoclines are identical in style to recumbent folds seen elsewhere in the Carboniferous and Permian rocks on the property, but here are rotated to a steeper dip. Fold axes plunge shallowly SSE; view is to the south.

Pla. 8 West wall of Ursa Pit. Mineralization in pit extends outward from the Ursa Fault into pale grey LMBC-a or LMBC-a±b subunit, beneath darker grey LMBC-c.



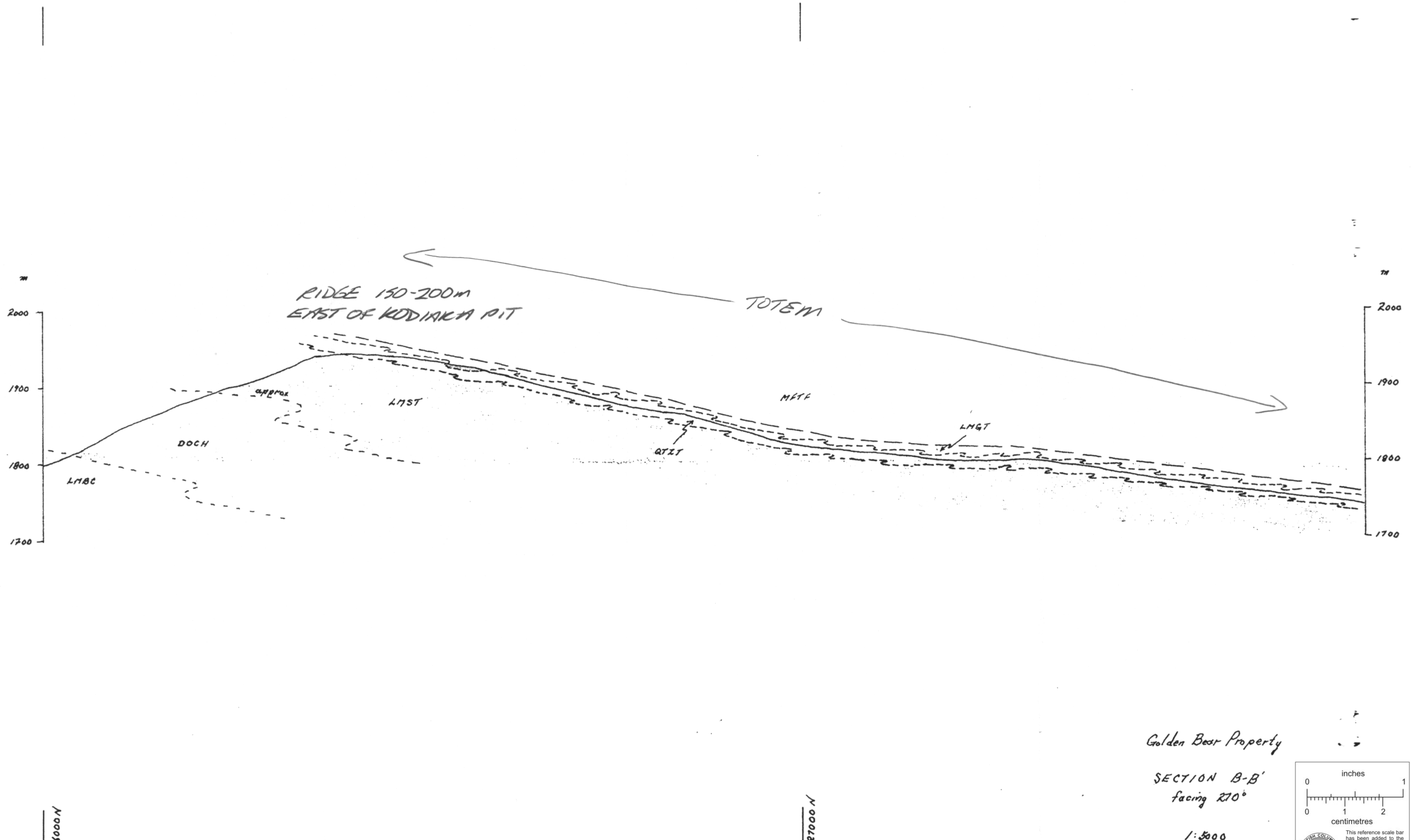
Golden Bear Property

SECTION A-A'
facing 242°

1:5000

inches
0 1
0 1 2
centimetres

W.A.B. Nov.'99 Fig. 2



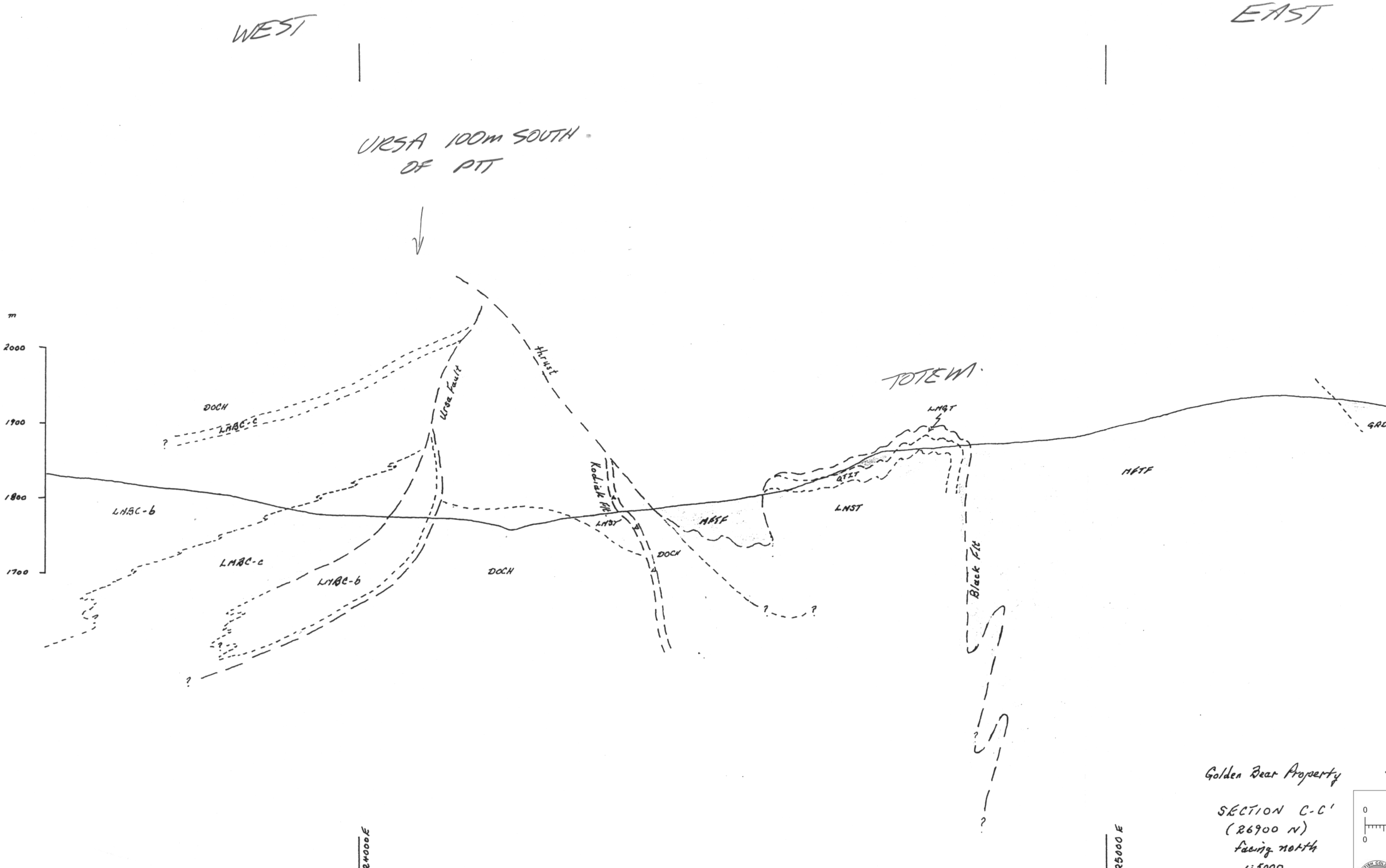
Golden Bear Property

SECTION B-B'
facing 270°

1:5000

W.A.B. Nov. '99 Fig. 3

inches
0 1
0 1 2
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.



Golden Bear Property

SECTION C-C'
(26900 N)
facing north
1:5000

W.A.B. Nov.'99 Fig. 4