GEOLOGY AND MINERAL DEPOSITS OF THE CASSIAR AND McDAME MAP AREAS, BRITISH COLUMBIA* (104P/3, 5)

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KEYWORDS: Regional geology, Cassiar platform, Sylvester allochthon, tectonic history, gold veins, asbestos, sedex deposits.

INTRODUCTION

Mapping at 1:25 000 scale of the Cassiar map area and the northwest quarter of the contiguous McDame sheet was completed during the summer of 1988. This concluded a 3-year program of mapping from the Yukon border north of the Midway silver-lead-zinc deposit to the Erickson gold mine, about 13 kilometres southeast of Cassiar (Figure 1-34-1). The northeast quarter of the Needlepoint Mountain map sheet (104P/4), including the Erickson mine area, was mapped by T. Harms in association with the Cassiar mapping program (Harms, 1989, this volume). The town of Cassiar is near the southwestern corner of the Cassiar map area, about 15 kilometres from the junction with the Stewart-Cassiar highway, which crosses the southern boundary of the map sheet.

Objectives of the Midway-Cassiar program are:

- To map the geology in detail and determine the settings and controls of known mineral deposits.
- To map the Sylvester allochthon in terms of significant lithotectonic units, to identify the units and structures within it that are favourable for Erickson-type gold-quartz occurrences, and to evaluate the asbestos potential of Sylvester ultramafic bodies.
- To identify structural-stratigraphic settings that are likely to host Midway-type manto deposits.
- To investigate other potential metallic and nonmetallic resources.

GEOLOGICAL SETTING

The main elements of the geology of the map area (Figures 1-34-1, 2 and 3) are identical to those described previously in the Blue Dome (104P/12) and Midway (104O/16) map areas (Nelson *et al.*, 1988a; Nelson and Bradford, 1987). Displaced North American strata of the Cassiar terrane, ranging in age from Hadrynian to Early Mississippian, are structurally overlain by the Sylvester allochthon, which occupies the core of the McDame synclinorium (Gabrielse, 1963). In the Cassiar and McDame map areas, components of the Sylvester allochthon range at least from Early Mississippian to Late Triassic age, and include marginal basin and arc volcanic-sedimentary sequences, and subcrustal ultramafite-gabbro complexes.

Middle to Late Cretaceous granitic stocks intrude miogeoclinal strata along the western margin of the Cassiar map area. The Eocene Mount Haskin stock lies in the southeast corner. High-angle faults occur near the western and eastern margins of the Sylvester allochthon, with the Marble Creek fault to the west cutting both autochthonous and allochthonous strata. This structure is a probable control for asbestos mineralization in the Cassiar mine as well as silver-lead-zinc replacement deposits of the Marble Creek system. The Blue Dome fault, recognized in the Blue Dome map area in 1987 (Nelson *et al.*, 1988b), has been traced southward through the Cassiar and McDame sheets, and is inferred to extend into the Cry Lake (104J) area. This is a high-angle fault system with probable lateral displacement, associated with lenses of serpentinite-matrix mélange. It truncates thrusts bounding lithotectonic units within the Sylvester allochthon, but is not known to cut underlying autochthonous strata.

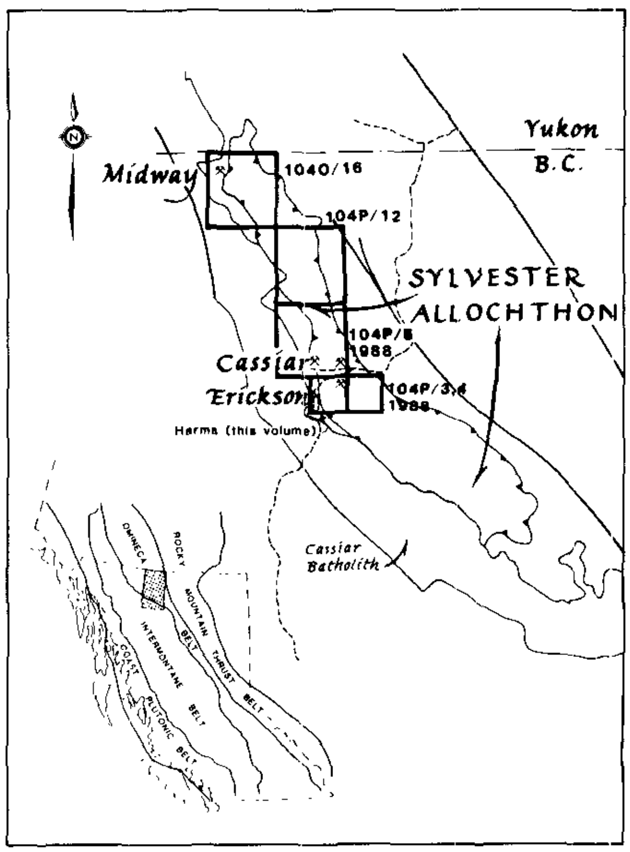

Figure 1-34-1. Location of the Cassiar and Needlepoint Mountain and McDame map areas (104P/3, 4, 5).

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

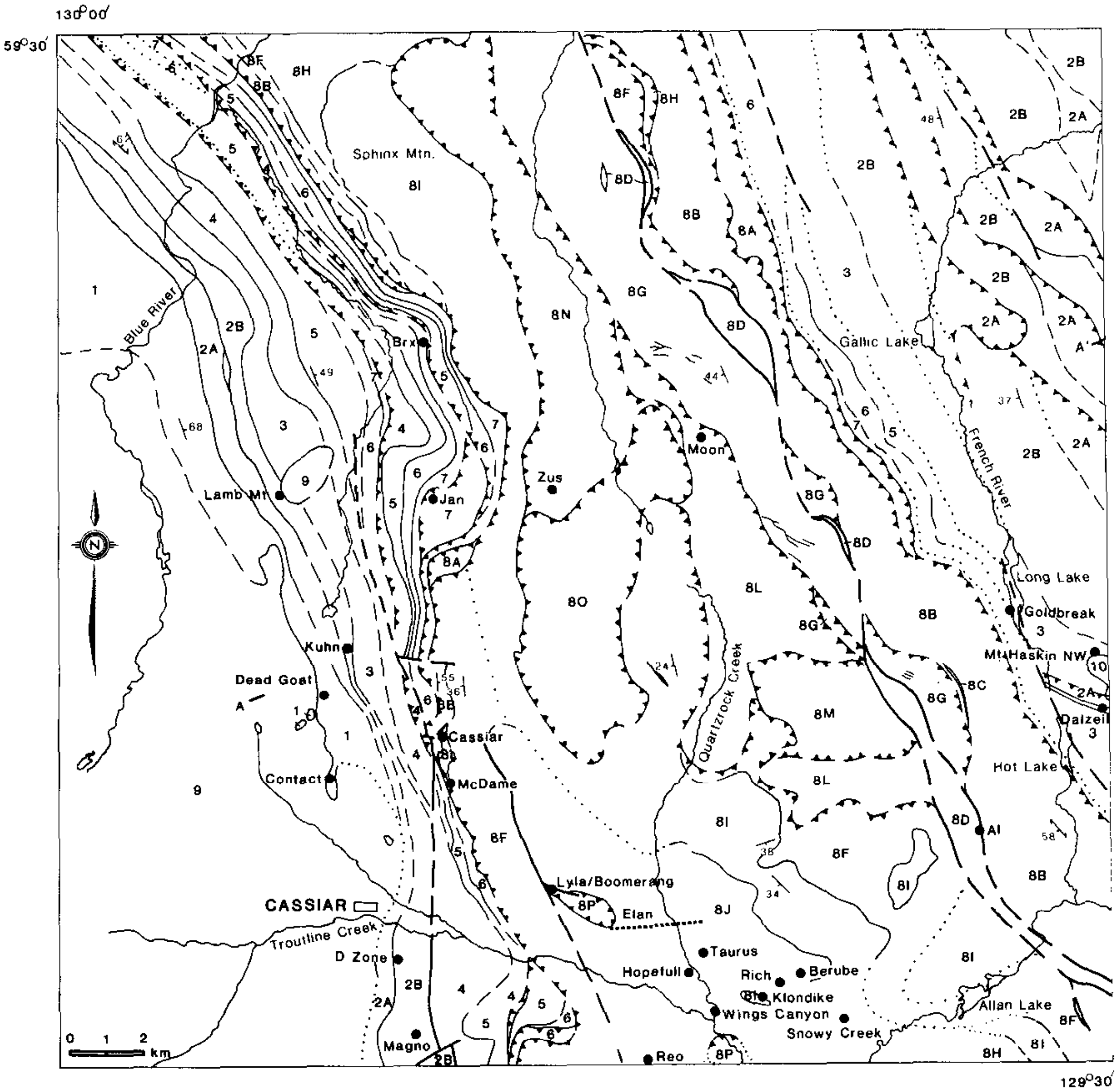

Figure 1-34-2. Geology and mineral occurrences of the Cassiar map area.

MIOGEOCLINAL STRATA

UNIT 1: INGENIKA GROUP (STELKUZ FORMATION) (HADRYNIAN)

The uppermost unit of the Hadrynian Ingenika Group, the Stelkuz Formation (Mansy and Gabrielse, 1978), is exposed in the western part of the Cassiar map area along the margin of the Cretaceous intrusions. Exposed thickness of the Stelkuz beneath the Boya Formation is about 1000 metres, its base truncated by the Cassiar stock. The Stelkuz Formation can be divided into three members. The lowest, about 200 metres thick, contains phyllite with minor interbedded quartzite, green phyllitic argillite and dolomitic sandstone. A middle member, about 350 to 400 metres thick, consists of siltstone with intercalated medium-bedded limestone, interbedded slate and limestone and minor massive limestone. The unit is characterized by two prominent ribs of laminated to medium-bedded limestone 5 to 10 metres thick. The upper member, about 400 metres thick, contains mainly green to olive-brown-weathering phyllite with minor quartzite. The contact with overlying Cambrian strata is gradational, with a gradual increase in quartzite upsection.

UNIT 2: ATAN GROUP (LOWER CAMBRIAN)

The Atan Group is exposed along both limbs of the McDame synclinorium on the eastern and western sides of the Cassiar map area. In the northeastern corner it forms a major duplex structure beneath a décollement in the overlying Kechika Group. The Atan Group includes the lower siliciclastic Boya Formation and overlying carbonates of the

LEGEND

EOCENE
10 Mt. Haskin stock: monzogranite

MID(?) AND LATE CRETACEOUS
9 Cassiar stock: monzogranite

DEVONIAN TO TRIASSIC
8 Sylvester allochthon

Division I

8A = IPsv: chert, argillite, basalt
8B = IMsi: argillite, chert, calcarenite, greywacke, exhalite, diabase

Division II

8C = Diabase, gabbro
8D = IIs: serpentinite, amphibolite, gabbro, basalt, ophicalcite
8E = IIMs: argillite, chert, calcarenite, greywacke
8F = IIMvs: basalt, diabase, chert, argillite, calcarenite, greywacke, conglomerate
8G = IIMPvsu: basalt, chert, argillite, diabase, serpentinite, ophicalcite
8H = IIMPsi: chert, tuff, diabase
8I = IIPvs: basalt, tuff, chert, quartz sandstone, rhodonite
8J = IIb: basalt
8K = IIPsi: black chert, argillite, diabase
8L = IICum: harzburgite tectonite, ultramafic cumulates, serpentinite
8M = IIP(?)Cgb: gabbro
8N = IIZMum: dunite, harzburgite tectonite, serpentinite
8O = IIPZMgb: gabbro
8P = IITrtms: slate, calcareous siltstone, limestone

Division III

8Q = IIIPPvs: augite (hornblende, plagioclase) porphyry, lapilli tuff, tuffaceous sandstone, limestone
8R = IIIPPs: limestone, tuffaceous sandstone, chert, volcanic breccia
8S = IIIP(?)t: tonalite
8T = IIIvs: tuff, limestone, quartz arenite, slate, variolitic basalt, chert

DEVONIAN TO MISSISSIPIAN
7 Earn Group: slate, siltstone, sandstone, exhalite

MIDDLE DEVONIAN
6 McDame Group: limestone, dolostone

LOWER DEVONIAN
5 Tapioca sandstone: dolomitic quartz arenite, quartzite, dolostone

ORDOVICIAN TO SILURIAN
4 Road River Group: black slate, calcareous mudstone, argillaceous limestone

CAMBRIAN TO ORDOVICIAN
3 Kechika Group: calcareous slate, siltstone, limestone

LOWER CAMBRIAN
2B Rosella Formation: limestone, dolostone, calcareous shale
2A Boya Formation: quartzite, siltstone

HADRYNIAN
Ingenika Group
1 Stelkuz Formation: phyllite, quartzite, limestone

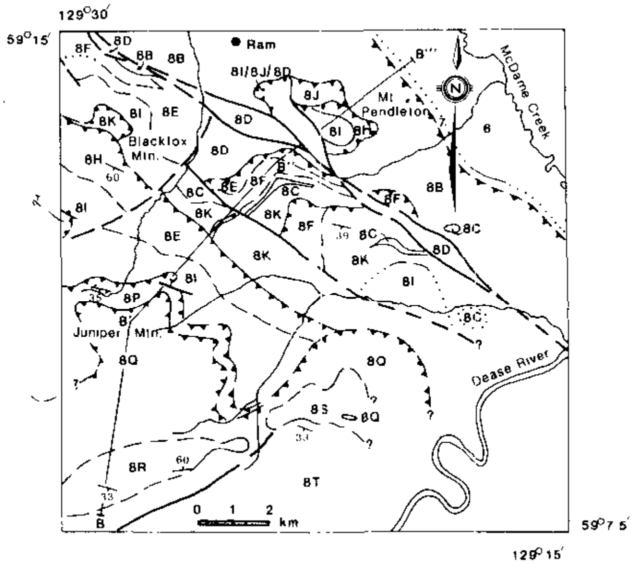

Figure 1-34-3. Geology and mineral occurrences of the McDame NW¼ (104P/3) map area.

Rosella Formation. The Boya Formation contains two members. The lower member consists of clean, well-sorted, white, green and pinkish quartzite, locally micaceous and commonly crossbedded, and minor quartz-pebble conglomerate. The upper member consists of rhythmically interbedded, grey-weathering, thin-bedded siltstone and brown-weathering medium-bedded sandstone. It is not always present, but where seen, appears to be gradational into interbedded siltstone and limestone of the overlying Rosella Formation. Thickness of the Boya Formation is about 200 metres.

The Rosella Formation consists mainly of well-bedded to massive blue-grey limestone and interfingering orange-weathering secondary dolomite. Sections measured by M. Pope (personal communication, 1988) in the eastern half of the map area contain thicknesses up to about 270 metres. A lower member contains interbedded siltstone and thin to medium-bedded limestone with archaeocyathids and trilobite fragments. This is overlain by thin to thick-bedded limestone which locally contains abundant oolitic and intraclastic horizons. Crosslaminated calcarenites are present locally, and a silty calcareous shale member occurs near the middle of the section.

The Rosella Formation is host to molybdenum-tungsten skarns and silver-lead-zinc mineralization adjacent to the Cassiar and Mount Haskin stocks. Molybdenum and tungsten mineralization is associated with metasomatic actinolite-garnet skarn, while silver-lead-zinc replacement bodies generally occur in unskarned marble.

UNIT 3: KECHIKA GROUP (CAMBRO-ORDOVICIAN)

The Kechika Group crops out in the western part of the Cassiar map area where it is strongly hornfelsed by the Troutline stock, and in similar exposures near Mount Haskin. Elsewhere it underlies valleys where it is covered by glacial and alluvial deposits. Where not hornfelsed, it consists of

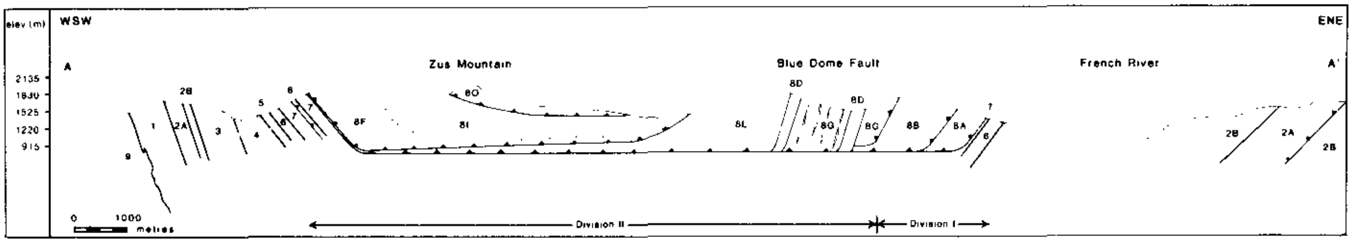

Figure 1-34-4. Cross-section A-A′, Cassiar map area.

strongly cleaved, pale grey, laminated silty calcareous slates. In contact aureoles Kechika slates are converted to tan to buff-weathering diopside hornfels and brown, commonly pyritic, biotite hornfels. Highly strained Kechika and Road River Group strata contain décollement horizons that floor and roof independent duplex structures on the east and west sides of the Sylvester allochthon, respectively.

UNIT 4: ROAD RIVER GROUP (ORDOVICIAN - SILURIAN)

The Road River Group consists of brown to black, friable calcareous mudstone, black slate and lesser black argillaceous limestone. Graptolites are common in well-cleaved slates and mudstones. It is well exposed on the western limb of the McDame synclinorium, but was not seen on the eastern limb. In the Blue Dome map area, north of the Cassiar sheet, only one exposure of Road River Group was noted east of the Sylvester allochthon (Nelson *et al.*, 1988a). This suggests that the allochthon conceals an east-to-west facies change, with shallow-water, fine-clastic and carbonate-shelf sedimentation to the east and deeper basins with fine black clastic off-shelf sediments to the west.

The duplex west of the allochthon floors well within the Road River Group, as graptolitic slates are found at the base of some thrust panels. Near the Cassiar mine, graptolitic slates are complexly imbricated with Tapioca or McDame dolomite, directly below the cherts that comprise the footwall to the serpentinite hosting the orebodies.

UNIT 5: TAPIOCA SANDSTONE (LOWER DEVONIAN)

Pale grey to buff well-bedded dolostone, dolomitic quartz arenite and quartzite of the Tapioca sandstone occur along both limbs of the McDame synclinorium. Its thickness appears to vary abruptly, and in places it is absent from the section. This may be due to block faulting and local uplift of the carbonate platform in Early Devonian time, with erosional removal of the Tapioca sandstone in places. This is consistent with observations made in the Blue Dome map area (Nelson *et al.*, 1988a).

UNIT 6: McDAME GROUP (MIDDLE DEVONIAN)

The McDame Group is conspicuously exposed on both limbs of the McDame synclinorium as resistant pale grey bands underlying recessive black clastic sediments of the Earn Group and Sylvester allochthon. Lithologies include well-bedded, laminated, dark grey fetid dolostone, thin to thick-bedded micritic limestone, and very fossiliferous wackestone and packstone. Highly fossiliferous exposures, including pelecypod and amphipora-rich beds, occur just east of the Sylvester allochthon near the northern boundary of the Cassiar map area. On the west side of the map area, calcite-healed solution breccias containing angular blocks up to a metre across occur locally. At the base of the McDame Group along the eastern side of the Sylvester allochthon, a breccia zone up to tens of metres thick extends several kilometres along strike. This zone is locally chaotic, with mixed pale grey, buff and dark grey unfossiliferous dolostone and limestone clasts, from millimetres to tens of centimetres across, in a white calcite matrix. It also contains graded breccias to coarse calcite sands. The linear nature and sorted material in this zone suggests that it may be related to a submarine fault scarp or tidal channel. Underlying dolostone of the Tapioca sandstone unit appears to be unbrecciated, but it is not certain whether Tapioca clasts occur in the breccias.

UNIT 7: EARN GROUP (UPPER DEVONIAN - LOWER MISSISSIPIAN)

The Earn Group forms part of several imbricates in a duplex structure on the west limb of the McDame synclinorium, but is poorly exposed on the eastern limb. Contrasting suites of lithologies vary along strike in different thrust panels, suggesting the interaction of north-south facies changes and variable amounts of shortening along different thrusts. The dominant lithology is black, rusty weathering graphitic slate. Coarser clastics are generally absent, but massive, dark grey, medium-grained quartzitic sandstone occurs in places south of the Cassiar mine, and greywacke crops out sporadically in sections near the north edge of the map area. Thick sections of very even, thin to medium-bedded rusty weathering siliceous and baritic exhalites occur in two thrust panels north of the Cassiar mine. These are associated with abundant quartz veins and local pyrite, chalcopyrite and tetrahedrite mineralization. Black slates and mudstones with nodular to lensoidal white barite, and black, pyritic, thin to medium-bedded porcellanite are associated with exhalite-bearing sections. Blue-grey weathering "Gunsteel" slates occur locally in all thrust panels.

SYLVESTER ALLOCHTHON

In the Cassiar map area the Sylvester allochthon occupies a flat-bottomed synclinorium flanked by autochthonous rocks (Figure 1-34-4). The northeastern limb of this structure underlies most of the northwest quarter of the McDame map area (Figure 1-34-5). The Blue Dome fault cuts the

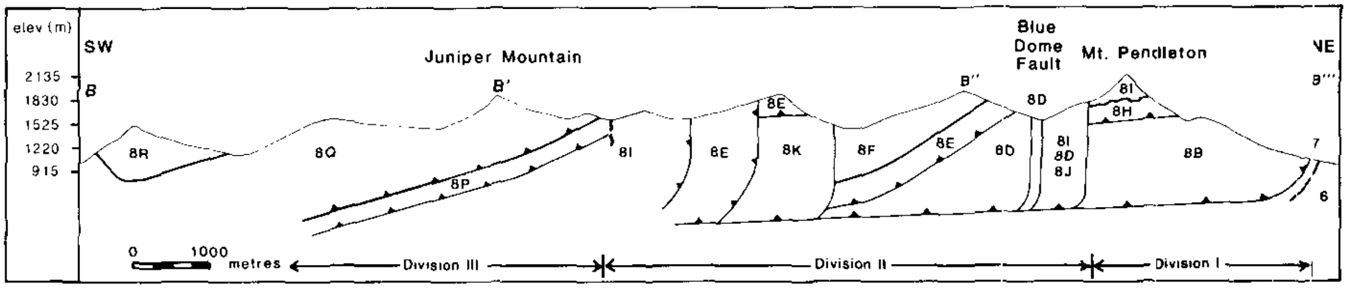

Figure 1-34-5. Cross-section B-B′-B″-B‴, McDame map area.

allochthon approximately parallel to its strike (Figures 1-34-2 and 3). This major high-angle fault extends from the western edge of the Blue Dome map area at least to the Dease River (Nelson *et al.*, 1988b).

Exposures in the McDame map area reach higher structural levels in the allochthon than do those in the Cassiar map area. The two cross-sections (Figures 1-34-4 and 5) show that the tripartite structural division developed in the allochthon in the Blue Dome and Midway map areas (Nelson *et al.*, 1988a) is also seen here. The three divisions form consistent structural/lithologic packages extending at least from the Yukon border to the Dease River, a total strike length of 120 kilometres. The following discussion focuses on the three divisions and their component slivers.

Sylvester unit designations include both those appearing on Figures 1-34-2 and 3 and in parentheses, those that appear on Open File maps for example, 8B(IMsi).

DIVISION I

Division I was defined in the Blue Dome and Tootsee Lake map areas as consisting mainly of pelagic and hemipelagic sedimentary sequences (Nelson *et al.*, 1988a). It is structurally the lowest unit in the allochthon, occurring in thrust contact directly above the autochthonous Earn Group. It thickens dramatically to the east, with thicknesses exceeding 500 metres east of the Blue Dome fault. On the western edge of the allochthon, Division I sedimentary slivers are generally less than 50 metres thick and never more than 150 metres. Figure 1-34-4 shows an abrupt thickness transition across the Blue Dome fault.

Mapping in 1988, and conodont data now available for the Blue Dome map area, suggest the presence of two major stratigraphic or pseudostratigraphic map units within Division I, one of Mississippian and one of Late Pennsylvanian(?) to Early Permian age.

Unit 8B(IMsi) consists of black argillite, black and green chert, bedded grey calcarenite which tends to be partly to wholly replaced by black blobby chert, sandstone, siltstone, a few diabase/diorite sills and rare quartz-pyrite-barite bedded exhalites. These lithologic associations occur both in the Blue Dome and Tootsee Lake map areas, for which precisely located conodont ages are now available, and from lithologically identical, so far undated sequences in the Cassiar and McDame map areas. All conodont ages are from the calcarenite. The most complete conodont assemblages are Late Tournaisian (Early Mississippian) age. Two samples give Late Mississipian ages and one an Early to Middle Pennsylvanian age. The sandstones have been discussed elsewhere (Nelson *et al.*, 1988a, 1988b; Nelson and Bradford, 1987). Major clasts include chert, radiolarian chert and protoclastic quartz. Trace minerals – muscovite, tourmaline and zircon – indicate a continental, metamorphic source for the sands. Similarity of ages and lithologies suggests that these rocks are facies equivalents of the autochthonous Earn Group, or black clastic group. We refer to them as "black clastic equivalents", to emphasise this similarity. Black clastic equivalents occur throughout the Slide Mountain terrane (Nelson *et al.*, 1988c).

Unit 8A(IPs) contrasts strongly with Unit 8B(IMsi). It consists mostly of green, red, maroon, grey and tan chert-argillite interlayers. A minor but characteristic component of IPsv is well-bedded chert-chip breccia, consisting of highly angular but well-sorted chert clasts identical to the bedded cherts that make up most of the unit. Graded bedding is a common feature of the chert-chip breccias. Highly vesicular green and maroon basalts form a minor part of Unit 8A west of Gallic Lake on the northern border of the Cassiar map area.

In the Cassiar map area, these two sequences occur in inverted structural order, with Unit 8A(IPs) at the base of the allochthon and Unit 8B(IMsi) in presumed thrust contact above it.

On the west side of the allochthon, Division I consists of thin slivers of Unit 8B(IMsi) and a variety of bedded cherts, including black chert, "salmon-and-green" chert and green chert. In many areas it is entirely absent and basalts of Division II form the base of the allochthon.

DIVISION II

Division II in the Blue Dome and Tootsee Lake map areas was defined as a set of basalt-diabase-sediment packages and ultramafite-gabbro-amphibolite slivers, structurally higher than Division I (Nelson *et al.*, 1988a). An identical structural succession is seen in the Cassiar and McDame map areas. Except in the Blue Dome fault zone, Division II consists of four major lithotectonic units. In ascending structural order, they are:

(1) Cassiar ultramafic-mafic sheet [8L(IICum), 8M(IIP?Cgb)].
(2) A panel consisting of volcanic-sedimentary sequences of Early Mississippian to Early Permian age [8E(IIMs), 8F(IIMvs), 8H(IIMPsi), 8I(IIPvs), 8J(IIb), 8K(IIPsi)].
(3) Zus Mountain ultramafic-mafic sheet [(8N(IIZMum), 8O(IIPZMgb)].

(4) Table Mountain sediments [8P(IITrtms)].

The Blue Dome fault zone, comprising Units 8D and 8G, is a discrete structural entity and will be discussed separately.

Volcanic-sedimentary Sequences

Volcanic-sedimentary sequences form the bulk of Division II and also of the allochthon. They consist of basalt, basalt breccia, tuff and diabase interbedded or intercalated as sills with a variety of sedimentary packages. Variations in the nature and inferred age of the component sediments have been used to define most of the subunits. Original contacts, either depositional or intrusive, are key to the interpretation of these units and their mutual relationships. The absence of such contacts, or their rarity in comparison to tectonic contacts, defines a finely slivered structural style. However, original contacts – for instance interbedded pillow basalt, tuff, and argillite, or diabase sills cutting chert – are very common. On this basis we interpret these units as depositional sequences which, although they may be repeated by thrusts, are largely intact.

Unit 8F is a sequence in which, basalt, pillow-basalt breccias and tuff are interbedded with black clastic equivalents – black argillite, chert, grey calcarenite in part or wholly replaced by black chert, sandstone, siltstone, chert-pebble conglomerate, and possibly exhalite (the Lang Creek showing, MINFILE 104P 008, in a part of the Needlepoint Mountain map area not included in 1988 mapping). The relative volume of basalt and black clastic sediments varies from 80:20 in the southeast quadrant of the Cassiar map area to 5:95 in some thrust panels in McDame map area. A few purely sedimentary parts of this sequence are large enough to be mapped separately as unit 8E (IIMS). The character of the sediments exactly parallels that of Unit 8B except for the presence of coarser clastic rocks and, in some panels, a much higher percentage of siliciclastics. Sandstone comprises over 80 per cent of the section in one panel northeast of Juniper Mountain. Chert-pebble conglomerate is restricted to Unit 8F on the western side of the allochthon, from Mount McDame south to Table Mountain. Sandstones contain tuffaceous material, and in some cases basalt fragments. Conodont ages from Unit 8F on Mount McDame and Lang Creek are Early Mississippian (M. Orchard, unpublished data). The identity of age and character of these sediments with Unit 8B suggests that the two are facies equivalents representing increasing volcanism to the west. Southwards in the McDame map area, increasing sill volumes in Unit 8B and decreasing volcanic material in Unit 8F blurs the distinction between them. The comparative abundance and coarseness of the siliciclastic rocks in Division II raises the intriguing possibility of a western source terrane.

Unit 8I is a mafic extrusive package interlayered with mainly bedded chert/argillite. Diabase feeder complexes developed in chert and argillite (8H) underlie Unit 8I north of Sphinx Mountain in the Cassiar map area, and on Mount Pendleton in the McDame map area. They are considered to be feeder complexes to the overlying extrusive packages – the basalts, basalt breccias, and aquagene dust tuffs. The cherts and argillites of Unit 8I are generally green and maroon or red, but may also be grey, black and tan. Their colorful aspect associates them with the varicoloured cherts of Unit 8A. The basalts and tuffs are drab green or bright green and maroon. Chert-chip breccias are present locally. Chert clasts in them are mixed with fragments of basalt; the matrix is generally tuffaceous. Coarse volcaniclastic layers are interbedded with basalt, tuff, quartz sandstone and green chert of Unit 8I on Blackfox Mountain and north of Snowy Creek. They contain clasts of local basalt, green and red chert, as well as coarse-grained gabbro, tonalite, trondjhemite and amphibolite. Bedded rhodonite occurrences are common, generally within undated grey, green and black chert below the brightly coloured cherts, but well above the black clastic equivalents. Conodont and radiolarian ages from green and red cherts interbedded with basalts in the Blue Dome and Tootsee Lake map areas are Late Pennsylvanian to Early Permian (M. Orchard, T. Harms, personal communication). Like the 8B-8F correspondence, the parallel age and character of the sediments in Units 8A and 8I suggest that they are two facies within the same basin.

North of Snowy Creek, Unit 8I overlies Unit 8F along 8 kilometres of strike length. The contact between the two is bedding-parallel and mapped as transitional because it lies within basalt and diabase sills. Across it, the argillites, sandstones and limestones of Unit 8F disappear upwards and are replaced first by black chert with scattered bedded rhodonite, and then by the green and maroon cherts and argillites that characterise Unit 8I. No single thrust contact could be outlined, although sheared contacts are seen, as everywhere in the allochthon. The Mississippian-Permian contact is considered depositional. This relationship shows that, at least in part, Permian volcanism succeeded Mississippian and stratigraphies can be constructed which span a major part of the Sylvester age range.

Unit 8K is restricted to the McDame map area. It consists of very well-bedded, uniformly dark grey to black, rarely pink, cherts and argillites, intruded by widely spaced but continuous diorite and diabase sills. The intrusive rocks do not exceed 10 per cent of the section, and extrusive equivalents – basalts and tuffs – were seen only in a single exposure. An Early Permian conodont age was obtained from the cherts by Gordey *et al.* (1982). This package, although equivalent in age to Unit 8I, contrasts strongly with it in the colour of the cherts and the lack of extrusive rocks. The structural proximity of the two units on Blackfox Mountain shows tectonic juxtaposition of apparently unrelated facies. Southwest of Mount Pendleton, Unit 8K structurally and perhaps depositionally overlies Unit 8F.

Unit 8J underlies most of the lowlands near the confluence of Quartzrock and Troutline Creeks. It is defined strictly on lithologic grounds. It consists almost exclusively of massive and pillowed basalt with extremely rare chert intercalations. The basalt is drab green to apple green where altered. In the Snowy Creek area it overlies the varicoloured chert-argillite of Unit 8I; but east of Mount McDame it overlies black argillite, tuff and sandstone of Unit 8F. This sort of disorderly structural succession characterises the tectonic style of the Sylvester allochthon (Harms, 1984); it may in part be due to rapid facies changes in the small rift-generated sub-basins where the volcanic-sedimentary sequences accumulated, as well as to later tectonic slivering.

The Ultramafic-mafic Sheets

Two major ultramafic-mafic sheets occur in Division II in the Cassiar and McDame map areas. They are disparate in character and occupy different structural levels. The lower Cassiar sheet outcrops extensively east of upper Quartzrock Creek. It dips below the volcanic-sedimentary sequences and reappears on the western limb of the synclinorium as the small serpentinite body that hosts the Cassiar asbestos deposit. East of Quartzrock Creek this sheet consists of block to mountain-sized slivers of gabbro, ultramafic cumulates, harzburgite tectonite, basalt and sediments, with serpentinite along tectonic contacts and internal shears. No internal order is apparent. The largest knocker is mapped separately as Unit 8M. This coarse-grained gabbro is commonly layered and includes more felsic differentiates – diorites and quartz gabbros. A zircon uranium-lead analysis is in progress.

The Zus Mountain sheet, including Units 8N and 8O, lies at the centre of the synclinorium in the Cassiar map area. To the north it projects across the Blue River valley into the Blue River ultramafite (Nelson *et al.*, 1988a). To the south, east of Mount McDame, it pinches rapidly to a set of small serpentinites and listwanites that structurally underlie the Triassic Table Mountain sediments (Unit 8P). These listwanites are an important component of the Erickson-Taurus gold-quartz system.

The ultramafic part of the Zus Mountain sheet, Unit 8N, is a fairly intact cumulate body containing abundant screens of harzburgite tectonite. Dunite is the most common cumulate lithology. Chromite grains are scattered within it. In places, for instance the northern slopes of Sphinx Mountain, the dunite contains fine chromite layers. Peridotite layers in the dunite consist of varying amounts of clinopyroxene and orthopyroxene. Because of extensive subsolidus deformation of the body, some of the orthopyroxene-rich layers are indistinguishable in appearance from harzburgite tectonites. The harzburgite tectonites themselves occur as screens a few metres to several hundred metres in areal exposure. They consist of large harzburgite grains, arranged individually or in trains and schleiren in a dunite matrix. Flaser and augen textures visible in hand samples attest to the very strong subsolidus deformation that these rocks have undergone. We follow the interpretations of Nicholas *et al.* (1980) in assigning the harzburgite tectonites to oceanic upper mantle and the cumulates to a magma chamber located near the crust-mantle interface. Here, the cumulates interfinger intimately with the harzburgitic primary mantle. This suggests a complicated geometry for the magma chamber; perhaps the Zus Mountain–Blue River body represents a level near or at its base.

The Zus Mountain gabbro body (Unit 8O) lies structurally above the ultramafite. It is sporadically well layered. It ranges from coarse-grained gabbro to, locally, trondjhemite. A Permian uranium-lead zircon date has been obtained from this body (H. Gabrielse, personal communication, 1987). It represents the upper levels of an oceanic magma chamber, probably the chamber whose base is represented by the Zus Mountain ultramafite.

Table Mountain Sediments

The structurally highest unit in Division II is Unit 8P, the Table Mountain sediments. They occur as klippen in the Cassiar map area southeast of Mount McDame and south of Wing's Canyon, and immediately below Division III in McDame map area. They include lustrous grey to black slate, thin-bedded, well-laminated calcareous siltstone, and grey limestone. Their Late Triassic age is established by a conodont collection from the Plaza pit at the top of Table Mountain (M. Orchard, unpublished data), and by collections of halobia near the Cusac vein (Harms, 1989, this volume). The presence of halobia limestone in this unit suggests that it is a facies variation of the halobia limestone that occurs at the structural top of Division II in the Blue Dome map area (Nelson *et al.*, 1988a), dated as Ladinian to Late Triassic by conodonts and macrofossils. The basal contact of the unit is everywhere sheared. Its structural position above independantly imbricated Late Paleozoic packages hints at an unconformable relationship, although the roof of a duplex involving Division II panels is also located within it.

DIVISION III

In the Blue Dome (104P/12) and Tootsee Lake (104O/16) map areas Division III occupies the highest structural level in the Sylvester allochthon (Nelson and Bradford, 1987; Nelson *et al.*, 1988). There, it is an Early Permian package of mainly intermediate volcanic rocks, shallow-water limestones with chert interbeds, and a zoned hornblende gabbro to granodiorite pluton (Nelson *et al.*, 1988a). This high structural level was eroded from the Cassiar area. South of Table Mountain, in the Huntergroup massif, Division III reappears, structurally overlying the Table Mountain sediments (Harms, 1989, this volume). Its lowest unit is informally termed the Huntergroup volcanics which extend southeastward into the McDame map area around Juniper Mountain (Figure 1-34-3). They are overlain by the limestones, cherts and epiclastic rocks of Unit 8R(IIIPPs). A nort...t-trending fault at least partly separates this sequence from a second Division III package, which includes Units 8T(IIIvs) and 8S(IIIP?t).

The Huntergroup volcanics Unit 8Q (IIIPPvs), are equivalent to Unit 4 of Diakow and Pantaleyev (1981) and Unit 2 of Gordey (1982). Gordey collected Early Pennsylvanian conodonts from thin limestone intervals near the base of the sequence. The unit is dominated by augite porphyry flows but also includes polymictic epiclastic and tuff breccias that contain felsic as well as intermediate clasts, hornblende and plagioclase porphyries, crystal and lapilli tuffs and tuffaceous sandstones, and scattered limestone pods. The overall unit is about 1000 metres thick. Its contact with the overlying Unit 8R is certainly depositional, but ranges from abrupt to transitional. At some points the contact involves intercalation of augite porphyries and highly fossiliferous calcareous volcanic sandstones over as much as 100 metres of section. Elsewhere, nearly pure, thick-bedded limestone (Unit 4 of Gordey *et al.*, 1982) directly overlies massive augite porphyry.

Unit 8R – corresponding to Gordey's Units 3 and 4, which are part of a single unit – is a mixed carbonate-chert-epiclastic sequence. Its two end-members are thick-bedded limestone, and polymictic volcanic breccia and sandstone with graded bedding. Intermediate between these are thick to

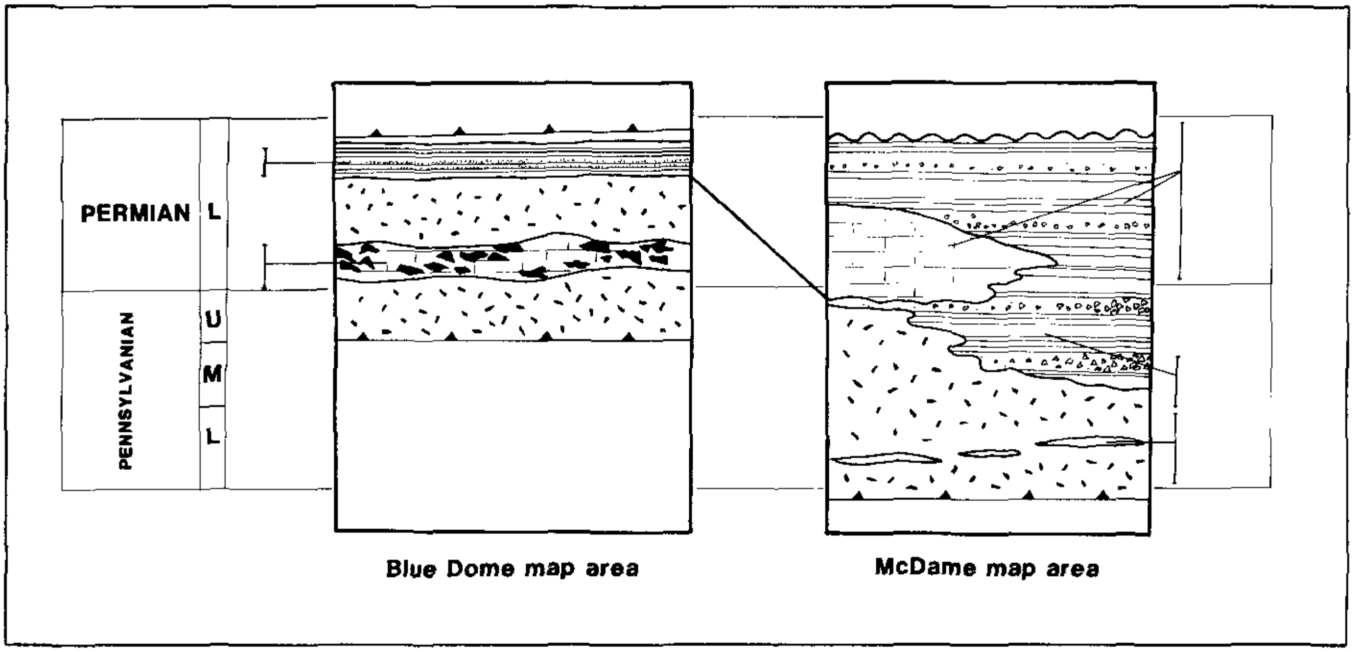

Figure 1-34-6. Comparative partial Division III stratigraphy, McDame and Blue Dome map areas.

medium-bedded limestone breccias that contain a variety of volcanic clasts. The clasts are identical to those in the volcanic breccias. They are red and green, and include basalt, andesite, quartz-phyric dacite, and uncommon intermediate intrusives and quartz sandstone. Augite porphyry clasts are notably absent, except near the base of the sequence. It is likely that the volcanic breccias were derived from contemporaneous bimodal volcanic areas. Green and red cherts are interbedded with the limestones. Gordey obtained Middle Pennsylvanian and Early Permian conodont ages from the unit. Our macrofossil collections include brachiopods, horn corals, crinoids and fusilinids. The richest faunas come from the calcareous tuffaceous sandstones that are interbedded with augite porphyries near the base of the unit.

The Pennsylvanian to Early Permian volcanic-sedimentary succession of Units 8Q and 8R shows a striking resemblance to Division III in the Blue Dome map area (Nelson *et al.* 1988a), although they differ in some details and the Blue Dome package is structurally complex. Figure 1-34-6 compares the two sequences. The augite porphyries in the Blue Dome area are latest Pennsylvanian to Early Permian, somewhat younger than the Huntergroup volcanics. They are structurally succeeded, probably in sheared depositional contact, by Early Permian limestone turbidites and interbedded sea-green chert (Unit IIIG). The limestones contain volcanic clasts, crinoid fragments and horn corals. Unit IIIG is almost certainly a distal equivalent of Unit 8R. It is structurally overlain by more augite porphyries and dacites. This may be a thrust repetition, or the resumption of Huntergroup-type volcanism.

Unit 8T(IIIvs) is separated from the Huntergroup volcanics in part by a northeast-trending fault, and in part by the tonalite body of Unit 8S(IIIP?t). Unit 8T includes Gordey's Units 1 to III. It contains a variety of volcaniclastic and sedimentary lithologies – thin-bedded green tuff and lapilli tuff, commonly with limestone pods and beds; quartz arenite; thin to medium-bedded limestone, subarkosic sandstone and grit; maroon and green slate; variolitic basalt; chert; argillite; and small diorite bodies. The fine intercalation of these units makes further subdivision impossible at 1:25 000 scale. The unit is so far undated.

Petrographic examination of the sandstones shows that they consist of protoclastic quartz and minor, equally deformed plagioclase; the trace mineral suite includes muscovite, tourmaline and zircon. The sandstones range from quartzites to matrix-supported greywackes with abundant sericite. They lack chert clasts, although their trace mineral suite indicates a metamorphic source like that of the sandstones in Divisions I and II. Quartzite clasts in the limestone breccias of Unit 8R are identical to these sandstones. In spite of the fault relationship between the two, this may indicate early proximity.

The tonalite body, Unit 8S is sheet-like in overall morphology. It is a homogeneous, coarse-grained intrusion consisting of plagioclase, quartz, about 10 per cent potassium feldspar, and chloritized mafic minerals. It contains inclusions and rafts of green tuff with thin limy beds, lithologies typical of Unit 8T. Although the present contact between the two units is sheared, it was probably originally intrusive. Limestones near the intrusion are converted to marble. The contact between the tonalite and the Huntergroup volcanics is strongly sheared and rocks in Unit 8Q adjacent to the tonalite are not hornfelsed. However the geometry of the tonalite suggests that it fills the fault between Units 8Q and 8T. A similar relationship between a Late Permian tonalite and a sliver-bounding fault is found in northeast Cry Lake map area (Harms, 1986). A uranium-lead zircon date for unit 8S(IIIP?t) is in progress by the Geological Survey of Canada.

THE BLUE DOME FAULT AND FAULT ZONE

The Blue Dome fault is a moderately to steeply dipping fault that trends northwesterly and lies, within the limits of present mapping, entirely within the Sylvester allochthon. It extends from the western edge of the Blue Dome map area, across the summit ridge of Blue Dome (Nelson *et al.*, 1988a), into the Cassiar and McDame map areas (Figures 1-34-2 and 3). It may continue through Mount Sylvester south of the Dease River. The fault contains large pods of serpentinite, Unit 8D(IIs). Unit 8G occurs as two elongate slivers next to the Blue Dome fault. These are considered part of the Blue Dome fault zone because of their structural style.

Unit 8D resembles serpentinites in other structural locations within the allochthon; for instance, in general aspect it resembles parts of the Cassiar ultramafic sheet. Blocks of texturally intact ultramafic rocks, gabbro, gabbro mylonite, amphibolite and basalt float within it. However, it also contains blocks and slivers of several types of breccia that do not occur in the Cassiar sheet: shear-brecciated serpentinite, ophicalcite and argillite-matrix polymictic breccias, and polymictic breccias like the "fanglomerates" that occur in the Blue Dome map area near the Blue Dome fault (Nelson *et al.*, 1988a). These breccias show a diversity of textures and clast compositions and may have formed at several different times. The ophicalcites are either monolithologic serpentinite breccias, or serpentinite-basalt-chert, both in a calcareous matrix. In a few occurrences they pass into sedimentary limestone. Similar ophicalcite-limestone associations have been described from dredge hauls of oceanic fracture zones (Lemoine *et al.*, 1987; Bernoulli and Weissert, 1985). We infer that these breccias formed in such a fracture zone, perhaps the precurser of the Blue Dome fault, while the supracrustal parts of Division II accumulated around it. The basement clasts in breccias in Unit 8I are further evidence for early surface exposure of mantle material. Definite interpretation of the ophicalcites awaits conodont ages. The "fanglomerates", on the other hand, contain a variety of clasts, including plagioclase and augite porphyries whose source is presumably the Huntergroup volcanics in Division III. Nelson *et al.* (1988a) argued that, because juxtaposition of Divisions II and III involved the Upper Triassic limestone, these breccias must be of Early Jurassic or younger age.

Unit 8G occurs as two slivers next to the Blue Dome fault (Figure 1-34-2). Its contacts against the Blue Dome fault, and also against other Sylvester units, dip moderately to steeply west. Lithologies in it – basalt, diabase, green, grey and red chert, black argillite and very minor sandstone – are indistinguishable from the volcanic-sedimentary sequences; structural style defines this unit. By contrast with the volcanic-sedimentary sequences, which exhibit an overall structural coherence and stratigraphic integrity, Unit 8G is internally slivered on a 10-metre to 100-metre scale. It is cut by numerous steeply dipping shear zones, with prominent flaser fabrics and gently plunging slickensides that define a dextral sense of motion. They are marked by discontinuous pods of highly sheared serpentinite, serpentinite breccia, ophicalcite, and argillite-matrix mixed-clast breccias including clasts of basalt, serpentinite, chert and gabbro. These faults mimic the Blue Dome fault on a smaller scale. Their trends, about 125 degrees on average, intersect it at a low angle. The presence of ophicalcite suggests an early history (Permian?) for these faults.

The possibility that breccias in the Blue Dome faults and in the sliver-bounding faults in Unit 8G range in age from syndepositional (Permian?) to syntectonic (Jurassic?), coinciding with the emplacement of the allochthon, suggests a long and complex history for this major fault zone. It may have been initiated as a transform fault in the basin where the volcanic-sedimentary sequences accumulated. At present, however, the Blue Dome fault crosscuts Sylvester thrust faults in the Blue Dome map area (Nelson *et al.*, 1988a), implying motion on it after, or at least during, the compressional event that telescoped the allochthon. Its apparent confinement to the Sylvester allochthon suggests that it does not penetrate the Cassiar platform, and thus developed prior to final emplacement. Later movement on the Blue Dome fault may be a result of transpressional tectonics during the assembly and transport of the allochthon towards its eventual resting place on the Cassiar platform. This interpretation follows the model proposed by Hansen (in press).

The Blue Dome fault projects southwards towards Sylvester Peak, and more tentatively along a zone of ultramafites south of the Rapid River in the Cry Lake map area (Gabrielse *et al.*, 1977). Significantly, the southern border of the Sylvester allochthon is not offset by this fault.

Although the magnitude of displacement on the Blue Dome fault is unknown, it is a major, through-going, probably transcurrent fault. Such faults can juxtapose related but differing facies: for instance the Tintina fault separates platformal and slope-basin facies of the North American margin. Facies juxtaposition across the Blue Dome fault may in part explain differences between the higher structural levels in the allochthon. For instance, the Nizi limestone (Gabrielse, 1963) only occurs east of the Blue Dome fault as projected; the Four Mile batholith (Harms, 1986) only to the west.

THE SYLVESTER ALLOCHTHON: SYNTHESIS AND HISTORICAL SUMMARY

Terrigenous sandstones are interbedded with other sediment types and, where present, with volcanic rocks in all three divisions of the Sylvester allochthon in the Cassiar and McDame map areas. This relationship establishes that all of the sandstone-bearing units, (IMs, IIMvs, IIPvs on Blackfox Mountain, IIIvs, and IIIPPs,) accumulated within the reach of turbidity currents from continental sources. Further, rocks that lie in depositional contact with these units – Unit 8I in Cassiar map area, 8I, and 8K – must represent prior or subsequent history of the same crust, not tectonically juxtaposed primary oceanic crust. These observations favour the depiction of the Sylvester allochthon as a strongly telescoped package of marginal basin and island arc elements that developed on the fringes of the ancestral North American continent. The basic geometry of the original Sylvester involved, from east to west, a subsiding sedimentary basin (Division I) that passed westward into a volcanic-sedimentary rift basin (Division II) with locally exposed subcrustal mantle, and furthest west, an arc founded on a rifted continental sliver (Division III). Only Divisions I and II belong to the Slide Mountain terrane as defined by Monger and Berg (1987). Division III, although minute, may merit separate terrane status.

Devono-Mississippian events – Radiolarian ages from the Cry Lake map area range as old as Late Devonian (Harms, 1986). The oldest conodont assemblages in the allochthon are Early Mississippian. Thus the subsidence that initiated accumulation of the supracrustal rocks of Divisions I and II began at the Devonian-Mississippian boundary. Black clastic equivalents, ubiquitous in both Division I and II, link these sequences to the autochthonous black clastic group, which has been tied to rift tectonics in the Selwyn basin and Kechika trough (Gordey *et al.*, 1987). Divisions I and II represent a rift trough that differs from these only in degree: in it, centres of basaltic volcanism developed early, and rifting continued until mid-Permian time. Westward-coarsening of the black clastic equivalents suggests that they sourced to the west, possibly in a thermally-uplifted basement sliver that later would be the foundation of the Huntergroup volcanic arc.

Pennsylvanian – Well-defined Pennsylvanian conodont ages are extremely rare in Divisions I and II, so Pennsylvanian history within them is a cipher. The Huntergroup volcanics may record the inception of the volcanic arc in Division III, which continued to be active through Early Permian time.

Permian – Permian sedimentary accumulations in Divisions I and II show a close resemblance. Both lack the siliciclastic rocks that characterise Mississippian sequences. Both consist mainly of green or colourful red and green cherts and argillites. They contain distinctive bedded chert-chip breccias, which are probably the result of synsedimentary faulting and submarine slumps of lithified material. Interbedded basalts in Division II also tend to be colourful; they provide a likely source for the iron in the ferruginous cherts. The bedded rhodonites record exhalitive activity. The black cherts in Unit 8K are intercalated with minor sills, but contain scanty evidence of extrusive events. They may represent a deep, euxinic sub-basin.

The association of Permian sediments with Mississippian sediments in Division I; and Permian basalts and sediments with Mississippian rocks in Division II suggests that the locus of rifting remained fairly stationary throughout the evolution of the basin. The chert-chip breccias reflect small fault scarps, while the gabbro and amphibolite clasts both in the Blue Dome fault zone and within the basalt-sedimentary sequence reflect the presence of more major structures.

The relationship documented by Harms (1986), in which a 276 ± 6 Ma tonalite seals a thrust fault that juxtaposes Mississippian and mid-Pennsylvanian units, may be indicative of a major tectonic event that affected the Sylvester allochthon as a whole. The youngest radiolarian ages obtained from volcanic-sedimentary sequences in Division II are at the boundary between Early and Middle Permian (Harms 1986 and unpublished data from Tootsee River and Blue Dome map areas); this suggests a cessation of basin development and rifting at this time.

Triassic – The Middle to Late Triassic history of the Sylvester allochthon is recorded solely by the carbonates and siliciclastics of the Table Mountain sediments. A conodont assemblage from this unit strongly resembles Selwyn basin fauna (Orchard, personal communication, 1988). Although its base is strongly sheared everywhere, the fact that it overlies a variety of Mississippian to Permian supracrustal and mantle slices over a minimum strike length of 50 kilometres suggests an unconformable relationship, remobilized into a décollement.

Jurassic – Jurassic compressional tectonics stacked the three divisions into their present order along easterly-directed thrusts, with the Table Mountain sediments in their depositional(?) position above Division II. Some of the transcurrent component of relative motion during this event was localized along the Blue Dome fault. The total amount of coastwise translation is unknown. Black clastic equivalents are found in the para-autochthonous Kootenay terrane at least as far south as Barriere (Schiarizza and Preto, 1987); the Sylvester assemblage may have developed outboard of the Eagle Bay assemblage, not the Cassiar Platform. In this, as in all Cordilleran studies, latitudinal pins are problematic.

STRUCTURE

During the Jurassic compressional event, the autochthonous strata of the Cassiar platform in the Cassiar map area formed duplex stacks with multiple repetitions. Décollement surfaces that divide the duplexes are located in the Road River–Kechika Group and in the Earn Group near the base of the Sylvester allochthon. Independant stacking of sub-Kechika; and Road River-Tapioca-McDame-Earn horses is beautifully demonstrated. A set of Rosella-Boya horses outcrops in the mountains in the northeast corner of the map area, east and north of the French River. Atan strata are not repeated west of the allochthon; instead, there are up to three repetitions of Road River–Tapioca–McDame–Earn strata. Both of these are anticlinal stacks; individual frontal ramps are not exposed except for one in the valley 7 kilometres north of Cassiar mine. Here, the Road River–Tapioca contact in the hangingwall appears to dip more gently eastward than the thrust itself; this relationship implies westward vergence.

The formation of anticlinal stacks on either side of the Sylvester allochthon in large part explains its synclinal geometry. In addition, the consistent northeastward dip of the Early Cambrian and Precambrian strata against the Cassiar batholith suggests that the batholith uplifted the stratigraphic pile during its emplacement. The Marker Lake batholith in map areas 105B/6, 7, 10 and 11 created a similar structural dome (Murphy, 1988).

Major post-Jurassic structures in the Cassiar map area are north-northwest to north-trending high-angle faults. The Marble Creek fault extends from the headwaters of Marble Creek to the vicinity of the Cassiar mine. Another fault trends north-northwest from the lowlands west of the Reo showing, through the saddle on the ridge west of the Boomerang vein. These faults parallel the Erickson Creek fault (Boronowski, 1988) on Table Mountain in the Needlepoint map area.

MINERALIZATION

The mineralization of the Cassiar-Erickson camp is the subject of an extensive and still-growing literature. Excellent descriptions of different types of mineralization can be found in Diakow and Pantaleyev (1981), Sketchley, *et al.* (1986), O'Hanley (1988), Cooke and Godwin (1984), and Gower *et* *al.* (1985). In this paper we emphasise systematics and the inter-relationships of the deposit types.

As shown in Table 1-34-1, mineralization in the Cassiar-Erickson camp can be divided into the following categories:

(1) Early Mississippian sedex deposits; minor massive sulphide volcanogenic exhalites; bedded Permian(?) rhodonite.

(2) Early Cretaceous mesothermal gold-quartz and related veins: the Erickson-Taurus system.

(3) Early Cretaceous(?) asbestos stockworks: the Cassiar and McDame mines.

(4) Late Cretaceous and Eocene skarns, replacements and veins associated with the Cassiar and Mount Haskins stocks, respectively.

SYNGENETIC MINERALIZATION

Siliceous and baritic exhalite horizons with associated silver, lead and zinc soil anomalies are widespread in the Earn Group west of the Sylvester allochthon, from the Blue claims in the Blue Dome map area (Nelson *et al.*, 1988a) south to within 7 kilometres of the Cassiar mine (Kuran, 1983). Blind targets may exist in the lowlands between Sphinx Mountain and the Blue River, where outcrop is very poor.

A new silica-barite exhalite was discovered in Unit 8B west of Hot Lake. This is the second occurrence of Mississippian sedex-type mineralization seen in Division I of the Sylvester allochthon. Unit 8F hosts the Lang Creek massive sulphide showing (104P 008) in 104P/4. This occurrence has been interpreted as volcanogenic and stratabound by Panteleyev (1978). It is of early Mississippian age (M. Orchard, unpublished data) and thus contemporaneous with the sedex exhalites of Division I. A small massive sulphide occurrence, chalcopyrite-sphalerite-pyrite-galena, located in the hangingwall of the Cassiar serpentinite on the east wall of the Cassiar pit, apparently parallels bedding in Unit 8F. It may be volcanogenic. Quartz-sericite schist and a diffuse silica-pyrite replacement body occur in Unit 8F in the cirque southeast of Mount McDame. These also bear a volcanogenic stamp: the silica-pyrite body may be a feeder. In general, the contrast of silica-barite-pyrite exhalites in Unit 8B with more sulphide-rich systems in Unit 8F represents a zoning of mineralization types, from sedex to volcanogenic, that matches the facies change from purely sedimentary to volcanic-sedimentary host rocks.

Locally continuous rhodonite beds occur in association with grey to black cherts near the base of Unit 8I. They are commonly impure and contain cherty silica, adularia, siderite, stilpnomelane and an unidentified brittle mica(?). Modern manganese-rich exhalites occur in the Red Sea and the northern Gulf of California. The Sylvester rhodonites may therefore indicate more significant exhalitive systems, perhaps like those that generated the Chu Chua massive sulphide deposit (Schiarizza and Preto, 1987), in equivalent rocks of the southern Slide Mountain terrane.

MESOTHERMAL GOLD: THE ERICKSON-TAURUS SYSTEM

The Erickson-Taurus system comprises a set of east-northeast-trending veins and vein swarms with accompanying strong carbonate alteration, that extends at least from Mount McDame in the north to Juniper Mountain in the southeast, a distance of 23 kilometres. A partial concentric zoning is seen in the area mapped, in that the northernmost veins – Elan, Boomerang and Lyla – and the Ram occurrence near Mount Pendleton southeast of the main showings, contain argentiferous tetrahedrite and little gold, while gold predominates in the central part of the system. Veins occur in the uppermost level of the volcanic-sedimentary package, directly below the Triassic Table Mountain sediments. The base of the sediments acted as a very effective physical and chemical barrier that localized the veins. There are two types of veins (Diakow and Pantaleyev, 1982). Type I veins (Jenny, Taurus) occupy steep fractures in basalts below the base of the sediments, with gold contents increasing toward the contact. Type II veins (Vollaug) follow the base of the sediments. Discontinuous listwanite bodies along this horizon seem to associate with higher gold values in the veins (A. Boronowski, personal communication, 1988). The listwanites, by association and texture, formed from primary serpentinite slivers. Slices of talc schist occur with listwanites above the Lyla and Boomerang trenches. These ultramafic scraps occupy the same structural level as the Zus Mountain body; they may be erosional remnants preserved under the Table Mountain sediments.

The Erickson-Taurus system is strongly elongate in a north-south direction, parallel to the set of late, high-angle faults. These faults terminate veins and are thus considered to be postmineral (M. Ball, personal communication, 1988). This relationship may be the result of their last motion, however. Their close proximity to the vein fractures suggests a genetic relationship. In a similar way, the Marble Creek fault further west intersects the eastern termination of the Magno massive sulphide replacement trend, and passes along the western side of the Cassiar pit. These north-trending faults may provide a structural link between the various modes of mineralization found in the camp.

The orientation of the stress field that gave rise to the Erickson-Taurus structures is problematic. The pattern of easterly vein trends in a overall northerly elongate swarm does not fit the configuration of an *en echelon* fracture set developed during dextral motion on a northwest-trending master fault or faults: according to theoretical and experimental models (for example Wilcox *et al.*, 1973) and field observations (Abbott, 1984), extension fracture sets in such a system should consist of north or north-northeast trending fractures arranged *en echelon* in a northwest-trending array. This, clearly, is not Erickson. Simple compression could generate joints as A-C joints and/or conjugate fractures (Wei, 1982), however, the Erickson-Taurus mineralization, dated at 125 Ma (Sketchley *et al.*, 1986), is much later than the main compressional deformation, and earlier than the tightening caused by emplacement of the 100 Ma Cassiar batholith. Continuing detailed structural studies by M. Ball are aimed at solving this problem.

The heat source for the Erickson-Taurus system has also been unclear, particularly as the mineralization predates the cooling of the Cassiar batholith by 10 to 15 Ma (Sketchley *et al.*, 1987). During 1988 fieldwork, granite inclusions were found in a lamprophyre dyke cutting a carbonate-altered zone north of Snowy Creek. Granite clasts have also been ob-

TABLE 1-34-1. MINERAL OCCURRENCES, 104P/5, 104P/3 (NW ¼)

Type	Names(s)	MINFILE	Economic Minerals	Description
1. Sediment-hosted exhalite	Jan	new showing	barite, chalcopyrite	Fine-grained, pale grey, bedded barite and irregular nodular to lensoidal white barite occur in a sequence of siliceous exhalites with disseminated pyrite and chalcopyrite in black rusty slates and porcellanites. (Earn Group).
2. Volcanogenic	—	new showing	chalcopyrite, sphalerite	On east wall of Cassiar asbestos pit, a small (1 m) lens of finely layered massive chalcopyrite-sphalerite-pyrite is hosted in fine tuffs with interbedded argillite.
3. Mesothermal Au (Ag) quartz veins	a. Taurus	104P 012	gold, tetrahedrite, arsenopyrite	East-trending, moderately to steeply dipping auriferous quartz veins are hosted in massive and pillow basalts. Veins have large carbonate-sericite-clay-pyrite alteration halos and pyrite-tetrahedrite selvages. An easterly trending lamprophyre dyke with granitic xenoliths occurs in the mine area. Production (1988): 4000 tonnes milled, production suspended in March. Reserves (June 1987): 42 600 tonnes, 6.4 g/t Au; 13 600 tonnes, 8.2 g/t Au (Taurus Resources).
	b. Hopefull Mack	104P 011 104P 010	gold, tetrahedrite	East-trending vertical to steeply south-dipping quartz veins in massive and pillow basalts occur in an extensive quartz-carbonate alteration zone. Recent I.P. surveys, trenching and diamond drilling indicate significant potential for open-pit reserves (Taurus Resources).
	c. Wing's Canyon (Red Rock)	104P 015	gold, tetrahedrite	An extensive zone of en echelon quartz veins and carbonate alteration trending 070/60S occurs in massive basalt. A selected sample of oxidized material contained 5.1 g/t Au (MINFILE).
	d. Rich Snow Creek	104P 014	gold, tetrahedrite	Quartz veins to about 80 cm in width with quartz-carbonate alteration halos cut massive basalt. Veins trend 045.
	e. Berube (Bozo)	104P 076	gold, tetrahedrite	En echelon 045-trending quartz veins with quartz-carbonate alteration cut massive and pillow basalt near a contact with underlying chert/argillite.
	f. Snowy Creek	none	gold, tetrahedrite	Intensely faulted and quartz-carbonate-altered basalt is cut by northeast-trending quartz veins and stringers.
	g. Klondike Fr.	104P 013	gold, tetrahedrite	A 2 m wide quartz knot occurs at the contact between strongly folded chert/argillite and overlying basalt or diabase. A sample across 1 m ran 5.47 g/t Au (MINFILE).
	h. Al (Dekalb)	104P 041	gold	Swarms of quartz veins cut very pyritic altered basalt and metasediments next to the Blue Dome fault zone.
	i. Reo (including Blueberry Hill)	104P 009	gold, tetrahedrite	Quartz veins to 5 m wide occur in a northeast-trending zone 180 m wide in basalt. Both 090 and 045 trending veins are present. A grab sample of graphitic quartz contained 1.02 g/t Au and 52 g/t Ag.
	j. Elan	104P 075	tetrahedrite	An easterly trending quartz vein with locally abundant tetrahedrite extends about 4 km in massive basalt. The vein is 1 to 3 m wide, with a strong quartz-carbonate alteration halo.
	k. Lyla Boomerang	new showing tetrahedrite		Tetrahedrite-bearing quartz veins are hosted in basalts immediately below Table Mountain sediments on the ridge north of the Elan vein.
	l. Ram	104P 042	tetrahedrite	An intensely fractured zone in argillite and chert contains tetrahedrite-bearing quartz veins.
4. Polymetallic vein	a. Brx	new showing tetrahedrite	chalcopyrite	Quartz-stockwork zones in black slate and porcellanite, blebs and disseminated pyrite-tetrahedrite-chalcopyrite (Earn Group).
	b. Goldbreak	104P 096	chalcopyrite	Irregular quartz veins up to 25 cm wide in Tapioca sandstone quartzite host disseminated chalcopyrite-pyrite. Twelve samples averaged 5.8 g/t Ag, 0.33% Cu. (MINFILE).
	c. unnamed	new showing azurite	malachite	Quartz veins in McDame Group limestone have selvages of malachite and azurite; about 2 km south of the Cassiar open pit.

TABLE 1-34-1. MINERAL OCCURRENCES, 104P/5, 104P/3 (NW ¼) — *Continued*

Type	Names(s)	MINFILE	Economic Minerals	Description
5. Replacement	a. Contact	104P 004	galena, sphalerite, chalcopyrite, tetrahedrite, molybdenite, dyscrasite, pyrargyrite, bismuthinite	Galena-sphalerite pods have replaced a marble bed in a screen of Hadrynian Stelkuz Formation hornfels. Garnet-diopside(-scapolite?) skarn is developed in marble near the showing. 25 tonnes milled (1956) produced 10 45' grams Ag, 25 kg Cu and 1947 kg Pb.
	b. D Zone including Lower, Middle and Upper zones and Granite Creek	104P 044 104P 080 104P 088	galena, sphalerite	Magnetite-galena-sphalerite pods occur in Rosella Formation marble and dolomite. In the Middle D Zone, 90 000 t grading 3.3% Pb, 6.3% Zn, and 70 g/t Ag have been outlined. A 7.6 m intersection in the Upper D Zone ran 4.73% Pb, 4.74% Zn, 240 g/t Ag, and 0.069 g/t Au. Tin values up to 0.12% have been obtained.
	c. Magno (Marble Creek, Silver Queen)	104P 006	galena, sphalerite	Irregular galena-sphalerite-magnetite-pyrrhotite pods occur along an easterly trending fracture system, about 1 km long, west of the north-trending Marble Creek fault. Drill-indicated reserves for the West, Middle West and East zones total 426 417 tonnes grading 5.92% Pb, 4.15% Zn, 192 g/t Ag (MINFILE).
	d. Mt. Haskin NW (A Zone)	104P 059	sphalerite, galena	Two pyrrhotite-sphalerite-galena-chalcopyrite lenses occur in skarn in the Rosella Formation.
	e. Dalziel	none	sphalerite	A massive pyrrhotite-diopside(?)-sphalerite lens occurs in Rosella Formation marble.
6. Skarn	a. Dead Goat (Balsam)	104P 079	scheelite, chalcopyrite, sphalerite	Massive pyrrhotite with sphalerite, chalcopyrite, scheelite and fluorite occurs as lenses in layered garnet-diopside skarn containing tremolite/actinolite, hosted by Stelkuz metasediments Drill-indicated reserves include 100 900 tonnes grading 0.49% WO_3 and 27 600 tonnes grading 0.39% WO_3 and 0.16% Cu.
	b. Kuhn	104P 071	scheelite, molybdenite, chalcopyrite, sphalerite	Rosella Formation zebra dolomite and marble is replaced by garnet-diopside skarn with pods and veins of massive magnetite and massive pyrrhotite containing disseminated scheelite, chalcopyrite and molybdenite. Drill indicated and inferred reserves for the Kuhn North zone include 409 300 tonnes grading 0.48% WO_3 and 0.134% MoS_2) and an additional 78 700 tonnes grading 0.50% WO_3.
	c. Lamb Mountain	104P 003	molybdenite, scheelite, chalcopyrite	Rosella Formation marbles are replaced by magnetite-garnet-diopside and retrograde actinolite skarn adjacent to the Lamb Mountain stock. Disseminated scheelite occurs in magnetite skarn and pyrrhotite lenses with abundant molybdenite rosettes in actinolite skarn. Massive pyrrhotite-chalcopyrite pods occur further from the stock
7. Ultramafite-hosted	a. Cassiar	104P 005	asbestos, jade	A crescent-shaped, moderately east-dipping and south-plunging stockwork of cross-fibre asbestos veins is developed in serpentinites of the Cassiar ultramafic sheet near the basal thrust of the Sylvester allochthon. This body has been mined since 1952.
	b. McDame	104P 084	asbestos	A stockwork of long-fibre asbestos veins is developed in serpentinite of the Cassiar ultramafic sheet, near the base of the Sylvester allochthon. At present, drill-indicated reserves are 16 Mt at 5.6% mill yield.
	c. Zus	104P 002	asbestos	Widely scattered cross-fibre asbestos veinlets occur in serpentinized ultramafic cumulates of the Zus Mountain ultramafic sheet.
	d. Moon	104P 036	asbestos	Chrysotile veins up to 0.6 cm wide cut serpentinite of the Cassiar ultramafic sheet.

served in postmineralization lamprophyres on the Erickson property (M. Ball, personal communication, 1988). These hint at the presence of cryptic intrusive bodies below the system.

ASBESTOS: CASSIAR AND McDAME OREBODIES

Both of the asbestos orebodies are located within a kilometre of each other, within serpentinite of the thin western edge of the Cassiar ultramafic-mafic sheet. The structural matrix of asbestos development was studied in detail by O'Hanley (1988), who concluded that asbestos formation occurred during a change from normal to dextral-reverse motion on the "45-degree shear", a north-trending fault that transects the Cassiar serpentinite. Pre-ore, magnetite-bearing fibre veinlets trend generally northwest, while ore veinlets trend northeast.

Regional mapping indicates that the Cassiar pit occupies a zone of anomalous structure. The Marble Creek fault outcrops in several benches above the main garage northwest of the pit. It juxtaposes bedded black and possibly salmon-and-green chert and argillite to the east, against black graptolitic Road River slate and calcareous slate to the west. Several thin dolomite slivers, located west of, and structurally lower than, the Road River slates, represent a Tapioca sandstone and McDame section that is anomalously thin and discontinuous compared to any other such section in the region. Moreover, the lower adit into the McDame deposit shows a similar lack of a well-developed Tapioca/McDame unit. Normal and/or transcurrent faulting at a low angle to bedding is required to thin the carbonate section to this degree. Further mapping in the vicinity of the mine is required to delineate the structural geometry of the faults around it.

PORPHYRY, SKARN AND CARBONATE-HOSTED SULPHIDE DEPOSITS

Intrusions of both Late Cretaceous and Eocene age have generated mineralized systems ranging from porphyry deposits within the intrusions, outward through skarns to veins and mantos in the surrounding carbonate rocks. The western edge of the Mount Haskins system is exposed east of Hot Lake. The skarns here, including the Mount Haskins A zone (MINFILE 104P 059) were studied by Gower *et al.* (1985). The Goldbreak vein (MINFILE 104P 096) is part of this system, which also shows a lively geochemical signature in stream sediments, with four anomalous samples ranging up to 2.6 ppm silver, 2300 ppm zinc, and 995 ppm lead (RGS 104P).

Late Cretaceous intrusions along the western side of the Cassiar map area have generated a suite of deposits, including porphyries (Lamb Mountain, Storie Moly; 0.5 kilometre south of the map area), skarns (Lamb Mountain, Contact, Kuhn) and silver-lead-zinc replacement deposits (D showings, Magno, Pant showing in 104P/4). The replacement deposits show the interaction of fluid source and flow-path controls. They are all located in Rosella or Stelkuz marbles close to the Cassiar stock; they also lie next to or along the Marble Creek fault. The D showings and the Magno massive sulphides form discontinuous bodies aligned in easterly trends that abut the northerly trending Marble Creek fault. The Pant tin-bearing massive sulphide showing occurs within the extension of the Marble Creek fault south of the Cassiar map area. The matrix of this system – Late Cretaceous intrusion and high-angle fault – is similar to the Midway manto deposit (Bradford and Godwin, 1988), except in this case the intrusion is well exposed and closer to the deposits.

MINERAL POTENTIAL

This paper has emphasised the broad extent of the Erickson-Taurus system. The strong fracture-controlled carbonate alteration and listwanite slivers that characterize it extend, below the base of the Table Moutain sediments, from Mount McDame in the north, through the Taurus and Erickson properties, and southeast past Juniper Mountain into a heavily forested valley that drains into the Dease River. This area is of particular regional interest because it contains the structural level in the Sylvester allochthon defined as favorable for Erickson-type gold-quartz veins, well-developed carbonate alteration and listwanites, but no known vein occurrences.

Although the silver-lead-zinc(-tin) bodies that have been found in the Marble Creek system are individually small, the overall size of the system – 5 kilometres from the Pant to the D showing – is encouraging to further exploration.

Although rhodonite has been known in the Sylvester allochthon (I. Lyn, personal communication), this study has shown bedded rhodonite to be a common occurrence in Unit 8I. It has potential both as a source of artistic material to small-scale craftsmen and as an indicator of exhalitive environments in the Slide Mountain terrane to large-scale metallogenetic modellers.

CONCLUSIONS

The Cassiar and McDame map areas contain a thrust-repeated miogeoclinal succession structurally overlain by the Sylvester allochthon. Fieldwork in 1988 has confirmed that the allochthon consists of: a Late Paleozoic North American marginal basin in Divisions I and II, partly underlain by oceanic crust; and a roughly coeval island arc in Division III. The latter should be excluded from the Slide Mountain terrane. The youngest Sylvester unit, the Middle to Late Triassic Table Mountain sediments, may have an unconformity-turned-décollement at its base.

Patterns of mineralization include Early Cretaceous asbestos and gold-quartz mineralization controlled by north-trending faults, and Late Cretaceous and Eocene porphyry-skarn-replacement systems created by the interaction of intrusions, high-angle faults and Paleozoic carbonates.

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REFERENCES

Abbott, J.G. (1984): Silver-bearing Veins and Replacement Deposits of the Rancheria District, *Department of Indian Affairs and Northern Development*, 1984, Yukon Geology and Exploration 1983, pages 34-44.

Bernoulli, D. and Weissert, H. (1985): Sedimentary Fabrics in Alpine Ophicalcites, South Pennine Arosa Zone, Switzerland, *Geology*, Volume 13, pages 755-758.

Boronowski, A. (1988): Erickson Gold Camp, Cassiar, B.C., NTS 104P/4 and 5, Abstract, in Smithers Exploration Group – *Geological Association of Canada, Cordilleran Section*, Geology and Metallogeny of Northwestern British Columbia Workshop, Program With Abstracts, page A10-A21.

Bradford, J.A. and Godwin, C.I. (1988): Midway Silver-lead-zinc Manto Deposit, Northern British Columbia (104O/16), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 353-362.

Cooke, B.J. and Godwin C.I. (1984): Geology, Mineral Equilibria, and Isotopic Studies of the McDame Tungsten Skarn Prospect, North-central British Columbia, *Economic Geology*, Volume 79, pages 826-847.

Diakow, L.J. and Panteleyev, A. (1981): Cassiar Gold Deposits, McDame Map-area, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1980, Paper 1981-1, pages 55-62.

Gabrielse, H. (1963): McDame Map-area, Cassiar District, British Columbia, *Geological Survey of Canada*, Memoir 319, 138 pages.

Gabrielse, H., Anderson, R.G., Leaming, S.F., Mansy, J.L., Monger, J.W.H., Thorstad, L. and Tipper, H.W. (1977): Geology of Cry Lake (104I) Map-area, *Geological Survey of Canada*, Open File 610.

Gordey, S.P., Abbott, J.G., Tempelman-Kluit, D.J. and Gabrielse, H. (1987): "Antler" Clastics in the Canadian Cordillera, *Geology*, Volume 15, pages 103-107.

Gordey, S.P., Gabrielse, H. and Orchard, M.J. (1982): Stratigraphy and Structure of Sylvester Allochthon, Southwest McDame Map Area, Northern British Columbia, *in* Current Research, Part B, *Geological Survey of Canada*, Paper 82-1B, pages 101-106.

Gower, S.J., Clark, A.H. and Hodgson, C.J. (1985): Tungsten–molybdenum Skarn and Stockwork Mineralization, Mount Reed–Mount Haskin District, Northern British Columbia, Canada, *Canadian Journal of Earth Sciences*, Volume 22, pages 728-747.

Hansen, V.L. (*in press*): A Working Model for Terrane Accretion and Continental Expansion: Yukon-Tanana and Slide Mountain Terranes, submitted to *Geology*, April, 1988.

Harms, T.A. (1984): Structural Style of the Sylvester Allochthon, Northeastern Cry Lake Map Area, British Columbia, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 84-1, pages 109-112.

——— (1986): Structural and Tectonic Analysis of the Sylvester Allochthon, Northern British Columbia: Implications for Paleogeography and Accretion, Unpublished Ph.D. Thesis, *The University of Arizona*.

——— (1989): Geology of the Needlepoint Mountain Map Area, Northeast Quarter (104P/4), *B.C. Ministry of Energy, Mines and Petroleum Resources*, This volume.

Kuran, V.M. (1983): Assessment Report on the ELO 2-7 and BRX 3-5 Claims, Liard Mining Division, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Assessment Report 11151.

Lemoine, M., Tricart, P. and Boillot, G. (1987): Ultramafic and Gabbroic Ocean Floor of the Ligurian Tethys (Alps, Corsica, Appenines): In Search of a Genetic Model, *Geology*, Volume 15, pages 622-5.

Mansy, J.L. and Gabrielse, H. (1978): Stratigraphy, Terminology and Correlation of Upper Proterozoic Rocks in Omineca and Cassiar Mountains, North-central British Columbia, *Geological Survey of Canada*, Paper 77-19.

Monger, J.W. and Berg, C. (1987): Lithotectonic Terrane Map of Western Canada and Southeastern Alaska. *United States Geological Survey*, Miscellaneous Field Studies, Map 1874-B.

Murphy, D.C. (1988): Geology of Gravel Creek (105B/10) and Irvine Lake (105B/11) Map-areas, Southeastern Yukon, *Indian and Northern Affairs Canada*, Yukon Region, Open File 1988-1, 61 pages.

Nelson, J. and Bradford, J. (1987): Geology of the Area Around the Midway Deposit, Northern British Columbia (104O/16), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1986, Paper 1987-1, pages 181-192.

Nelson, J., Bradford, J.A., Green, K.C. and Marsden, H. (1988a): Geology and Patterns of Mineralization, Blue Dome Map Area (104P/12), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork, 1987, Paper 1988-1, pages 233-243.

Nelson, J.L., Harms, T.H., Bradford, J.A., Green, K. and Marsden, H. (1988b): Blue Dome Map Area, 104P/12, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Open File 1988-10.

Nelson, J.L., Ferri, F. and Schiarizza, P. (1988c): Emplacement of the Slide Mountain Terrane: Obduction or Shortening?, (Abstract), *in* Proceedings, *American Geophysical Union*, 35th Annual Meeting, Victoria, B.C., page 6.

Nicholas, A., Boudier, F. and Bouchez, J.L. (1980): Interpretation of Peridotite Structures from Ophiolitic and Oceanic Environments, *American Journal of Science*, Volume 280-A, pages 192-210.

O'Hanley, D.S. (1988): The Origin of Alpine Peridotite-hosted, Cross Fiber, Chrysotile Asbestos Deposits, *Economic Geology,* Volume 83, pages 256-265.

Panteleyev, A. (1978): Cassiar Map Area (104P), *B.C. Ministry of Energy, Mines and Petroleum Resources,* Geological Fieldwork, 1977, Paper 1978-1, pages 51-60.

Schiarizza, P. and Preto, V.A. (1987): Geology of the Adams Plateau–Clearwater–Vavenby Area, *B.C. Ministry of Energy, Mines and Petroleum Resources,* Paper 1987-2, 88 pages.

Sketchley, D.A., Sinclair, A. and Godwin, C.I. (1986): Early Cretaceous Gold-silver Mineralization in the Sylvester Allochthon, near Cassiar, North-central British Columbia, *Canadian Journal of Earth Sciences,* Volume 23, pages 1455-1458.

Wei, M. (1982): Geology of the Glen Hope Property, Cassiar, B.C., Unpublished B.Sc. Thesis, *The University of British Columbia,* 51 pages.

Wilcox, R.E., Harding, T.P. and Seely, D.R. (1973): Basic Wrench Tectonics, *American Association of Petroleum Geologists Bulletin,* Volume 57, pages 291-313.