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WINDY CRAGGY DEPOSIT AND ADJACENT

GEOLOGY OF THE ALSEK-TATSHENSHINI RIVERS AREA (114P)

BY D.G.MACINTYRE

INTRODUCTION

Ten days were spent during the 1983 field season mapping in the vicinity of Falconbridge Nickel Mines limited - Geddes Resources limited Windy Craggy deposit (MacIntyre 1983). A total of 86 geologic stations were established in the map area, which covered approximately 300 square kilometers (figure 1). The primary purposes of this project were to define the stratigraphic and structural setting of the Windy Craggy deposit and assess the mineral resource potential of the surrounding area. This report summarizes the preliminary results of this work.

The map-area is part of the Alsek Ranges of the St.Elias Mountains and is characterized by jagged ridges and peaks rising to 2200 metres above a base elevation of 800 to 1000 metres. Almost all of the cirques and valleys in the area are occupied by glaciers. Outcrop is limited by the extent of ice cover. The steep and unstable nature of much of the outcrop in the area made mapping difficult and many areas could not be sampled for safety reasons. Marginal weather conditions also restricted access to higher elevations during the mapping project. Thus much of the area has been mapped from a distance or via helicopter with geologic contacts assumed rather than defined. The locations of geologic stations are shown in figure 2 which summarizes the geology as it is known to date.

GEOLOGIC SETTING

The Alsek-Tatshenshini map area is part of the Alexander Terrane of the Insular Tectonic belt (figure 1). Recent geologic mapping by Campbell and Dodds (1983) suggested that this area was underlain by complexly deformed Paleozoic clastic and carbonate rocks of relatively low metamorphic grade. Mafic volcanic units lithologically similar to those exposed in the vicinity of the Windy Craggy deposit were known to occur in the early Paleozoic part of the stratigraphic succession and for this reason the deposit was believed to be Paleozoic in age. However, limy beds in the stratigraphic hangingwall of the deposit have consistently yielded Late Triassic conodonts (MacIntyre, 1983) thus suggesting the presence of early Mesozoic volcanic-sedimentary units in the stratigraphic succession. (These rocks are lithologically and chronologically aligned with those of Wrangellia thus suggesting considerable complexity to the geologic evolution of the area.)

GEOLOGY

The map-area is underlain by intermediate to mafic submarine volcanic units that have variable amounts of interbedded limy

[These rocks are believed to be Late Triassic or(?) younger in age and are thought to overlie an(upper Paleozoic to Late Triassic sequence of calcareous argillite and siltstone (unit 2) and a Lower to mid Paleozoic calcareous clastic and carbonate sequence (unit 1).]

argillaceous sedimentary rocks. (These rocks are believed to be predominantly Triassic in age and to overlie late Paleozoic (Devono-Mississippian?) limestone (unit 1).) ? rewrite as The stratigraphic succession as described in this report is based mainly on traverses completed north of the East Arm Glacier where a relatively complete southwest dipping section is exposed and accessible. It is assumed that this section is both representative for the area as a whole and that it is not complicated by major faults. Neither of these assumptions may be correct.

The oldest known part of the section (unit 1) is represented by a thick succession of laminated carbonate, calcareous mudstone-siltstone (lower part) and more massively bedded carbonate (upper part). Apparently above this unit, but generally in fault contact, is a vast sequence of limy argillaceous rocks (unit 2). These rocks are...

STRATIGRAPHY

not all R necessarily?

The ~~Triassic~~ stratigraphy (figure 3) has been subdivided into map units on a lithological basis. (The base of the section is apparently represented by a thick section of limy argillaceous rocks (unit 2) that is) ? rewrite as believed to be overlain by andesitic flows with minor intercalations of limy argillite and limestone (unit 3). A thin unit of felsic and mafic pillow lavas and porphyritic flows (unit 4) locally separates these rocks from an overlying unit comprised of pillowed and non-pillowed intermediate to mafic flows and tuffs and interbedded limy argillite, siltstone and minor chert and limestone (unit 5). Overlying unit 5 is a thick (>1500 metres ?) pile of mafic pillow lava (unit 6) that has no appreciable amount of interbedded sedimentary rock. Fine to medium-grained dioritic sills and dykes (unit 7) occur throughout the Triassic succession and Jurassic -Cretaceous age plutons (unit 8) occur on the periphery of the map-area.

Unit 1

Map unit 1 is comprised of medium to thin bedded grey, cream and orange-brown weathering limestone or marble with interbedded calcarenite and limy argillaceous siltstone. These rocks are well exposed in the creek valley south of the Tats showing where highly contorted bands of marble and calcarenite outcrop on the north facing slope. A major fault occupies the valley bottom and separates these calcareous rocks from massive volcanics and diorite south of the creek.

North (?). Do you mean the E-W creek immediately S of TATS?

Grey weathering limestone also outcrops northeast of the East Arm Glacier along the crest of a northwest trending ridge. Apparently this unit has yielded Devonian macrofossils (Knopf and Valle, 1981) and late Eifelian to early Givetian conodonts (~~G.S.C. locality~~ (R.B. Campbell pers. comm.)). The lower half of the ridge is underlain by black weathering shales which apparently dip northeastward underneath the limestone unit. It is not certain whether these rocks stratigraphically underlie the Devonian limestone or are part of the Triassic or(?) older succession (unit 2) in fault contact with the limestone. Beyond the limits of the map-area, calcareous clastic carbonate rocks correlated with unit 1 also have yielded Ordovician conodonts and macrofossils (R.B. Campbell, pers. comm.)

Unit 2

The predominant lithologies that comprise map-unit 2 are black to dark grey weathering limy argillaceous siltstone and shale. Thin beds of tuff also occur locally within this unit, which for the most part is recessive in nature. This unit is well exposed west of the Tats glacier, northeast of the East Arm glacier and on the east side of the south trending glacier that forms the eastern margin of the map-area. Tuff bands within this unit help outline tight northwest verging isoclinal folds.

The stratigraphic relationships between unit 2 and units 1 and 3 are not well established. (Norian (~~early~~ Late Triassic) age conodonts have been extracted from samples of lithologically similar rocks outcropping on the ridge west of Windy Craggy (C.Dodds ,personal communication), but it is not certain if these limy argillaceous rocks are part of unit 2 or a volcanic deficient facies equivalent of unit 5b.) Hopefully samples collected from unit 2 elsewhere in the map area will yield diagnostic conodont fauna to help resolve the relative stratigraphic position of these rocks.

Late Triassic (Norian) conodonts have been extracted from rocks of unit 2 outcropping west and north of Tats Glacier (C. Dodds, pers. comm.). However, just how much of this part or all of unit 2 is Late Triassic (or includes volcanic deficient facies equivalents of unit 5b) is as yet uncertain.

Unit 3

Map unit 3 is comprised mainly of massive, thick-bedded, locally amygdaloidal, grey to orangy brown weathering, intermediate volcanic flow and tuff beds separated by thin beds of limy siltstone and banded limestone. Microdioritic sills and dykes are also common within this unit. These rocks are well exposed north of the East Arm Glacier where they dip steeply to the southwest and outcrop as a prominent northwest trending ridge. The general lack of pillowed flows distinguishes this unit from compositionally similar units which are believed to be higher up in the Triassic succession. This criteria may not in fact be valid and the unit may be a non-pillowed facies equivalent of unit 5a. Compare whole rock chemistry, thin section petrography of two volcanic units. Falconbridge analyses of volcs in the TATS area are Mg-rich tholeites. No known analyses exist of up the younger pillowed flows.

[illegible]

Unit 4

A distinctive unit of felsic pillow lava outcrops on the west facing slope of the ridge east of the Tats glacier. The pillow lava is typically porphyritic with a dark cherty rind outlining pillows. Non-pillowed porphyritic flows and felsic crystal and ásh tuff are also included with this unit. Similar rocks outcrop at the same stratigraphic position on the south facing slope of the ridge north of the East Arm glacier. This unit may prove to be an important marker unit within a sequence of predominantly intermediate to mafic volcanics.

The original chemical composition of the rocks that comprise unit 4 is not certain. Although the porphyritic pillow lavas are relatively siliceous and light-coloured these characteristics may be due to superimposed hydrothermal alteration that may be genetically related to massive sulphide deposits that apparently occur higher up in the stratigraphic sequence.

Unit 5

Map unit 5 can be subdivided into a lower unit (5a) which is comprised of pillow lava and amygdaloidal flows with minor intercalations of limy argillite, siltstone and chert and an upper unit (5b) which is predominantly limy siltstone and argillite interbedded with andesitic tuffs and flows. The volcanic flows of unit 5a appear to be somewhat more basaltic and pervasively altered to a chlorite-carbonate assemblage than the predominantly unaltered to weakly altered tuffaceous rocks of unit 5b. Zones of disseminated and stringer pyrite that both cross-cut and parallel bedding also occur within unit 5a. Rocks of this unit are believed to form the stratigraphic footwall of the Windy-Craggy deposit.

The thickness and percentage of intercalated volcanics is quite variable in unit 5b. Immediately east of Windy-Craggy this unit appears to be over 1000 metres thick and is predominantly limy siltstone; north of the East Arm glacier volcanics predominate and the unit is probably less than 200 metres thick. Assuming there are no major faults that cut out or repeat parts of these sections (a dangerous assumption!) a local thickening of this unit in the vicinity of the Windy Craggy deposit is inferred. Perhaps a structurally controlled sedimentary trough was present in Late Triassic time, with limy detritus and rift related flows and tuffs accumulating within the trough.

Unit 6

Map unit 6 is comprised almost entirely of massive mafic pillow lava with little or no intercalated sedimentary rocks. This unit is very resistant and forms jagged ridges and near vertical cliff faces in the area east and southeast of the Windy Craggy deposit. In this area the unit appears to be in excess of 1500 metres thick. The top of the unit has not yet been recognized. Agglomerate consisting of drawn out clasts of lava suspended in a muddy or tuffaceous matrix (unit 6a) occurs at the base of the pillow lava sequence. These rocks are very distinctive and may prove to be a useful marker horizon for the map-area.

The great thickness of mafic pillow lava represented by unit 6 implies a prolonged period of submarine extrusive activity followed formation of the Windy-Craggy deposit and deposition of turbiditic sediments of unit 5b. The pillow lavas appear to occupy the core of a northwest trending synclinorium which also coincides with the greatest thickness of unit 5b as mentioned previously. These observations are compatible with a depositional model in which sediments and submarine volcanics have accumulated within a trough centered on a major submarine rift system that may have been related to sea floor spreading.

Unit 7

Numerous dykes and sills of grey-weathering medium to fine-grained dioritic rock occur within map units 2 through 5 ; particularly in the vicinity of the Windy-Craggy deposit. These intrusive rocks are texturally and probably compositionally identical to flows within units 3 and 5b and they are assumed to be the subvolcanic equivalents of these rocks. The sills are difficult to recognize unless the contact is well-exposed and many of the flows mapped in the area may in fact be sills. Hopefully isotopic age dating and petrographic and geochemical studies will help resolve some of these ambiguities.

A diorite-volcanic complex (unit 7a) is exposed along the bottom half of the ridge east of the Tats glacier. This complex is characterized by very coarse grained hornblende rich diorite and partly to totally recrystallized mafic volcanic flows. The diorite in places appears to have formed as a result of recrystallization of the mafic volcanic rocks. Segregations of mafic-rich diorite are also present and locally cross cut the volcanic stratigraphy. Hornblende rich dykes cut rocks in the vicinity of the complex and may be genetically related to the core of the complex. In one locality a breccia dyke composed of clasts of volcanic rock partially to totally replaced by hornblende in a finer-grained hornblende diorite matrix was observed.

Medium to coarse-grained diorite to quartz diorite (unit 7b) outcrops in the lower part of the creek draining the Tats showing and in the major creek valley southwest of the showing. This intrusive body appears to form the core of the diorite-volcanic complex suggesting the complex represents a transitional zone between the intrusive and overlying volcanic strata.

Unit 8

Map unit 8 includes granitic rocks of probable Jurassic age. These rocks are part of a series of intrusive bodies that outcrop in the Alsek-Tatshenshini area. Potassium-argon isotopic ages of 156+19 and 141+8 million years have been determined by the Geological Survey of Canada on hornblende extracted from intrusive bodies east and southeast of the map area.

STRUCTURE

The structure of the map area is characterized by major northeast and northwest trending faults that offset steeply tilted fault blocks. Isoclinal folds with northeast dipping axial planes and plunges to the northwest occur within incompetent limy argillaceous rocks and the mineralized zone at the Windy Craggy property. Elsewhere massive volcanic units do not apppear to be significantly deformed although interbeds of limy argillaceous rocks are often sheared and tightly folded suggesting movement along these less competent units. A broad syncline is defined by stratigraphic tops as deduced from pillow orientations and the areal distribution of unit 6 which is assumed to occur high in the Triassic stratigraphic succession.

MINERAL OCCURRENCES

Windy-Craggy

Exploration work continued on the Falconbridge Nickel Mines Limited - Geddes Resources Limited Windy-Craggy deposit during the 1983 field season. A total of 4141 metres of drilling was completed in 8 drill holes. This work confirmed the northwest extension of the massive sulphide deposit. Drill hole 83-14, which tested the ground between drill holes 82-11 and 82-12 (MacIntyre, 1983) is reported to have intersected 61.23 meters averaging 1.21 percent copper, 11 grams/tonne (0.32 oz/ton) gold and 11.6 grams/tonne (0.34 oz/ton) silver (George Cross Newsletter No.197, October 12,1983). This intersection included a 23.7 meter section averaging 19.9 grams/tonne (0.58 oz/ton) gold. This intersection indicates that the Windy-Craggy deposit may have significant gold potential. Final results of the 1983 drilling program have not yet been released to the public.

One of the primary objectives of this project was to define the stratigraphic position of the Windy - Craggy deposit. On the basis of mapping completed to date it appears that the deposit occurs at the transition between units 5a and 5b. That is, the stratigraphic footwall is comprised of pillow lava with minor intercalations of chert and limy argillite and the stratigraphic hangingwall is comprised of limy siltstone and argillite with interbedded andesitic tuff and flows. These stratigraphic units are offset by high angle reverse and normal faults as shown in the cross-section of figure 2.

I am uncertain of the validity of unit 5a. More likely a transitional contact change in succession to water content of volcanics! 5a' unit is probably of unit 6.

The stratigraphic interval that corresponds to that hosting the Windy-Craggy deposit is exposed on the north side of the East Arm glacier. Zones of pervasive chlorite and sericite alteration with disseminated and stringer pyrite mineralization do occur in in this part of the volcanic sequence, typically producing prominent gossans. No stratabound massive sulphide mineralization was observed however. Analyses of samples from these zones (samples 4 and 5, table 1) indicate relatively low base and precious metal contents. There may be an enrichment of barium in sample 4.

How does this compare with airborne EM anomaly?

Your stratigraphy may be right [illegible]

CONCLUSIONS

Fieldwork in the Alsek-Tatshenshini rivers area indicates that a thick (>3000 meters?) section of Late Triassic andesitic to basaltic flows and limy argillaceous sedimentary rocks is preserved within a roughly rectangular fault-bounded area. Stratabound massive sulphide deposits occur at several different stratigraphic levels within the Triassic succession and broad zones of disseminated stringer sulphides both cross-cut and parallel the stratigraphy. These sulphide zones appear to be spacially associated with the presence of fine-grained dioritic sills and dykes in underlying rocks. These intrusive rocks are lithologically and probably compositionally similar to flows within the succession. The presence of a structurally-controlled trough is inferred by anomalous thickening of sedimentary and volcanic units in the vicinity of the Windy-Craggy deposit.

A model of hydrothermal vents occuring within a rift trough centered on a spreading center analogous to the modern day Guaymas Basin in the Gulf of California (e.g. Scott et al., 1983) is favoured as the environment for the formation of the mineral deposits of the area. The inferred trough was the site of rapid accumulation of submarine flows, clastic and carbonate detritus and injection of subvolcanic dioritic intrusions both before and after the main mineralizing events. No ophiolite sequence has yet been observed in the area although the diorite-volcanic complex exposed near the Tats showing may have formed in a manner analogous to that proposed for ophiolite complexes. The lack of well-developed ophiolite complexes suggests that the inferred spreading center may have been short-lived and did not evolve past the earliest stages of crustal spreading.

One of the most significant results of the work done in the Alsek-Tatshenshini rivers area during 1983 is the recognition of the fact that the deposits of the area may have significant amounts of gold associated with them. Undoubtedly this will have a profound influence on future exploration not only at Windy-Craggy but at other prospects in the area.

ACKNOWLEDGEMENTS

The author would like to thank Falconbridge Nickel Mines Limited and Geddes Resources Limited for logistical support during the mapping project. Without their assistance the project would not have been possible. I would also like to acknowledge Dick Campbell, Chris Dodds and Ken Dawson of the Geological Survey of Canada who very generously shared the geologic data they acquired during an earlier visit to the area. Some of the geology shown on the geologic map accompanying this report is derived from their observations. Finally I would like to thank Joe Cadham, pilot for Pacific Helicopters for excellent service under less than ideal conditions and Mike Fournier for his very cheerful and able assistance in the field.

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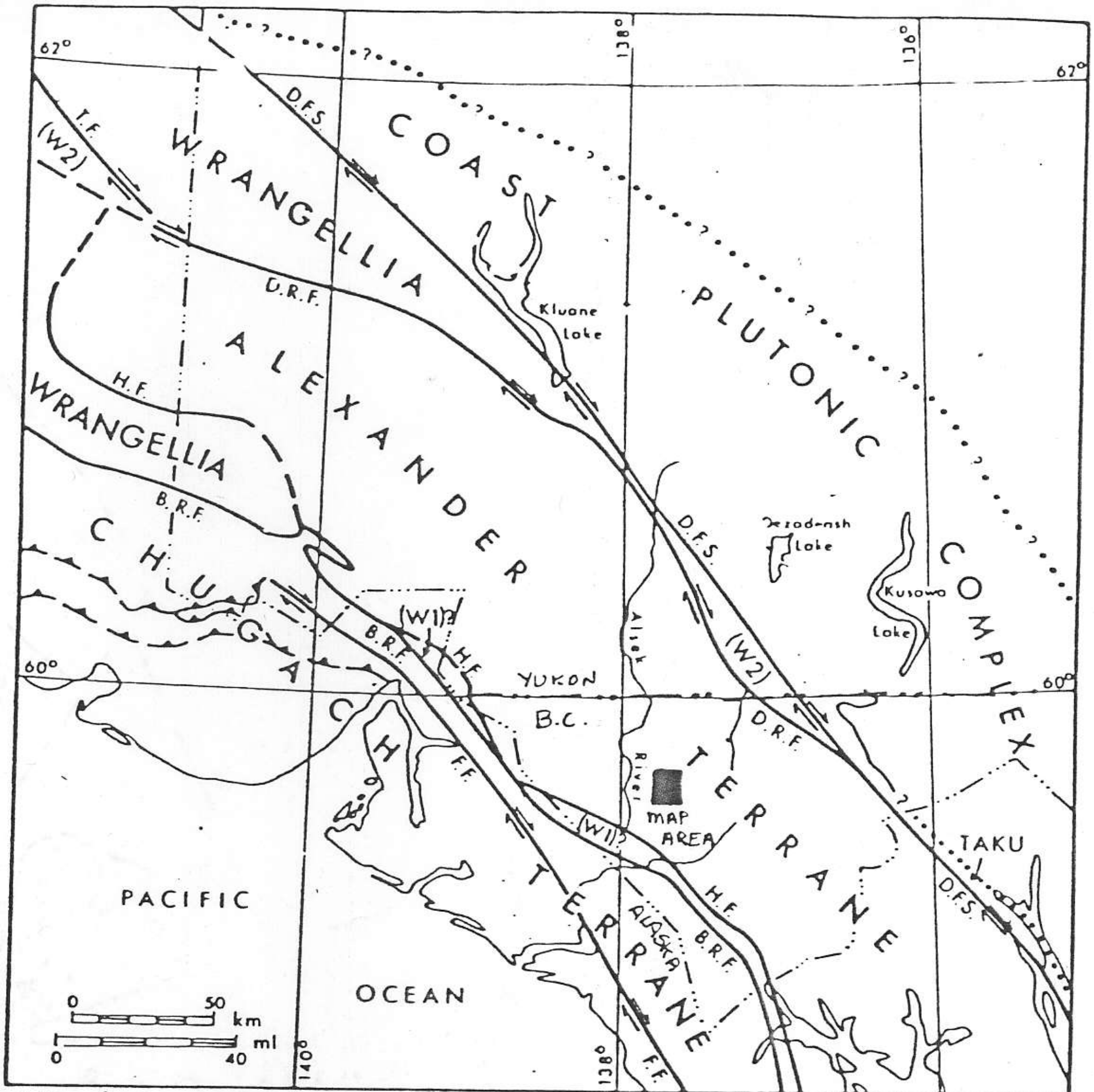


After Campbell & Dodds, 1983

Fig 1


B
Paleozoic ?
ARM
GLACIER
5a?
5b?
6620000N
Paleozoic ?
LEGEND
JURASSIC - CRETACEOUS
8 granitic intrusions
TRIASSIC OR YOUNGER
7 microdioritic intrusions; 7a - diorite-volcanic complex; 7b - diorite, quartz diorite
LATE TRIASSIC AND (?) YOUNGER (whole or in part)
6 mafic pillow lava; 6a - agglomerate
5a - limy argillite, chert
5b - limy siltstone, argillite, tuff and flows
4 felsic pillow lava, porphyry flows
3 amygdaloidal flows, minor limy argillite,

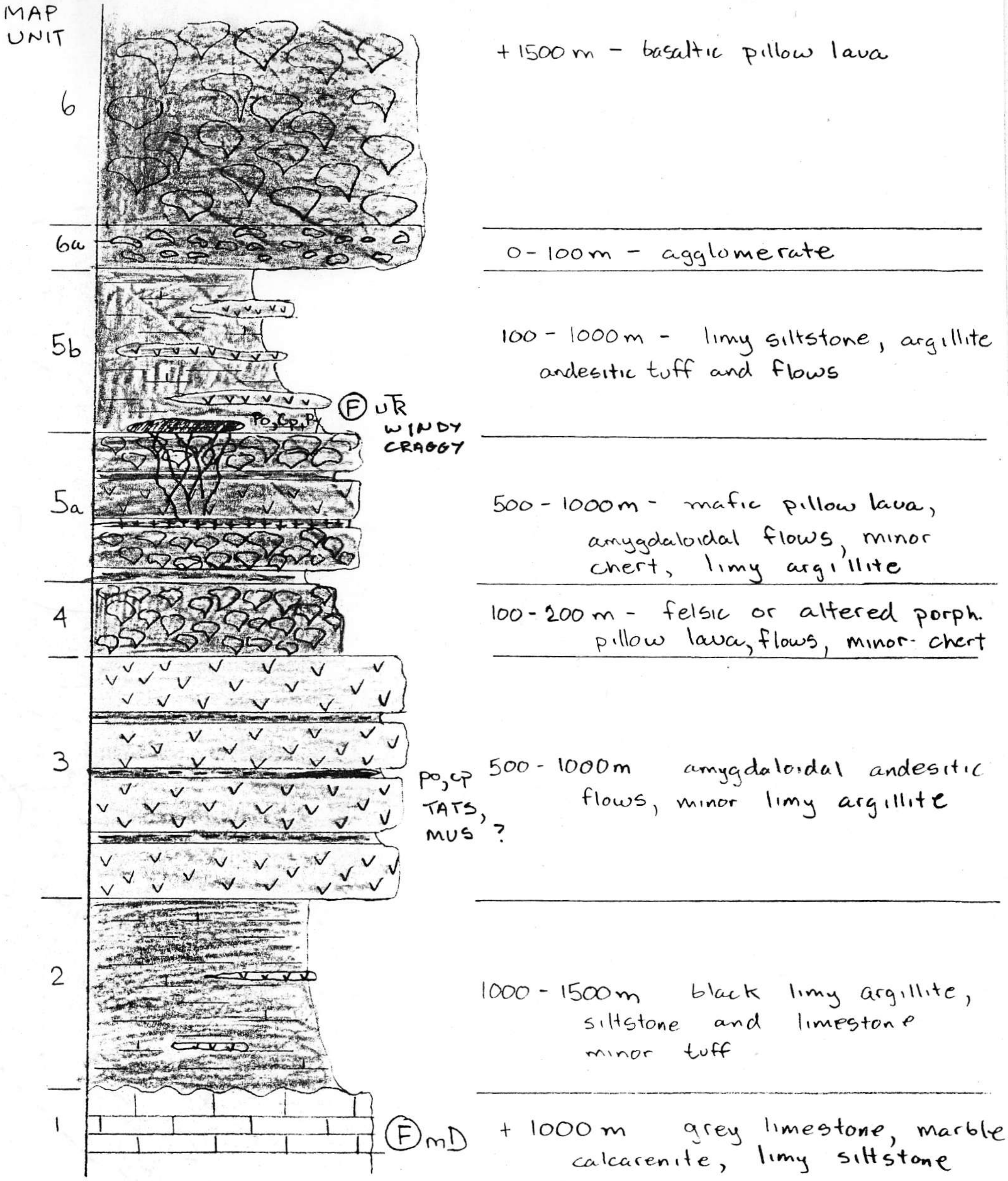
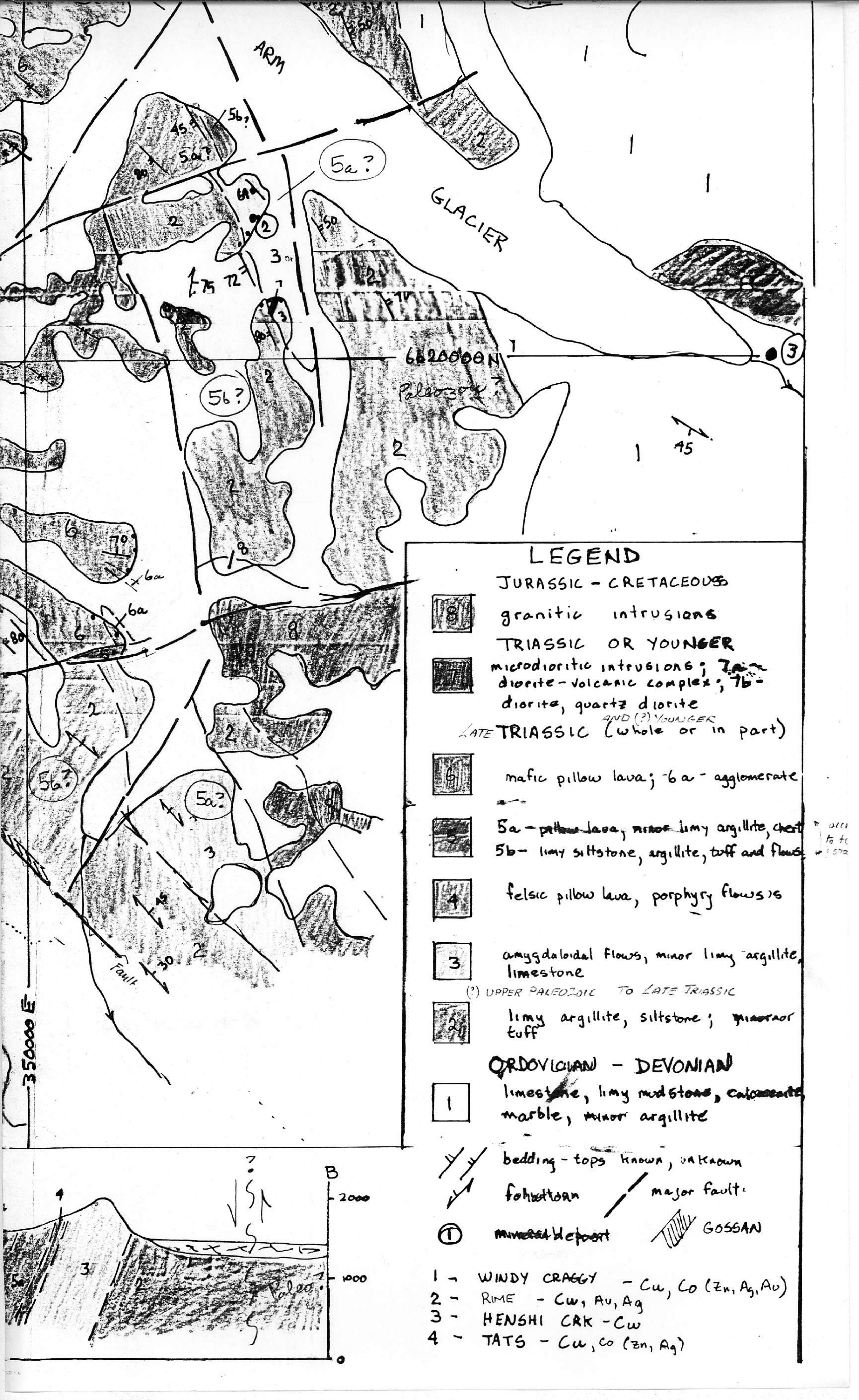

MAP UNIT
6
+1500 m - basaltic pillow lava
6a
0-100 m - agglomerate
5b
100-1000 m - limy siltstone, argillite andesitic tuff and flows
Po, Cp, Py
(F) uTR
WINDY CRAGGY
5a
500-1000 m - mafic pillow lava, amygdaloidal flows, minor chert, limy argillite
4
100-200 m - felsic or altered porph. pillow lava, flows, minor chert
3
Po, cp
TATS, MUS ?
500-1000 m amygdaloidal andesitic flows, minor limy argillite
2
1000-1500 m black limy argillite, siltstone and limestone minor tuff
1
(F) mD
+1000 m grey limestone, marble calcarenite, limy siltstone

Fig 3


ARM
GLACIER
5a?
5b?
Paleozoic?
6620000N
350000E
Fault
LEGEND
JURASSIC - CRETACEOUS
8 granitic intrusions
TRIASSIC OR YOUNGER
7 microdioritic intrusions; 7a - diorite-volcanic complex; 7b - diorite, quartz diorite
LATE TRIASSIC AND (?) YOUNGER (whole or in part)
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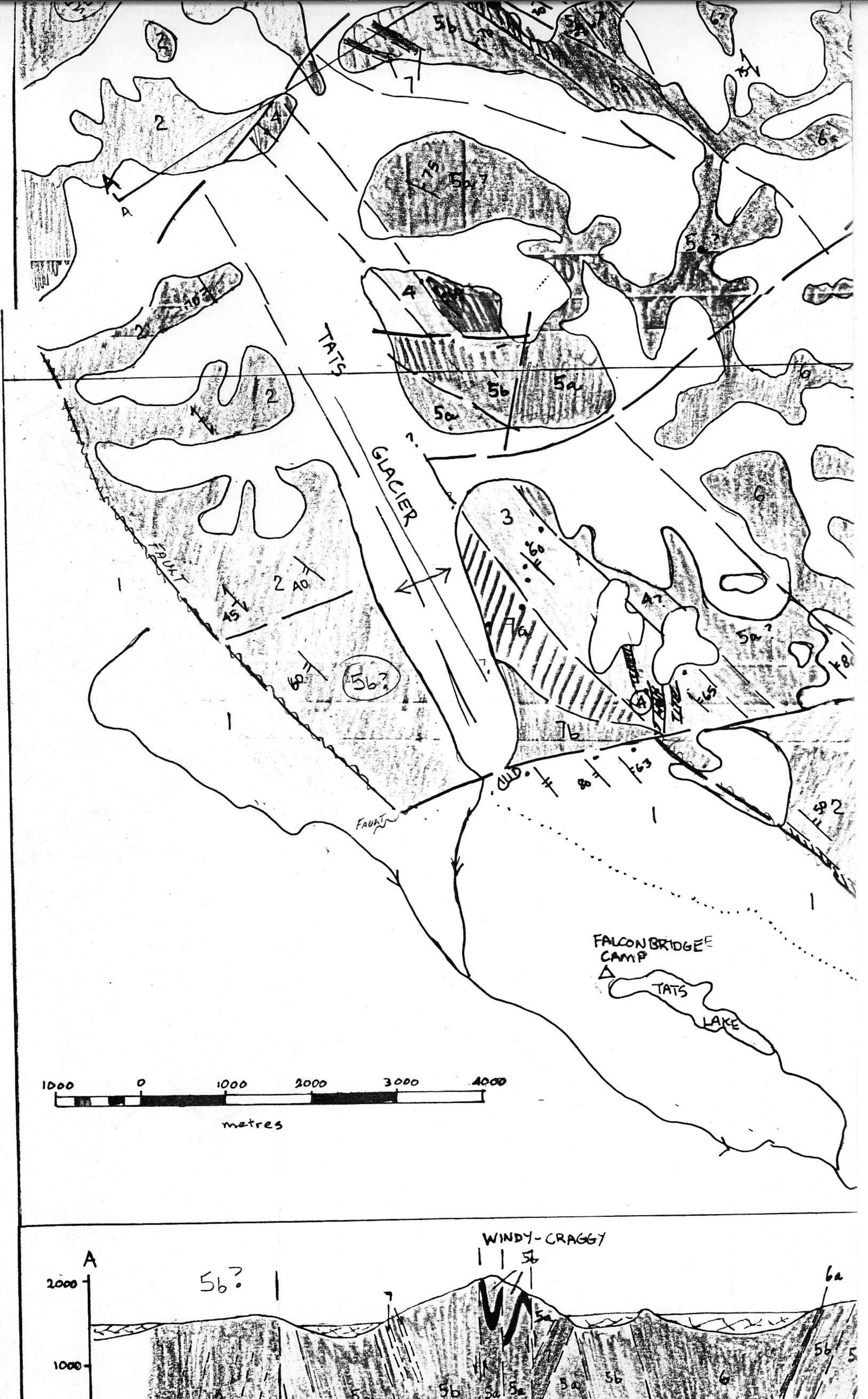
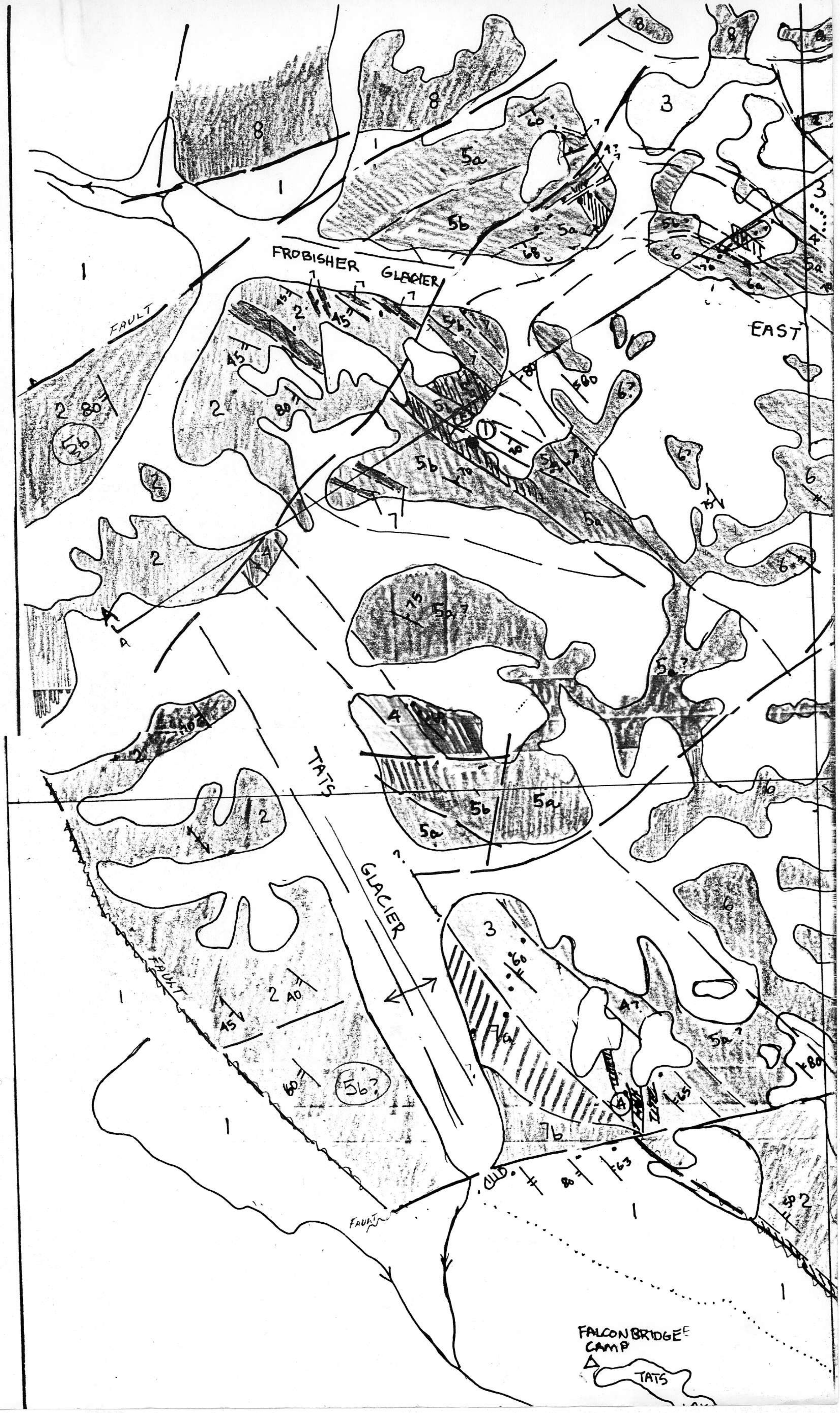
5 5a - pillow lava, minor limy argillite, chert
5b - limy siltstone, argillite, tuff and flows
4 felsic pillow lava, porphyry flows
3 amygdaloidal flows, minor limy argillite, limestone
(?) UPPER PALEOZOIC TO LATE TRIASSIC
2 limy argillite, siltstone; minor tuff
ORDOVICIAN - DEVONIAN
1 limestone, limy mudstone, calcareous marble, minor argillite
bedding - tops known, unknown
foliation
major fault
mineral deposit
GOSSAN
1 - WINDY CRAGGY - Cu, Co (Zn, Ag, Au)
2 - RIME - Cu, Au, Ag
3 - HENSHI CRK - Cu
4 - TATS - Cu, Co (Zn, Ag)
B
2000
1000
0
Paleo


TATS
GLACIER
FAULT
FAULT
FALCONBRIDGE CAMP
TATS
LAKE
1000
0
1000
2000
3000
4000
metres
5b?
A


WINDY-CRAGGY
A
2000
1000
0
5b?
2
4
5a
5b
5a
5a
5a
5b
6
6a
5b



FROBISHER GLACIER
FAULT
EAST
TATS
GLACIER
FAULT
FAULT
FALCONBRIDGE CAMP
TATS

CIM Van Apr 85

Paper No. 141 — 10:00

The Hidden Creek Cupriferous Massive Sulphide Deposit, Anyox, B.C.

R.J. SHARP, Cominco Ltd., Vancouver, B.C.

(Abstract not available at press time)

Paper No. 142 — 10:30

Geologic Setting of the Windy-Craggy Massive Sulphide Deposit, Northwest British Columbia.

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The massive cobaltiferous pyrrhotite-pyrite-chalcopyrite Windy-Craggy deposit is located in the rugged Saint Elias Mountains of northwest British Columbia. Host rocks are folded and chlorite-altered Late Triassic (Early Norian) pillow basalts with limy and cherty sedimentary interbeds. These rocks occur within a fault-bounded area that is surrounded by Paleozoic sedimentary rocks of the Alexander Terrain. The lack of an ophiolite sequence and the apparent calc-alkaline composition of the pillow basalts suggests in-situ deposition near an inter-basin rift. Stratabound mineral deposits in similar stratigraphic sequences elsewhere in the Alexander Terrain are barite and sphalerite-rich, suggesting lower temperatures of formation than Windy-Craggy.