GEOLOGY AND PATTERNS OF MINERALIZATION, BLUE DOME MAP AREA, CASSIAR DISTRICT* (104P/12)

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KEYWORDS: Regional geology, Blue Dome, Cassiar platform, Sylvester allochthon, Blue River ultramafite, Midway deposit, sedex deposits, polymetallic veins, chromite platinum.

INTRODUCTION

The Blue Dome map area is located about 60 kilometres north of Cassiar and 40 kilometres west of the Stewart-Cassiar Highway (Figure 1-21-1). It is currently accessible only by horse or helicopter. Mapping at 1:25 000 scale was completed in the summer of 1987, as the second of three seasons' work which is planned to cover the area between the Yukon border north of the Midway silver-lead-zinc manto occurrence and the Erickson gold mine near Cassiar.

Objectives of this study are:

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

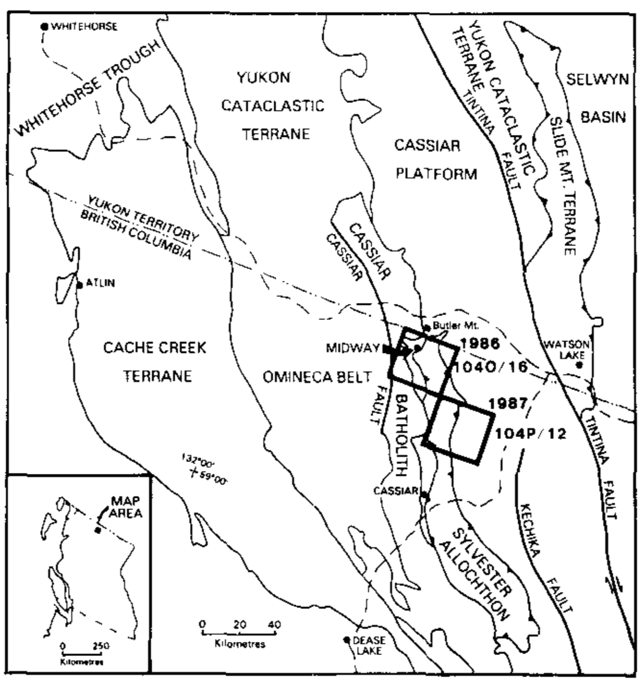

Figure 1-21-1. Location of the Blue Dome map area, 104P/12.

As the focus of mapping moves progressively southward, the third objective assumes greater importance. As discussed in the section on mineralization following, in the Blue Dome map area the Lower Cambrian Rosella Formation replaces the McDame Group as the major host for epigenetic mineralization. In the current study area the investigation of potential resources includes platinum potential in the Blue River ultramafite, a layered dunite-peridotite intrusion; and also syngenetic barite mineralization.

GENERAL GEOLOGY

The general geologic-tectonic setting of the Blue Dome area is identical to that described for Midway (Nelson and Bradford, 1987). Both are situated in the Cassiar platform, with an exposed autochthonous stratigraphy ranging in age from Early Cambrian to Early Mississippian. In the Blue Dome area, these strata form a southwest-dipping panel, disrupted to the east by high-angle faults (Figure 1-21-2). The Sylvester allochthon structurally overlies the Cassiar platform; the interface is either a thrust or a regional décollement. Components of the allochthon in 104P/12 probably range from Early Mississippian to Late Triassic. They are not indigenous to the Cassiar platform. Some are of very distal North American affinity; others entirely lack ties to North America.

The mid-Cretaceous Cassiar batholith cuts and metamorphoses the Sylvester allochthon in the southwest corner of the area. A major strand of the dextral Kechika fault lies immediately east of 104P/12 (Gabrielse, 1963). High-angle faults in the eastern part of the area may be related to it, although only stratigraphic (vertical) throws can be documented. Silicified breccia occurrences with chalcopyrite, bornite, sphalerite and galena are spatially related to these faults.

MIOGEOCLINAL STRATA

UNIT 1: ATAN GROUP (LOWER CAMBRIAN)

The Atan Group crops out over broad areas in the eastern half of the map area (Figure 1-21-2). Most exposures are of the younger carbonate-rich Rosella Formation, which consists of limestone with lesser yellowish crystalline secondary dolomite. Limestone beds are generally very thick

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and intercalated with thinner platy beds, commonly bioturbated micrites. Scattered rich accumulations of archaeocyathids indicate local reef buildups. Grey and red shales are interbedded with pure limestone in some Rosella outcrops.

The Rosella Formation hosts several quartz-breccia zones with base metal and, less commonly, precious metal mineralization, as at the Pip, Ella Rose, Ax and other prospects. The One Ace Mountain copper-bearing quartz vein showings to the north (104P/13) also lie within Rosella limestones.

The older Boya Formation is restricted and poorly exposed. In addition to quartzite and siltstone, it includes red shales immediately below the base of the Rosella Formation (in the core of the anticline north of Little Blue River). In contrast to map sheet 104O/16, no turbiditic siliciclastic rocks were seen in the Boya Formation here.

UNIT 2: KECHIKA GROUP (CAMBRIAN-ORDOVICIAN)

Monotonous thin-bedded calcareous shales and limestones of the Kechika Group outcrop in the eastern part of the map area. They weather in characteristic light shades of gold, yellow, orange and light olive-green. Identical lithologies make up the Kechika Group in the northeastern corner of 104O/16. These thin-bedded argillaceous rocks show strong to extreme deformation, in contrast to the gently warped Rosella limestones. Together with the overlying Road River slates they are the locus of a major décollement.

UNIT 3: ROAD RIVER GROUP (ORDOVICIAN-SILURIAN)

Black slates of the Road River Group were only observed in one outcrop. This absence of exposure is probably due to southward thinning of the unit from the Midway area, in addition to its friable, recessive character.

UNIT 4: TAPIOCA SANDSTONE (LOWER DEVONIAN)

The Tapioca sandstone in the present area consists almost entirely of quartz arenite, without the extensive dolomites and sandy dolomites that occur in 104O/16. Fragments of quartz arenite within the overlying McDame Group at two localities, the Shawn Barite prospect and near the centre of the map area, suggest erosion of the Tapioca prior to McDame deposition.

UNIT 4A: SANDPILE GROUP (ORDOVICIAN TO LOWER DEVONIAN)

East of the main Kechika fault, Gabrielse (1963 and personal communication, 1986) points out that Lower Paleozoic stratigraphic relationships differ from those adjacent to the Sylvester allochthon. The Road River Group is restricted to Ordovician age; Silurian strata are platformal rather than slope facies dolomites, dolomite breccias, dolomitic quartzites, cherty dolomites and quartzites. These are included in the Sandpile Group. Superficially the Sandpile and the Tapioca sandstone are similar. They differ in time-span of deposition and details of lithology. For instance, highly fossiliferous strata only occur in the Sandpile Group. The Tapioca sandstone is characteristically barren. The quartz arenites and dolomitic quartz arenites, which dominate the Tapioca, are subordinate to dolomites in the Sandpile.

In the eastern third of the map area, strata overlying the Kechika Group include dolomite, dolomitic quartz arenite, dolomitic siltstone, dolomite breccia and limestone. Graptolites and crinoids are abundant in some exposures. This fossiliferous character distinguishes the sequence, shown as Sandpile Group on Figure 1-21-2, from the Tapioca sandstone that occurs further to the west, beyond throughgoing, northwest-striking faults.

UNIT 5: MCDAME GROUP (MIDDLE DEVONIAN)

The McDame Group shows considerable facies variation, although outcrops are too scarce to allow reconstruction of paleogeography. In several of the existing exposures, the McDame consists of fossiliferous fetid dolomites identical to those exposed near the Tootsee River in 104O/16. At other localities, however, notably in the canyon of Jug Creek, spectacular mixed-clast dolomite breccias and megabreccias underlie Earn argillites; they apparently represent a fore-reef accumulation.

UNIT 6: EARN GROUP (UPPER DEVONIAN - LOWER MISSISSIPPIAN)

The thick turbiditic package that forms the Earn Group in the Midway area, with its characteristic thick chert-quartz sandstones and pebble conglomerates, thins to the south such that in the Blue Dome area, only distal equivalents are present. Here, the Earn Group is about 200 metres thick and consists of black argillite with minor thin siltstone and limestone. In the southwestern corner of the area, it interfingers with the grey Gunsteel slate. Exhalites are common within it, occurring both here (Blue claims) and north of Alec Chief Creek.

THE SYLVESTER ALLOCHTHON

The northern Sylvester allochthon consists of three major divisions (Figure 1-21-3; Table 1-21-1). In ascending structural order, they are:

I. A basal northeastward thickening wedge of para-autochthonous sedimentary rocks, mainly cherts and argillites with lesser limestone and chert arenite, minimal diorite/diabase sills and no serpentinite.

II. A middle division dominated to the northeast by basalt and diabase slices with minor chert and argillite rafts, and which includes significant amounts of serpentinite further to the southeast. This division also includes slices of lower crustal gabbro, amphibolite, the Blue River ultramafite, Triassic limestone and syntectonic (?) fanglomerate.

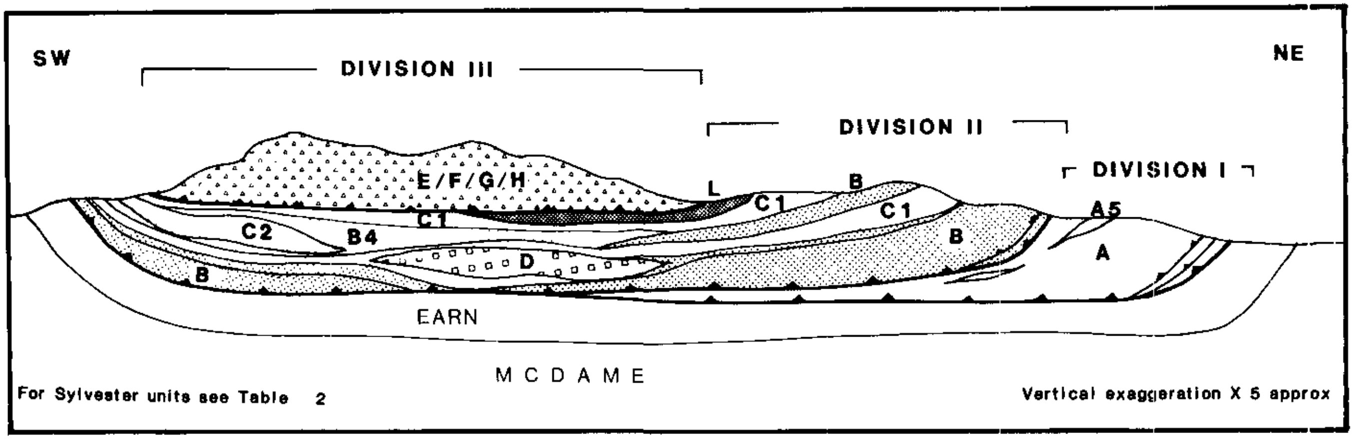

Figure 1-21-3. Schematic cross-section of the Sylvester allochthon, 104O/16 and 104P/12.

TABLE 1-21-1. THE SYLVESTER ALLOCHTHON: MAJOR DIVISIONS AND THEIR COMPONENT LITHOTECTONIC UNITS

Unit in Figure 1-21-2 (this report) and Figure 3-6-2 (Nelson and Bradford, 1987)	Lithologic Subpackages	Description	Localities	Relationship to Other Lithologic Subpackages
		DIVISION I		
7A — Chert, argillite, limestone, greywacke	(1) Grey, green, black chert, grey-black argillite component	Bedded chert with intercalated argillite; also black ribbon chert. Black argillite may include (2) and (3). Conodont ages in 104O/16 Early Mississippian — Pennsylvanian. Minor igneous bodies.	Extensive	
	(2) Limestone	Impure limestone with lithic fragments; purer grey limestone. Small lenses to continuous beds.	Shambling Mtn. (104O/16); NW corner, 104P/12	With (1). Some at least is depositionally within the chert-argillite sequence. Related to (3).
	(3) Limestone extensively replaced by massive black chert	In places silicification is so extensive that the unit is a massive black chert with minor limestone blobs.	104O/16, NW corner; 104P/12	In apparent depositional contact with chert-argillite.
	(4) Salmon and green chert	Salmon-coloured to tan to green chert with interbedded sea-green argillite; minor rusty weathering limestone.	104O/16 only	Thin continuous intercalations in (1): tectonic and/or depositional contacts.
	(5) Greywacke	Interbedded with argillite, chert; may be intruded by diorite/diabase. Contains detrital muscovite, zircon, tourmaline.	NW corner, 104P/12; minor occurrences throughout (1) in both map areas	Depositional relationships with (1).
	(6) Red argillite to argillaceous chert; green to green-grey chert		Alec Chief Creek, NW corner 104P/12	Depositional contacts with (1).
		DIVISION II		
7B — Basalt, diabase, chert, argillite, diorite, gabbro	(1a) Diabase-basalt sill complex with lesser chert, argillite	Unit characterized by up to 95% fine to medium-grained mafic intrusive (mainly sills). Sedimentary component variable: black argillite; black, red, green to grey chert; argillite.	104O/16, widespread; 104P/12, widespread	Transitional to 7B(2).

Unit in Figure 1-21-2 (this report) and Figure 3-6-2 (Nelson and Bradford, 1987)	Lithologic Subpackages	Description	Localities	Relationship to Other Lithologic Subpackages
	(1b) Argillite, chert, diorite, basalt	Argillite and/or chert with minor (<10%) sills. Transitional to 7A.	104P/12; NW quarter	
	(2) Aphanitic basalt flows, pillowed flows, flow and pillow breccia; local red and green chert	Extrusive suite equivalent to 7B(1). In 104O/16, contains areas of chert-matrix breccia with flattened clasts; in 104P/12, extensive flow breccia.	104O/16, widespread; 104P/12, widespread; north of major normal fault (NW quarter)	Transitional to 7B(1a).
	(3) Basalt, tuff, chert, tuffaceous siltstone	Orange-weathering, dark green fine-grained tuff, tuffaceous siltstone, laminated tuff, cherty tuff, chert. Tuffs contain scattered mafic and siliceous fragments.	104P/12, NW quarter	
	(4) Pillow basalt, diabase, gabbro, chert, argillite, black slate, tuff	Highly heterogeneous unit that contains extrusive and intrusive basaltic component, sediments and tuffs interbedded with basalt (including Mississippian chert with radiolaria in 104O/9). In part shows very strong deformation, greenschist facies metamorphism.	104P/12, SW quarter	Close structural association with Blue River ultramafite.
7C — Serpentinite and structurally associated units	(1) Serpentinite	Texturally pristine to highly tectonized.	104O/16, large masses on Foggy and Gum Mtn., South Post Ridge; 104P/12, large masses on Blue Dome and near Chromite Creek	
	(2) Blue River ultramafite	Peridotite, dunite, in part layered. Contains chromite layers, concentrations. Texturally pristine with minor serpentinization.	Chromite Creek to Ice Lake (104P/12 – 104O/0).	
	(3) Polymictic breccia	Highly variable breccia-conglomerate. Angular to rounded clasts of basalt, diabase and greenschist equivalents; serpentinite, coarse-grained gabbro, chert, felsic volcanics. In places monolithologic. Rare sand lenses.	104P/12, Blue Dome, NW corner; 104O/16, Foggy Mtn.?, Rocky Top	Contains clasts from 7B, C, D, G.
	(4) Greenschist, brecciated greenschist	Plagioclase-quartz-actinolite schist with strong mylonitic fabric. Brecciated with epidote-rich matrix.	104O/16, Foggy Mtn.; 104P/12, Blue Dome	Close association with 7C(3).
	(5) Amphibolite	Fresh hornblende-plagioclase rock, strong planar to linear fabric.	104O/16, Foggy Mtn.; 104P/12, Chromite Creek	Included in 7D in 104O/16.

Unit in Figure 1-21-2 (this report) and Figure 3-6-2 (Nelson and Bradford, 1987)	Lithologic Subpackages	Description	Localities	Relationship to Other Lithologic Subpackages
7D — Coarse-grained, in part foliated, gabbro, locally brecciated and/or cut by dykes	(1) Gabbro	Coarse-grained to pegmatitic, originally pyroxene gabbro. Has undergone upper greenschist/lower amphibolite facies metamorphism. In places highly foliated to mylonitized.	104O/16, Foggy Mtn. and vicinity	Clasts of this gabbro occur in limy-matrix breccia on Gum Mtn. Preliminary conodont age is Early Mississippian.
	(2) Gabbro dyke complex	Foliated gabbro cut by extensive very fine-grained mafic dykes (not foliated).	104O/16, Foggy Mtn.	
7L — Triassic limestone		Grey platy limestone with halobia, ammonites, belemnites. Upper Triassic age.	104P/12, south of Oblique Creek	
		DIVISION III		
7E — Trachyandesite flows, subvolcanic intrusives, pyroclastic-epiclastic sediments; minor dacite and rhyolite		These units occur in a gradational sequence on South Post Ridge with a centre marked by predominance of subvolcanic lithologies (plagioclase porphyries) at its east end. K-spar is nearly ubiquitous. This unit is not seen in 104P/12.	104O/16 only; South Post Ridge, Rocky Top	
7F — Zoned hornblende gabbro-granodiorite complex			104O/16, mountain east of Gum Mtn.	Cut by trachyandesite dykes of identical chemistry and mineralogy to 7E. May be basement to 7E.
7G — Lower Permian basic, intermediate and felsic volcanic rocks and limestones	(1) Augite and plagioclase porphyries; epiclastic breccias; limestone with volcanic clasts; tuff		104P/12, south of Oblique Creek, north of Chromite Creek	
	(2) Well-bedded calcarenite and chert		104P/12, south of Oblique Creek.	Intimately related to to 7G(1).
7H — Permian limestone	Massive grey to white limestone with parafusulina		104P/12, north of Chromite Creek	

III. An upper division composed of intermediate to felsic volcanic rocks and shallow-water limestones. In the Midway area, the upper division consists of a basaltic trachyandesite edifice built on an earlier zoned calc-alkalic intrusion (Nelson and Bradford, 1987; Figure 1-21-4). In 104P/12, the upper division contains intermediate volcanic rocks with interbedded Lower Permian limestone, Permian parafusilina limestone and undated, but probably Permian, bedded calcarenites.

Detailed lithologic descriptions of Sylvester units are given in Table 1-21-1. This table is modified after Table 3-6-1 of Nelson and Bradford (1987) with the addition of new units from the current area. It is arranged according to the threefold structural breakdown summarized above, which derived from work in the 1987 season. The divisions

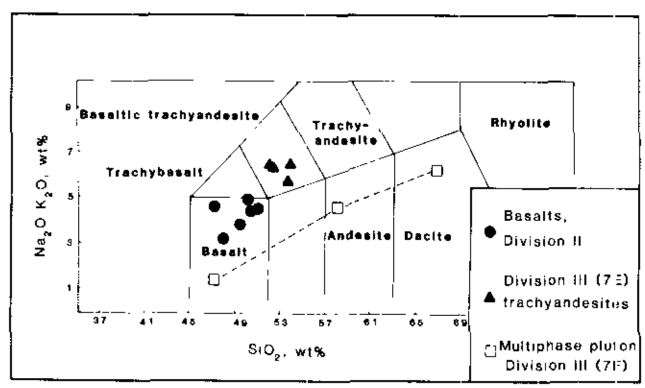

Figure 1-21-4. Alkali-silica plot for igneous rocks from the Sylvester allochthon in 104O/16.

were created primarily as easily mappable major units. The inclusion of upper crustal basalts, limestones and ultramafic material within Division II does not imply co-origin, but that these units are tectonically intercalated at a scale too fine to be depicted on any but very detailed geologic maps. The distinction between Divisions I and II will probably break down in subsequent mapping further south, since existing maps of 104P/04 and 104P/05 show volcanic material and serpentinite near the eastern limit of the Sylvester allochthon (Diakow and Panteleyev, 1981; Gordey *et al.*, 1982). Division III, however, is a variable but coherent entity that differs radically from the lower structural divisions.

In the Blue Dome map area, Division I is transitional across a strongly telescoped contact to the uppermost autochthonous North American stratigraphic unit: the Devonian – Lower Mississippian Earn Group. In several localities near its base, thrust imbrications interleave Earn and Sylvester sediments. Most of these repetitions occur within 100 metres of the main Sylvester-Earn break (Figure 1-21-2). In the northwest corner of 104P/12, a package of dark grey chert-quartz arenite, black slate, black and green argillite, black bedded chert and baritic to siliceous exhalite forms the structural top of Division I, 500 metres above its base. Sandstones within this package contain detrital muscovite, tourmaline and zircon. They and the exhalites link it almost certainly to the autochthonous Earn. In contrast to the "true" Earn, however, this package is intruded by diabase and diorite-leucogabbro sills allied to the mafic intrusive and volcanic suites of Division II. It thus provides a tie between the lower part of the Sylvester allochthon and the distal edge of Late Paleozoic North America.

The contact between Divisions I and II is invariably structural, and varies from abrupt to somewhat transitional. In some localities, massive basalt or diabase, with only minor chert rafts, is thrust over cherts and argillites lacking any igneous component. In many cases, however, a transitional facies separates the two divisions: argillite and/or chert with significant diabase sills; or basaltic tuffs intercalated with other sediments. This pattern of successive thrust slices having an increasing igneous component upwards is suggestive of a collapsed lateral facies progression.

The contact between Divisions II and III is abrupt, profound and demonstrably a thrust of regional proportions. East of Mount Major Powell, Lower Permian volcanics and sediments structurally overlie Upper Triassic limestone. Elsewhere the base of Division III is observed in contact with every other lithotectonic element of Division II.

DIVISION I

This lowest division of the Sylvester allochthon (Unit 7A in Nelson and Bradford, 1987) is nearly devoid of igneous rocks, except for diabase and diorite sills in the transition to Division II. It contains no serpentinite. It comprises a number of lithologic variants, but few mappable subunits. Conodont data from 104O/16 so far show Early Mississippian to Pennsylvanian ages (Irwin and Orchard, this volume). It structurally overlies the autochthonous Earn Group, which ranges up to Early Mississippian (Irwin and Orchard, this volume). Thus the base of Division I in 104O/16, albeit a zone of strong structural discontinuity, is not a thrust *sensu stricto*, but rather a regional-scale décollement. The internal structural style of Division I remains enigmatic due to lack of detailed microfossil control.

DIVISION II

Although it contains a wide variety of lithotectonic elements, Division II retains a peculiar integrity based on its structural position; the recurrence of major units in it such as basalt, diabase and serpentinite; and its unique interleaved tectonic style. The role of serpentinite seems to have been crucial in the development of Division II, whether as thin "lubrication" separating adjacent sheets, or as a low strength medium surrounding blocks and slices of more competent lithologies.

Major lithotectonic units within Division II are listed in Table 1-21-1. The extrusive basalt unit and the diabase-basalt-chert-argillite unit represent parts of a single intrusive-extrusive igneous suite (Unit 7B). Transitional contacts from diabase with chert rafts to 100 per cent extrusive (?) basalt breccia have been observed. Red and green chert, where intruded by basalt sills, shows soft-sediment deformation textures, indicating penecontemporaneous sedimentation and igneous activity. Radiolaria from one of these cherts in the Midway map area gave an Early to Middle Permian boundary age (T. Harms, personal communication, 1986). It should be emphasized that none of the basalts and diabases are typically ophiolitic, that is, they are not primary oceanic crust. They were emplaced into a pre-existing sedimentary basin developed on older crust, the nature of which is unknown. Whole-rock geochemical analyses of Division II basalts and diabases in the Midway area have been obtained. On an alkali-silica diagram (Figure 1-21-4) they plot as normal basalts. Trace element analyses are in progress.

In the Blue Dome area, the northeastern margin of Division II is a set of basalt and diabase-dominated thrust sheets and wedges. Most contacts are gently dipping, except for eastward ascending thrust ramps developed at the northeastern limit of exposure of Division II. Toward the southwest in 104P/12 and throughout 104O/16, Division II is mechanically and in some localities volumetrically dominated by masses of scaly serpentinite, which separate slivers and blocks of other lithotectonic units. Basalt, basalt breccia and diabase-chert form slivers throughout, but at higher structural levels may alternate with slices of amphibolite, greenstone and polymictic fanglomerate, for instance on Blue Dome. This structural style suggests initial juxtaposition by thrusting(?) of mantle and lower crustal rocks over upper crustal lithologies, followed by extensive imbrication of the package. East of Mount Major Powell, Triassic limestone occurs as the highest structural slice in Division II, covered by a thin skin of serpentinite that further southwest widens abruptly to become the Blue River ultramafite.

The polymictic fanglomerate unit offers insights into the structural history of Division II. Textures in it vary from monolithologic breccias of angular coarse-grained gabbro or diabase clasts to waterlain polymictic conglomerates that contain pebbles to boulders of gabbro, metabasalt, basalt, diabase, chert, serpentinite and plagioclase-augite porphyry (dacite/andesite) and are intercalated with sandstone and siltstone. All of these lithologies can be assigned to lithotectonic units within Division II, except the plagioclase porphyries, which are identical to lithologies within Division III. The structural involvement of Triassic limestone at the contact between Divisions II and III indicates that felsic rocks were not in proximity to Division II until after Carnian time. These breccias and conglomerates may have formed during emplacement of the allochthon, in front of thrust toes which then moved over their own debris.

DIVISION III

The highest structural division in 104P/12 lies above the highest serpentinite. In ascending order, it consists of the following units:

(1) Permian *parafusilina* limestone north of Chromite Creek.

(2) Augite and plagioclase porphyry flows and pyroclastics; epiclastic intermediate to felsic volcanic conglomerate; welded tuff-breccias with strong planar fabric; and green tuffaceous limestone containing volcanic clasts from penecontemporaneous extrusion and a variety of fossils including *spirifirella* (Early Permian, E.W. Bamber, personal communication, 1987), fusulinids, crinoids, bryozoa and horn corals.

(3) Coarse to fine-grained, well-bedded limestone turbidites, including calcarenites with graded bedding intruded by numerous augite porphyry dykes, overlain in transitional depositional contact by sea-green chert and tectonically by maroon tuffs and crinoidal limestone.

(4) Intermediate to felsic volcanic rocks, similar in lithologies to (2).

Contacts between the four units are thin (1 to 2 metre) mylonitic zones; the amount of transport across them is not known. In general, the lack of internal deformation in Division III contrasts strongly with the tectonic style exhibited in Division II. A notable exception to this is the intense folding in the limestone turbidites, which has resulted in major overturns of that package.

Division III in 104O/16 is so far undated, although a zircon separate is in progress. Its character, however, alkalic intermediate rocks superimposed on calcalkalic intrusive basement (Figure 1-21-4), is consistent with the nature of Division III in 104P/12. The reefal limestones in 104P/12 suggest shallow-water deposition, and thus thicker crust than that expected for the mafic sequences and chert-argillite packages of Division II. In both map areas, intermediate igneous rocks are restricted to the uppermost structural division. A further extension of this overall pattern may be found south of Cassiar, where Gordey *et al.* (1982) mapped augite porphyry basalts and limestones of Pennsylvanian age at the highest exposed structural level in the Sylvester allochthon. Although they may be more mafic than the augite porphyries in the Blue Dome map area, these rocks are of a different lineage than the basalt/diabase of underlying structural panels.

IMBRICATION AND EMPLACEMENT OF THE SYLVESTER ALLOCHTHON

In general, successively higher tectonic slices in the northern Sylvester allochthon contain facies that are successively more distal, that is, more allochthonous to North America. From base to exposed top, the allochthon consists of para-autochthonous sedimentary rocks, imbricated with and transitional to the youngest North American strata; structurally overlain in transitional contact by basaltic intrusive and extrusive rocks, which become imbricated, particularily at higher structural levels, with serpentinite and lower crustal material; and finally a relatively intact suite of intermediate igneous rocks and limestones. Division I sediments show a clear North American affinity. Their upward transition to Division II is best explained as a thrust-telescoped facies boundary. Thus only the highest structural division lacks elements which are spatially linked to North America. It is truly exotic, not simply with respect to the Cassiar platform, as is the case for Divisions I and II. Its emplacement must have involved at least hundreds of kilometres of relative movement, much of which was taken up within the structural packages below it. The schematic cross-section (Figure 1-21-3) shows marked eastward thickening of Division I. As the allochthon was emplaced, a series of thrust imbricates propagated in front of it within the highest levels of the distal North American sedimentary sequence, creating a wedge of slices like snow in front of a plough.

Deformation within Division II was far more complex. Near its eastern, leading edge, thrust ramps climb both at the base and between slices from an overall flat floor, probably because of the eastward thickening wedge of sediments in front of it. At higher levels and further west, ultramafites and lower crustal rocks were emplaced in a sheet or sheets over the basalts.

STRUCTURE

The internal structure of the Sylvester allochthon is discussed above. Structural patterns in the autochthonous rocks are consistent with the duplex model for the Cassiar platform (Harms, 1986; Nelson and Bradford, 1987): décollements are likely within the highly deformed Earn and Kechika groups, while the more competent massive carbonates and siliciclastic strata show far less internal folding and faulting. A few local thrust ramps were noted, particularly in the southwest corner of 104P/12, where Earn-McDame repetitions occur on the steep slopes below the base of the Sylvester. Their vergence is unknown.

Late high-angle faults are identified by their stratigraphic throws. The two most continuous faults trend north-northwest (Figure 1-21-2). Shorter faults connect them, some causing block rotations and anomalous steep south-eastward dips. The presence of inferred Sandpile Group rocks to the east of the eastern fault and Tapioca sandstone to the west of the western fault (*see* Units 4, 4A above) suggests that these faults coincide with a lower Paleozoic shelf-slope facies transition. They may be strands of the Kechika fault system. Another major strand lies immediately to the east of the Blue Dome map area, along Tisigar Lake (Gabrielse, 1963).

MINERALIZATION AND EXPLORATION POTENTIAL

Six different styles of alteration and mineralization occur in distinct geologic settings within map area 104P/12: (1) sediment-hosted baritic exhalites in the McDame and Earn groups; (2) polymetallic veins hosted by Lower Cambrian platformal carbonates; (3) quartz veins in marine sediments and mafic volcanics of the Sylvester allochthon and Earn Group; (4) sulphide-bearing alteration zones in intermediate volcanic hosts; (5) magmatic oxides and sulphides in the Blue River ultramafite; and (6) molybdenite in the Cassiar batholith. Individual showings are discussed following and are summarized in Table 1-21-2 with locations indicated in Figure 1-21-2.

Nelson and Bradford (1987) discussed the mineral deposits in the Midway area in terms of three mineralizing episodes: one syngenetic in the Devono-Mississippian; another in the Mid-Cretaceous, related to the main phase of the Cassiar batholith; and a third in the Late Cretaceous to Eocene, related to small fluorine-rich intrusive bodies. The syngenetic deposits in the Blue Dome area occur over a somewhat greater time span than in 104O/16 (as old as Givetian, as opposed to Famennian through Early Mississippian). The polymetallic veins differ somewhat in style, mineralogy and setting from late epigenetic deposits in 104O/16 such as Midway. Some of them are located along faults, although not within a single swarm like the Tootsee River fault system (Nelson and Bradford, 1987). The sulphide-bearing alteration zones and the ultramafic-hosted magmatic deposits in the Sylvester have no known correlatives in the Midway area. Some of the epigenetic deposits are localized along faults, but none of them can be linked to a single, dense set of high-angle faults like the Tootsee River system.

SEDIMENT-HOSTED EXHALATIVES

At the Shawn (Captain Lake) showing, Middle Devonian McDame Group platformal carbonates host coarse-grained, white, stratiform barite interbedded with dolomitic siltstones 100 metres above the McDame-Tapioca contact. Barite also occurs as crosscutting veins and breccia clasts or replacement zones up to 1 metre across in both the McDame Group and Tapioca sandstone. Graded sedimentary breccias, with barite, McDame and Tapioca clasts, occur stratigraphically above the bedded barite. This style of mineralization suggests a continuum between crosscutting veins and exhalative barite. The overlying sedimentary deposits may have resulted from coeval mineralization and fault movement locally exposing Tapioca sandstone.

Devono-Mississippian Earn Group E-turbidites host the Chief and Blue showings, which consist of laminated fine-grained quartz-barite-pyrite exhalites with local minor galena and/or sphalerite. Crosscutting sulphide-rich mineralization occurs at both showings, although contacts with the exhalites is not exposed. An economically insignificant exhalite was noted in an Earn analogue within the Sylvester in the northwestern corner of the map area.

The Earn exhalites closely resemble Devono-Mississippian occurrences in the Midway area (Nelson and Bradford, 1987) while the Sylvester occurrence may be a lateral, time-equivalent exhalite. The Shawn Barite showing extends the known time span of exhalative mineralization in the Cassiar platform to include the mid-Devonian.

POLYMETALLIC VEINS IN PLATFORMAL CARBONATES

Five zones of silicification and stockwork quartz veining occur within Lower Cambrian platformal carbonates. Two of these, the Ella Rose and Cyathid Mountain, were discovered in the course of our mapping in 1987. The Ax showing, which was trenched in 1969, subsequently lay idle until it was rediscovered in 1987, nearly simultaneously by our crew and an independent prospector.

The Pip (Captain Lake) showing consists of anastomosing quartz veins in silicified carbonate breccias with locally abundant copper mineralization. It lies adjacent to a highly brecciated fault zone between Rosella carbonates and

TABLE 1-21-2
MINERAL OCCURRENCES
104P/12

Type/Age	Name(s)	MINFILE No.	Economic Minerals	Description
1. Sediment-hosted exhalatives				
(1) McDame Group (mid-Devonian)	Shawn Barite, Captain Lake	104P-049	barite, chalcopyrite	Coarse stratiform barite beds up to 1 metre thick, associated veins, replacements within McDame dolomitic breccia and siltstone. Barite contains minor chalcopyrite. $BaSO_4$ from 52.1 to 90.1 weight per cent (W.H. Thompson, 1982, Assessment Report 10334).
(2) Earn Group (Devono-Mississippian)	(a) Chief Southwest	104P-103	barite, chalcopyrite, pyrrhotite	Bedded quartz-pyrite-barite exhalites in Earn clastics. Large boulder of quartz stockwork with chalcopyrite and locally massive pyrrhotite-pyrite.
	(b) Blue	104P-104	barite, galena, sphalerite	Bedded quartz-pyrite-barite exhalites from 0.5 to 11.0 metres thick are exposed at four locations along a 7-kilometre strike length. All localities contain minor galena with only local yellow sphalerite and low silver values (Cordilleran Engineering Ltd., 1982, Assessment Report 10751).

TABLE 1-21-2—*Continued*
MINERAL OCCURRENCES
104P/12

Type/Age	Name(s)	MINFILE No.	Economic Minerals	Description
2. Polymetallic veins in carbonates (Upper Cretaceous)	(a) Ax	104P-106	galena, chalcopyrite, barite, chalcocite, sphalerite	Silicified zone 10 to 15 metres wide with 30-centimetre to 1-metre-wide mineralized zone exposed along 300 metres. Contains massive to disseminated galena, coarse white quartz with chalcopyrite-barite-chalcocite and late brecciated quartz with iron oxides and galena blebs. Grab samples assayed 248, 2 and 40 ppm silver, <20, <200 and <20 ppb gold, respectively. Hosted in Lower Cambrian Rosella Formation.
	(b) Ella Rose (new discovery)	104P-097	chalcopyrite, covellite	A 20-metre-wide zone of silicification in dark grey brecciated dolomite. Quartz is fine grained and vuggy with limonite and malachite. Chalcopyrite, covellite, brown sphalerite and galena occur in boulders in a sloughed creek bank 20 metres north of the outcrop. A grab sample from the showing assayed 24 ppm silver and <20 ppb gold.
	(c) Captain Lake, (Pip)	104P-060	chalcopyrite, chalcocite	Silicified zone with locally intense stockwork with chalcopyrite-chalcocite occurs along a highly brecciated fault contact between Kechika calcareous shale and Atan carbonates. The zone is up to 40 metres wide and exposed along 125 metres. Best assays reported are 1.36% copper over 25 metres (N.B. Vollo, 1976, Assessment Report 6087). An old trench exposes similar mineralization 600 metres on strike to the northwest.
	(d) Cyathid Mtn. (new discovery)	104P-098	chalcopyrite	A strong quartz stockwork with very minor chalcopyrite is exposed over 70 metres by 15 metres. Grades into a limonitic calcite breccia zone 1.5 kilometres along strike to the northeast.
3. Veins in marine sediments and volcanics (Upper Cretaceous to Eocene)	(a) Chief East	104P-102	pyrite, chalcopyrite	A northwest-trending gossanous zone (0.5 by 3.5 kilometres) of strong quartz-sericite-pyrite alteration that hosts numerous quartz veins with pyrite and chalcopyrite. Hosted in Sylvester chert-argillite.
	(b) Reggie (new discovery)	104P-099	galena, pyrite	*En échelon* tension gashes in a narrow zone up to 0.7 metre wide with disseminated galena and minor pyrite.
	(c) Lat. 59°45′, Long. 130°00′			Intense quartz veining with minor graphite in Sylvester sediments is exposed over 800 by 250 metres.
4. Alteration within Division III intermediate volcanics (age uncertain)	(a) Mare	104P-105	chalcopyrite, pyrite	Numerous small zones of quartz-carbonate-clay-pyrite-chalcopyrite alteration. Extensive sampling by Falconbridge Limited yielded only two anomalous samples: 222.13 grams per tonne silver, no gold; 4.6 grams per tonne silver, 2.38 grams per tonne gold (T. Bruland, 1983, Assessment Report 11335)
	(b) Lat. 59°34′, Long. 129°38′		chalcopyrite, pyrite	Small zone of quartz-carbonate-clay-pyrite-chalcopyrite alteration with thin quartz-carbonate veinlets.
5. Magmatic ultramafic-hosted mineralization	(a) Ice Lake	104P-055	chromite	Disseminated to semimassive chromite as pods in peridotites at two locations in the Blue River ultramafite. Largest pod is exposed over 15 centimetres by 15 metres. In 104O/09 adjacent to 104P/12.
(1) Chromite (age uncertain, probably between Upper Devonian and Late Permian)	(b) Anvil chromite (new discovery)	104P-100		Semimassive to massive chromite occurs over 3 metres by 50 centimetres in talc-altered peridotite within the Blue River ultramafite.
(2) Nickel (age uncertain)	(c) Nickel Creek, Blue River Nickel, Heazlewood	104P-001	heazlewoodite	Heazlewoodite was identified by X-ray diffraction in partially serpentinized dunite. Assays to 0.21% nickel (Wolfe, 1969).
	(d) Anvil Nickel (new discovery)	104P-100	pyrrhotite, pentlandite	Semimassive net-textured sulphides and plagioclase occur along the margin of a coarse-grained, foliated gabbro within the Blue River ultramafite.
6. Molybdenite in the Cassiar batholith (Late Cretaceous)	(a) Blue Dome	104P-054	molybdenite	A small pod less than 1 metre long with 5% MoS_2 was reported by Wolfe (1969) within the Cassiar batholith.
	(b) Anvil Molybdenum (new discovery)	104P-101	molybdenite	A 0.5-metre-wide quartz vein with <1% molybdenite is exposed along a 100-metre strike length, adjacent to a biotite granodiorite dyke cutting the Blue River ultramafite.

Kechika calcareous phyllite. The Cyathid Mountain showing is similar but is not adjacent to a fault contact and contains only very minor chalcopyrite. The Ax and Ella Rose showings are narrow, high-angle silicified zones containing fine-grained, vuggy and coarse white quartz with significant copper sulphides, galena and sphalerite, and abundant malachite and azurite. A sample from a galena-rich pod at the Ax showing assayed 248 grams per tonne silver. A small zone of silicification, with no visible sulphides, was noted 3.5 kilometres northwest of the Ax.

The Ella Rose and Pip showings are located on fault contacts between Atan and Kechika groups (Figure 1-21-2). The Ax showing is on the southern extension of the same fault as the Ella Rose. The Cyathid Mountain stockwork grades into a zone of brecciation and calcite spar 1.5 kilometres to the northeast. These features all point to the importance of structural control for this kind of mineralization. These showings may be related to an episode of late Cretaceous to Eocene intrusion and lead-zinc-silver mineralization (Panteleyev, 1980; Nelson and Bradford, 1987).

VEINS IN MARINE SEDIMENTS AND MAFIC VOLCANIC ROCKS

Numerous quartz veins occur throughout the Devono-Mississippian Earn Group and Late Tournaisian to Permian(?) oceanic sediments and mafic volcanics of the Sylvester allochthon. Three of these zones are of potential economic interest. The Chief East showing is a north-trending zone of rusty weathering quartz-sericite-pyrite alteration in Sylvester sediments, 500 metres wide and up to 3.5 kilometres long. This zone contains numerous quartz veins with malachite staining and oxidized pyrite and chalcopyrite, and is coincident with a smaller lead-zinc-silver anomaly reported in soils by Cordilleran Engineering Ltd. (Assessment Report 10974). The alteration superficially resembles that associated with Late Cretaceous fluorine-rich intrusives southeast of the Midway deposit (Nelson and Bradford, 1987).

The Reggie showing consists of *en échelon* quartz-filled tension gashes with galena and minor pyrite in Earn Group graphitic argillite.

In the extreme northwest corner of the map area, a 250 by 800-metre east-trending zone of intense quartz veining cuts unaltered, highly folded Sylvester sediments.

ALTERATION WITHIN INTERMEDIATE VOLCANICS

Plagioclase and/or pyroxene porphyritic flows and pyroclastic rocks in Division III of the Sylvester allochthon host minor disseminated pyrite and chalcopyrite in widely distributed, small alteration zones. The Mare showing consists of several small gossanous exposures of quartz, carbonate, clay, pyrite and chalcopyrite alteration which occur within a broader zone of bleached, carbonate-altered volcanics. These zones have been extensively sampled by Falconbridge Limited and are generally low in gold and silver (*see* Table 1-21-2). A smaller, mesoscopically similar zone occurs on the west flank of Mount Major Powell.

These alteration zones are irregular in shape and generally unrelated to significant geological structures. An exception is the showing east of Mount Major Powell, which is located on a normal fault of probable Cretaceous or Eocene age.

ULTRAMAFITE-HOSTED MAGMATIC MINERALIZATION

The Blue River ultramafite hosts two types of magmatic mineralization. The Ice Lake chromite showing (104O/09) contains two separate pods of massive to disseminated chromite within poorly layered peridotite and dunite. Similar chromite occurrences were noted at three other widely separated localities within the ultramafite, including the Anvil showing where massive chromite occurs within serpentinite and talc-altered peridotite. Disseminated to semimassive magnetite occurs as layers within partially serpentinized dunite between Chromite and Nickel creeks. These may have been chromite layers that were altered to magnetite during serpentinization of the olivine. These ultramafite-hosted chromite layers may contain significant platinum group metals. Rock and stream sediment analyses are in progress.

Magmatic, net-textured, semimassive pyrrhotite occurs at the Anvil nickel showing along the margin of a foliated gabbro within the Blue River ultramafite. Two other semimassive pyrrhotite occurrences, of magmatic or contact metasomatic origin, were noted within ultramafic rocks near the margin of the Cassiar batholith. The pyrrhotite may be associated with nickel and possibly with platinum group metals. Analyses are pending.

Wolfe (1965) identified heazlewoodite (NiS_2) using X-ray diffraction techniques on samples of dunite from Nickel Creek that contained up to 0.49 per cent nickel, but nickel sulphides have not been identified in the field.

MINERALIZATION WITHIN THE CASSIAR BATHOLITH

The Anvil molybdenum showing is a single quartz vein, 50 centimetres wide, that runs parallel to a granodiorite dyke cutting the Blue River ultramafite. Wolfe (1965) also reported the presence of a pod of molybdenite 1 metre long within the Cassiar batholith.

SUMMARY

Polymetallic silver-bearing vein deposits hosted by Lower Cambrian Atan carbonates constitute the most significant exploration targets in map area 104P/12. The known showings extend across the eastern half of the map area and to the north (104P/13) where a similar showing is exposed on One Ace Mountain. They appear to be localized along high-angle faults that may be minor fault strands related to westward stepping of the Kechika fault. There are many quartz veins in the Sylvester allochthon and Earn Group although few contain visible sulphides and all lack significant alteration haloes and structural controls that are readily apparent in the Cassiar gold camp. The magmatic sulphides and oxides in the Blue River ultramafite are an under-explored target for platinum group metals.

CONCLUSIONS

Geologic mapping of the Blue Dome map area (104P/12) has added two important pieces of information to the ongoing study of the Midway-Cassiar region:

(1) The northern Sylvester allochthon shows a consistent large-scale stacking order. The highly allochthonous Division III, characterized by intermediate igneous rocks and shallow-water limestones, lies above Divisions I and II, which are related to North America, but not indigenous to the Cassiar platform where they currently rest. The allochthon appears to become progressively more exotic upwards, with the furthest travelled, most foreign material at the structurally highest levels. This premise will allow reconstruction of marginal rift-basin geometry and facies for Divisions I and II.

(2) Two significant mineralized quartz breccia systems in Rosella carbonates, the Ella Rose and the Ax showings, have been added to existing knowledge of mineralization in the Blue Dome area. At the Ella Rose, high-angle fault control is clear; at the Ax, it is more cryptic but nevertheless likely, as shown by steep northwest vein trends, proximity to the inferred extension of the fault that hosts the Ella Rose, and local slickensides.

These occurrences are different in style from the manto mineralization at Midway and Butler Mountain, but they are similarily keyed to massive carbonates and late faulting, probably related to regional dextral movement. Thus the interaction of transcurrent faulting and Paleozoic carbonate hosts, proposed as ore controls further north (Abbott, 1984; Nelson and Bradford, 1987), remains valid at least as far south as the French River and probably beyond.

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