GEOLOGY OF THE NORTHEAST NEEDLEPOINT MOUNTAIN AND ERICKSON MINE AREAS, NORTHERN BRITISH COLUMBIA* (104P/4)

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INTRODUCTION

As part of a 3-year program of geologic mapping from the Yukon border south through the Midway, Cassiar and Erickson mining camps (Nelson and Bradford, 1987a; 1987b; 1989, this volume; Nelson *et al.* 1988a; 1988b), 1:25 000-scale mapping was conducted in the northeast quarter of the Needlepoint Mountain (104P/4) map area during the 1988 field season (Figure 1-35-1). Since Gabrielse's (1963) original 1:250 000-scale McDame map, excellent but schematic geologic maps by Diakow and Panteleyev (1981), Gordey *et al.* (1982), and Panteleyev and Diakow (1982), have served as the only available detailed maps of this area. Consequently, the objectives of this project are:

- To map the geology of the study area in detail.
- To identify, map, and date significant lithotectonic units within the Sylvester allochthon.
- To examine the structural and stratigraphic setting of the Erickson deposit in the context of the geology and geologic history of the study area.

REGIONAL GEOLOGY

The Sylvester allochthon is a vast, composite klippe of middle to late Paleozoic, to earliest Mesozoic oceanic rocks that rests entirely on top of the Cassiar terrane, which is a northward-displaced fragment of the western North American Paleozoic miogeoclinal continental margin. Lithologies of the Sylvester allochthon are, in part, coeval with but distinctly different in nature from the North American strata against which they are juxtaposed (Harms, 1986). On this basis the Sylvester has been included as part of the Slide Mountain terrane, an accreted suspect terrane (Monger and Berg, 1987).

In the study area, this relationship can be seen on the west side of the base of Needlepoint Mountain (Figure 1-35-2). Cherts and basaltic rocks of the Sylvester allochthon overlie North American carbonate and clastic strata across a planar, layer-parallel basal fault that dips steeply east-northeast. This fault is part of the terrane boundary of the Sylvester allochthon; the basal Sylvester fault has the same planar, layer-parallel character, and is generally gently dipping, under the entire allochthon (Nelson and Bradford, 1987b).

Above and below this boundary, the distinctive assemblages of the North American Cassiar terrane and the Sylvester allochthon are each deformed separately by different characteristic suites of structures. Late Paleozoic North American miogeoclinal strata are telescoped within a duplex structure between roof and sole faults along the basal Sylvester/Earn Group contact and within the top of the Road River/Kechika Group respectively. These structures are interpreted to be the result of shortening associated with emplacement of the Sylvester allochthon (Harms, 1986). At least two panels of McDame and Earn group strata occur within the map area. Exposure is insufficient to unequivocally deter-

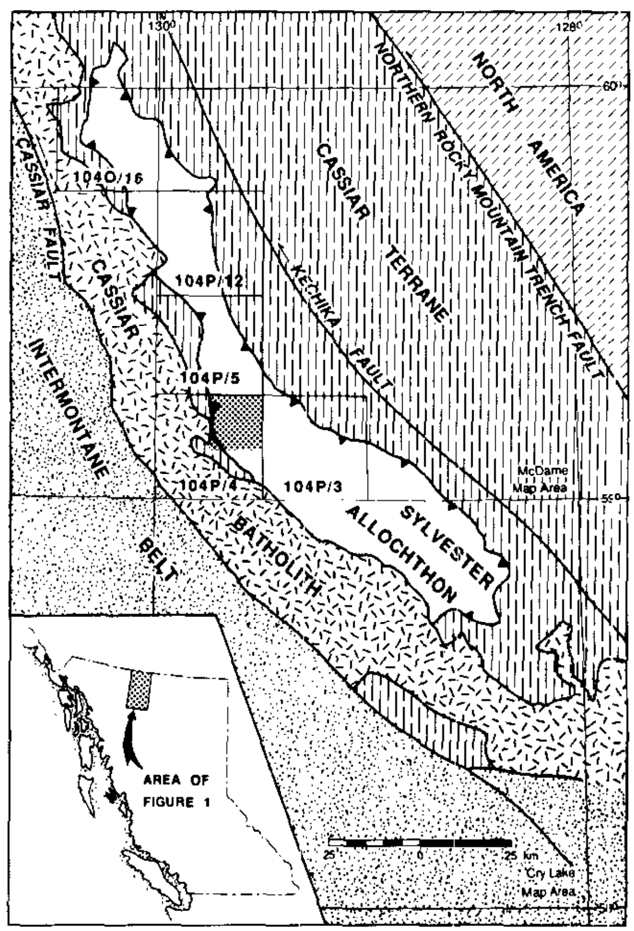

Figure 1-35-1. Location of Needlepoint Mountain (104P/4) map area (shown in stipple).

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British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

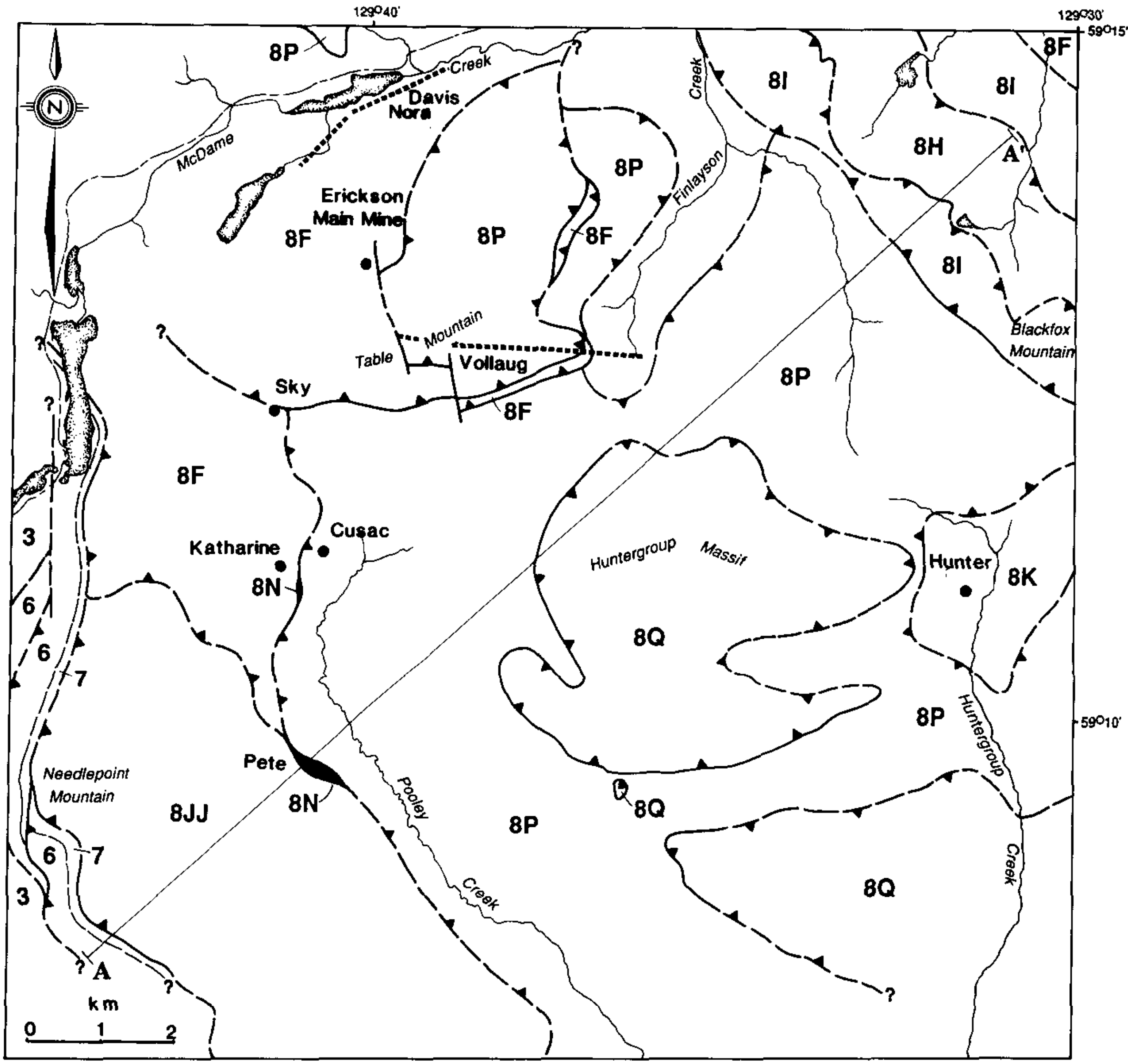


Figure 1-35-2. Geology of 104P/4 NE ¼ map area.

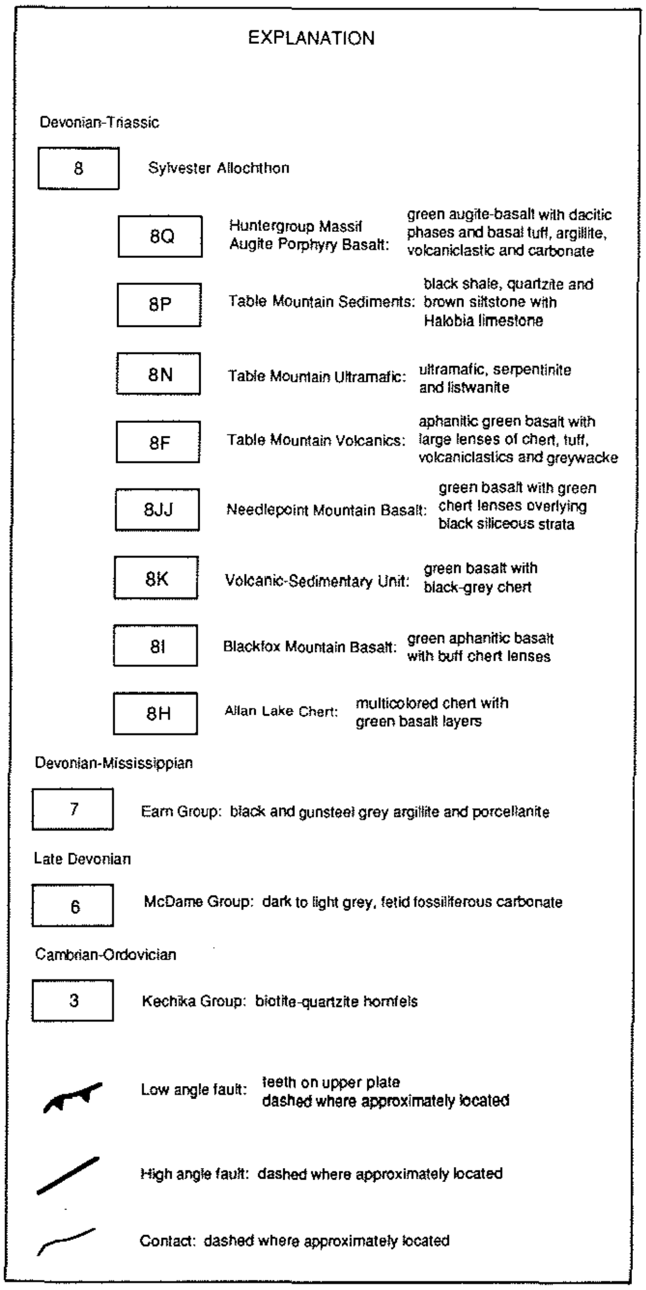
mine the vergence of the duplex, but minor structures suggest westward vergence correlative with that seen to the south along the east flank of the allochthon in the Cry Lake map area, and probably also to the north in the Cassiar map area (Harms, 1985; Nelson and Bradford, 1989, this volume).

In contrast, the structural style of the Sylvester allochthon is characterized by innumerable, stacked fault-bounded lenses (Gordy *et al.*, 1982; Harms, 1986). Each slice is comprised of one or several related lithologies; many are lithologically quite distinctive in character. Although distinctive lithologic suites may be repeated in several discontinuous tectonic slices, most of the fault-bounded lithotectonic units seem geologically unrelated and have coeval but contrasting, or even incompatible, characters and histories. These lithotectonic slices appear to have been derived from a number of different oceanic environments. Telescoping and amalgamation of the various units in the Sylvester happened in part well prior to, and in part coevally with, obduction or accretion of the allochthon.

NEEDLEPOINT MAP AREA

NORTH AMERICAN UNITS

North American miogeoclinal strata are exposed beneath the west side of the Sylvester allochthon along the west edge of the map area. The sequence dips moderately to steeply (up to 60°) northeast below the basal Sylvester fault. The characteristics of the North American units, as they occur in the Needlepoint Mountain area are consistent with the general



descriptions found in Gabrielse (1963). Only the uppermost units of the sequence are exposed within the map area. A high-angle fault along the western edge, extending south from the Cassiar area (Nelson and Bradford, 1989, this volume), may disrupt the North American sequence; the Road River Group and Tapioca sandstone, which elsewhere occur between the Kechika and McDame groups, are missing. The Cassiar batholith lies immediately west of the map area; portions of the North American sequence are metamorphosed by it.

Unit 3: Kechika Group

Rocks which may be part of the Kechika Group crop out along the Stewart-Cassiar Highway on the western edge of the map area. They are dark, rusty, biotite quartzites, probably the result of contact metamorphism associated with the Cassiar batholith.

Unit 6: McDame Group

Light to dark grey, fetid micritic limestone of the mid-Devonian McDame Group, locally *Amphipora* and *stringocephalus*-bearing, crops out along the western base of Needlepoint Mountain and includes a small area of limestone breccia several metres long. The McDame and the overlying Earn argillites are involved in two thin, thrust-duplex panels below the base of the Sylvester allochthon.

Unit 7: Earn Group

The Devono-Mississippian Earn Group, in this area, consists of black argillite, black porcellanite and gunsteel-grey shale. It is relatively thin (approximately 30 metres), but as the top of the unit is at the basal Sylvester fault, this may be an incomplete section. Nevertheless, regionally, the stratigraphic thickness of the unit is known to increase dramatically northward from the southernmost McDame map area to the northern tip of the Sylvester allochthon (Harms, 1986).

SYLVESTER ALLOCHTHON LITHOTECTONIC UNITS

Unit 8: Sylvester Allochthon

The Sylvester allochthon consists of a varied assemblage of oceanic lithologies: banded radiolarian chert, argillite, carbonate, ultramafite, gabbro, and basic and intermediate volcanics; and probable distal continentally derived lithologies: greywacke and quartz sandstone, and relatively more felsic intrusive rocks. Previous work (Gordey *et al.*, 1982; Harms, unpublished data) has shown these lithologies to occur in every age ranging from Late Devonian through Triassic. Each lithology, either singularly, or within a suite of a few genetically related lithologies, occurs as a fault-bounded lens or slice. These lenses together comprise the large-scale structural and tectonostratigraphic framework of the allochthon (Figure 1-35-3). Because of this distinctive internal character, the lithotectonic slices themselves constitute the most accurate and descriptive map unit for the Sylvester and have been used as such in this report. Consequently, contacts between all Sylvester map units in this area are faults.

Wherever possible by direct correlation, units of the Sylvester allochthon in this report have been named in conformity with informal names used by Nelson and Bradford (1989, this volume). However, Divisions I, II and III of Nelson *et al.* (1988a), are not distinguished in this study area; accordingly those designations do not appear in unit symbols. Microfossil dating is in progress on samples collected from most of the units of this map area. Therefore, unless a unit age is known from previous work, the designation "PzTr" is temporarily assigned based on the known age range of the allochthon.

Unit 8Q (lIPHapb): Huntergroup Massif augite-porphyry basalt. The Huntergroup Massif in this map area, together with the Juniper Mountain region to the east, is underlain by an extensive, distinctive volcanic suite. This volcanic unit corresponds to Unit 2 of Gordey *et al.* (1982), and Unit 4 of Diakow and Panteleyev (1981). The unit

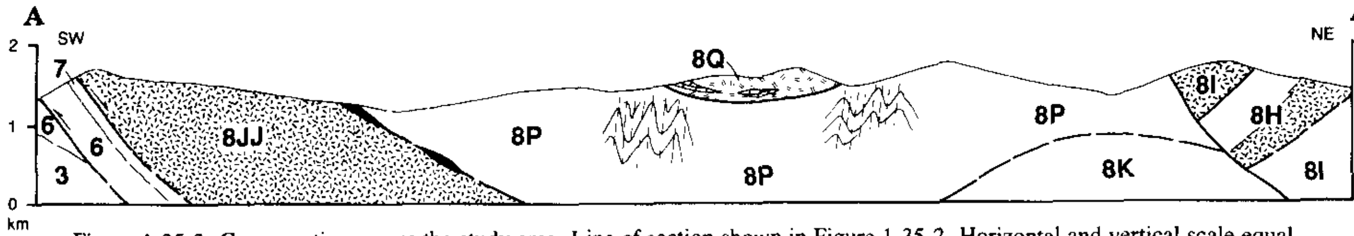


Figure 1-35-3. Cross-section across the study area. Line of section shown in Figure 1-35-2. Horizontal and vertical scale equal.

consists largely of homogeneous augite-porphyry basalt with an aphanitic sea-green groundmass. Small (1 to 2 millimetres or less) subhedral to round, black augite phenocrysts constitute up to 10 per cent of the rock. Locally abundant pale green plagioclase phenocrysts also occur. The unit becomes much more heterogeneous at its base, where it may include coarse volcaniclastic breccia, interbedded green tuff and black siliceous argillite, and minor medium-grained andesitic to dacitic intrusive phases. Black argillite at the base of the unit is, in places, faulted against black shales at the top of Unit 8P, the Table Mountain sedimentary unit. Unit 8Q sediments are distinguished by their siliceous character, lack of uniform bedding or slaty cleavage, and the presence of interbedded tuff. The base of the Huntergroup Massif volcanic suite is also characterized by a band of discontinuous, large (up to hundreds of metres in length) carbonate pods approximately 10 metres thick. The distribution of the carbonate suggests they are primary reefs and interflow deposits. However, the carbonate is commonly pervasively recrystallized, and only rare crinoid stems are preserved. Gordey *et al.* (1982), recovered Early Pennsylvanian conodonts from one of these carbonate lenses. On this basis the volcanic suite is considered Pennsylvanian in age. The Huntergroup volcanic unit is at least 600 metres thick.

Unit 8P (TrTMs): Table Mountain sedimentary unit. The Table Mountain sedimentary unit is remarkably uniform over its significant outcrop area. It consists of homogeneous black shale with thin, brown, commonly carbonaceous siltite horizons, and minor massive black, fine-grained quartzite beds. It is distinguished by a pervasive, well-developed slaty cleavage that parallels bedding. Bedding and cleavage are commonly steeply dipping to vertical as they have been folded on the outcrop scale and/or finely crenulated by a second phase of deformation. Weakly developed axial planar cleavage locally accompanies second phase folds. This folding is disharmonious with, and truncated by, the subhorizontal tectonic base of overlying units. Outside the map area (Nelson and Bradford, 1989, this volume) the Table Mountain sedimentary unit includes rare carbonate interbeds; these were not observed in exposures in this study area. However, a distinctive *Halobia*(?)-bearing carbonate occurs locally at the base of the unit on the south side of Table Mountain. Unit 8P corresponds to Unit 1 of Gordey *et al.* (1982) and Unit 3 of Diakow and Panteleyev (1981).

Unit 8N (TMum): Table Mountain ultramafic unit. This unit includes serpentinite, listwanite, ultramafic and altered ultramafic rocks which occur in small (most too small to be mapped) discontinuous lenses that decorate the fault surface at the tectonic base of the Table Mountain sedimentary unit (Unit 8P). Listwanite in this unit commonly shows relict ultramafic texture that suggests it is the result of pervasive alteration of serpentinite and ultramafic bodies. Unit 8N listwanites host the higher concentrations of mineralization in the Erickson deposit.

Unit 8F (PzTrTMvs): Table Mountain volcanic-sedimentary unit. Aphanitic green basalt volumetrically dominates this unit. However, large lenses of various sedimentary rocks, which are either inclusions or interlayers, occur within the basalt. The sedimentary members include green and black chert, siliceous argillite, coarse volcaniclastic rocks and poorly sorted greywacke. Black siliceous argillite, volcaniclastics and greywacke of Unit 8F occur along the crest of Table Mountain, in direct juxtaposition with overlying Unit 8P, the Table Mountain sedimentary unit. Unit 8F sediments can be distinguished by the lack of slaty cleavage and siliceous nature of the argillite, and by the poor compositional sorting of the coarser clastics; characteristics which are not true of the consistently homogeneous Table Mountain sedimentary unit. Whether the several sedimentary lithologies which occur within the basalts of Unit 8F represent one coherent stratigraphic sequence may be determined from microfossil dating in progress.

Unit 8F volcanic-sedimentary rocks and structurally overlying Unit 8P sedimentary strata, with discontinuous ultramafic pods between, make up the tectonically layered, subhorizontal sequence which underlies Table Mountain. This sequence has been thrust over itself along a shallow to moderately north-northwest-dipping fault which nearly circumscribes Table Mountain. The interaction of these two fault surfaces produces the complex outcrop pattern of the two lithotectonic units.

Unit 8JJ (PzTrNMb): Needlepoint Mountain basalt unit. The Needlepoint Mountain basalt unit is largely composed of aphanitic green basalt with ubiquitous chlorite stringers. Locally it includes small (less than 50 metres in length) lenses of recrystallized white to grey bedded chert, which appear to be large country rock inclusions in the igneous body. Southwest of Needlepoint Mountain the basalts are intimately intruded by fine to medium-grained gabbro or diorite bodies which gradually become the dominant lithology through the southern half of the unit. On Needlepoint Mountain, the basalt rises steeply to the east, forming the 60° dip-slope of the east flank of the castellated peak. The west side of the peak is underlain by an east-tapering wedge of sedimentary strata that is approximately 150 metres thick at its thickest, and consists of bedded black siliceous argillite with minor interbedded grey siltstone and carbonate. The contact between these sediments and the overlying basalt is demonstrably intrusive, albeit nearly planar. The sediments are included in Unit 8JJ for this rea-

TABLE 1-35-1
MINERAL OCCURRENCES, NEEDLEPOINT MOUNTAIN, NE

Type	Name(s)	MINFILE Number	Economic Minerals	Description
Mesothermal Au (-Ag)	(a) Erickson (Jennie, Maura)	104P 029	gold, tetrahedrite	Steeply dipping multiphase quartz veins in sheared basalts contain free gold and gold disseminated within pyrite and tetrahedrite. Total production from Erickson, Vollaug and Cusac veins since production began in 1978 has been 490 000 tonnes grading 15.6 g/t Au and 11.3 g/t Ag (Boronowski, 1988).
	(b) Vollaug	104P 019	gold, tetrahedrite	An easterly striking ribbon-quartz vein dips 30° along the contact between footwall listwanites and overlying Triassic sediments. A strike length of 2.7 metres is exposed. About 107 000 tonnes grading 10.5 g/t Au have been mined (Boronowski, 1988).
	(c) Cusac (Eileen, Katherine)	104P 070	gold, tetrahedrite	A quartz vein trending 060-070/60N has been mined along a strike length of 300 metres. Mineralization occurs in listwanite zones bounding the upper contact of basalt-sediment sequences. Gold grades average 30 g/t (MINFILE).
	(d) Sky	104P 078	gold, tetrahedrite	A quartz vein 4 metres wide lies along an east-trending fault dipping 75N. Listwanite occurs along the hangingwall between the vein and Triassic sediments. Erratic gold assays up to 36 g/t have been reported (MINFILE).
	(e) Pete	104P 025	gold, tetrahedrite	East to northeast-trending quartz veins up to 1.8 metres wide carry tetrahedrite and minor gold.
	(f) Hunter	104P 034	gold, tetrahedrite	A wide north-trending shear zone contains northeasterly trending quartz veins up to 1 metre wide. Erratic gold values up to 6.9 g/t have been reported (MINFILE).
	(g) Rocky Ridge Gold Hill Nora	104P 016 104P 017 104P 018	gold, tetrahedrite	A zone with quartz veins trending 040-050 and 070 can be traced for 2.5 kilometres. Erratic gold assays up to 35 g/t over 0.6 metre have been reported (MINFILE).

son. Needlepoint Mountain basalts are overlain by Unit 8P along a largely concealed east-dipping fault contact in the Pooley Creek drainage.

Unit 8I (PzTrBMb): Blackfox Mountain basalt unit. The crest of the easternmost ridge of Blackfox Mountain is underlain by Unit 8I. Within the study area, Unit 8I is a green aphanitic basalt with minor phaneritic, fine-grained gabbroic phases. It includes numerous, small (approximately 30 metres in length) lenses of strongly recrystallized, honey-coloured bedded chert as rafts within the basalt. Elsewhere (Nelson and Bradford, 1989, this volume), Unit 8I has more variable characteristics.

Units 8F, 8JJ and 8I together comprise most of Unit ii of Gordey *et al.* (1982). In the course of this work the three units have been separated firstly on the basis of differences in included sedimentary lithologies, and secondly on the basis of differences in structural setting. In contrast to Gordey *et al.*, in this study the Table Mountain sedimentary unit (8P) is mapped as overlying Blackfox Mountain basalt (Unit 8I) along a moderately to steeply east-dipping fault.

Unit 8H (PzTrch): Allan Lake chert unit. A well-bedded, multicoloured chert sequence, including green, white, black and brick-red cherts occurs in the northeast corner of the study area, along the ridge south of Allan Lake, and continues onto Blackfox Mountain. This distinctive chert package has been mapped as Units 8H and 8A by Nelson and Bradford. The Allan Lake chert unit includes layers of green fine-grained basalt at its base and so is here correlated with Unit 8H. Unit 8H is overlain by Unit 8I basalts across a west-dipping fault that roughly parallels bedding in the cherts.

Although there is no outcrop, Units 8I and 8F are shown as repeated below Unit 8H cherts across the extreme northeast corner of this map area. They have been extrapolated from along-strike exposures mapped by Nelson and Bradford in immediately adjacent areas.

Unit 8K (PzTrsi): Unit 8K occurs in a tectonic window through Unit 8P in the headwaters of Huntergroup Creek. There, it is a massive, green aphanitic volcanic suite including minor amounts of black to grey chert. The chert is moderately recrystallized and displays only relict bedding.

STRUCTURE

A network of slice-bounding faults within the Sylvester allochthon is the main set of structures in the study area. The nested, low-angle, layer-parallel nature of these structures is consistent with that in the Sylvester allochthon regionally. Together they constitute a very large-scale structural fabric. Additionally, within and around the study area, other structure sets are superimposed on this fundamental pattern. Several through-going, steep north to north-northwest-trending faults have been mapped immediately north of this study area, in the Cassiar map area (Nelson and Bradford, 1989, this volume). One of them, the Marble Creek fault, may continue south along the extreme western border of 104P/4, and may truncate the North American section mapped there (Gabrielse, 1963). Closely spaced sets of northeast-trending fractures with negligible offset occur in several places within the map area. The southeast flank of Needlepoint Mountain is cut by these fractures as is Table Mountain, where the set is associated with alteration and mineralization in the Erickson system. Mineralized veins and fractures in the Erickson mine are also cut by north-trending faults with minor offsets, most too small to be mapped at the scale used in this study (M. Ball, personal communication, 1988). These faults may be related to the large north to north-northwest-trending faults, like the Marble Creek fault, that occur in the surrounding region.

MINERALIZATION

The Erickson mineralized system is described in Nelson and Bradford (1989, this volume). Table 1-35-1 shows the veins of this system in 104P/4 NE ¼. Total production to date from the Erickson, Cusac and Vollaug veins has been about 490 000 tonnes grading about 15.6 grams per tonne gold and 11.3 grams per tonne silver (Boronowski, 1988). Erickson mineralization can be placed in the context of the pattern of the structures described above. The mineralization is localized at the base of Unit 8P, the Table Mountain sedimentary unit, which appears to have acted as an effective barrier to migration of fluid due to its inability to sustain fractures. Mineralization is further concentrated along the base of the sedimentary unit in listwanite bodies that are the altered equivalents of ultramafic lenses of Unit 8N. Veins either parallel the basal contact of Unit 8P, or are developed in the east-northeast-trending fracture system that abuts the basal contact. These veins suffer minor offset along the north-trending fracture system.

In this way, important structural controls on the Erickson mineralization system stem from both Sylvester allochthon structural patterns, and from younger sets of structures superimposed on the Sylvester. The advantageous juxtaposition of host lithologies and subhorizontal tectonic layering result from processes inherent to the Sylvester allochthon. Younger (126 Ma, Sketchley *et al.*, 1986), fracture sets controlled circulation of mineralizing fluids within the allochthon.

SUMMARY AND CONCLUSIONS

Fieldwork in 1988 has shown that North American miogeoclinal strata and Sylvester allochthon lithotectonic units in the northeast Needlepoint Mountain map area are consistent with the regional character of those assemblages. Devono-Mississippian carbonate and clastic strata at the top of the miogeoclinal sequence occur in at least two, probably west-vergent, duplex panels below the basal Sylvester fault. The Sylvester assemblage includes fine-grained clastic (8P), dominantly chert (8H), ultramafite (8N), intermediate volcanic (8Q) and several basalt-sedimentary (8F, 8JJ and 8I) lithotectonic units in a nested stack of fault-bounded slices. Superimposed on this Sylvester framework is a set of mineralized northeast-trending fractures and a set of minor and locally through-going north-trending faults. The Erickson mineralization appears to be controlled by both the large-scale distribution of Sylvester lithotectonic units and subhorizontal structures, and localized, crosscutting steep structures.

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