PRELIMINARY STRUCTURAL ANALYSIS OF MINERALIZED UNITS IN THE SWIFT RIVER REGION

T. Liverton &
Luiz J.H. D'el-Rey Silva

March 2000

CONTENTS

FIGURES

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

Claim Status Report

06 March 2000

	Claim Name and Nbr.	Grant No.	Expiry Date	Registered Owner	% Owned	NTS #'s
R	BOND 1 - 20	YB89935 - YB89954	2001/09/17	Said Secerbegovic	100.00	105-B-03
R	BOND 21	YB90646	2001/10/16	Said Secerbegovic	100.00	105-B-03
R	BOND 22	YB90645	2001/10/16	Said Secerbegovic	100.00	105-B-03
R	BOND 23 - 34	YB89957 - YB89968	2001/09/17	Said Secerbegovic	100.00	105-B-03
R	BOND 35 - 36	YB90647 - YB90648	2001/10/16	Said Secerbegovic	100.00	105-B-03
R	TANIS 1 - 4	YB16408 - YB16411	2000/09/05	Hardy Hibbing	50.00	105-B-03
				Said Secerbegovic	50.00	
R	TANIS 11 - 14	YB16418 - YB16421	2000/09/05	Hardy Hibbing	50.00	105-B-03
				Said Secerbegovic	50.00	
R	TANIS 21 - 24	YB16428 - YB16431	2000/09/05	Hardy Hibbing	50.00	105-B-03
				Said Secerbegovic	50.00	
	TBMB 1 - 6	YA91276 - YA91281	2002/08/11	Hardy Hibbing	100.00	105-B-03
	TBMB 13 - 15	YA91282 - YA91284	2002/08/11	Hardy Hibbing	100.00	105-B-03

Criteria(s) used for search:

CLAIM NAME: BOND, TANIS, TBMB   CLAIM STATUS: ACTIVE & PENDING   REGULATION TYPE: QUARTZ

Left column indicator legend:

R - Indicates the claim is on one or more pending renewal(s).

P - Indicates the claim is pending.

Total claims selected : 57

Canada

PRELIMINARY STRUCTURAL ANALYSIS OF MINERALIZED UNITS IN THE SWIFT RIVER REGION

INTRODUCTION

During August 1999 geological mapping was commenced in the Swift River area in an attempt to develop a structural model for the region and to assess the importance of folding to continuity of massive sulphide horizons. The best rock exposures in the region were used to document the style of folding: the 'Window' exposure on the original Dan showing was mapped in extreme detail and observations made on the few good exposures on the TBMB claims.

Mineralization in this region has been previously described as being skarn type due to the pyroxene-amphibole-garnet silicate mineral assemblages (e.g. Bremner & Liverton, 1990). A reinterpretation of the finely-banded siliceous rock unit at the 'Window' exposure of the Dan showings as a rhyolite and that of cherty layers as exhalites would indicate that the mineralization is of stratabound massive sulphide type (VMS).

REGIONAL GEOLOGY

The region south of the upper Swift River consists of a varied assortment of rock units of uncertain affinity relative to Palaeozoic continental North American strata. Immediately north of the river at the Dan property there is a faulted sequence of lower Palaeozoic strata that contain sufficient macrofossils for correlation with displaced continental strata as being part of the Cassiar terrane. To the south of the river the assemblages are unfossiliferous, considerably more deformed than the Cassiar terrane sequence and show mineralogies consistent with regional metamorphism up to amphibolite grade in the Ram Creek Assemblage. These rocks have been divided into various assemblages (Stevens and Harms, 1995; Roots et al., 2000), with faulted boundaries in part.

Two horizons of sulphide mineralization are known (Fig. 1):

(a) Sulphides (pyrrhotite, sphalerite, galena and chalcopyrite sometimes with magnetite) in various proportions over a possibly imbricated stratigraphic sequence of at least 500 m, extending from the Dan prospect through the Lucy showing to exposures at the Atom prospect south of Crescent Lake (8km WNW). This mineralization is within the Ram Creek Assemblage as described in Roots et al. (2000) and,

(b) Further sphalerite-galena mineralization found at three localities along regional strike that include the Bound, Mod and TBMB prospects. This horizon is 3$^1/_2$ km south of the Dan-Atom trend and has been included in the Klinkit Assemblage of Roots et al. (2000).

STRATIGRAPHY

Northern trend

At the Dan ('Window') exposures the structurally lowest unit exposed is a quartz-rich marble that contains occasional millimetre- to decimetre-scale sphalerite and less frequently galena bands. The northern (lower) margin of the exposed marble is intercalated with garnet-diopside and aphanitic diopside-amphibole 'hornfels', plus possibly fault-bounded blocks of a few metres dimension of finely (mm) banded chlorite-pyrite (Bremner and Liverton, 1990), the latter having been mapped in 1990, but now being covered by till washed into the trench and not visible for re-evaluation.

This is followed to the south by green calc-silicates (predominantly amphibole) follow and these are sulphide- or magnetite- rich. Massive garnet±sphalerite±magnetite is immediately above. A sharp contact is observed with a succession of grey to pale green, finely banded tuffs, flow-banded rhyolite and possible siliceous exhalites. Metre-scale sulphide-rich layers (pyrrhotite + chalcopyrite) are seen in this section. The green (?) tuffs are pyroxene-scapolite rich.

At the upper limits of the artificial exposures boulders of diorite proto-mylonite are seen, which may represent either sheared dykes or material from the margin of the main (?Jurassic) diorite dyke ≈1km to the south at the ridge crest, the eastern continuation of that intrusion above Crescent Lake.

At the Lucy showing the stripped area shows a sequence of strongly banded magnetite-diopside-actinolite in 1-2mm thick layers with lesser actinolite-pyrite rock in the lower part of the exposed succession. Outcrop 6m (stratigraphically) to the SW has banded chlorite-quartz-epidote + pyrite + sphalerite or actinolite-quartz + pyrite + sphalerite ± chalcopyrite. Galena is present as a trace.

Southern trend

The southern mineralized sequence is found within highly siliceous, green finely laminated (?) tuffs and grey cherty sediments (that may be exhalites) that contains a marble horizon. This marble is exposed on ridge crests at least from the west edge of the TBMB claims to the Bond claims and may correlate with the discontinuous marble mapped to the east by the G.S.C. That marble has been tentatively assigned to the Klinkit Assemblage, showing conformable contact with metavolcanics to the north (Roots et al. 2000). At the showings on the Bond claims mineralization consists of banded magnetite with sphalerite at the marble-volcanic contact (Liverton, 1998). Mineralization on the TBMB trend differs somewhat from that on the Bond: it is also associated with the marble horizon, but consists of coarse, massive galena and sphalerite to around 1.5m width in a chlorite-rich calc-silicate rock. Massive cherts outcrop immediately south.

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STRUCTURAL GEOLOGY
WINDOW

At the 'Window' exposure the calc-silicate and marble bands display evidence for three periods of deformation:

D_1: Recumbent, isoclinal folds of 'wavelength' of a few metres with gentle, predominantly SE plunges;

D_2: West-vergent open folds approximately coaxial with the D1 structures. Their axial planes dip from 60° to 80° to the SSW;

D_3: An extensional event that produced possibly some boudinage observed particularly in the east part of the exposures, and NNE to NNW striking high-angle fractures showing fault displacements on a centimetre scale.

These structures are best described by reference to the accompanying map and section (Figs. 3 & 4).

The deformation is, however, not entirely homogeneous. At the marble / calc-silicate contact (see Fig. 3, immediately south of station 'B') there are a number of metre-scale sheath folds, plunging steeply southward. These likely indicate that there was a strain gradient across the contact.

Implications for mineral exploration (Fig. 5) are as follows:
The D_1 isoclinal folding can cause rapid repetition of a single mineralized layer;
mesoscopic-scale D_2 folding, with a near-horizontal enveloping surface can concentrate the sulphide horizon into a flat-lying sheet, as is seen at the 'Window' exposure;
and repetition of the mineralized unit may occur due to macroscopic scale D_2 folding. In addition, it is very likely that during the D_2 event, the overturned limbs of the D_2 structures could be sheared: i.e. become reverse fault zones. Evidence for this occurrence is likely to be occurrence of high-strain zones as seen on the TBMB claims.

TBMB AREA

Unfortunately at the time of writing this report the structural sketches and measurements made on the TBMB claims had not been received from Professor D'el-Rey, who has returned to Brasil and is compiling the structural part of a paper on this district, so a brief description is all that is possible now. During the fieldwork detailed observations were made on the best exposures on the TBMB-Bond claim blocks. These are the trench designated 'C' in the previous mapping (Liverton, 1999) and natural exposures to the NE (see Fig. 6). The natural exposures show interbedded sandy limestone, schist and finer-grained siliciclastics that show a similar deformation to that mapped at the 'Window'. Tightly isoclinal F_1 folds are seen to be re-folded by F_2. Orientation of the fold axes is similar to that observed in the northern mineralized horizon. Apart from the same implications for repetitions of mineralization seen at the 'Window', these

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High-strain zone

Evidence for a zone of high strain on the Bond claims is found in blocks of ductilely deformed siliceous metasediments in felsenmeer on the steep slope east of the baseline of the 1998 control survey (see Fig. 6). These blocks exhibit re-folded chevron folds that are extremely apressed with disharmonic structures in their cores (see Liverton, 1998, Fig. 11). The zone appears to be quite narrow, as blocks of this material are quite scarce in the talus. It is considered to represent a reverse fault zone, although rather than being a low angle thrust as suggested in 1998, this material likely is from a steep-dipping zone and may be a reverse-faulted F_2 fold limb. This interpretation does ot preclude there being a younger low-angle thrust at the main ridge on the Bond claims (i.e. immediately north of the label "carbonate unit" on Fig. 1) since that interpretation was based on observation of a zone containing phacoids of marble and quartzite in the saddle at that location.

FURTHER EXPLORATION ON THE TBMB AND BOND CLAIMS: COMMENTS AND RECOMMENDATIONS

At present the claim group suffers form a lack of quality, detailed geological mapping. The TBMB and Bond 16 to 22 claims should be mapped at a scale of no greater than 1:2000 and preferably with detailed documentation of key exposures (e.g. 1: 200 scale) showing structural detail. Because of the complexity of the geology here lithologic mapping alone is insufficient: the maximum amount of structural data needs to be gleaned from the outcrop. The whole of the steep face around the "high strain zone" should be carefully examined to find undisturbed exposure, especially since the work of 1999 indicated that a copper-bearing horizon seen in trench "E" may extend up the slope. If this postulated zone is a steeply dipping reverse fault, then implications for exploration are that any repetition of the known TBMB mineralization may be in the hanging wall and its projected location in outcrop could be to the south of any major fault bounding the Swift River Assemblage and chert-bearing assemblage to the south as mapped by Stevens and Harms (1995), which traces close to the western edge of the TBMB claim block.

The possibility of thickening of mineralized horizons in F_1 folds and F_2 hinge zones has not been considered previously for this property. An attempt to trace stratigraphy during detailed mapping will at least make it feasible to evaluate whether the exposed mineralization represents one horizon or not.

As recommended in the previous assessment report geophysics should also be tested on the property to see if the magnetic expression of the mineralization in the main trench can be followed eastward under the alpine meadow.

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REFERENCES

Bremner, T. and Liverton, T. 1991. Crescent, Dan *property descriptions in:* Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada: Yukon Exploration 1990 p. 25-30.

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Stevens, R.A. and Harms, T.A. 1995. Investigations in the Dorsey terrane, Part 1: stratigraphy, structure, and metamorphism in the Dorsey Range, southern Yukon Territory and Northern British Columbia. *In:* Current Research Part A. Geological Survey of Canada, Paper 1995-A p. 117-127.

STATEMENT OF QUALIFICATIONS

Luiz J.H. D'el-Rey Silva

BSc in geology, Universidade de Brasília
MSc in structural geology (Supervisor: Gabor Gaal) Universidade de Brasília
PhD in structural geology and tectonics, University of London 1992 (Supervisor: Ken McClay)

25 years experience in mining and exploration geology, including being Mine Superintendent at the Caraíba Mine and Chief Geologist of exploration for that company

For the past 7 years Professor of Structural Geology at the Universidade de Brasília, Brasil

Fellow of the Geological Society, Member of the Geological Society of America

Timothy Liverton

BSc in geology and geophysics, University of Sydney 1965
BSc (Hons) in economic geology, University of Adelaide 1968
PhD in geochemistry, petrology and structural geology, University of London 1992

26 years experience in mining and exploration geology in Australia, Canada, Norway, Portugal and Brazil

1997-1998 Visiting Professor in economic geology at the Universidade de Brasília

Fellow of the Geological Society, Member of the Geological Society of America, Fellow of the Geological Association of Canada

COST STATEMENT

Luiz J.H. D'el-Rey Silva:	7 days @ $ 700 per day	$4900-
Travel expenses, air fare		$1500-
Accomodation, Whitehorse		$220-
Timothy Liverton:	8 days @ $ 600 per day	$4800-
Vehicle,	8 days @ $ 100 per day	$800-
Field supplies		$240-
Total:		$12460-

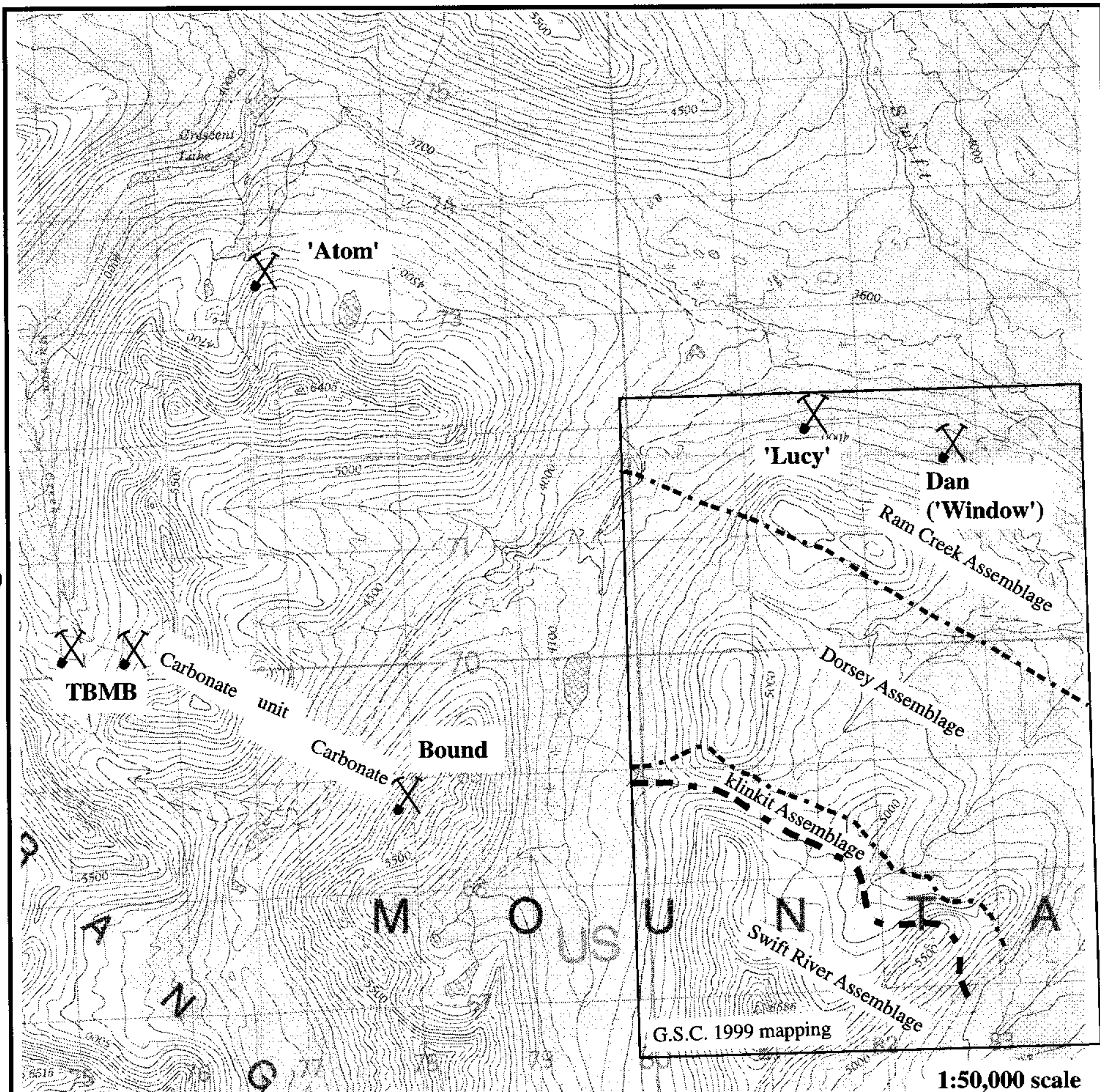
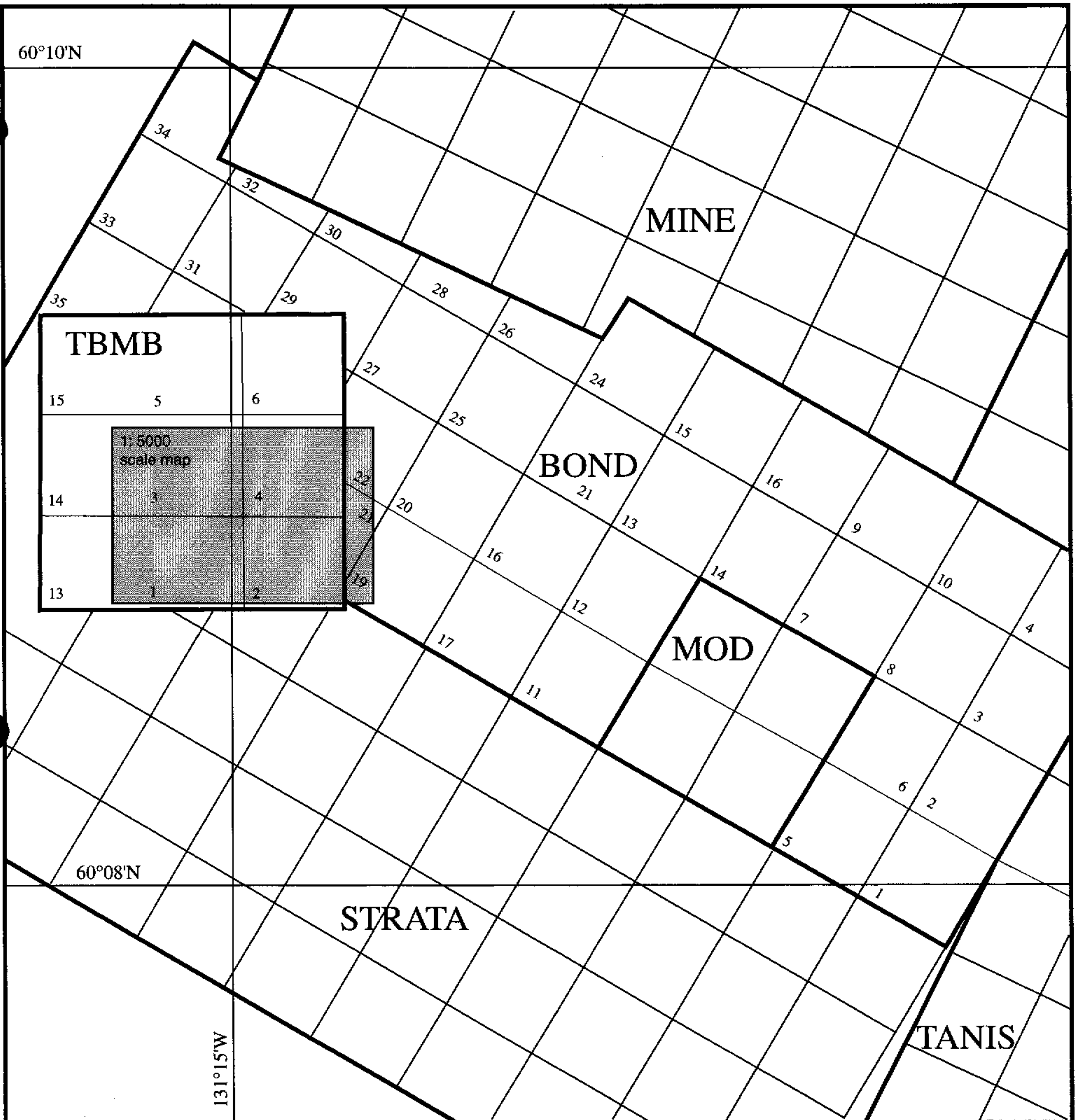


Figure 1

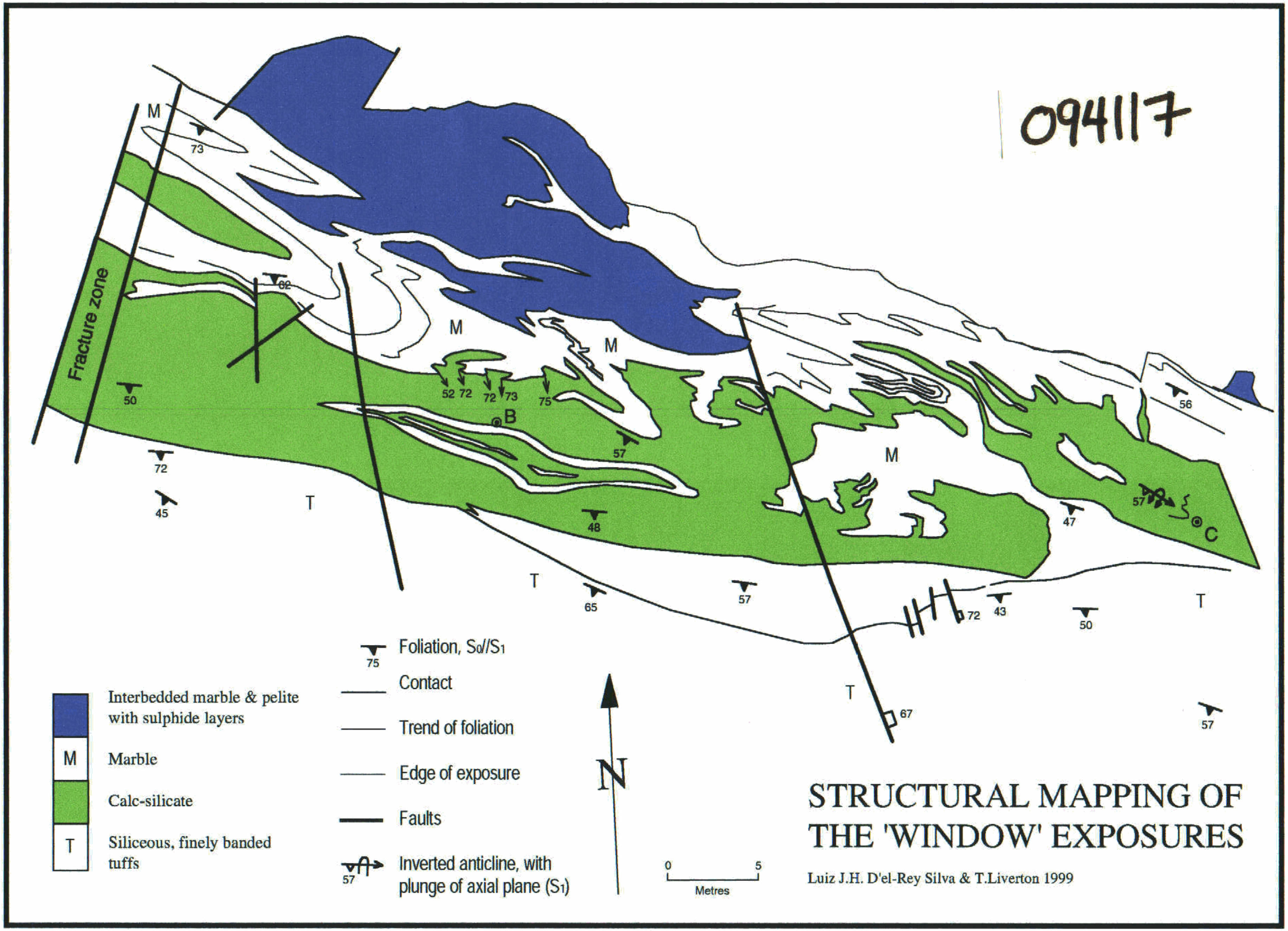
TOPOGRAPHIC MAP OF THE SWIFT RIVER AREA (PART OF 105 B-3) SHOWING MINERAL PROSPECTS CURRENTLY UNDER INVESTIGATION AND EXTENT OF NEW MAPPING BY THE G.S.C.



CLAIM MAP 105B-3
LOCATION OF TBMB & BOND GROUPS

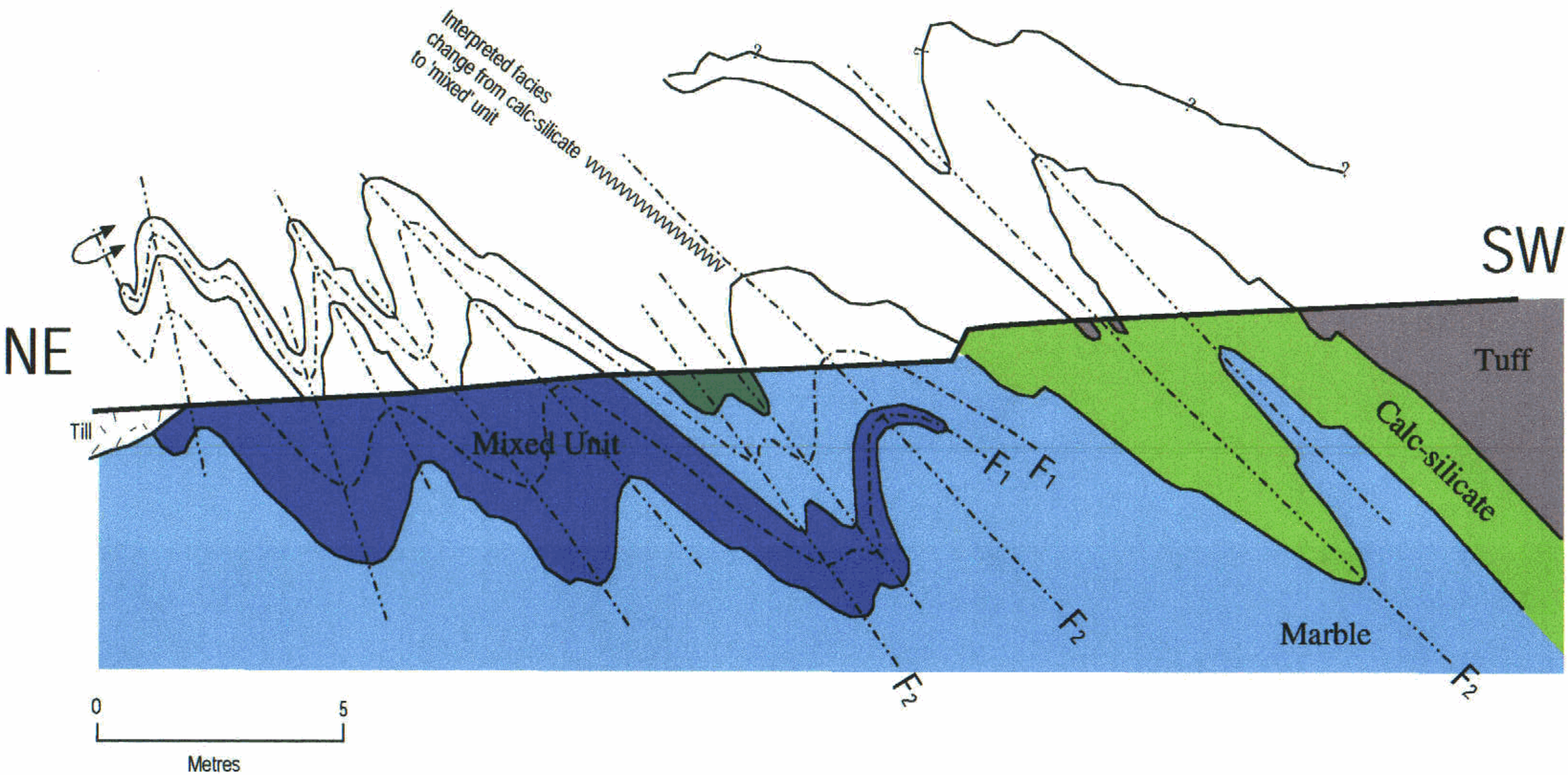
Scale = 1:25,000

Figure 2.



STRUCTURAL MAPPING OF THE 'WINDOW' EXPOSURES

Luiz J.H. D'el-Rey Silva & T.Liverton 1999



CROSS SECTION THROUGH THE WEST END OF THE 'WINDOW' EXPOSURE

094117

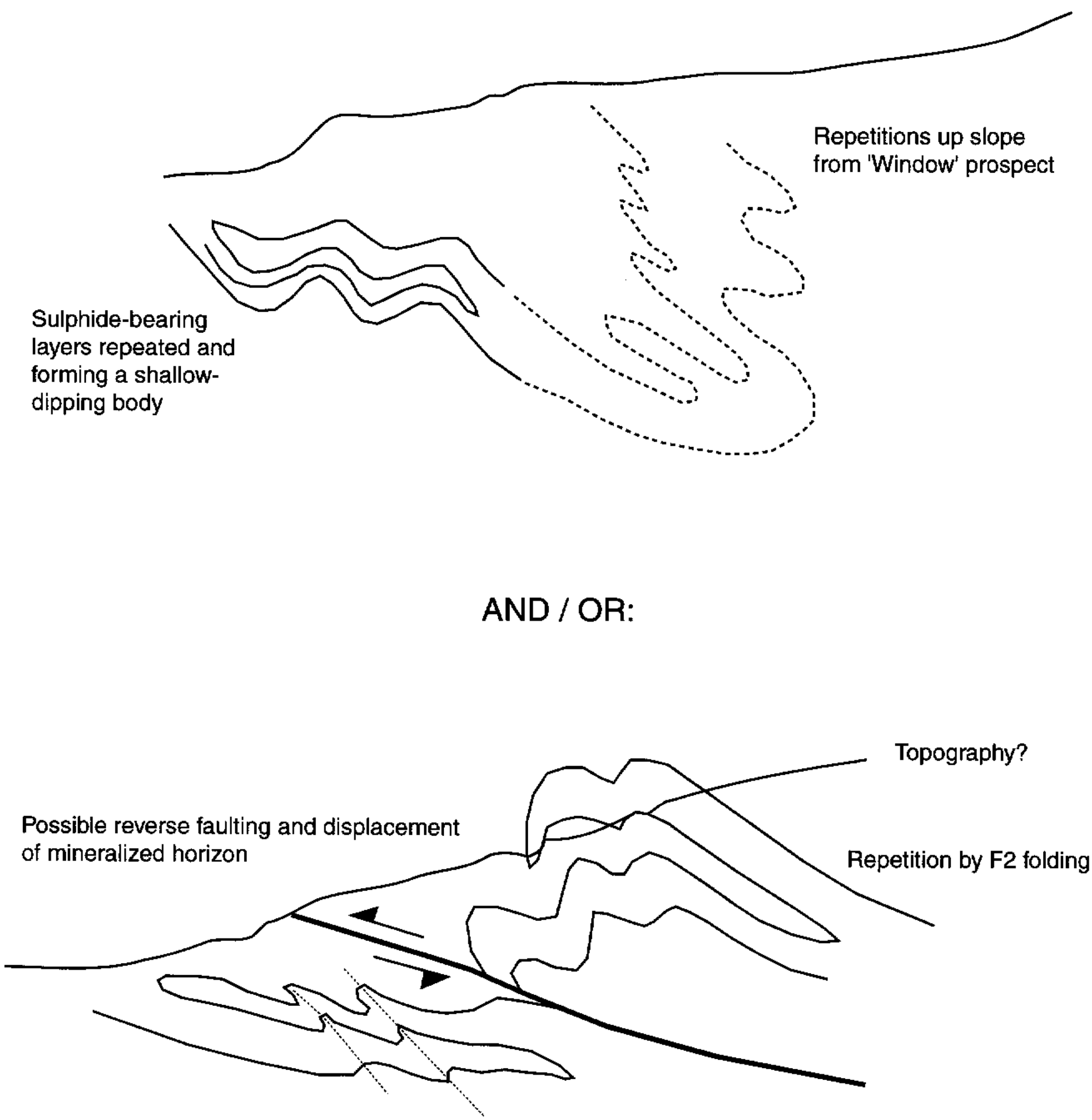
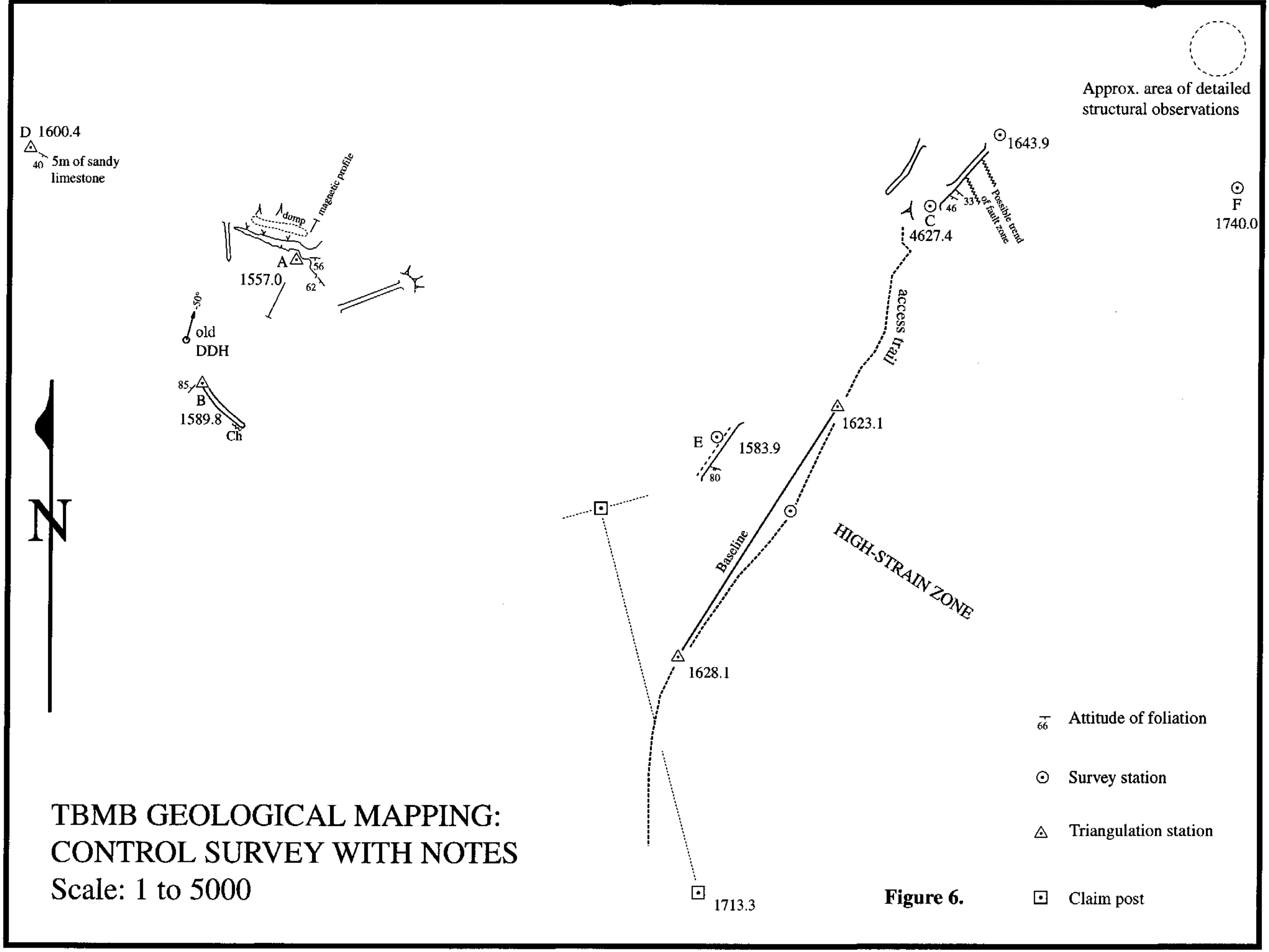


Fig. 5 CARTOON TO ILLUSTRATE POSSIBLE EFFECTS OF FOLDING ON MINERALIZED HORIZON(S)



TBMB GEOLOGICAL MAPPING:
CONTROL SURVEY WITH NOTES
Scale: 1 to 5000

Figure 6.

A structural analysis of the upper Swift River area (105B/3), Yukon, Part I: Dan Zn occurrence and implications for sulphide mineralization[1]

Luiz José Homem D'el-Rey Silva[2]
University of Brazil

Timothy Liverton,[3] *Suzanne Paradis*[4,5] *and Charlie Roots*[4,6]

D'el-Rey Silva, L.J.H., Liverton, T., Paradis, S. and Roots, C., 2001. A structural analysis of the upper Swift River area (105B/3), Yukon, Part I: Dan Zn occurrence and implications for sulphide mineralization. *In:* Yukon Exploration and Geology 2000, D.S. Emond and L.H. Weston (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 289-300.

ABSTRACT

Marble, calc-silicate rock and pelitic layers of the Ram Creek assemblage surrounding the Dan Zn (± Cu-Pb-Ag) occurrence display ample evidence of a monocyclic structural evolution with three main events of progressive deformation (D_1-D_3). These events developed a tightly folded package of west-northwest-trending tectonites. Primary planar structures (S_0) generally lie sub-parallel to two tectonic foliations (S_1 and S_2), which dip shallowly to steeply southwest. Inter-foliation slip (D_3) resulted in a transverse, sub-vertical foliation (S_3) that dips generally shallowly to moderately north. Cross-sections based on new mapping and fold analysis indicate that similar folds containing stratabound zinc-sulphide mineralization should be present south of the Dan occurrence, as part of regional north-northeast-verging folds or a thrust-fault-repeated succession.

RÉSUMÉ

Les couches de marbre, de silicate calcique et de pélite de l'assemblage de Ram Creek entourant les indices de zinc (± Cu-Pb-Ag) Dan renferment de nombreuses indications révélant qu'elles ont été l'objet d'une évolution structurale monocyclique qui comprend trois principales déformations progressives (D_1-D_3). Ces phases de déformation ont été à l'origine de la formation d'un ensemble de plis fortement serrés formés de tectonites orientées ouest-nord-ouest. Les textures planaires primaires (S_0) sont en général presque parallèles aux deux foliations tectoniques (S_1 et S_2), de pendage sud-ouest faible à prononcé. Le glissement inter-foliation (D_3) a produit une foliation subverticale transversale (S_3) de pendage nord généralement faible à modéré. Les coupes basées sur une nouvelle cartographie et une analyse des plis montrent que des plis similaires renfermant une minéralisation de zinc et de sulfure stratiforme sont vraisemblablement présents au sud des indices Dan. Ils feraient partie des plis de vergence nord-nord-est d'importance régionale ou d'une succession répétée par des failles de chevauchement.

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[4]*Geological Survey of Canada*

[5]*P.O. Box 6000, Sidney, British Columbia, Canada V8L 4B2, paradis@pgc-gsc.nrcan.gc.ca*

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INTRODUCTION

This paper reports on detailed structural studies carried out in the Swift River area of stratabound zinc mineralization in southern Yukon Territory. The study area is accessed by mineral exploration roads, about 24 km northwest of the Pine Lake airstrip near the Alaska Highway at kilometre 1162. Massive sulphide mineralization was discovered in the area in 1946 by Hudson Bay Mining and Smelting Co. Ltd., and examined intermittently since then, most recently by First Yukon Silver Ltd., Cominco Ltd. and Birch Mountain Resources (Indian and Northern Affairs Canada, 1993; Burke, 1998). Although the area has been regionally mapped (Poole et al., 1960; Stevens and Harms, 2000) and the Dan area mapped in detail (Bremner and Liverton, 1991), there has been no structural analysis of the complex folds in the mineralized areas. The man-made bedrock exposures described here comprise the east and west showings of the Dan zinc occurrence (also known as the BAR; Yukon MINFILE, 1997, 105B 027), where the largest claim owner is currently First Yukon Silver Ltd. Along the structural trend to the west are the Lucy, Gossan and Atom showings (the latter is the Crescent occurrence, Yukon MINFILE, 1997 - 105B 026). A similar structural study was carried out on the nearby TBMB claims (Fig. 1; D'el-Rey Silva et al., this volume).

REGIONAL GEOLOGY

The western headwaters of the Swift River encompass the northeastern edge of the Dorsey Terrane (Gordey et al., 1991), where it borders on the western edge of the Cassiar Terrane (Fig. 1). Dorsey Terrane is divided into litho-tectonic assemblages (Stevens and Harms, 1996), which in the upper Swift River area include Ram Creek (metavolcanic rocks, meta-siliciclastic rocks, marble and meta-plutonic rocks), Dorsey (predominantly chlorite-muscovite-feldspar-quartz schist), and Swift River (dark argillite and chert, with quartzite intervals) assemblages (note that Dorsey assemblage is a subset of Dorsey Terrane). The assemblages trend southeast, as do intrusions which separate the first two: the Ram stock, a ~ 259 Ma old deformed granodiorite (Stevens, 1996), and a diorite of probable Jurassic age. The contact between Ram Creek assemblage and Cassiar Terrane lies covered beneath the upper Swift River valley, and is thought to be a fault zone. The Dan occurrence is less than 10 km northeast of the Cretaceous Seagull Batholith and less than 2 km southwest of the Cassiar Batholith.

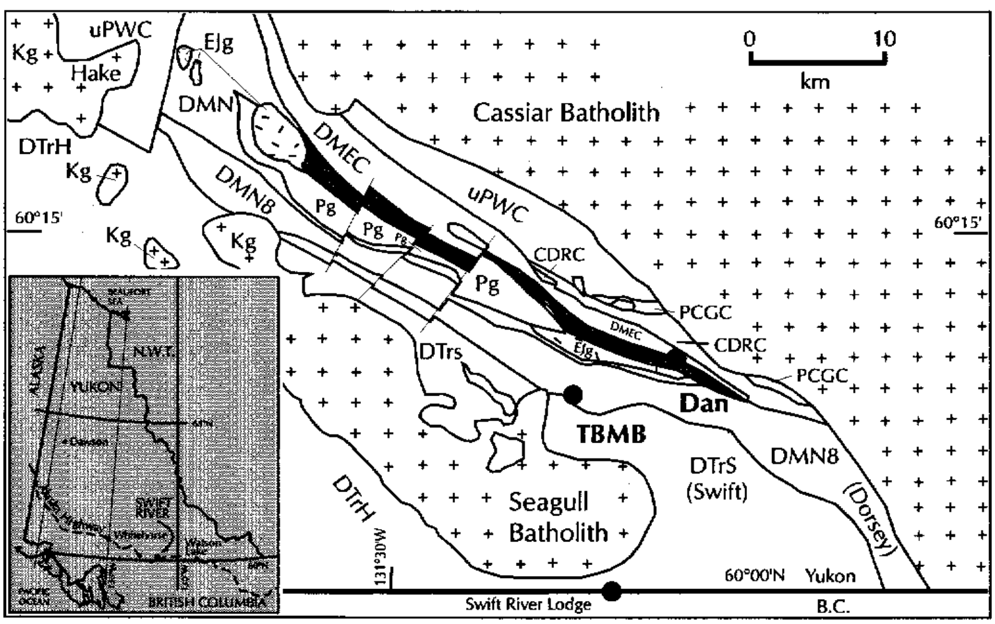

Figure 1. Location of the Swift River area in southern Yukon. Geology adapted from Gordey and Makepeace (1999). Labelled units are: Kg – Cretaceous intrusions; EJg – Jurassic intrusions; Pg – Ram stock (Permian); DTrH – Klinkit assemblage; DTrS – Swift River assemblage; DMN8, DMN – Dorsey assemblage; DMN9 – Ram Creek assemblage (shaded); and rocks of the Cassiar Platform, including: DMEC – Mid-Paleozoic argillite; CDRC, PCGC – Lower Paleozoic carbonate; and uPWC – Late Proterozoic clastic rocks. The area of Figure 2 is covered by the dot marking the Dan occurrence. (The TBMB claims, the subject of D'el Rey Silva et al. (Part II, this volume) are also shown).

GEOLOGY OF THE SWIFT RIVER AREA

The relatively low elevation showings of the Dan occurrence are hosted by the Ram Creek assemblage, containing metavolcanic rocks (felsic, intermediate and mafic protoliths are suspected), argillite, meta-siltstone and marble, all of which have been deformed and metamorphosed to at least upper greenschist facies. Compositional contacts are the only primary feature remaining, with the exception of probable igneous-flow texture (fiamme) observed in thin sections of metavolcanic layers (S. Gordey, pers. comm., 1995) and beta-quartz phenocrysts (pers. comm., First Yukon Silver Resources Ltd., 1995; pers. comm., Birch Mountain Resources Ltd., 1998). Marble is only abundant in the vicinity of the Dan occurrence, but was intersected in drill core to the west (beneath Lucy showing; T. Liverton, pers. comm., 2000). In the area of the Dan occurrence, the pelitic rocks are a contact-metamorphosed succession of garnet-diopside-actinolite calc-silicate hornfels, and the marble contains bands of diopside and garnet. Disseminated to banded and massive pyrrhotite and magnetite with some sphalerite, chalcopyrite and pyrite is distributed in pods and blebs along the deformed contact between white and green calc-silicate rock (possibly meta-tuff) and the marble. The sulphide layers appear to follow a branching system of reverse faults and steeply dipping cross-faults of minor displacement (Bremner and Liverton, 1991). At other occurrences, the mineralization style is similar but the host rock varies: dark metavolcanic rock predominates at the Lucy showing, whereas at the lower Atom showing, the alternating tectonic bands of garnet-epidote and quartz-chlorite are similar to non-mineralized parts of the Dan showings. Another mineralized area, 4 km southwest of Dan (the TBMB claims; Yukon MINFILE, 1997, 105B 029) is discussed in D'el Rey Silva et al. (Part II, this volume). Previously all the mineralization was interpreted as skarn (Abbott, 1986; Bremner and Liverton, 1993), but is here considered sedimentary (possibly volcanic-) exhalative, deformed and subsequently contact metamorphosed by much later intrusions.

METHODS

The Dan occurrence has eastern and western showings (Fig. 2) that are outcrops enhanced by bulldozer excavation and pressure washing (H. Hibbing and D. Schellenberg, pers. comm., 1990). The resulting surface is roughly planar to the north-facing slope (Fig. 3) that is largely controlled by shallowly dipping fractures.

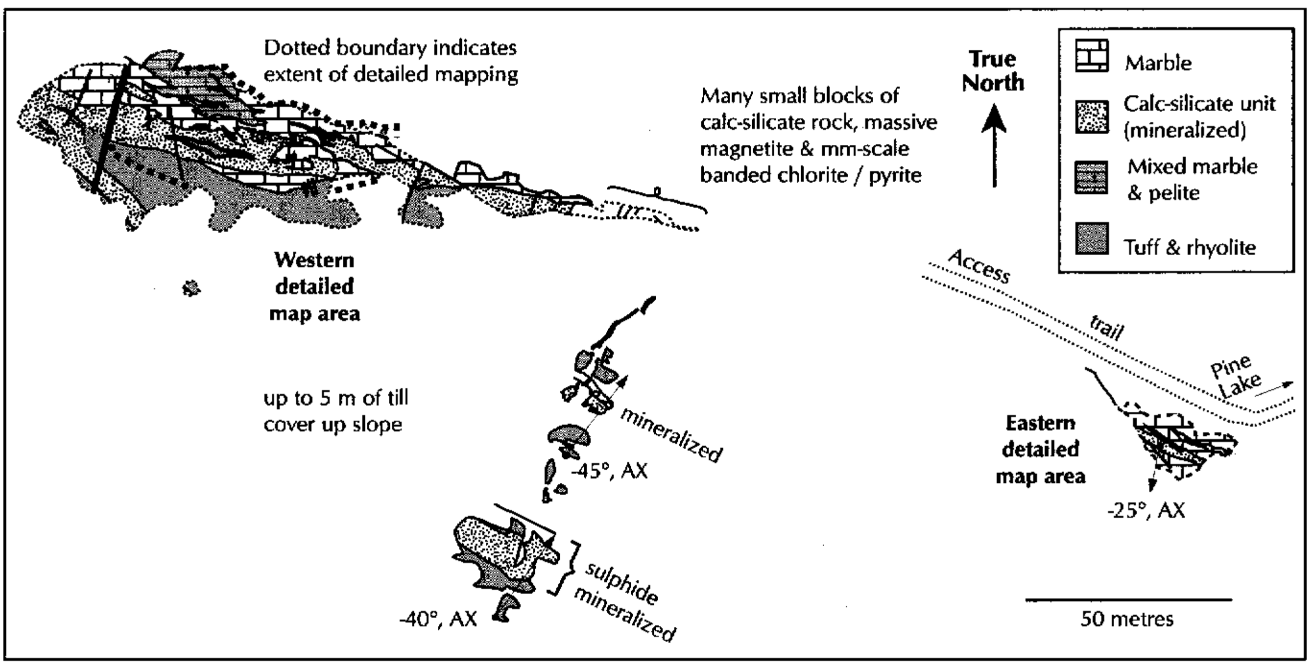

__Figure 2.__ Exposure of the Dan Zn-Pb-Ag occurrence, indicating the western and eastern parts (Figs. 4a and 5) that have been mapped in detail by the second author during 1990, 1996 and by the first author during this study. Arrows on three exposures indicate drill holes with plunge and core size (AX).

Mapping at 1:100 and 1:200 scales was performed with the aid of a plane table, alidade, and tape, and fold hinges, fold limbs, contacts, and intersecting structures were precisely located. Contacts and folds were drawn directly on the plane table whilst still at the outcrop; such documentation helped the authors understand the effects of fold superposition, particularly in the western part of the Dan. At every change in direction of the contact between the marble and calc-silicate rock, an F_1, F_2, or both types of fold could be identified. Samples of different rock units and different types of ore were collected in the field. Studies of the petrology and mineralogy of the host rocks, as well as analyses for stable and radiogenic isotopes (O, C, Sm-Nd) are in progress.

The resulting geological maps are simplified in Figures 4a and 5. Some F_1 and several F_2 folds are large enough to show on the maps. All attitudes mentioned herein follow the dip-direction method.

Figure 3. *Eastward view of washed bedrock at western showing, showing a thin, dark calc-silicate layer interleaved with light marble. The ladder was used in taking the photograph of the fold shown in Figure 8.*

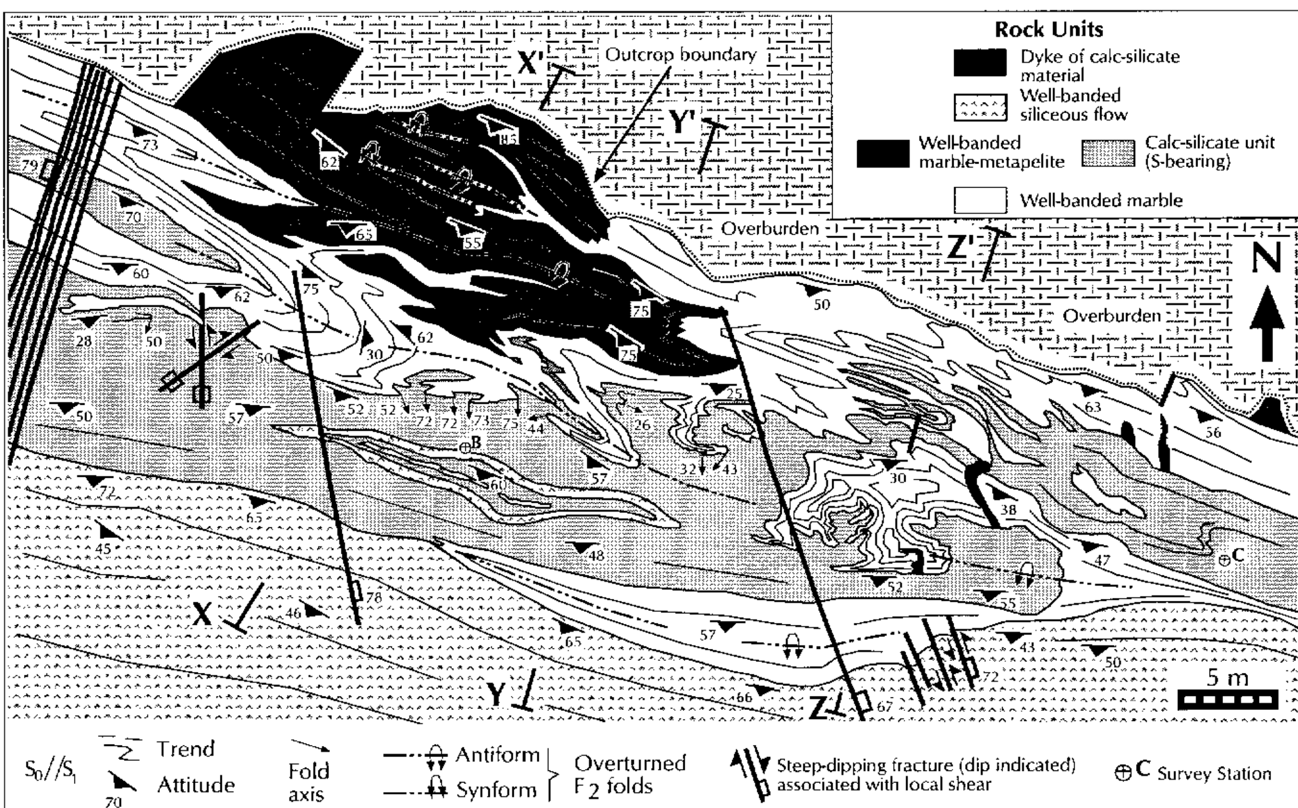

Figure 4a. *Lithostructural map of the western part of the Dan occurrence (reduced from 1:200-scale mapping) showing cross-section locations (XX', YY' and ZZ').*

SUMMARY OF STRUCTURES AND

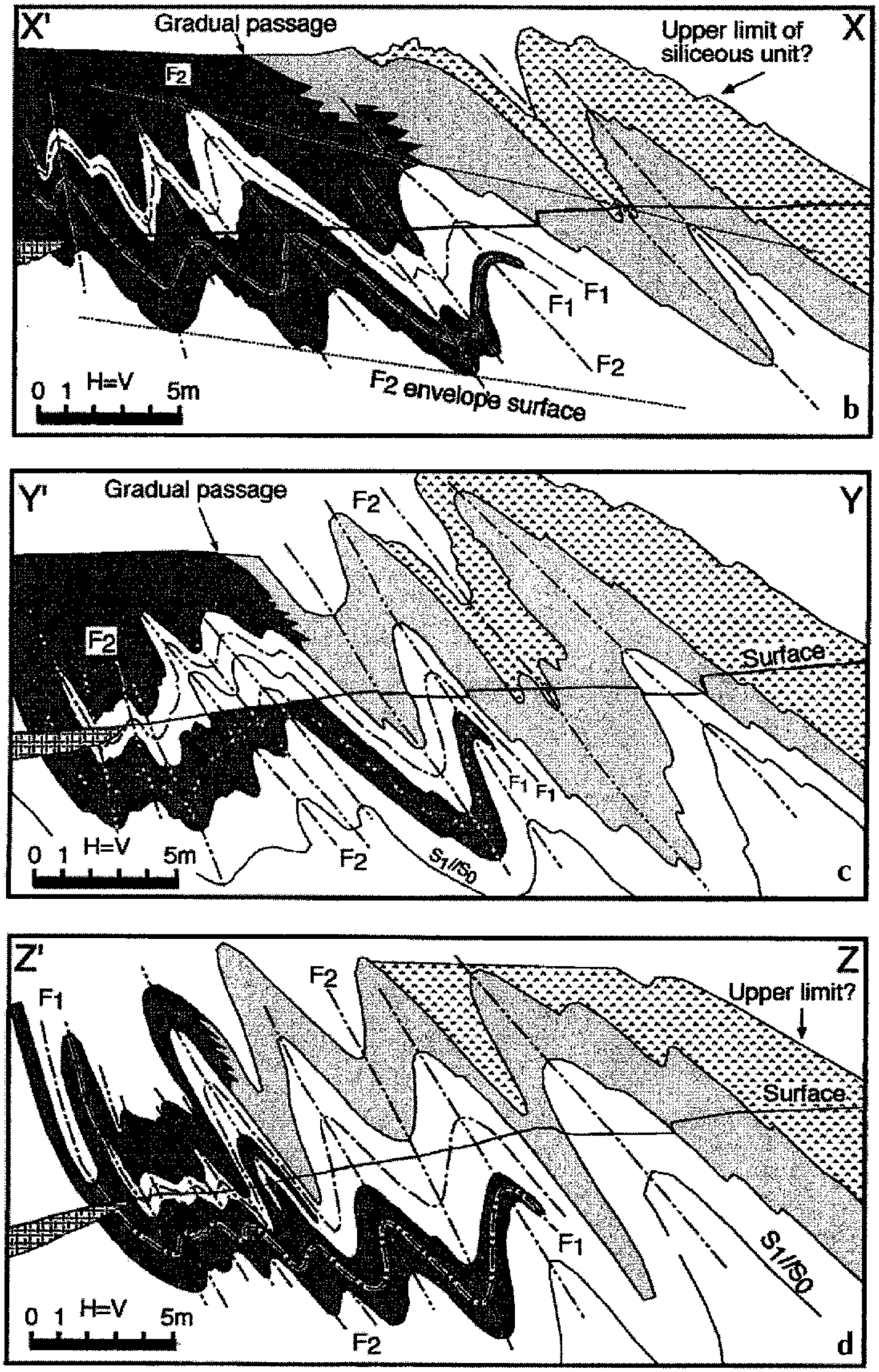

Fig. 4b,c,d. *Vertical cross-sections for the western part of the Dan occurrence. Structures related to the D_3 event, such as sub-vertical fractures and sub-vertical faults, have been omitted for clarity. H = V: horizontal = vertical.*

DEFORMATION

Structures in the studied area result from two events of highly ductile deformation (D_1-D_2) and from a late event of brittle-ductile deformation (D_3). The two earlier events imprinted several micro- to mesoscopic-scale structures on the sedimentary layering (S_0), such as folds (F_1, F_2) and their associated planar and linear fabric elements: axial plane foliations (S_1, S_2), intersection lineations ($L_{1\text{-}0}$, $L_{2\text{-}1}$) and fold axes (B_1, B_2).

As a consequence, the area consists of a packet of east-southeast-trending S-tectonites containing three planar foliations ($S_0//S_1//S_2$) commonly sub-parallel and dipping shallowly to steeply to the southwest. Linear structures such as L_1, L_2-1, B_1, B_2 are also sub-parallel and trend southeast, with a gentle plunge commonly to northwest or southeast.

The D_3 event developed folds (F_3) with their associated planar structures, such axial planar foliation (S_3). A set of shallowly dipping fracture planes (S_{3a}) are tertiary fractures that exacerbated glacial erosion. Linear structures of D_3 (fold axis and intersection lineation) are controlled by the dip of $S_0//S_1//S_2$. They are not discussed further because they do not affect the distribution of rocks and mineralization.

PRIMARY LAYERING (S_0)

The intercalation of metasedimentary and metavolcanic rocks with markedly different compositions occurs on scales between 1 and 10 m. On a small-scale, S_0 is marked by cm- to dm-thick beds of different colour within each sedimentary unit. For example, within the marble unit, beds of grey meta-pelites are intercalated with dominant beds of white marble.

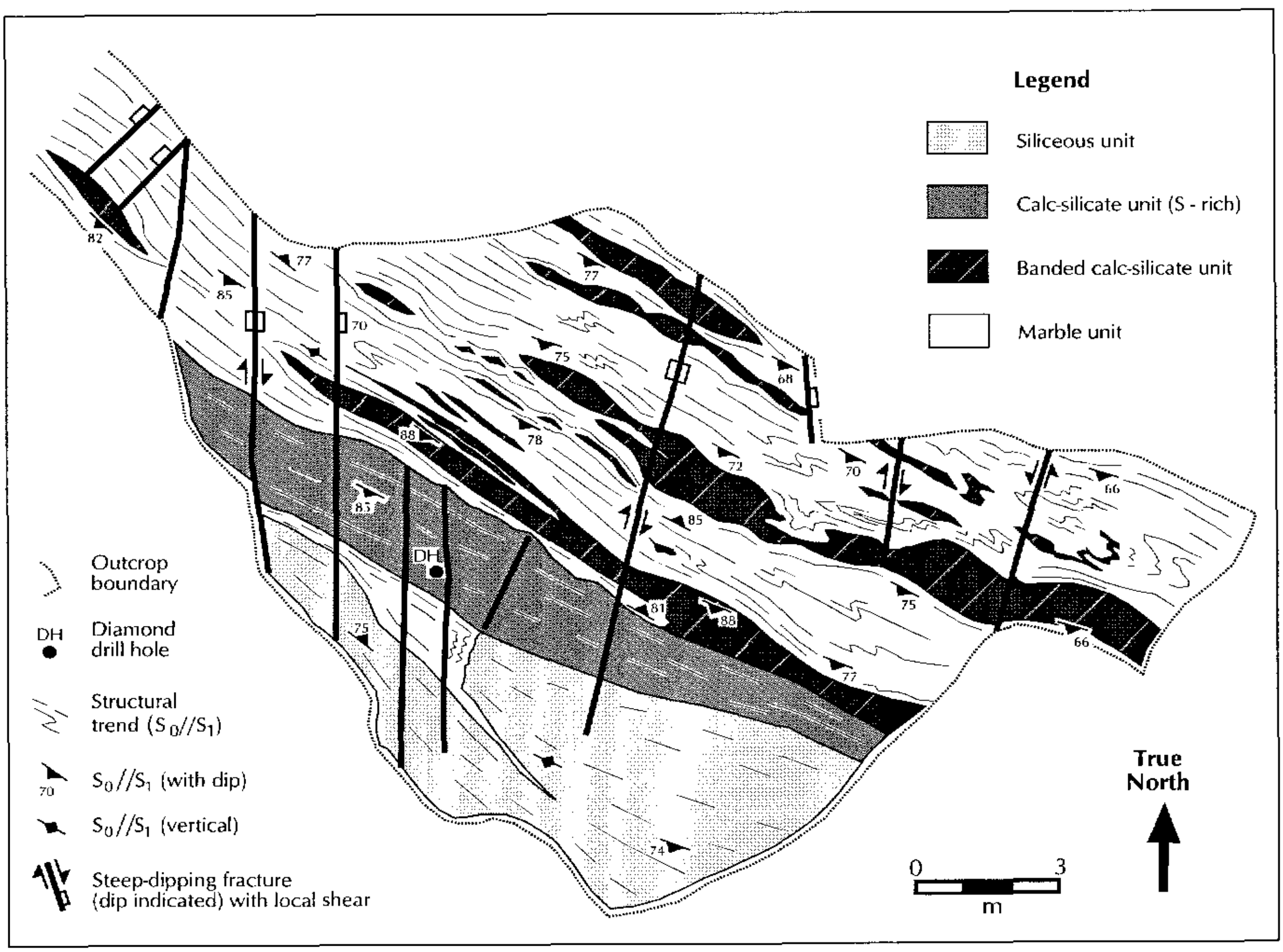

Figure 5. Lithostructural map of the eastern part of the Dan occurrence, based on 1:100-scale geological mapping.

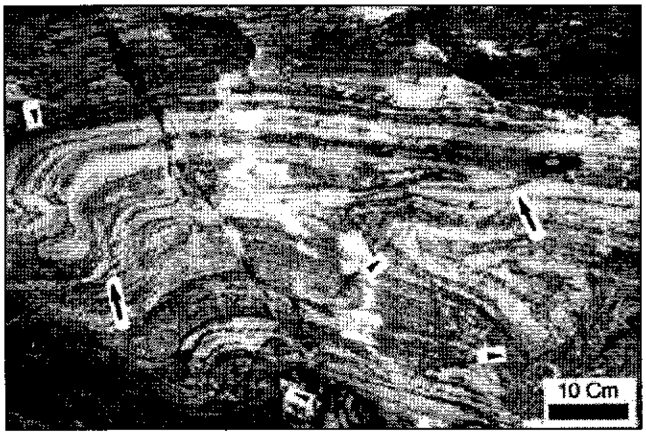

Figure 6. *F_1 folds in the white marble unit of the eastern part of the Dan occurrence. Thick arrows indicate two hinges. The whole package displays $S_0//S_1$ and is co-axially refolded by F_2 folds (other arrows). F_1 and F_2 folds display Z and S asymmetry, respectively.*

THE D_1 DEFORMATION

This event is characterized by isoclinal folds (F_1) and their associated axial planar foliation (S_1). This folding affected S_0 throughout the area and developed a longitudinally continuous packet of well-layered, low-grade metamorphic rocks, within which the F_1 fold hinges can be traced easily in many places. These hinges are contained within the packet of layers and commonly exhibit an amplitude of 0.1-1.0 m, whereas the fold limbs are several metres to tens of metres long. This supports the interpretation that D_1 was an event of very ductile deformation, and the F_1 folds compare well with class 3 folds of Ramsay (1967). F_1 folds have a strong axial planar foliation (S_1) that is sub-parallel to S_0, except in the F_1 hinges, where S_1 cuts across the primary layering (Fig. 6).

S_0-S_1 forms a set of southeast-trending planar structures that dip from 40° to 80° generally southwest, everywhere in the Swift River area. However, the average dip angle of S_0-S_1 is greater in the eastern (Fig. 7a) than in the western part (Fig. 7b) of the Dan. The F_1 fold axes (B_1) plunge shallowly to NW or to SE, in the Dan (Fig. 7g) and also regionally.

The S_1 foliation is commonly defined by flattened crystals of carbonate and quartz, and phyllosilicates such as fine-grained white mica (sericite), chlorite and some biotite. A slaty cleavage is visible in some fine-grained siliciclastic units. The S_1 / S_0 intersection lineation ($L_{1\text{-}0}$) is parallel to the B_1 fold axes (Fig. 7g).

THE D_2 DEFORMATION

The D_2 event of deformation is defined by several pairs of mesoscopic F_2 folds and their associated axial plane foliation (S_2) that affect S_0 and all D_1 tectonic structures. The F_2 folds are co-axial with F_1 (Fig. 8), as indicated by the S_0-S_1 stereograms (Fig. 7-b). However, by comparison with the stereograms of $B_1 + L_{1\text{-}0}$ and $B_2 + L_{2\text{-}1}$, the poles of B_1 and $L_{1\text{-}0}$ are generally dispersed around southerly directions (Fig. 7g), partly because F_1 are non-cylindrical folds (Williams and Chapman, 1979) may have evolved into sheath folds (discussed later).

The F_2 folds are southeast trending, commonly tight, display m to 10-m scale, and are moderately inclined to up-right (Fig. 8). F_2 axial planes dip between 80° and 90° northeast and southwest in the eastern part of the Dan (Fig. 7c), and around 40°-60° to the southwest in the western part (Fig. 7d). In contrast, the fold axes exhibit a plunge to northwest or southeast in both parts of the area (Fig. 7h). These folds have a strong and penetrative axial planar foliation (S_2) with similar orientation and associated mineralogy as S_1. The authors therefore interpret similar conditions of deformation during D_1 and D_2. The intersection between planes of S_2 with S_1 and S_0 develops a penetrative lineation that overprints $L_{1\text{-}0}$ in most of the area. It is generally hard to separate these two lineations in the field, but both may be identified locally.

The F_1 and F_2 folds are difficult to distinguish because their respective structures are generally parallel. Numerous examples of fold interference were found in the mapped area. During mapping, a fold was identified as F_1 only if it could be shown to be affected by another fold (F_2), although this method is equivocal in some cases.

SHEATH FOLDS AND THE FOLD INTERFERENCE MAP PATTERN

Sheath folds are a common feature at the Dan occurrence and can be identified along folded contacts. Sheath folds are tight to isoclinal and show hinge lines bent more than 90°, resulting from superposition of fold phases or very high strain on folds with curving hinges (Ramsey and Huber, 1987, p. 638). The F_1 sheath folds at the Dan occurrence are best observed between the marble and calc-silicate units in the western part of the study area where they are 1-3 m in amplitude (perpendicular to the axis of the sheath $B_1 + L_{1\text{-}0}$; Fig. 9).

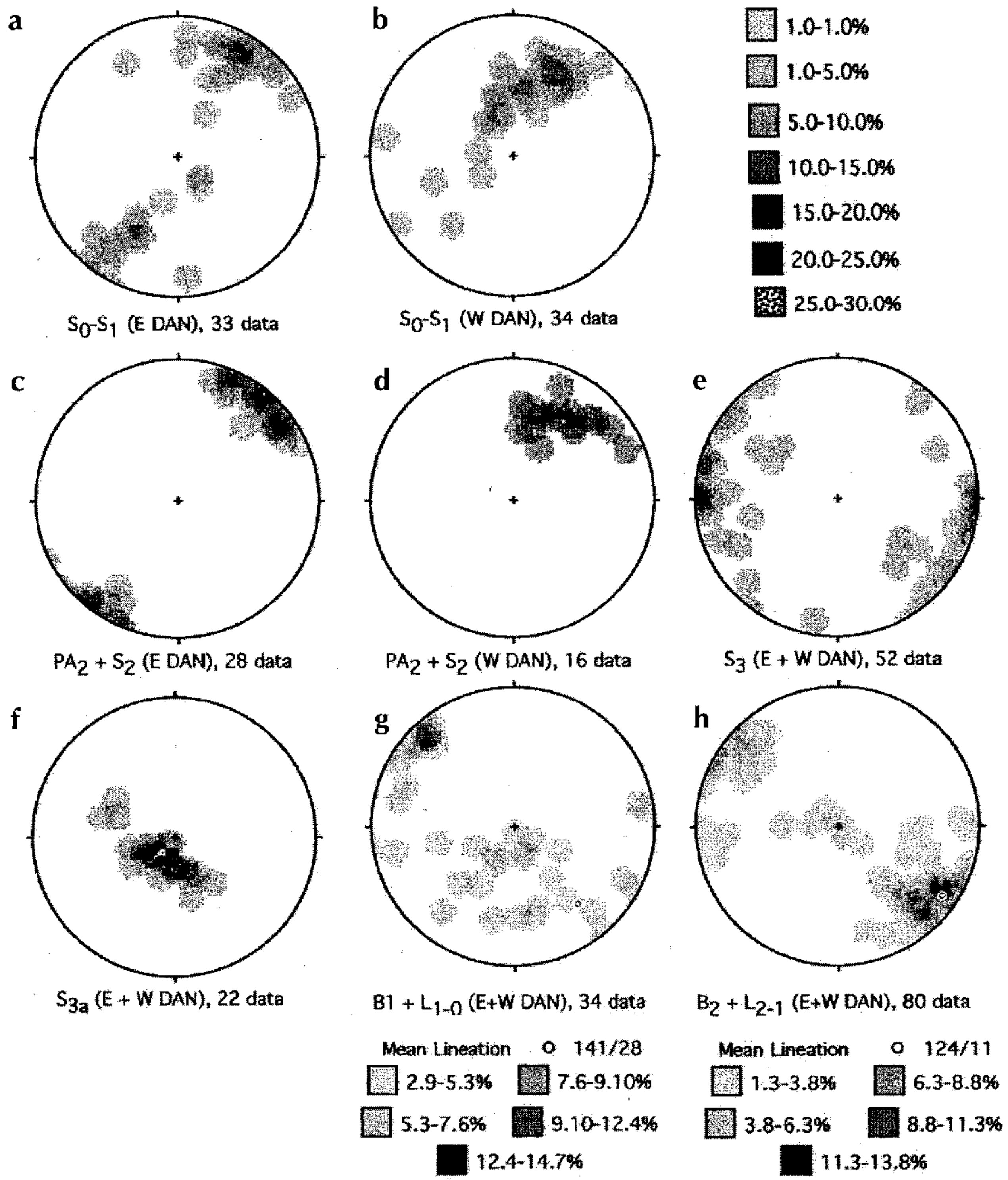

Figure 7. *Lower hemisphere Schmidt equal area density stereoplots for: (a-f) poles to: planar structures developed during D_1 - D_3; and (g,h) main linear structures developed during D_1 and D_2. Sources are eastern and western showings of the Dan occurrence, as noted.*

The interpretation that the sheaths are F_1 folds is based on the observation that the axial plane of the sheaths dip at intermediate angles to south-southwest, sub-parallel to the dip of the layers, and that the sheath folds are affected by F_2 folds of dm- to m-scale. Sheath folds of F_2 have not been identified. The repetition of layers in outcrop suggests large-scale co-axial folds, which are used in drawing north-northeast-trending cross-sections.

VERTICAL CROSS-SECTIONS

The vertical cross-sections of the western Dan showing depend upon an interpretation that the layers of marble and pelitic material (in the north) undergo a metamorphic facies transition southward into the calc-silicate unit. This gradual transition is consistent with the observation that they are spatially related in the centre of the western part of the Dan (Fig. 4b); both layers are in contact with the marble unit; both lie along the same trend, and are separated by a few metres. The internal consistency of structural observations allows us to construct other cross-sections up plunge to the west.

The sections display a syncline-anticline pair of isoclinal F_1 folds for which the axial planes dip generally at low angle to south-southwest, but steeper dips are also common due to several F_2 folds with axial planes dipping 45°-75° south-southwest. The enveloping surfaces of the F_2 folds are interpreted to dip shallowly to the south-southwest, parallel to the hinges of F_2 antiforms and synforms.

Actually, a sequence of m-scale folds in the part of the outcrop close to survey station C (right side of Fig. 5a) implies that the sulphide-bearing layers structurally overlie the marble unit in that outcrop. The intense ductility during D_1 and D_2, coupled with the presence of sheath folds visible at surface (and are likely present in the sub-surface) preclude fully balancing the cross-sections.

The outcrop pattern of the layers record, in map view and in cross-section, progressive folding (F_1 + F_2) with a general vergence to north-northeast. As a consequence, the layers became interleaved on a scale compatible with the thickness of the original beds (cm-dm), because the F_1 folds are isoclinal and the length of their limbs is great compared to the wavelength, particularly if compared to that exhibited by the F_2 folds.

THE D_3 DEFORMATION

This event imprinted folds (F_3), axial plane foliations (S_3), and a set of low-angle-dipping fracture planes (S_{3a}) that affect the D_1-D_2 tectonites in a sub-perpendicular relationship that is systematic across the study area, although D_3 structures are not relevant to spatial distribution of the layers.

The F_3 folds (Fig. 10) are gentle to open, with an S_3 axial plane foliations all trending south, on average, with a steep to sub-vertical dip to westerly and easterly directions, as statistically demonstrated for the eastern and western parts of the Dan occurrence (Fig. 7e). The

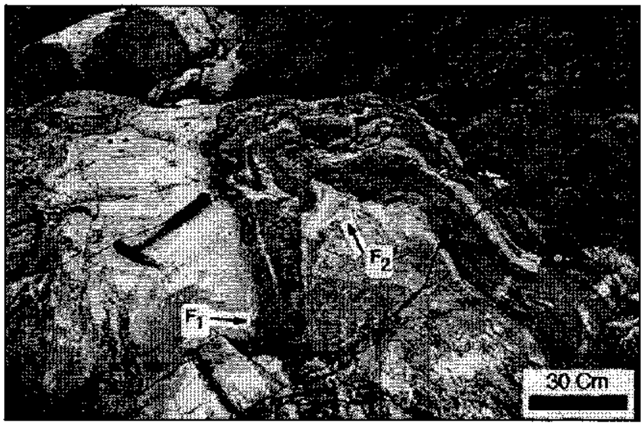

Figure 8. A thin layer of calc-silicate rock (dark) interleaved with the marble unit (white) indicates F_1 x F_2 co-axial interference pattern. Note the long limbs of F_1 folds refolded by F_2. From the eastern end of the western showing of the Dan occurrence. Larger view shown in Fig. 3.

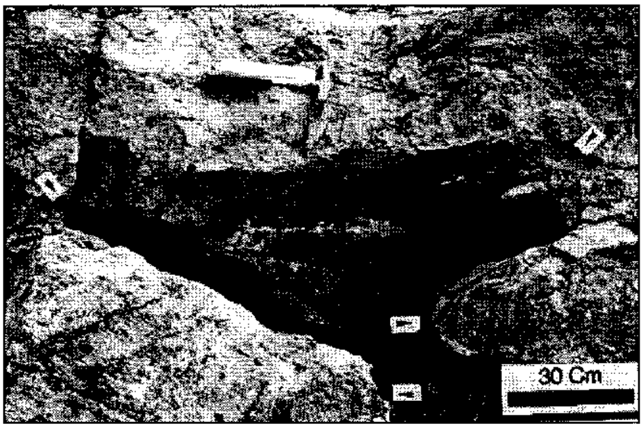

Figure 9. Eroded hole left by m-scale core of an F_1 sheath fold that affects calc-silicate rock and marble. The four F_1 hinges indicated by the arrows all plunge about 72° to the south-southeast.

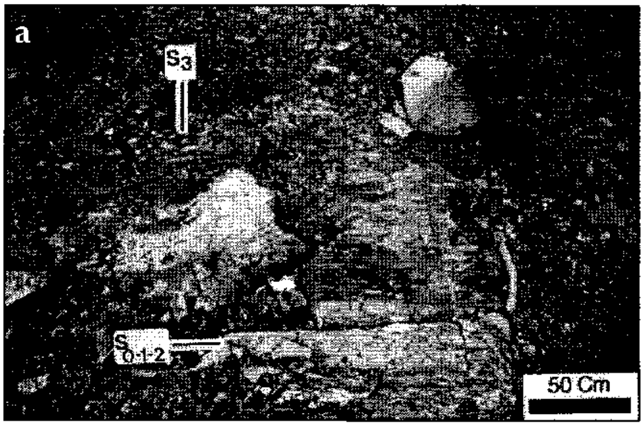

Figure 10. *(a) Southward view of siliceous (light) and calc-silicate (dark rock) tectonites, which display a east-southeast-trending anisotropy composed of S_0, S_1 and S_2. All are sub-parallel to surface (labeled S_{0-1-2} in the picture), and affected by open to tight F_3 folds associated to a well developed, northerly trending, sub-vertical S_3 foliation, shown in detail in (b). Note geometry of F_3 and the pressure-solution-type S_3 foliation.*

folds are sub-vertical bends that affect the anisotropic packet described in the previous sections, so the fold axes and the intersection lineation (B_3 and $L_{3-2/1/0}$) generally plunge steeply to the south, as it is controlled by the dip of S_0, S_1, or S_2, or even by the dip of all of these, together. The F_3 bends are generally 1 m in size, and commonly display a kink-style.

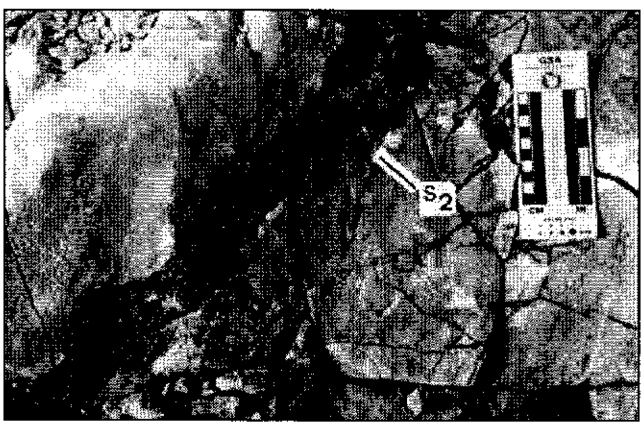

Figure 11. *Dyke of calc-silicate material fills a north-trending extensional fracture in the marble unit, western part of the Dan occurrence. The dyke cuts across D_1-D_2 structures (S_2 foliation is labeled), but is also affected by dm-scale folds and crosscut by their axial plane foliation, both developed late in the D_2 event. The plunge of the fold axis (and dyke) is sub-vertical, controlled by the dip of the extension fracture.*

Two sets of D_3 planar foliations are common in the study area. The S_3 foliation is generally a well developed, sub-vertical, spaced cleavage locally displaying a component of pressure solution. The S_{3a} foliation is a spaced cleavage that trends generally west-northwest and dips shallowly to the north (Fig. 7f). The ubiquitous S_3 foliation is not always associated to F_3 folds. The west end of the western outcrop of the Dan is marked by a closely spaced set of S_3 planes (Fig. 4a). The layers are so intensely crosscut that they give the impression of a fault zone although no significant displacement was determined. Carbonate veins are also found along the planes of S_3 and S_{3a}.

In the western part of the Dan a south-trending sub-vertical set of brownish green dykes (Fig. 11) cuts S_1-S_2 and is affected by dm- to m-scale folds with sub-vertical axial planes and vertical fold axes that the authors interpret as late S_2.

CONCLUSIONS

The trenches in the lower part of the Dan occurrence are along the normal limb of a major F_2 fold, which is aligned with other F_1 and F_2 folds. The authors suggest that additional stratiform mineralization could be present in folds up slope to the south of the Dan, beneath overburden. It is a new strategy for mineral exploration in the upper Swift River area.

The F_3 folds and the S_3 foliation may be understood in terms of a layer-parallel compression that took place as soon as the rocks in the area attained the east-southeast regional trend with dips to south. The rocks then behaved as a more competant anisotropic package. The authors envisage a progressive evolution of deformation for D_1-D_3 in the upper Swift River area in a single tectonic cycle. The attitude of the dykes and their shortening by an overall N-S compression illustrate the orientation of maximum compressive stress. In contrast, the S_{3a} foliation is sub-horizontal and may have assisted erosion. Hence S_{3a} planes control the slope of the outcrop.

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A structural analysis of the upper Swift River area, southeast Yukon (105B/3), Part II: The TBMB claims and implications for the regional geology[1]

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ABSTRACT

The TBMB claim group, 4 km southwest of the Dan occurrence in the upper Swift River area of stratiform zinc occurrences, reveals the nature of the host rocks and style of folding. A train of east-southeast-trending, east-northeast-verging, km-scale F_1 overturned anticlines and synclines dominates the area. These folds clearly control the distribution of low metamorphic grade tectonites (in map and vertical cross-sections) and a structural model allows definition of general stratigraphy of the TBMB and BOUND claim areas. A lower, an intermediate, and an upper unit of siliciclastic metasedimentary rocks are separated by two intervening units of base-metal-sulphide-bearing strata (acid to intermediate metavolcanic rock and marble, respectively). Based upon the repetitive F_1 folds (possibly associated with thrust faults) and the similarity of rock types in the TBMB and Dan areas, the authors propose a structural linkage between them.

RÉSUMÉ

Une étude structurale effectuée dans la région de l'indice TBMB, à 4 km au sud-ouest de l'indice Dan, dans la région du cours supérieur de la rivière Swift où se trouvent des indices de zinc stratiformes, a permis d'apporter des éclaircissements quant à la nature du plissement et les roches encaissantes. Un cortège d'anticlinaux et de synclinaux F_2 déversés, d'importance kilométrique, orientés est-sud-est et de vergence est-nord-est prédomine dans la région. Ces plis contrôlent nettement la répartition des tectonites de faible degré de métamorphisme (voir carte et coupes verticales) et un modèle structural permet de définir la stratigraphie générale de la région des indices TBMB et BOUND. Les unités inférieure, intermédiaire et supérieure des roches métasé entaires silicoclastiques sont séparées par deux unités intercalaires de strates renfermant des sulfures de métaux communs (respectivement des roches métavolcaniques acides à intermédiaires et du marbre). La présence de plis F_2 répétitifs (vraisemblablement associés à des failles chevauchantes) et la similarité des types de roches présentes dans les régions de TBMB et de Dan semblent indiquer qu'il existe un lien structural entre celles-ci.

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INTRODUCTION

In the 1940s, prospectors for Hudson Bay Mining and Smelting Co. Ltd. found sphalerite and magnetite in the north-flowing tributaries of the western headwaters of the Swift River; since then at least eight showings have been discovered. Most have mineralogy characteristic of skarn deposits, but this may be a later overprint as a result of syn-tectonic and post-tectonic plutonism. Several aspects of the occurrences suggest possible volcanogenic or exhalative origin, including:

- mineralized horizons traced up to 19 km in strike length; and
- spatial correlation with tuffaceous and volcanic-epiclastic host-rocks.

All mineral showings are in ductile-deformed metamorphic rock. If they are stratiform, resolution of the stratigraphy is of utmost importance in exploration. However this stratigraphy can only be resolved with the aid of detailed structural analysis. Once the structural style is known, it may be possible to predict the location of buried or blind mineralization.

This paper presents the results of detailed geological mapping in the vicinity of the TBMB and BOUND claims (*Munson occurrence; Yukon MINFILE 1997, 105B 029*). The structures are then compared with those described in a companion study of the Dan occurrence (D'el-Rey Silva et al., Part I; this volume) and their relationship is discussed.

REGIONAL GEOLOGY

The mineralized occurrences lie within late Paleozoic strata of the Yukon-Tanana Terrane (Fig. 1). In this area, four

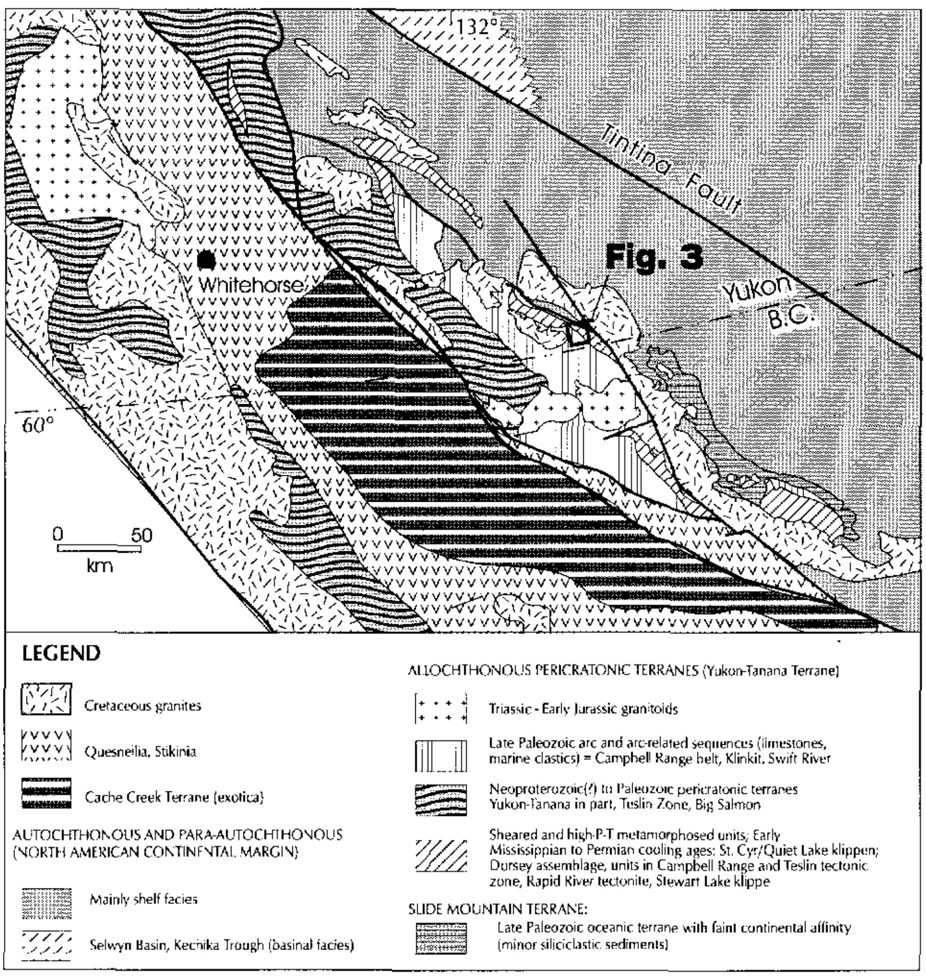


Figure 1. *Generalized terrane map for northern British Columbia and southern Yukon (enlarged from Nelson et al., 2000). The Swift River district lies at the northeast edge of allochthonous pericratonic terranes, generally referred to as Yukon-Tanana Terrane.*

lithostratigraphic assemblages have been recognized (Stevens and Harms, 1996, 2000; Roots et al., 2000; Fig. 2): Swift River, Klinkit, Dorsey and Rum Creek assemblages. The northern group of showings (including Dan, Lucy, and Atom; see Fig 3) are located along the regional trend of the Ram Creek assemblage. Roots & Heaman (in press) determined that at least some of the interleaved metavolcanic and siliciclastic rocks of the Ram Creek assemblage are older than 340 Ma. In contrast, the southern group of showings (includes the BOUND and TBMB claims) are included in the Dorsey assemblage by Stevens and Harms (2000). The Dorsey assemblage contains a thin, persistent felsic meta-tuff horizon dated 365 Ma (Roots and Heaman, in press) and is regionally more deformed than the neighbouring Ram Creek (to the north) and Swift River (to the south) assemblages. A resistant diorite, believed of early Jurassic age, occupies the contact between the Dorsey and Ram Creek assemblages in this area. Therefore the structural relationship is equivocal here, although in northern British Columbia the Dorsey assemblage overrides the Ram Creek assemblage on a mid-Permian thrust (Nelson et al., 1998).

The Ram Creek assemblage near the Dan occurrence includes mafic to intermediate metavolcanic rocks and discontinuous quartzite, marble and calc-silicate rock.

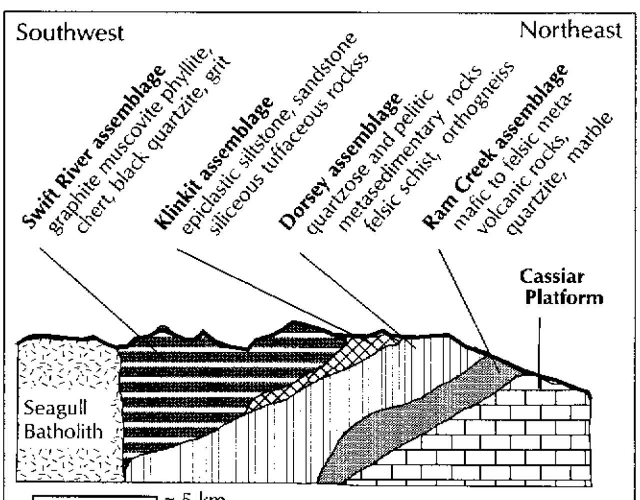


Figure 2. Schematic cross-section of lithotectonic units in the Swift River district, as described by Stevens and Harms (1996). The Dan occurrence lies within Ram Creek assemblage; the TBMB and BOUND claims lie to the southwest, in the area shown here as Dorsey and Klinkit assemblage.

Dorsey assemblage consists of mafic gneiss structurally overlain by muscovite± biotite schist, quartzite and minor marble. About 10 km east of the TBMB these rocks yielded P-T estimates ranging from 609-732° C and at least 7.7 kbar (Stevens, 1996). In contrast the Ram Creek assemblage, although strongly foliated and sheared, contains some primary depositional features and exhibits retrograde lower greenschist facies metamorphism.

GEOLOGY OF THE TBMB CLAIM AREA

The north-facing alpine cirque of the TBMB (Fig. 4) is underlain by meta-siliciclastic rocks (layered sericite-quartz schist, quartzite, minor phyllite) with m- to dm-scale intercalation of laminated meta-sandstone, meta-siltstone and metavolcanic rock, calc-silicate schist and banded white to pinkish yellow marble. Plane-table mapping and structural interpretation were required in order to separate these rocks into stratigraphic units.

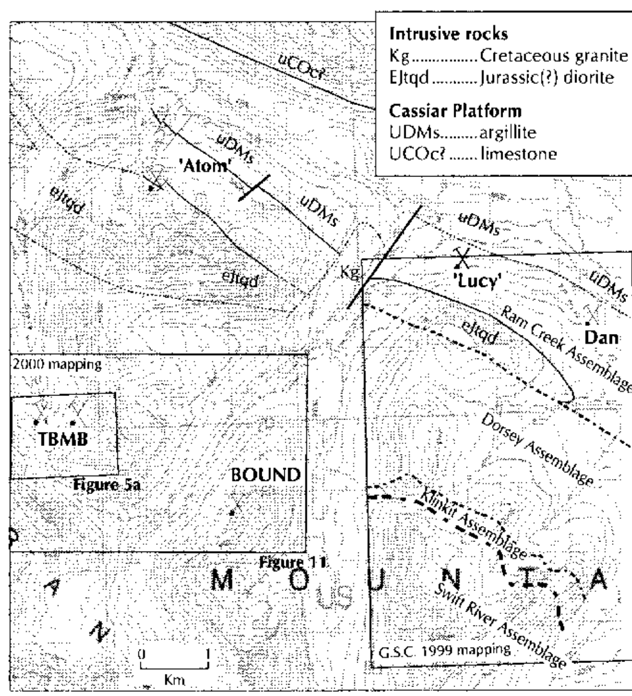


Figure 3. Topographic map (NTS 105B/3) of the upper Swift River area indicating the spatial relationship of showings mentioned in the text. Some contacts are shown from regional mapping by Stevens and Harms (2000); faults are heavy dashed lines.

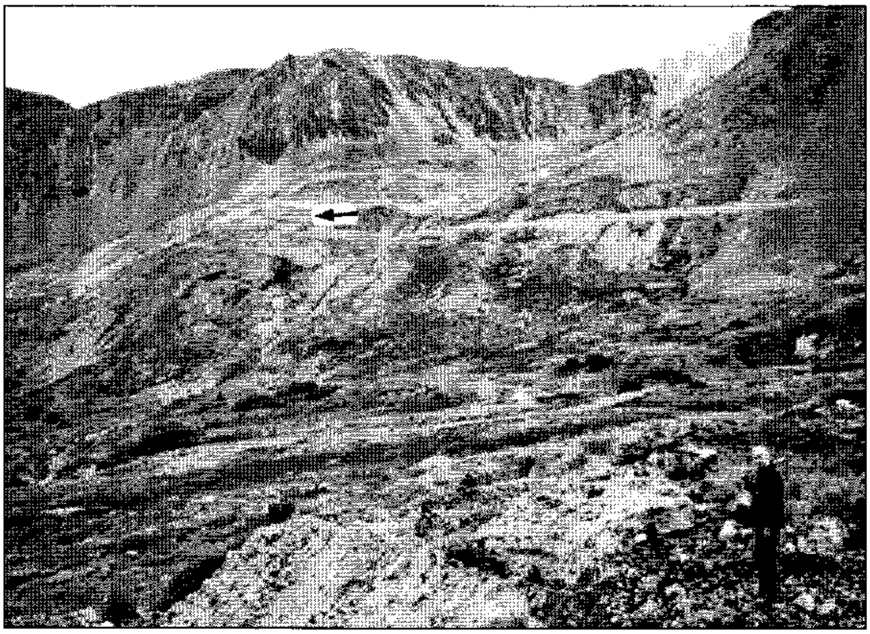


Figure 4: An east-facing view of the TBMB area, which is mostly underlain by micaceous siliciclastic rocks. The light-coloured marble exposed on the ridge crest at right is in the hinge of the Northern anticline. Trench C (see Figs. 5a and 11) is indicated by the arrow.

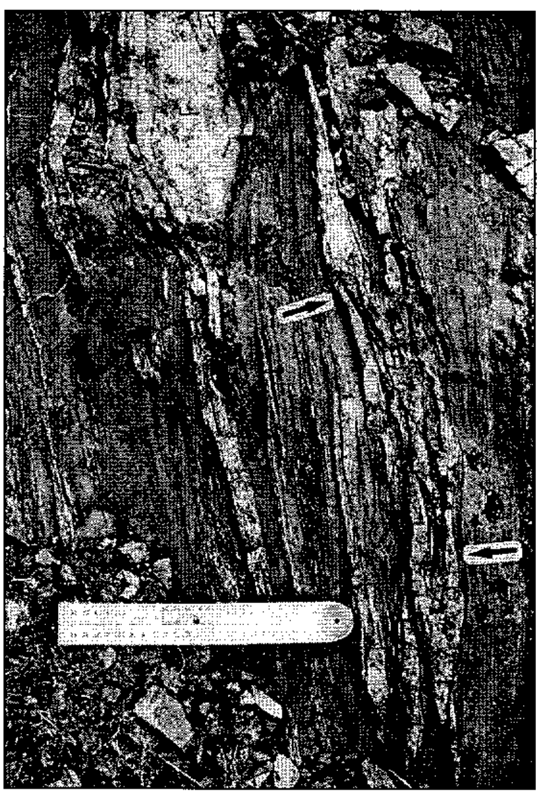


Figure 6. *Interleaved layers showing several F_1 folds (the arrows point to F_1 fold hinges) in light grey marble and light brown metapelites. Attitudes at this location are: B_1 = 060/141°, and $S_0//S_1$ = 214°/70°. Instrument at bottom left is 10 cm long.*

FIELD METHODS

Detailed geological mapping and structural analyses were carried out in an area about 1500 by 1000 m. Figure 5a is based upon 1:2000-scale mapping and shows the location of 59 rock exposures, numbered for reference. These include natural outcrops protruding from rubble as well as three mineral exploration trenches. Using surveying tape and compass, some exposures were mapped in detail (1:100- and 1:200-scale). In addition, a ridge spur about 3 km east of the TBMB (includes the 'BOUND' claim; see Fig. 3) was also investigated.

SUMMARY OF STRUCTURES

All the rocks in the area are polydeformed. The deformation events (D_1-D_3) are similar in scale and style to those of the Dan area (D'el-Rey Silva et al., Part I; this volume). In summary, D_1 developed a pervasive, layer-parallel foliation (S_1) that is axial planar to generally isoclinal F_1 folds from cm- to m-scale (Fig. 6). These structures were affected by a D_2 event, which developed F_2 folds and the axial plane foliation S_2, although S_0/S_1 and S_2 remain sub-parallel in most parts of the area. In several localities the superposition of F_2 on F_1 folds was observed. In detail, it is manifest by a co-axial interference pattern at cm- to dm-scale. Both S_1 and S_2 are defined by sericite, biotite and some chlorite, as well as flattened quartz and carbonate grains. As a consequence, the D_1-D_2 deformation developed a set of greenschist-facies tectonites characterized by an east-southeast-trending

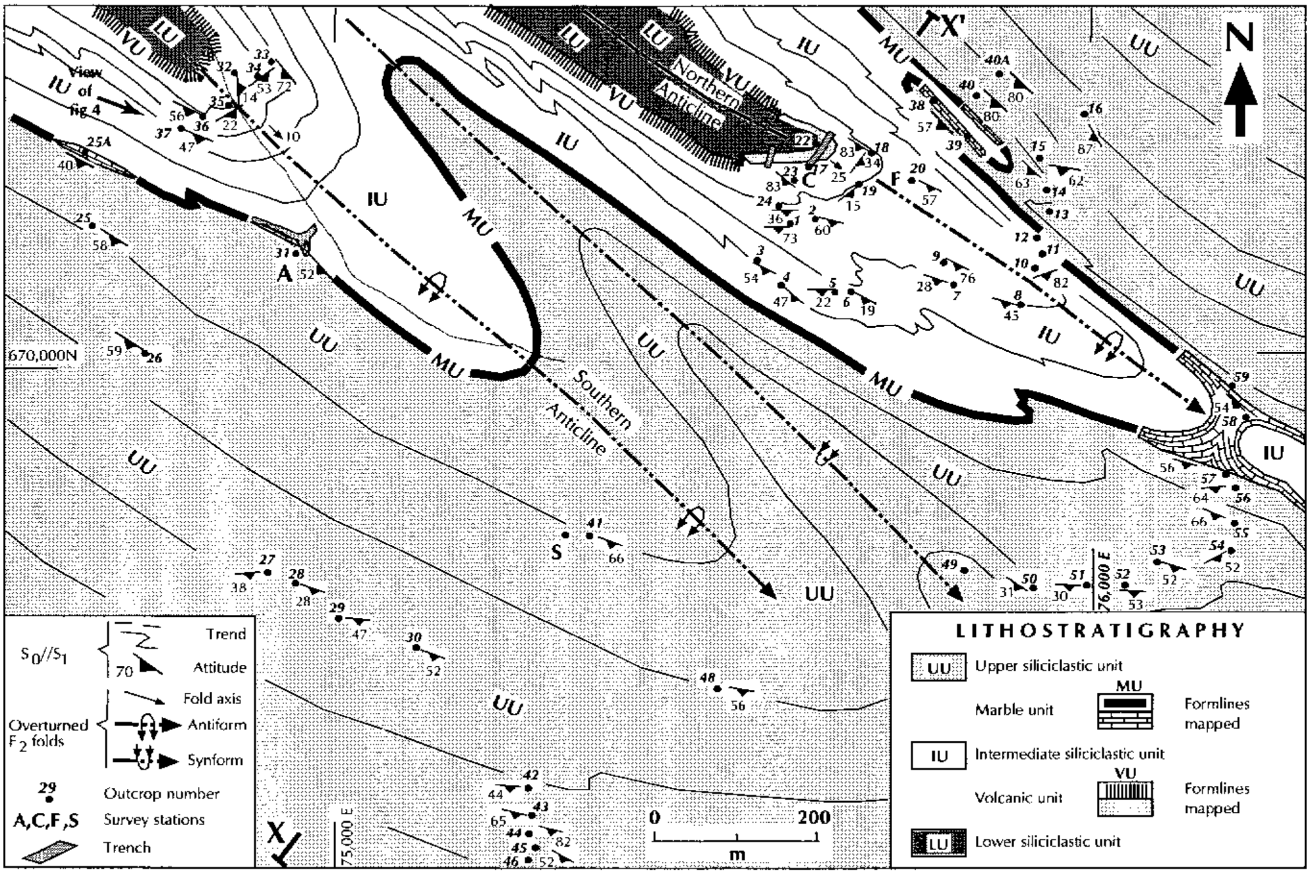


Figure 5a. Summary lithostructural map of the TBMB area with outcrops numbered. Thin lines within units are formlines, drawn along S_0/S_1 structural trends and using the marble and metavolcanic layers as markers. The D_2 and D_3 structures are omitted for clarity. Letters A and C indicate survey stations with nearby exploration trenches.

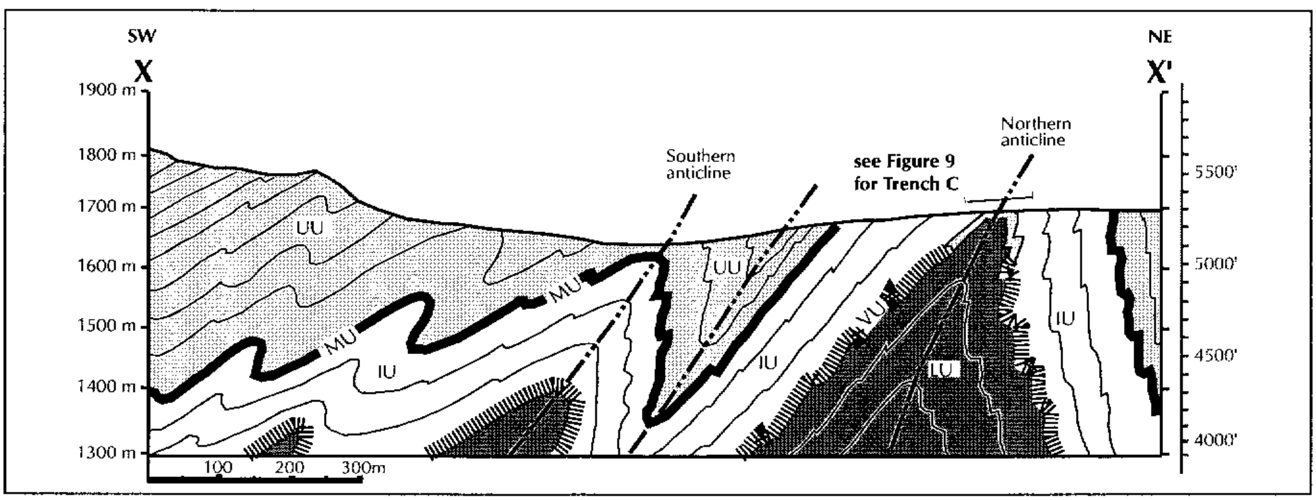
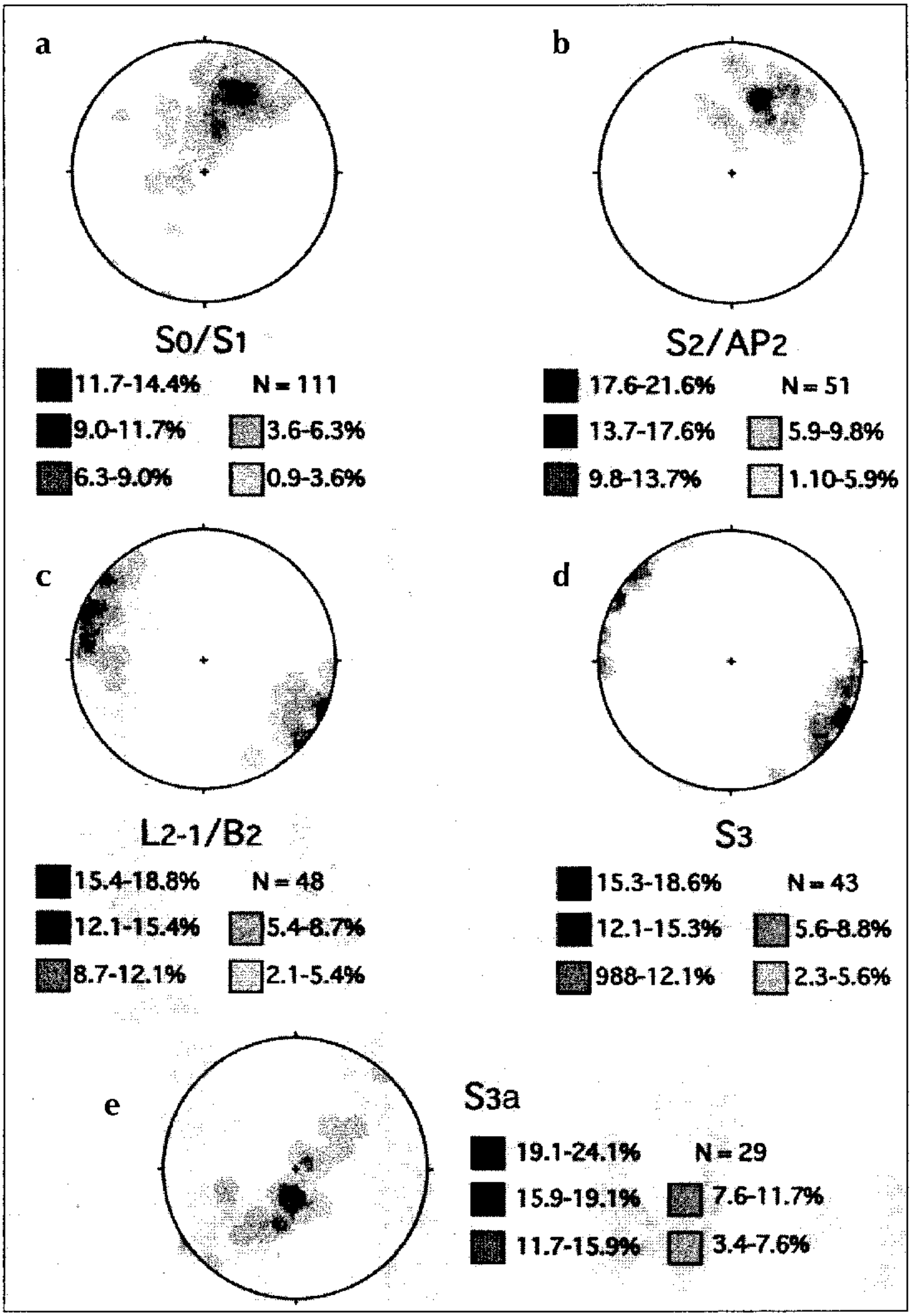


Figure 5b. Summary vertical section across the TBMB area, based on the demonstration of the Southern and Northern anticlines, with an inferred intervening syncline. Two other kilometre-scale F_2 folds have been interpreted along the normal limb of the Southern anticline. F_1 folds have been omitted, basically for a reason of scale, but they have been noticed in several outcrops. Details in text.

Figure 7. Density stereograms of D_2 and D_3 structures in the lower hemisphere of Schmidt-Lambert net. (a) Poles to compositional layering and foliation defined by planar minerals; (b) poles to D_2 penetrative foliation and axial planes of minor folds; (c) intersection lineation of S_1 and S_2 and second phase fold axes (B_2); (d) poles to third phase axial plane foliation; (e) poles to spaced cleavage.



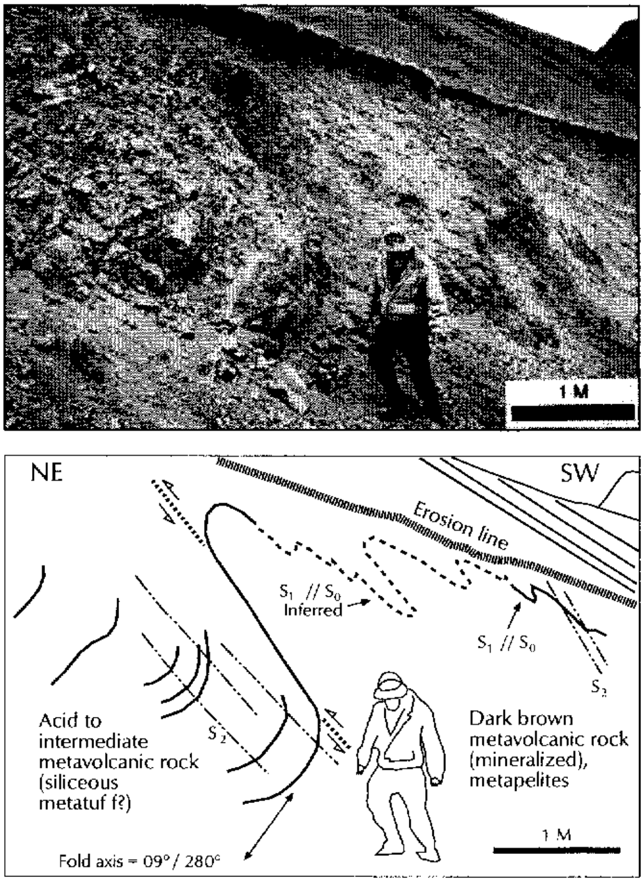


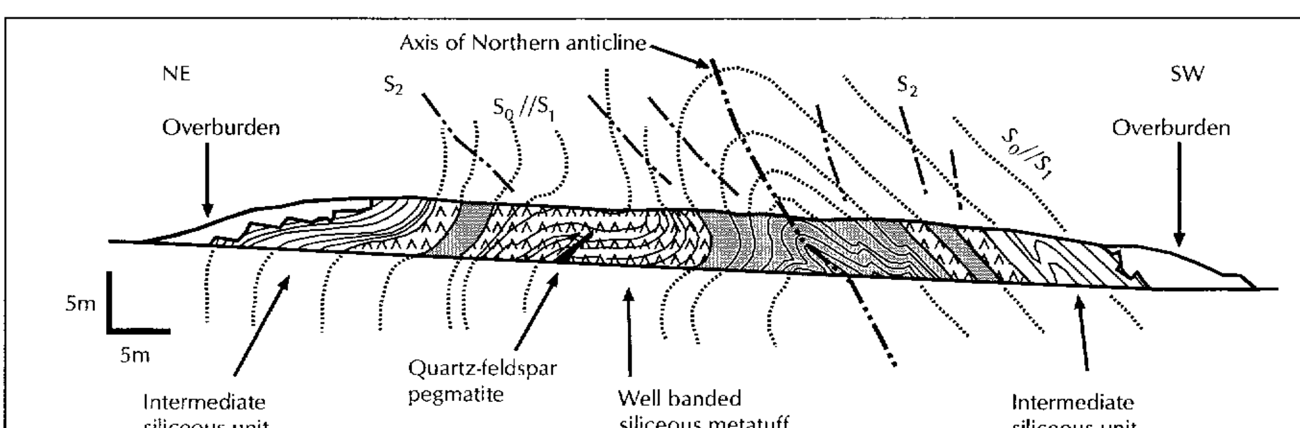
Figure 8. *Wall of exploration trench near station C, revealing folded micaceous quartzite and metapelite. Despite the advanced stage of physical weathering, structural analysis resolved F_2 folds (up to 10-m-scale) with asymmetric geometry and overturned limbs, possibly associated with south-dipping thrust faults. The attitudes of $S_1//S_0$ and S_2 measured in the limb of the southernmost fold are respectively 215°/42° and 210°/52°. The axis of the major fold is 09°/280°.*

penetrative and anisotropy of $S_0/S_1/S_2$ planes. These planes dip southerly at moderate to high angles.

The structures of the first two events define a sub-horizontal, north-northeast-trending maximum compressive stress, with a sub-horizontal intermediate stress parallel to the east-southeast-trending fold axis of the F_1 and F_2 folds (Fig. 7 and stereonets in D'el-Rey Silva et al., Part I; this volume). The D_3 event is characterized by open to tight, generally <1-m-scale, kink-style F_3 folds, and by a penetrative foliation (S_3) that dips steeply and cross cuts $S_0/S_1/S_2$ planes. These D_3 structures are the plane of intermediate stress (commonly to west-northwest; Fig. 7d); another set of fractures, planes and spaced cleavage (S_{3a}, Fig. 7e) dips shallowly and generally northward and defines the plane of minimal compressive stress. As a whole, the D_1-D_3 evolution appears to be progressive, and suggests a single tectonic cycle.

Two localities of continuous exposure, as well as the spatial relationship between the S_2 foliation with the S_0/S_1 planes, and asymmetry of m- to dm-scale parasitic F_2 folds, demonstrate the existence of two larger F_2 anticlines. These are termed Northern and Southern anticlines in Figure 5. The upright limbs of these F_2 folds dip 30° to 55° south-southwest, whereas the overturned limbs dip between 70° to 85° south-southwest. Definition of these major folds permit inference of an intervening overturned F_2 syncline, shown in the vertical cross section (Fig. 4b). These structures are described in detail as follows.

Figure 9. *Sketch of the eastern wall of the trench near C (Figure 8 is from slightly left of centre), illustrating the sequence of mineralized metavolcanic layers (shaded).*



THE NORTHERN ANTICLINE

The Northern anticline, nearly 1 km wide, is defined in the northeastern part of the area. South of the trace of the axial plane, outcrops 3 to 9 systematically display S_2 dipping more steeply south than S_0/S_1, thus defining the normal limb. In outcrops 10 through 16 north of the axial trace, S_2 dips less than S_0/S_1, and defines the shorter limb. The hinge is well exposed along a 70-m-long, northeast-trending trench close to survey station C (Fig. 8 and 9).

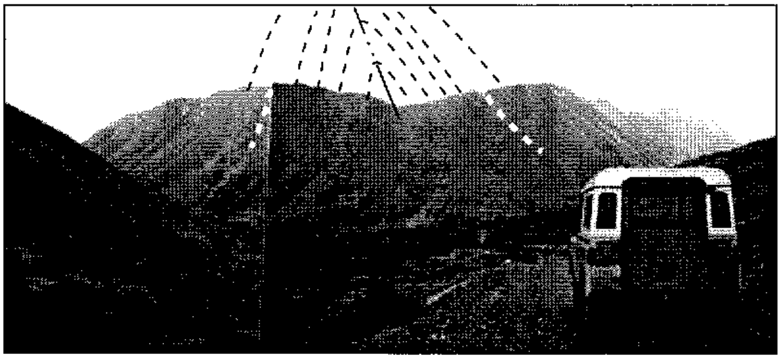


Figure 10. An eastward view of the spur containing the BOUND claims. The dashed white line marks the approximate position of the discontinuous marble layer. The general structure is interpreted as the continuation of the Northern anticline.

From outcrop 16 the overturned limb is exposed on the ridge crest that forms the northern limit of mapping. This outcrop consists of east-southeast-trending, sub-vertical siliciclastic rocks. Eastward, the ridge crest turns to the south and trends across the strike of different rock units (outcrops 59 to 52). The hinge of the Northern anticline (see Fig. 5a) passes through the 120-m-wide marble unit (outcrops 59, 58 and 57). The hinge is preserved by the ridge topography; on the east-facing slope this marble unit extends as two separate limbs.

The marble layer is exposed along the overturned limb of the Northern anticline as

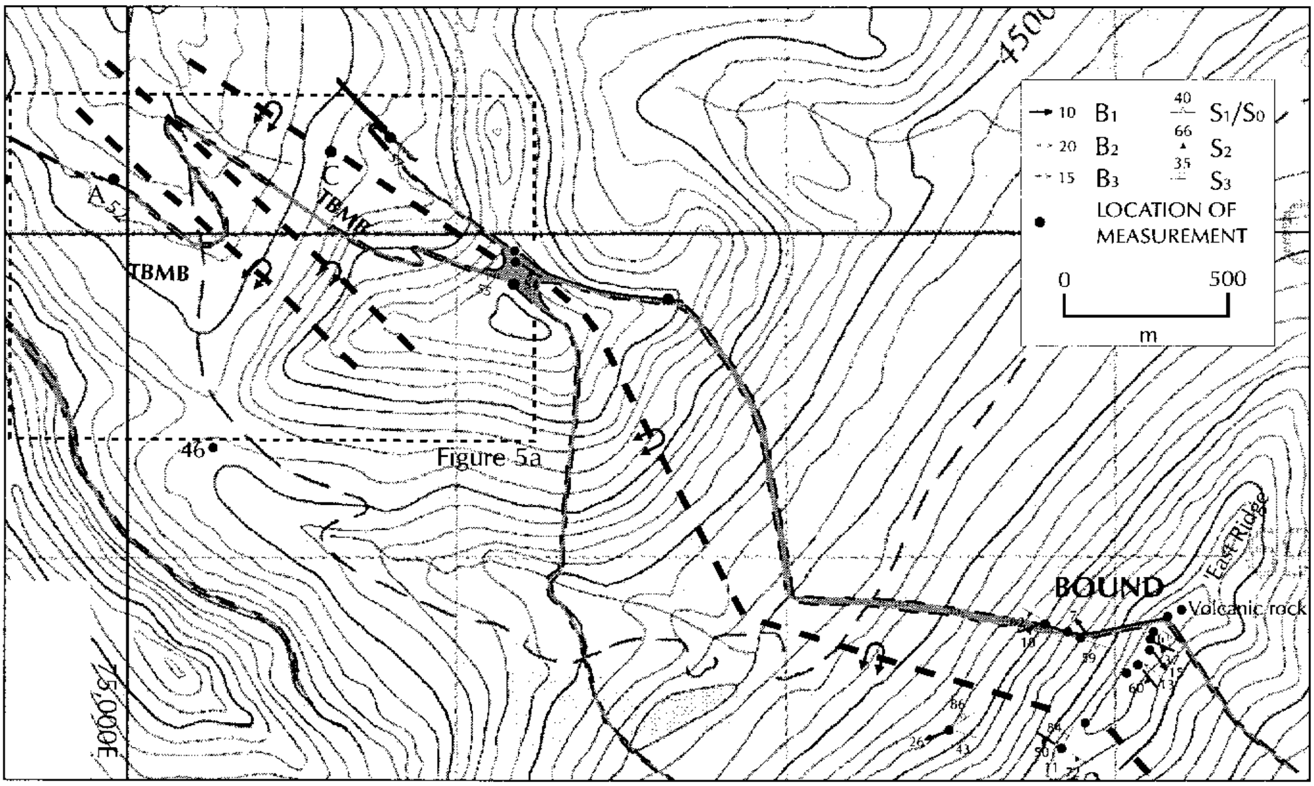


Figure 11. Simplified map of the area enclosing the TBMB and BOUND claims. The marble layer (shaded) indicates the position of the F_2 folds. Bends in the marble layer in valleys reflect use of the "rule of V's" for dipping planar structures (Ragan, 1985).

well, particularly to the east of trench C. Outcrops 38 and 39 contain beautiful examples of isoclinal F_1 folds (Fig. 6). The angular relationships between the S_2 foliation and the previous planar structures reveal a 10-m-scale anticline-syncline pair (outcrops 38 and 39) that are parasite folds on the overturned limb of the Northern anticline.

THE SOUTHERN ANTICLINE

This is a nearly 500-m-wide structure defined along a succession of outcrops in the northwestern border of the area (numbers 26, 25, 25A, 37, 36, 35, 32, 34, and 33; see Fig. 5a). The fold hinge is outlined by a nearly 200-m-long exposure of >1-m-thick layers of sericite-quartz schist and sericite quartzite along a northeast-flowing creek between outcrops 37 and 33. The layers display well-defined composite banding (S_0/S_1) with several cm- to dm-scale intrafolial F_1 folds. The upright, southern limb of the Southern anticline (defined between outcrops 37 and 26) encloses a layer of marble (outcrop 25A) along strike with a marble layer mapped east-southeast in trench A (outcrop 31).

LITHOSTRATIGRAPHY

The lithostratigraphy of the area was determined after the definition of the Northern and Southern anticlines. It consists of five units (Fig. 5a): Lower, Intermediate and Upper siliciclastic units (respectively LU, IU, UU), separated by metavolcanic and marble units (respectively VU and UM). Tracing the marble marker horizon around the hinge of the Southern anticline and through the intervening syncline, one reaches the hinge of the Northern anticline at the eastern part of the area (outcrop 57; see Fig. 5a). The metavolcanic rocks also turn around the hinge of the Northern anticline, but are structurally lower than the marble. The formlines for the VU unit respect the scale of the folds and the attitudes measured along the normal limb of the Northern anticline (outcrops 3-11 and 17-24). These two marker units permit division of the siliciclastic rocks into three units, as shown in the vertical cross-section (Fig. 5b).

STRUCTURE NEAR THE BOUND CLAIM

The same rock types are present 3 km southeast of the TBMB area, and similar D_1-D_3 structures are evident. The east-southeast-trending layers cross a ridge spur containing a discontinuously exposed marble horizon (Fig. 10). The angular relationships between S_2 and S_0/S_1 along the crest indicate that the southern part of the ridge corresponds to the longer upright limb of an anticline, whereas the northern part of the crest, in which the layers are sub-vertical, corresponds to the shorter limb. The authors interpret this structure as a major overturned F_2 anticline that is the eastern continuation of the Northern anticline (Fig. 11).

CONCLUSIONS

The mapping and structural analysis of the TBMB area has shown that the scattered, isolated outcrops of marble constitute a marker horizon within a coherent stratigraphic succession. Furthermore, the overturned anticline defined by this stratigraphy continues at least 3 km to the east. This detailed work therefore extends the possibility that a general stratigraphy can be worked out, at least on the scale of a single mountain, where distinct marker horizons are present. This is profoundly important to the search for stratiform sulphide mineralization. At the trench near survey station A, 12% Zn has been sampled, and sphalerite is also found in the trench near station C.

There is little doubt that the structures mapped in the TBMB area are related to those of the Dan area; the same deformation phases and structural style are present at both. Clearly the entire region underwent many of the same deformational events.

Could all these rocks have the same protolith? The first and second authors have examined both areas and propose that rocks of the TBMB area are part of the Ram Creek assemblage. The proposition that the Ram Creek assemblage extends as far south as TBMB requires that the belt of Dorsey rocks (Stevens and Harms, 1995; 2000) between the two localities is either not exposed or tightly infolded. The former is more likely, because on the regional scale a south-dipping thrust brings Dorsey assemblage rocks over top of the Ram Creek assemblage. This problem cannot be resolved until the intervening ridge (north of the TBMB and south of the Atom showings) has been examined, and this is planned for 2001.

Another intriguing possibility is that the marble exposed at the TBMB and Bound showings corresponds to the large limestone outcrops about 4 km further east (area shown on Fig 2; illustrated in Fig. 12 of Roots et al., 2000). The marble at the latter locality is thicker (varies from 20 to 50 m) than at the TBMB (2-10 m) and appears to be less deformed; it contains unidentified crinoids and other organic debris, and includes carbonate blocks in darker phyllite near its structural base (Roots et al., 2000). To resolve this, the stratigraphic sequences must be described for both areas, and outcrops flanking the kilometre-wide valley separating this area from the spur containing the BOUND claim warrant careful examination.

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