GEOLOGY OF THE AREA AROUND THE MIDWAY DEPOSIT NORTHERN BRITISH COLUMBIA* (104O/16)

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INTRODUCTION

The Midway silver-lead-zinc manto deposit is located in map area 104O/16, 10 kilometres south of the British Columbia-Yukon border and approximately 80 kilometres west of Watson Lake, Yukon (Figure 3-6-1). Access is by means of a 23-kilometre gravel road that leads south from Milepost 701 on the Alaska Highway. Truck bridges span the Rancheria and Tootsee Rivers.

This report presents the results of a geologic mapping project conducted between June 9 and August 28, 1986. Four 1:25 000-scale open file geologic maps covering 104O/16 are being prepared; these will be released in January 1987. This season's mapping was the initial phase of a four-year project funded by the Canada/British Columbia Mineral Development Agreement; the project will cover an area extending from the Yukon border to Cassiar.

Objectives of the study are as follows:

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

GEOLOGY

The Midway area lies within the Cassiar Platform, a splinter of the North American continental shelf that was carried perhaps 750 kilometres to the northwest outboard of the dextral Tintina fault (Gabrielse, 1985). Miogeoclinal strata ranging from Lower Cambrian to Lower Mississippian (Figure 3-6-3) form the footwall of a regional bedding-parallel thrust (Figure 3-6-2). The hangingwall of the thrust is the Sylvester Allochthon, an internally imbricated suite of oceanic upper and lower crustal rocks and ultramafites. Fossil ages so far obtained from the Sylvester Allochthon in the Cry Lake and McDame map areas range from Late Devonian to Late Triassic (Gordey *et al.*, 1982; Harms, 1986). Emplacement of the allochthon occurred between Late Triassic and mid-Cretaceous time. In the McDame map area the predominantly mid-Cretaceous Cassiar batholith intrudes the Sylvester Allochthon. This relationship is not seen in 104O/16, where Cassiar intrusions cut only miogeoclinal rocks. Northwest-trending mylonitic zones are developed within the batholith. Potassium-argon ages from mylonites collected near map area 104O/16 suggest mid to Late Cretaceous transcurrent displacement.

MIOGEOCLINAL STRATA

UNIT 1 — ATAN GROUP (LOWER CAMBRIAN)

The oldest strata exposed in map sheet 104O/16 correlate with the Atan Group, which, in the McDame map area, has been subdivided into the lower, dominantly siliciclastic Boya Formation (1A) and the upper carbonate-dominated Rosella Formation (1B) (Fritz, 1980). Exposure of Atan Group rocks in 104O/16 is restricted to fault-bounded panels in the area immediately west of the Cassiar batholith (Figure 3-6-2).

The Boya Formation is dominated by siliciclastic rocks — well-sorted white, grey and black quartzites with muscovitic partings and poorly sorted, characteristically black turbiditic deposits. The turbidites range from black slate through thin-bedded siltstone to quartzose greywacke and quartz-pebble conglomerate. Streaky grey and black limestone beds up to 15 metres thick occur sporadically within the siliciclastic sequence. The Rosella Formation consists predominantly of streaky grey limestone or marble and orangey-buff-weathering dolomite; individual beds are generally greater than 100 metres thick. The top and, in most cases, the bottom of the Rosella Formation are either unexposed or truncated by intrusive contacts or faults. In some areas (south of Tootsee Lake, on the ridge southeast of the Amy property, and in drill core on the Silverknife property) thin-bedded argillite, hornfels or phyllite comprise up to 15 per cent of the Rosella Formation. At the southern "bend" of the Tootsee River, a platy limestone 100 metres thick separates black pyritic argillite assigned to the Boya Formation from thin-bedded calc-silicates and phyllite. The limestone and the thin-bedded units are assigned to the Rosella Formation. Pure marble is intercalated with thin-bedded calc-silicates in Silverknife drill core.

Rosella Formation carbonates host manto or replacement sulphide mineralization on the Silverknife claims (Mineral Inventory 104O-048) in British Columbia and also at the Butler Mountain occurrence in the Yukon.

UNIT 2 — KECHIKA GROUP (CAMBRIAN-ORDOVICIAN)

Thin-bedded calcareous shales and siltstones with minor thin pure limestone interbeds occur in fault-bounded slices along Big Creek in the northeast corner of the map area. They weather silvery to light yellowish or orange, and are characteristically strongly deformed and cut by small-scale internal thrusts or décollements.

These rocks correlate with the Kechika Group as described in the McDame map area (Gabrielse, 1963). Exposures of thin-bedded calc-silicate and biotite hornfels in contact with the Cassiar batholith in the northwest quarter of the area, and on Canamax' Heap claims east of the Ewen Barite road, are also included in the Kechika Group.

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

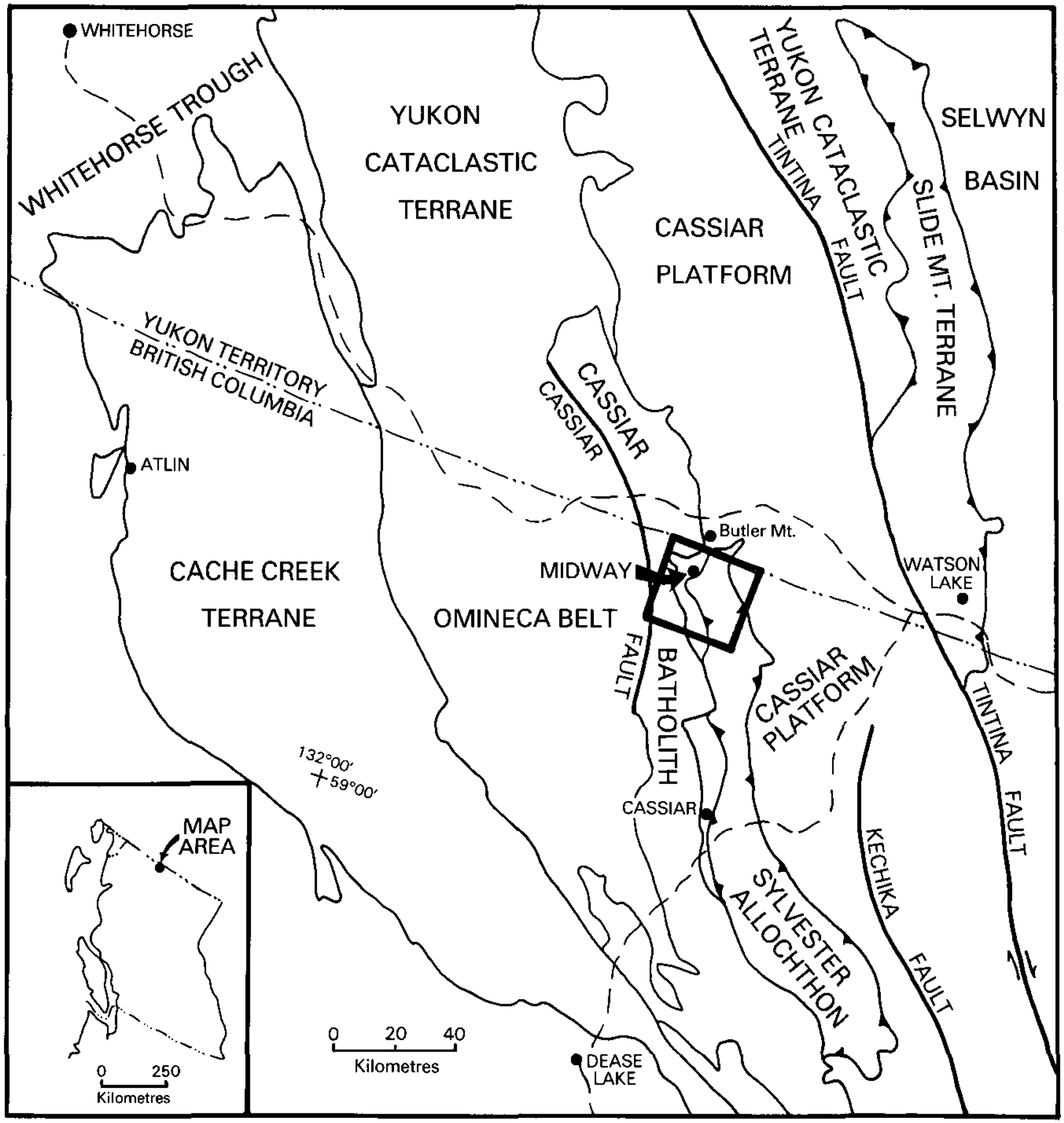
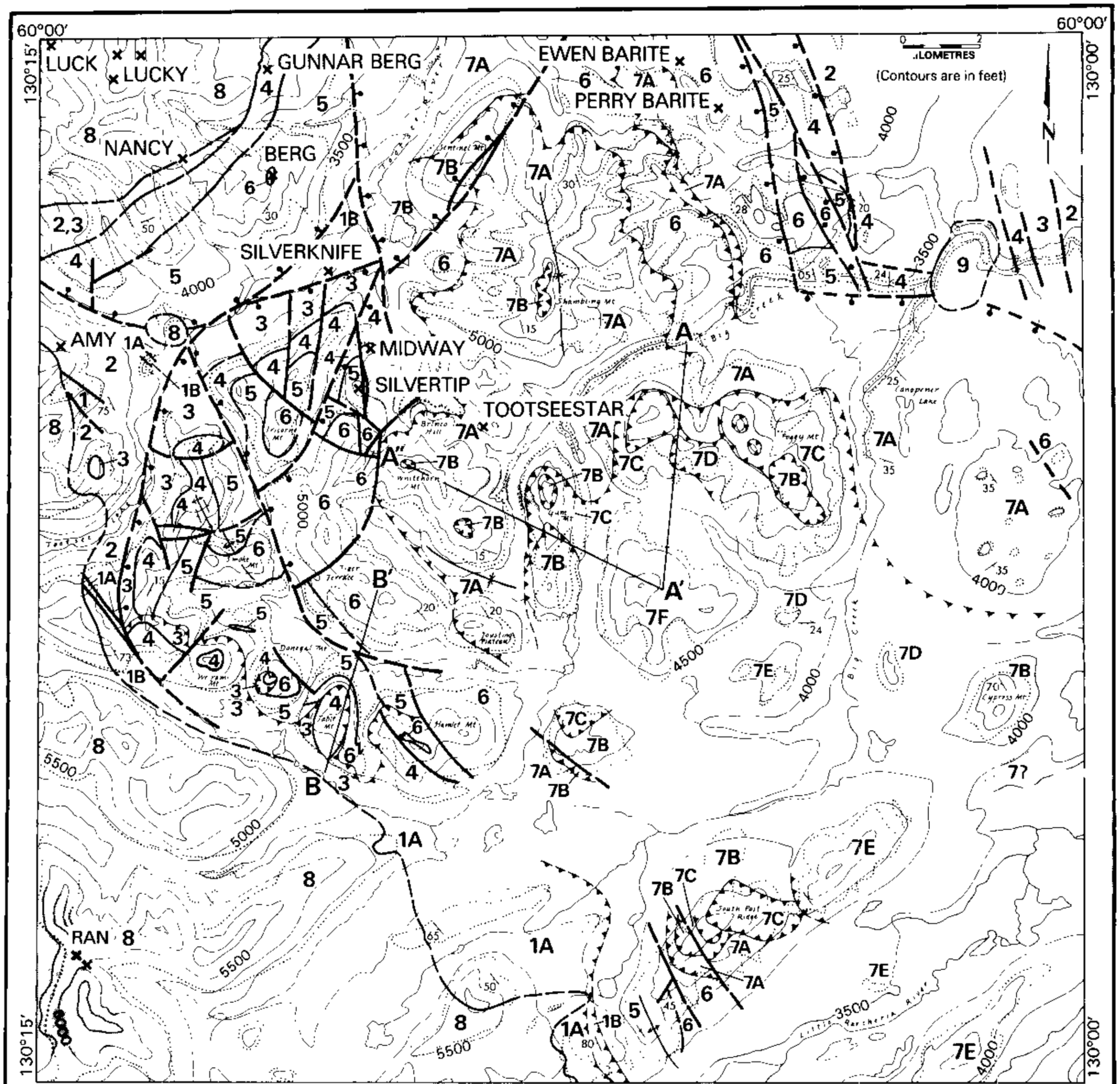


Figure 3-6-1. Location of map sheet 104O/16.



LEGEND

MIOCENE-PLIOCENE

9 *Tuya Volcanics: olivine basalt*

CRETACEOUS AND ? EOCENE
CASSIAR BATHOLITH

8 *granite, granodiorite*

DEVONIAN TO TRIASSIC?
SYLVESTER ALLOCHTHON

Note: order of units does not correspond to relative ages or tectonic stacking sequence

7A *chert, argillite, limestone; minor volcanic extrusive component*

7B *chert, argillite, basalt, diabase; includes some 7C, 7D, 7E, 7F*

7C *serpentinite; may contain blocks of all other lithologies*

7D *coarse-grained, in part foliated, gabbro, locally brecciated and/or cut by dykes*

7E *trachyandesite flows, subvolcanic intrusives, pyroclastic to epiclastic sediments*

7F *zoned hornblende gabbro-tonalite-granodiorite complex*

DEVONIAN-MISSISSIPPIAN
EARN GROUP

6 *slate, siltstone, greywacke, chert-pebble conglomerate*

MIDDLE DEVONIAN
McDAME GROUP

5 *dolomite, limestone*

LOWER DEVONIAN
TAPIOCA SANDSTONE

4 *dolomitic quartz arenite; quartzite, dolomite*

ORDOVICIAN-SILURIAN
ROAD RIVER GROUP

3 *black limey slate, slate, argillaceous limestone, limey siltstone*

CAMBRIAN-ORDOVICIAN
LOWER KECHIKA GROUP

2 *thin bedded limey slate, siltstone; limestone*

LOWER CAMBRIAN
ATAN GROUP

1B *Rosella Formation: thick limestone, dolomite, shale, minor slate*

1A *Boya Formation: quartzite, slate, siltstone, conglomerate, limestone*

quartz-sericite alteration

Figure 3-6-2. Geology and mineral deposits, map sheet 104O/16.

The Amy occurrence (MI 104O-004), a conformable silver-lead-zinc replacement deposit, is hosted by an anomalously thick (5 to 40 metres) limestone lens, probably a patch reef, in the Kechika Group.

UNIT 3 — ROAD RIVER GROUP (ORDOVICIAN-SILURIAN)

The Road River Group is exposed at the base of Tricorne Mountain, south and east of Tootsee Lake, in thrust sheets on Weirami, Donegal and Table Mountains, on the ridges northwest of the Tootsee River, and in fault slices along Big Creek. It consists of approximately 200 metres of very fissile black, graphitic limy slate and black argillaceous-graphitic limestone, with minor interlayers of black noncalcareous slate and pure dolomite. The uppermost part of the Road River Group, directly below the Tapioca sandstone, is a platy, grey graphitic siltstone that contains impressions of the graptolite *diplograptus* (?) that are up to 10 centimetres long. Isolated lenticular dark grey quartzite units, 1 to 10 metres thick and tens of metres long, occur in Road River exposures south of Tootsee Lake. They are probably the result of tectonic shredding of the base of the Tapioca sandstone, rather than a gradational Road River-Tapioca sandstone contact.

UNIT 4 — TAPIOCA SANDSTONE (LOWER DEVONIAN)

The Tapioca sandstone is an informal name proposed by Gabrielse (1969) for the rocks that lie stratigraphically between the Road River and McDame Groups (formerly Sandpile Group). The unit contains the diagnostic "tapioca" sandstone — quartz grains of high roundness and sphericity in a dolomite matrix — but also thick intervals of pure white, grey and black quartzite, and pure massive dolostone. In some areas the base of the Tapioca sandstone is quartzite in abrupt contact with sooty black Road River shale. In others (Table Mountain, Weirami Mountain, Donegal Mountain) the basal unit is a distinctive wavy bedded, light grey, buff-weathering, fine-grained, bioturbated dolomitic sandstone. This unit passes transitionally downwards into siltstone of the uppermost Road River Group.

The Tapioca sandstone passes transitionally upwards into laminated or massive dolostone. We place the Tapioca-McDame contact at the top of the highest significant sandy layer. It should be noted that laminated dolostones above the sandstones have been included within the Tapioca sandstone unit (Gabrielse, 1969); therefore the lowest part of the McDame Group in our mapping is the upper formation of the Tapioca sandstone as defined by Gabrielse (1969).

UNIT 5 — McDAME GROUP (MIDDLE DEVONIAN)

The McDame Group hosts manto silver-lead-zinc mineralization at Midway. The McDame is a platformal carbonate accumulation. Strong facies variations occur within it. McDame exposures in northwestern 104O/16 consist of lower dark grey, buff-weathering, laminated to massive, commonly fetid dolostone, overlain by dark grey, highly fossiliferous, locally platy limestone, which is dolomitized in part. Biostromal accumulation of *amphipora*, *thamnopora*, *stringocephalus*, *syringapora* and *stromatoporoids* indicate a flourishing fauna of relatively low diversity. Shallowing upward sequences are shown by local accumulations of cryptalgal laminites, stromatolites and *stromatotacti*, indicative of an intertidal to subtidal environment. *Amphipora*-rich limestones are also seen on Donegal Mountain, eastern Table Mountain and South Post Ridge.

In contrast, McDame exposures in the northeastern part of the area are wholly dolomitic and nearly barren of fossils. They show thin micritic bedding, rip-up clasts and sedimentary breccias, and may represent a nearshore high-energy environment. The top of the McDame on Hamlet Mountain and on the west side of Table Mountain is also unfossiliferous dolostone. Either local facies variations or significant differential erosion may account for the strong differences between these exposures and nearby exposures of *amphipora* limestones.

Two early phases of karsting affected the uppermost McDame. The earliest, pre-Earn, event is shown by irregular paleotopography, with up to 200 metres of relief, at the McDame-Earn contact. Depressions in the top of the McDame are commonly filled by rose, buff and silver-coloured dolomitic (?) porcelanous siltstones that are atypical of the Earn proper. The best exposed examples of this are in the vicinity of the Berg showing (MI 104O-015) and on Hamlet Mountain. Further solution collapse postdated Earn deposition but occurred before Mesozoic tectonism. On Donegal and Smoke Mountains, angular fragments of porcelanous black basal Earn shale occur in breccia at and below the McDame-Earn contact. None of these fragments show the fine crenulations that developed in nearly all Earn slates during the major deformational event. Karst features within the upper McDame include large (up to 3 metres diameter) tubes and cavities, particularly northwest of the Tootsee River, and brecciation accompanied by coarse dolomitization, best seen on Smoke Mountain. Solution breccias and spar-filled vugs are seen throughout the McDame.

Breccias consisting primarily of lowermost Earn slate clasts are abundant in the upper McDame in the vicinity of the Midway deposit. Most of these contain crenulated slate clasts and/or sulphide clasts; hydrothermal quartz forms the breccia matrix in some cases. A third solution event thus postdated Jurassic deformation, and probably accompanied mineralization. In this case, hydrothermal fluids rather than cold groundwater probably instigated solution collapse.

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

This turbiditic sequence, formerly included in the lower Sylvester Group (Gabrielse, 1969), has been reassigned by Gabrielse (Gabrielse and Mansy, 1980; H. Gabrielse, personal communication, 1986) to the Earn Group, a lithologically similar package of roughly equivalent age that is recognized from MacMillan Pass in the Yukon to the Gataga area of British Columbia (Gordey *et al.*, 1982; McClay and Insley, 1986). The Earn Group includes black slate, thin-bedded siltstone, thin to thick-bedded sandstone, chert-pebble conglomerate, and volumetrically minor but economically significant baritic, siliceous and sulphide-rich exhalites that are accompanied in some instances by chert and limestone.

Cordilleran Engineering Ltd. has constructed a viable internal Earn stratigraphy in the vicinity of the Midway deposit: two broadly coarsening upward sequences with exhalative horizons concentrated in the lower half of the second fine-grained clastic sequence. Abrupt facies variations and lack of fossil control precluded development of Earn stratigraphy at the scale of mapping.

Black shales at the base of the Earn Group abruptly and unconformably overlie McDame carbonates. The Earn Group comprises the youngest autochthonous strata in map area 104O/16. Its upper contact is a thrust, the base of the Sylvester Allochthon.

THE SYLVESTER ALLOCHTHON (UNIT 7)

The Sylvester Allochthon is a pile of discrete lithotectonic units, which have been dismembered and tectonically interleaved. Some units are linked by pre-emplacement events, while others have nothing in common except their present proximity. The allochthon as a whole overrode the Earn Group along a planar master thrust that was subsequently deformed into open folds (Figures 3-6-2 and 3-6-4).

The allochthon has been subdivided by field mapping into six lithotectonic units (Figure 3-6-2) and 15 subunits (Table 3-6-1).

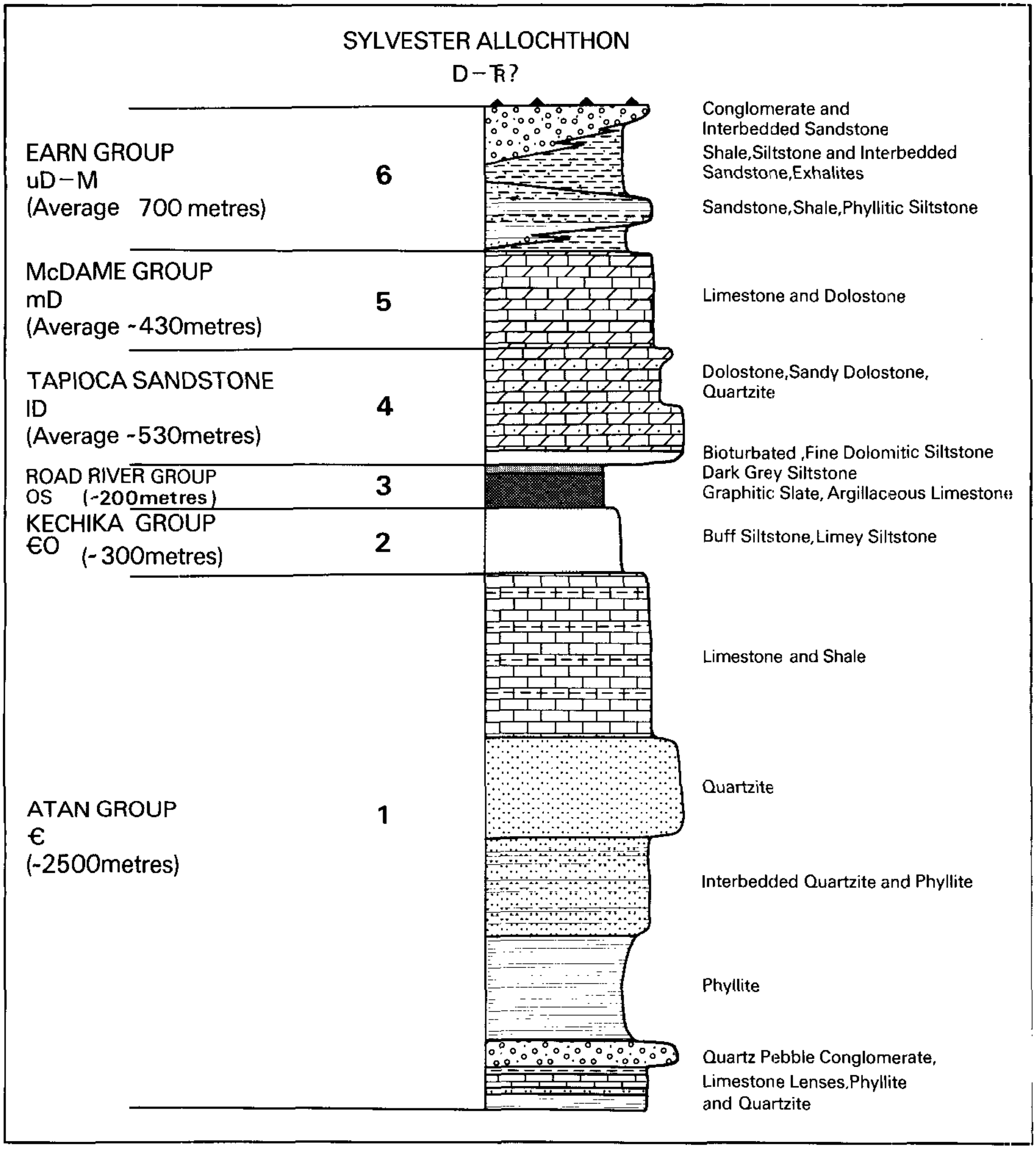


Figure 3-6-3. Geological columns of autochthonous units, map sheet 104O/16.

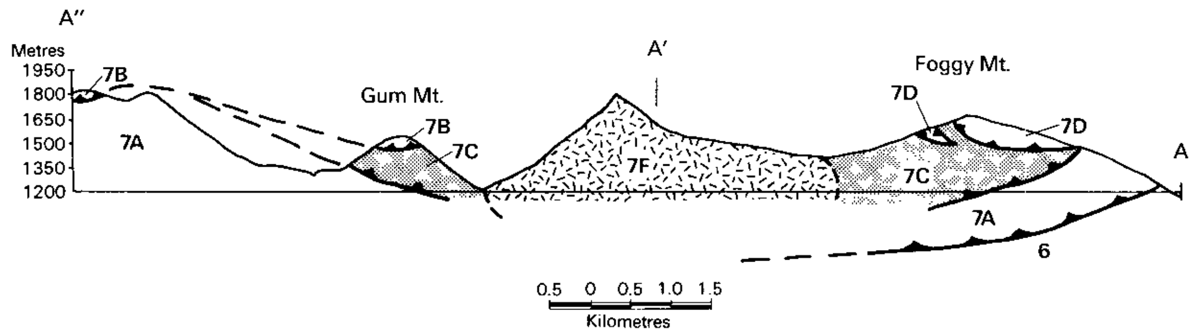


Figure 3-6-4. Cross-section A-A'-A" of Sylvester Allochthon from Big Creek to Gum Mountain.

Subdivision is based on: recurring distinctive lithologies, for example, salmon pink chert interbedded with sea green argillite; lithologic suites, for example, subvolcanic massive andesite, flow breccias containing subvolcanic andesite clasts, and intercalated andesitic greywacke-siltstone; or similar geologic histories, for example, chert intruded by numerous basalt/diabase dykes. As shown in Table 3-6-1, the allochthon is dominated by "oceanic" lithologies: cherts, argillite, limestone; basalt flows and breccias; basalt/diabase dykes and sills; a coarse-grained gabbro that is strongly foliated to mylonitic in part, and locally intruded by diabase dykes; and extensive ultramafites. Subordinate "nonoceanic" lithologies include Unit 7E, a trachyandesite suite with derived sediments and subvolcanic equivalents; Unit 7F, a zoned hornblende gabbro to granodiorite complex that intrudes cherts; and minor terrigenous siliciclastic greywackes that contain detrital muscovite, tourmaline and zircon. Individual thrust-bounded slices of a single unit may be widely scattered. They range in size from sheets that compose entire mountains down to blocks a few metres in diameter that are enclosed in scaly serpentinite. This degree of dismemberment suggests large-scale boudinage.

The Sylvester Allochthon was assembled into its present form during two or more distinct episodes of telescoping. Late Paleozoic thrust imbrication has been documented by Harms (1986) in the Cry Lake map area and may be important elsewhere; this event is unrelated to the Sylvester-North America encounter. Internal telescoping of the allochthon accompanied its emplacement onto the North American continental margin during Jurassic time.

CASSIAR BATHOLITH (UNIT 8 — CRETACEOUS-EOCENE)

Intrusive rocks of the Cassiar batholith occupy the western border of 104O/16. Coarse-grained quartz monzonite, with pink orthoclase megacrysts, and coarse-grained biotite-hornblende grandiorite constitute 98 per cent of these exposures. The remainder are younger intrusive phases — medium-grained granites, particularly on the Ran claims and at the Lucky showing, and ubiquitous but narrow pegmatites and aplites. In the southwest corner of the area, northwest-trending mylonite zones cut megacrystic quartz monzonite and granodiorite, but not the younger medium-grained granite. Displacement indicators such as asymmetric pressure shadows and folded aplite dykes show right lateral and also east-side-up motion across these zones.

Mineralization within the Cassiar batholith includes gold-bearing porphyry type (Ran claims) and vein swarms [Nancy (MI 104O-013), Lucky, Luck (MI 104O-033) showings]. Economic minerals include molybdenite, gold with pyrite, argentiferous galena, and argentite.

STRUCTURE

Two regional structural events affected the rocks in 104O/16. The older event, the Early Jurassic collisional episode, involved major shortening of the North American continental margin and also emplacement of the Sylvester Allochthon. The younger event reflects Late Cretaceous-Early Tertiary wrench faulting. More than 90 per cent of the relative movement between the Sylvester Allochthon and North America must have been taken up along the Sylvester-Earn contact. The 10 metres or so across this contact are never exposed. Thin sandstone beds in the uppermost Earn have been disrupted and rotated. The remaining relative movement penetrated into the miogeoclinal pile where its effects coincide in style, geometry and timing with those of the overall crustal shortening process. Thin-bedded argillaceous units — Earn slates and the Kechika Group — were intensely strained, while thick, brittle units — primarily the McDame-Tapioca sandstone - moved as rigid blocks bounded above and below by décollements. Analogous duplex-style deformation has been documented further south in strata below the Sylvester Allochthon by Harms (1986). In 104O/16, a set of northeast-vergent thrust ramps developed in North American strata within the range between Weirami Mountain and Hamlet Mountain (Figure 3-6-2). These thrusts show characteristic "snake's head" morphology (Suppe, 1983) in cross-section (Figure 3-6-5) and die out over a short distance to the northeast. Thrust imbrication of the McDame Group may occur near the Berg showing.

South and west of the Ewen Barite occurrence (MI 104O-050), a northeast-vergent bedding-parallel thrust brings Earn strata over basal Sylvester cherts (Figure 3-6-2). This structure developed late in the deformational episode, after the Sylvester Allochthon was essentially in place.

Map-scale folds are scarce. The style of deformation — shortening concentrated within favourable stratigraphic horizons — did not favour development of major folds but minor structures are ubiquitous. One or more slaty or fracture cleavages are common. Minor structures include bedding-parallel cleavage in all slaty rocks, fine crenulations on slaty cleavages, minor to outcrop-scale folds, boudinage, rodding and pencil cleavage, clast elongation in conglomerates, and fibrous quartz growth around pyrite nodules.

TABLE 3-6-1
MAPPABLE LITHOTECTONIC UNITS WITHIN THE SYLVESTER ALLOCHTHON

Unit in Figure 3-6-2	Lithologic Subpackages	Description	Localities	Relationship to Other Lithologic Subpackages
7A: chert, argillite, limestone	1. grey, green, black chert, grey-black argillite	bedded chert with intercalated argillite; also black ribbon chert (less common). Probably embraces a considerable age span, probably internally imbricated. Minor andesite slivers, carbonate-altered "felsic" sills on Whitehorn Mtn.	widespread in 7A	
	2. limestone	impure limestone with lithic fragments; purer grey limestone. Small lenses in (1); occurs as a mappable unit only on Shambling Mtn.	Shambling Mtn.	with (1). Some at least is depositionally within the chert-argillite sequence; the unit on Shambling Mtn. may be a tectonic slice
	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	Shambling Mtn. Whitehorn Mtn. Jousting Plateau Foggy Mtn.	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	east of Shambling Mtn. West of Canopener Lake Jousting Plateau Whitehorn Mtn.	intercalated in (1). On Jousting Plateau, apparent gradational contact. Elsewhere probably tectonic boundaries
	5. greywacke	slivers or interbeds within (1): not large enough to be mappable but significant genetically. Contain detrital muscovite, tourmaline, zircon		
7B: chert, argillite, basalt, diabase	1. chert-argillite with diabase and basalt sills and dykes	grey to green chert and argillite — includes green tuffs with chert fragments. Intruded by very fine-grained to aphanitic basic intrusive rocks that compose up to 75% of unit	Shambling Mtn. (top) North Foggy Mtn. Cypress Mtn. Whitehorn Mtn. (top) Sentinel Mtn. (SE ridge)	
	2. aphanitic basalt flows, pillowed flows, pillow breccia, dykes; local red ferruginous chert and green chert	apparently same igneous lithologies as (1) but extrusive material predominates. This unit contains areas of highly flattened breccias, with volcanic and chert clasts in ferruginous or green chert matrix	Sentinel Mtn. (top) Gum Mtn. Foggy Mtn. Hill west of Gum Mtn. (top)	

Unit in Figure 3-6-2	Lithologic Subpackages	Description	Localities	Relationship to Other Lithologic Subpackages
7C: serpentinite	1. serpentinite	parts are thoroughly tectonized — scaly, boudin-filled; other parts retain primary textures, bastites. Serpentinite masses contain blocks and slivers of other lithologies, e.g. gabbro blocks on Foggy Mtn.	Foggy Mtn. Gum Mtn. South Post Ridge Hill east of Hamlet Mtn.	
7D: Coarse-grained, in part foliated gabbro, locally brecciated and/or cut by dykes	1. gabbro	coarse-grained gabbro. Originally pyroxene-plagioclase gabbro. Has undergone extensive upper greenschist-lower amphibolite metamorphism. In places highly foliated to mylonitized	Foggy Mtn.	
	2. gabbro-dyke complex	foliated gabbro cut by extensive very fine-grained unfoliated mafic dykes	Foggy Mtn.	
	3. brecciated gabbro	foliated gabbro ± basalt clasts in very fine-grained dust-tuff matrix; on Gum Mtn. clasts of this lithology occur in limestone matrix	Foggy Mtn. Gum Mtn. Hill south of Canopener Lake	
7E: Trachyandesite flows, subvolcanic intrusives, pyroclastic-epiclastic sediments	1. Trachyandesite flows and coarse pyroclastic material are predominant.		South Post Ridge Hill south of Foggy Mtn.	All of these units occur in a gradational sequence with a centre marked by predominance of subvolcanic lithologies at the east end of South Post Ridge.
	2. Subvolcanic porphyritic intrusions are predominant.			
	3. Epiclastic sediments (greywacke-volcanic siltstone) are predominant.			
7F: Zoned hornblende gabbro-tonalite-granodiorite complex			Mtn. east of Gum Mtn.	cut by "andesite" dykes similar to the trachyandesites of 7E. May be basement to 7E

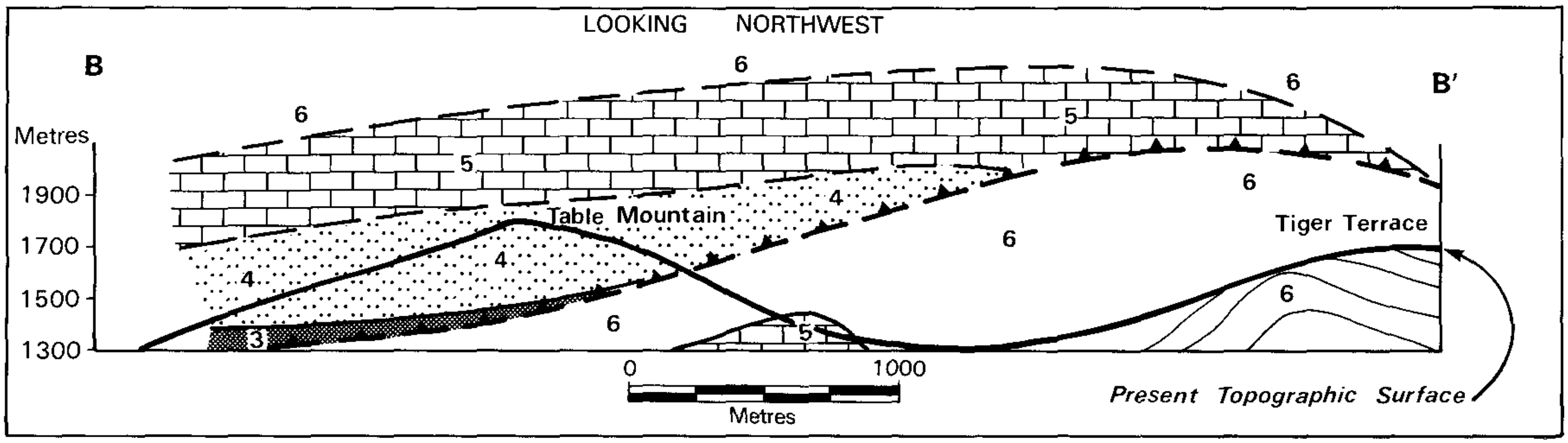


Figure 3-6-5. Cross-section B-B' of thrust ramps in autochthonous strata, Table Mountain.

Minor structures in autochthonous and allochthonous rocks coincide geometrically. In most of the area fold axes and linear structures trend northwest and plunge gently northwest and southeast.

The overall Jurassic episode involved several superimposed generations of folding and cleavage. In a given outcrop, isoclinal folds may be succeeded by coaxial but upright folds; or two sets of crenulations diverging by 15 to 20 degrees may deform the same bedding-parallel cleavage. Bedding-parallel cleavage is always the earliest planar structure. It is succeeded in some outcrops by a steep southwest-dipping cleavage and in others by one that dips to the northeast.

Atan and Kechika rocks next to the Cassiar batholith define a separate structural domain, identified by steep (30 to 60-degree) plunges of fold axes. High-angle faults separate this domain from the rest of the map area and commonly juxtapose disparate stratigraphic units within it.

The second major deformation is expressed as swarms of high-angle faults that equally offset both autochthonous and Sylvester rocks. One concentration of faults occupies the Tootsee River valley, with a major horsetail around the Midway deposit. A second set of faults is located east of the Ewen Barite. These two fault systems form part of a regional pattern that links the northern end of the Kechika fault to the Cassiar fault. The overall fault pattern probably developed in order to transfer motion and accommodate strains between these two major dextral transcurrent faults. Timing of the motion is poorly constrained, but some strands of the Tootsee River system apparently predate the Cassiar batholith.

Late minor east to northeast-trending structures include chevron and kink folds, *en échelon* extension gashes and dilatant quartz veins. They concentrate in Earn and Sylvester rocks in the northwestern part of the map area. They probably developed in response to movement on the Tootsee River fault system.

MINERALIZATION AND MINERAL OCCURRENCES

Three major episodes of mineralization can be identified in *104O/16*, Upper Devonian-Lower Mississippian, mid-Cretaceous and Late Cretaceous-Eocene. Each episode produced a distinctive type or types of mineral deposit (Table 3-6-2).

(1) **Upper Devonian-Lower Mississippian** — The Earn Group hosts baritic exhalites, such as Perry and Ewen Barite; and siliceous exhalites in the Midway area and south to Tiger Terrace, which contain pyrite and to a lesser extent sphalerite and traces of galena. These deposits fit the sedex model (Carne and Cathro, 1982).

(2) **Mid-Cretaceous** — Mineralization associated with the main phase of the Cassiar batholith includes: molybdenite in quartz veins and scheelite in adjacent skarns at the Nancy showing; and silver-lead-zinc replacement lenses and veins at the Amy occurrence. Greisenized, tourmaline-bearing granite from the Amy area has been submitted for potassium-argon dating.

(3) **Late Cretaceous-Eocene** — Mineralization that postdates the main phase of the Cassiar batholith is associated with late intrusive phases, such as medium-grained granite or porphyritic rhyolite dykes, and/or with zones of strong sericite alteration. The nature of the mineralization varies dramatically, depending on the host rock. Massive carbonate units host manto-type deposits: Midway in the McDame Group, Silverknife and Butler Mountain (southern Yukon) in the Rosella Formation. The Cassiar batholith hosts silver-lead-zinc veins, such as the Lucky and Luck, and porphyry-type mineralization within and south of the Ran claims where quartz veins within an extensive sericite alteration zone carry sporadic molybdenite and gold and silver values.

The Tootsee River fault system exerted structural control over the location of several important deposits: Midway (MI 104O-047), Silverknife and Butler Mountain fall within it. Midway lies at the intersection of a linear defined by a series of west-northwesterly trending sericite alteration zones (Gum Mountain-Pyrrhotite Creek, Brinco Hill) and the Tootsee River fault system. These alteration zones contain quartz stockworks, abundant secondary pyrite and minor silver-lead-zinc in veins, seen in float at base of Gum Mountain. The Tootsee Star vein showing (MI 104O-039) may also be related to this system. Porphyritic rhyolite dykes occur on Gum Mountain and at the base of Pyrrhotite Creek.

TABLE 3-6-2
MINERAL OCCURRENCES, 104O/16

	Name	Minfile No.	Economic Minerals	Description
I. Upper Devonian-Lower Mississippian Sedex type, in Earn Group	1. Midway exhalites — Discovery Zone, Upper Zone, etc.	104O-038	sl, gn? py	bedded siliceous pyritic exhalites; in some cases with minor barite, sphalerite, galena. in fine-grained Earn clastics
	2. Ewen Barite	104O-050	barite	pure, bedded barite exhalite in fine-grained Earn clastics
	3. Perry Barite		barite	pure, bedded barite exhalite in fine-grained Earn clastics; more or less on strike with Ewen Barite, forms a synclinal keel cut off above by a shallowly dipping thrust/decollement
II. Deposits related to main phase of Cassiar batholith (probably mid-Cretaceous)	4. Nancy	104O-013	mb, gn, sl, scheelite, py	molybdenite, plus minor pyrite, galena, sphalerite in quartz veins cutting coarse-grained granite; scheelite in adjacent skarns in Kechika Group rocks

	Name	Minfile No.	Economic Minerals	Description
II. Deposits related to main phase of Cassiar batholith (probably mid-Cretaceous)	5. Amy	104O-004	sl, gn, aspy, freibergite, py	concordant lead-zinc-silver replacement zones in limy Kechika Group sediments adjacent to Cassiar batholith. The Kechika sequence is cut by several coarse-grained muscovitic, greisenized late stage dykes of Cassiar batholith
III. Deposits of Late Cretaceous to Eocene age A. Manto Lead-Zinc Silver	6. Midway — Lower Zones Discovery and Silver Creek Deposits	104O-047	gn, sl, aspy, py, po, marcasite, cpy freibergite, pyrargyrite, geocronite, cassiterite	irregular replacement Ag-bearing massive sulphide bodies at or near top of McDame Group
	7. Silverknife	104O-048	gn, sl, pyrargyrite, tetrahedrite, py	sulphide replacement zones, generally concordant, in marble at gradational Atan-Kechika contact. Hornfelsing is pervasive although source not exposed. No surface showings. Strike length reported 137 m, true width 4.6 m. Weighted average assay values to 511 g/tonne Ag, 3.7 g/tonne Au, 12.25% Pb, 4.8% Zn
B. Lead-Zinc-Silver Veins	8. Tootsee Star	104O-039	gn, sl, py	quartz veinlets in narrow shear zone hosted by Sylvester argillites-cherts. A grab sample assayed 35.3 g/tonne Ag
	9. Lucky		gn, sl, tet?	Two northeast-trending veins, marked by boulder trains on B.C. side of border, cut medium-grained granite and megacrystic (main phase Cassiar) granite
	10. Luck	104O-033	gn, sl, cpy	one out of the five veins in this occurrence is located on the B.C. side of the border. They all trend roughly east-west and cut Cassiar granite
	11. Silvertip	104O-003	gn, sl, tetrahedrite, stannite, py	lead-zinc-silver replacement bodies in McDame limestone; surface exposures highly oxidized. Presence of tin indicates magmatic hydrothermal source
	12. Ran, Reb, Hat claims	104O-037	py, mb, argentite, gn, sl, cpy	Extensive sericite alteration zone in Cassiar batholith; fine-grained granite, rhyolite dykes. Mineralization in quartz veins: Au to 0.7 g/tonne on Reb claims (A.R. 9128), Ag to 3800 g/tonne on Ran claims (grab sample this program).
IV. Other	13. Berg	104O-015	gn, sl, py, hydrozincite, cerussite	highly oxidized mineralization, mostly chunks of Fe-Mn gossan, occurs where a thin screen of Earn sediments overlie McDame limestone
	14. Gunnar Berg	104O-032	gn, mb, scheelite	quartz breccia zone in Tapioca sandstone quartzite adjacent to altered, quartz-veined Cassiar contact. Mineralization is minor

Exploration for manto deposits of the Midway type should focus on the following three parameters:

(1) Massive carbonate host rocks. Although Midway is localized within the McDame Group, where early karsting played a role in ground preparation, the Cambrian Rosella Formation also hosts manto mineralization and should not be overlooked.

(2) Proximity to major normal fault systems. The Tootsee River fault system extends 15 kilometres north of the Yukon border, where it intersects a segment of the Kechika fault. The fault system east of the Ewen Barite deposit and its northward extension into the Yukon are also favourable structural targets.

(3) Association with sericite alteration and felsic dykes. The magmatic hydrothermal systems that give rise to manto mineralization in massive carbonates tend to produce an "epithermal" imprint in noncarbonate rocks.

CONCLUSIONS

Map area 104O/16 is underlain in part by autochthonous miogeoclinal strata ranging from Lower Cambrian to Lower Mississippian. The youngest autochthonous stratigraphic unit, the Earn Group, hosts baritic and siliceous exhalites analogous to sedex deposits east of the Tintina fault. The Sylvester Allochthon overrode the North American continental margin in Jurassic time as part of a collisional event that produced a wide variety of major and minor structures, including northeasterly verging thrusts that involve miogeoclinal rocks.

Late Cretaceous to Eocene major high-angle wrench fault systems in 104O/16 developed in response to larger scale dextral movement on the Kechika and Cassiar faults.

Manto silver-lead-zinc deposits postdate the main, mid-Cretaceous phase of the Cassiar batholith. They are controlled by the coincidence of favourable massive carbonate host rocks (McDame or Atan), major high-angle faults, volumetrically insignificant amounts of felsic intrusive rocks and, in the case of Midway, are spatially associated with strong sericite alteration in noncarbonate lithologies.

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