STRATIGRAPHY AND TECTONICS OF THE GATAGA AREA NORTHEASTERN BRITISH COLUMBIA* (94E/16, 94F/14, 94K/4, 94L/1, 94L/7, 94L/8)

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INTRODUCTION

This paper presents the results of two field seasons regional and detailed mapping of the Gataga area of northeastern British Columbia (Figure 3-7-1), within NTS sheets 94E/16, 94F/14, 94K/4, 94L/1, 94L/7 and 94L/8. The research described forms part of a multidisciplinary study of the tectonics, sedimentation and mineralization of the middle to late Paleozoic Kechika trough.

The Gataga area contains major stratiform barite-zinc-lead mineralization, for example, the Driftpile Creek, Bear and Saint occurrences (McClay and Insley, 1986; MacIntyre, 1981, 1983; Carne and Cathro, 1982). The objectives of the research program are: to determine the stratigraphy and structure of the Gataga area; to determine the nature and extent of the stratiform mineralization; to investigate the mineralogy and geochemistry of the mineral deposits; and to develop models for their deposition and distribution. In the 1986 field season detailed structural and stratigraphic mapping was carried out at a scale of 1:20 000 over approximately 3000 square kilometres of the Gataga area (Figure 3-7-1).

Previous work in the Gataga area has chiefly been reconnaissance style 1:250 000-scale mapping (Gabrielse, 1962; Taylor and Stott, 1973; MacIntyre, 1981, 1983) and detailed exploration of the Driftpile and Bear mineralization by Archer Cathro & Associates on behalf of the Gataga Joint Venture (Carne and Cathro, 1982). This project began in 1985 with detailed mapping of the Driftpile Creek area (McClay and Insley, 1986) and continued in 1986 with a regional mapping program designed to investigate the tectonics and stratigraphy of the Gataga district. Strata range from Late Precambrian (Hadrynian) to Mississippian in age and occur in a 180-kilometre-long, northwest-trending complex fold and thrust belt within the western Rocky Mountains. The stratiform barite-iron-zinc-lead mineralization occurs in Devonian siliciclastic rocks of the Kechika trough, the southern extension of the Selwyn Basin in the Yukon.

LOCATION AND TOPOGRAPHY

The Gataga area lies within the Muskwa Range of the northern Rocky Mountains, between the Kechika River (the northern extension of the Rocky Mountain Trench) to the west, the Gataga River to the east and northeast and Weissener Creek to the south. Elevations range from 1100 metres to over 2500 metres, and the area is characterized by long ridges and valleys parallel to the dominant northwest-trending structural grain. Treeline reaches up to the 1500-metre elevation with abundant vegetation of mixed woodland in valley bottoms and poplar, pine and grasses on higher ground. The best outcrop is found in river sections and at the higher elevations. Access to the area was by helicopter from Sturdee Valley (in the Toodoggone area) or fixed-wing aircraft from Dease Lake. A 640-metre dirt airstrip, approximately 2 kilometres from the base camp on Driftpile Creek (latitude 58°04′ north; longitude 125°55′ west), at an elevation of 1340 metres, is suitable for small fixed-wing aircraft.

GEOLOGICAL SETTING OF THE GATAGA AREA

The Gataga fold and thrust belt includes part of the northwest-trending Kechika trough, the southern extension of the Paleozoic Selwyn Basin (Figure 3-7-1). It is bounded on the west by the Rocky Mountain Trench-Kechika dextral strike-slip fault system (Gabrielse, 1985) and on the east by folded and thrusted Hadrynian siliciclastics (Taylor and Stott, 1973) (Figure 3-7-2). Strata within the Gataga area include: Hadrynian through Late Cambrian platformal siliciclastics and carbonates; Cambro-Ordovician through Silurian fine-grained siliciclastics, carbonates and cherts; mid-Devonian to Mississippian fine-grained, black siliciclastics of the Kechika trough. The Gataga fold and thrust belt comprises four distinct tectono-stratigraphic assemblages bounded by steeply southwesterly dipping thrust faults verging to the northeast (Figure 3-7-2). Within each thrust slice the strata generally young westwards. In addition to the stratiform sulphide deposits of the Gataga area, the Kechika trough also hosts the Cirque, Elf and Fluke barite-zinc-lead deposits (MacIntyre, 1983) further to the south (Figure 3-7-1). These deposits are considered to have formed from metalliferous fluids discharged into local basins along contemporaneous block faults related to crustal extension during the Middle to Late Devonian (Gordey *et al.*, 1982; MacIntyre, 1983).

STRATIGRAPHY

Stratigraphic nomenclature adopted in this report follows that of Fritz (1980), Gabrielse (1962), MacIntyre (1983) and Taylor and Stott (1973). Strata range in age from Hadrynian through to early Mississippian and form a complex northwest-striking fold and thrust belt. Generally recessive Ordovician through Devonian shales, siltstones, cherts, thin limestones and lensoidal bodies of chert pebble conglomerate form a highly deformed core in the eastern part of the thrust belt, centred about the Driftpile Creek

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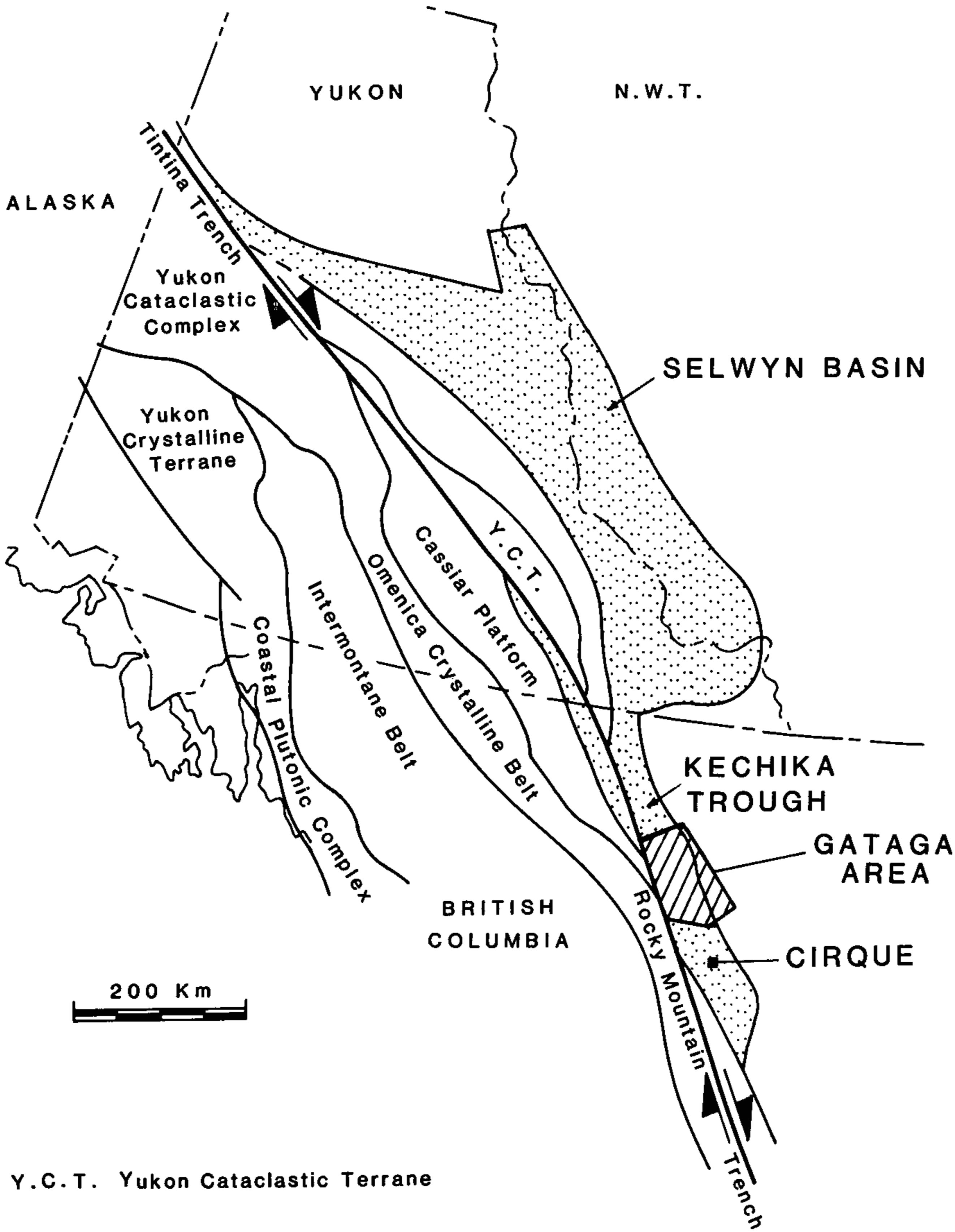

Figure 3-7-1. Regional setting of the Gataga area in the Kechika trough of Northeastern British Columbia.

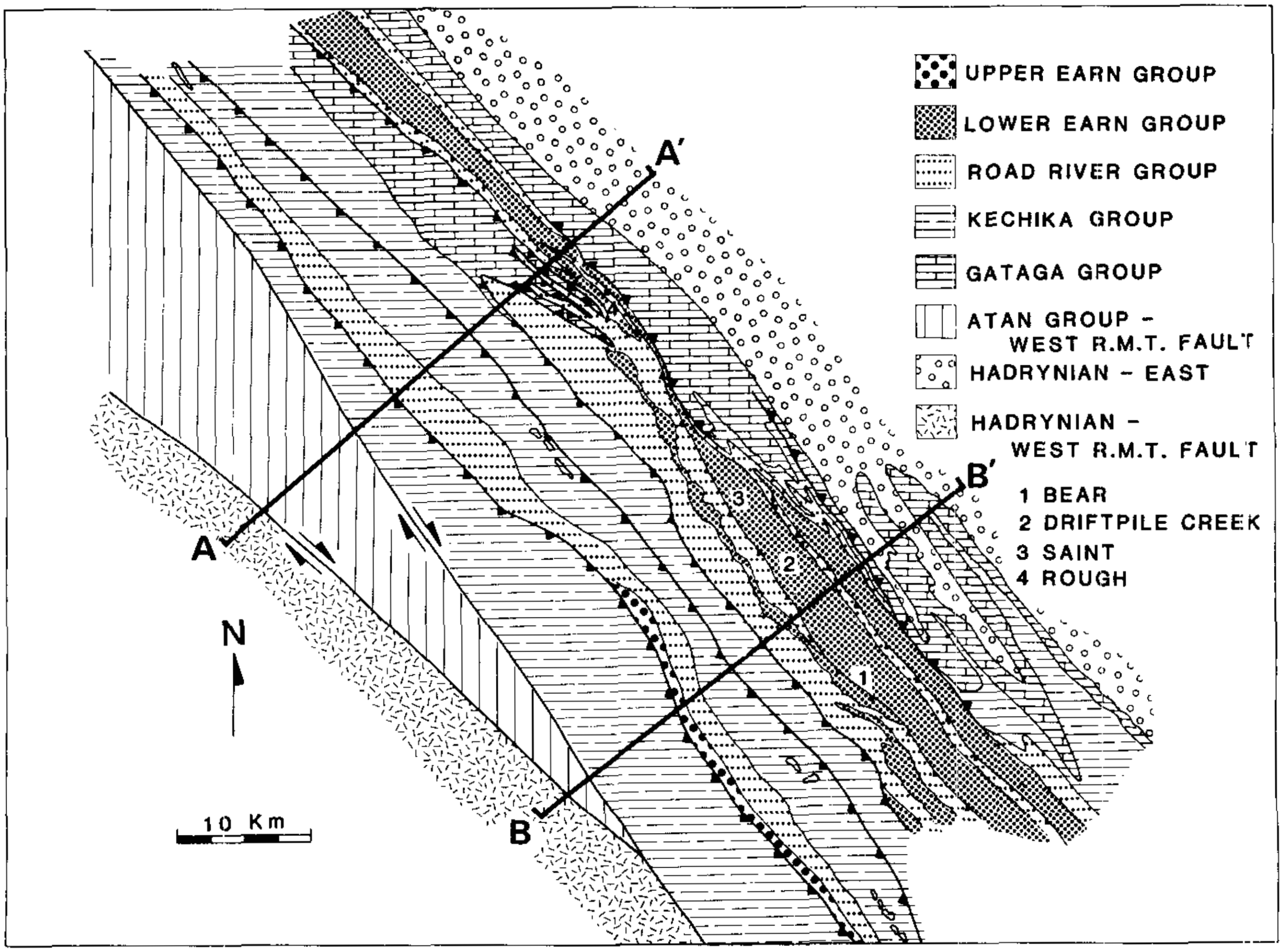

Figure 3-7-2. Summary geological map of the Gataga area.

deposit (Figure 3-7-2). These siliciclastic rocks are flanked to the west by more resistant, west-dipping thrust panels of strongly folded Cambrian through early Ordovician limestones, dolomites, dolomitic siltstones and phyllites of the Kechika Group (Figure 3-7-3). Thick, strongly resistant, steeply dipping panels of folded and thrust Proterozoic argillites and sandstones together with Cambrian quartzites and limestones form the eastern margin of the Gataga area. Stratigraphic columns incorporating data from both the eastern and western parts of the area are shown in Figure 3-7-3. In places accurate thickness determinations are hampered by the intense deformation and cleavage development.

LATE PROTEROZOIC (HADRYNIAN) — EASTERN PART OF THE MAP AREA

The lowermost strata exposed in the map area are a thick succession of green slates, phyllites, brown sandstones, quartz pebble grits and minor oolitic limestone lenses. These lithologies are interpreted to be Late Proterozoic (Hadrynian) in age (Taylor and Stott, 1973), and form the cores of anticlines and the hangingwall panels of thrust sheets at the eastern margin of the map (Figure 3-7-2). They are generally poorly exposed and strongly deformed with penetrative cleavages found in the phyllitic units.

LATE PROTEROZOIC (HADRYNIAN) — WESTERN PART OF THE MAP AREA

West of the Rocky Mountain Trench dextral strike-slip fault (Figure 3-7-2) strongly deformed metaquartzites and schists of the Late Proterozoic Swannell Formation (Evanchick, 1985) form the resistant outcrops of the Sifton Ranges. The quartzites are in places strongly sheared and recrystallized and have reached garnet-grade upper greenschist facies metamorphism. These units were not mapped in detail.

GATAGA GROUP (CAMBRIAN) — EASTERN PART OF THE MAP AREA

The Gataga Group (informal name) comprises a thick (1.1 to 2.0 kilometres) miogeoclinal succession of shallow water clastic sediments and carbonates that form the eastern outcrops of the fold and thrust belt (Figure 3-7-4). The Gataga Group comprises six mappable members — three clastic units and three carbonate units (Figure 3-7-3), most of which can be traced throughout the map area.

The lowermost member, the Lower Clastic unit, consists of 100 to 150 metres of thin to medium-bedded quartzites and phyllitic siltstones that conformably overlie the Late Proterozoic phyllite suc-

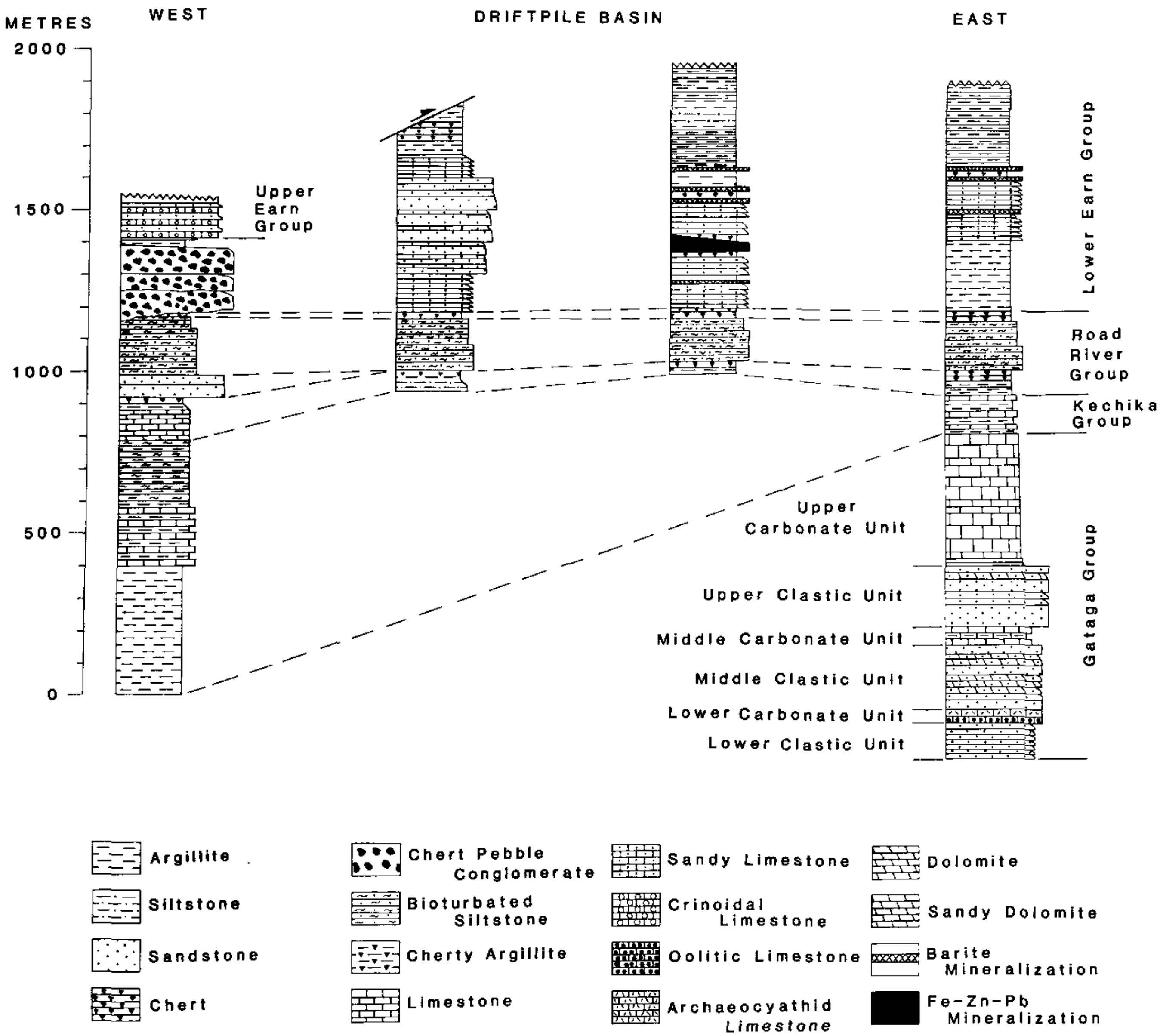

Figure 3-7-3. Summary stratigraphic columns for the Gataga area.

cession. It is overlain by a distinctive 20 to 60-metre-thick Lower Carbonate unit that consists of medium to thick-bedded, grey oolitic and Archaeocyathid limestones. These limestones are in turn overlain by approximately 200 metres of medium to thick-bedded white quartzites and buff-weathering dolomitic grits and sandstones. These lithologies typically exhibit well-developed tabular and trough crossbedding. The quartzite beds contain abundant well-developed *skolithos* trace fossils.

The Middle Carbonate unit comprises 60 metres of distinctively purple-grey-weathering, medium-bedded limestones with interbedded calcareous and noncalcareous shales. This forms a regional marker unit in most of the map area. The Middle Carbonate unit is followed by approximately 200 metres of thick-bedded white orthoquartzites and buff-weathering dolomitic grits and sandstones — the Upper Clastic unit. In places the orthoquartzite beds contain abundant *skolithos*. The Upper Clastic unit grades upwards into a distinctive medium to thin-bedded, buff-weathering fenestral dolomite that is overlain by medium to massively bedded grey, fine-grained micritic, oolitic and algal laminated limestones. These shallow water limestones and dolomites of the Upper Carbonate unit are in places approximately 1 kilometre thick and form very resistant and rugged outcrops in the eastern and northern parts of the area.

Fritz (1980) measured sections from the Upper Carbonate to within the Middle Clastic unit and assigned the latter to the late Lower Cambrian *Bonnia-Olenellus* zone based upon trilobites recovered from the overlying Middle Carbonate.

In the northern part of the Gataga area the Middle Clastics, Middle Carbonates and Upper Clastics rapidly thin out whereas the Upper Carbonate may increase in thickness.

ATAN GROUP (CAMBRIAN) — WESTERN PART OF THE MAP AREA

West of the Rocky Mountain Trench strike-slip fault (Figure 3-7-4) a fault-bounded panel of Atan Group strata crops out. These rocks comprise thick units of folded and faulted carbonates and quartzites (Gabrielse, 1962; Mansy and Gabrielse, 1978) but were not mapped in detail during the course of this study.

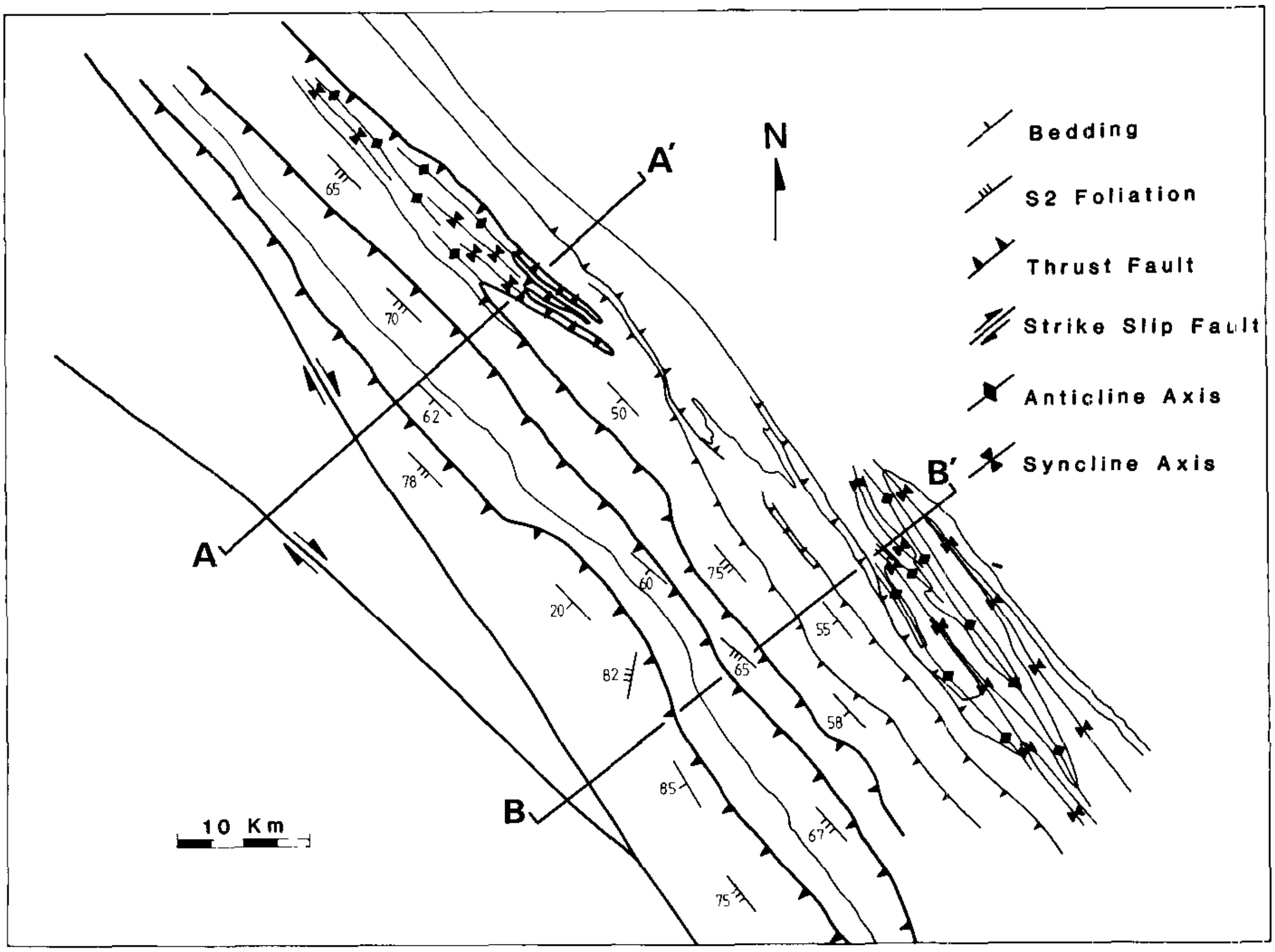

Figure 3-7-4. Tectonic sketch map of the Gataga area.

KECHIKA GROUP (UPPER CAMBRIAN-ORDOVICIAN)

The Kechika Group rocks appear to conformably overlie the Gataga carbonates in the eastern part of the map area. Here the Kechika Group consists of approximately 150 metres of grey-brown-weathering calcareous phyllites with intercalated thin-bedded limestones and is apparently conformably or paraconformably overlain by Ordovician black argillites and cherts.

In the western part of the map area the Kechika Group occurs in three major thrust panels (Figure 3-7-2). Within these thrust sheets the thin-bedded phyllites and calcareous phyllites of the Kechika Group are highly deformed, making estimation of their true stratigraphic thicknesses extremely difficult. A minimum of 400 metres of poorly laminated grey-blue phyllites passes upward into grey-brown phyllites with intercalated medium-bedded grey limestones. In this part of the map area the intercalated limestone beds are more abundant and generally thicker than in the east. The calcareous phyllites and limestones are in turn overlain by 200 metres of bioturbated whispy argillites containing *zoophycos* and irregular burrow trace fossils; rare trilobite fragments have also been found in this part of the section. This upper unit of the Kechika Group is characterized by distinctive orange-weathering ferroan dolomitic beds up to 12 metres thick.

ROAD RIVER GROUP (ORDOVICIAN TO LOWER DEVONIAN)

Ordovician through Lower Devonian Road River rocks conformably overlie the Kechika Group. In the Gataga area the basal Road River rocks are a thin (approximately 30 to 60 metres thick) succession of recessive, graptolitic carbonaceous black argillites, cherts and minor thin limestones. In the eastern and central parts of the area these units are overlain by 130 to 170 metres of resistant, distinctive orange-weathering dolomitic micaceous siltstones (Figure 3-7-3) containing Silurian graptolites and abundant burrow and grazing trail trace fossils. This Silurian siltstone is a distinctive map unit in the Gataga area; it is overlain by recessive, silver-grey-weathering black argillites, black cherts and minor limestones of early Devonian age. In the western part of the area (Figure 3-7-2) the thin-bedded Ordovician limestones are succeeded by 70 metres of thick-bedded brown-weathering quartzites with thin chert pebble grit beds at the base. These resistant quartzites are overlain by at least 180 metres of thin-bedded laminated to intensely bioturbated dolomitic siltstones of similar facies to that found in the eastern part of the map area. The intense deformation in the fine-grained siliciclastics of the basal sections of the Road River Group make thickness determinations and stratigraphic correlations difficult.

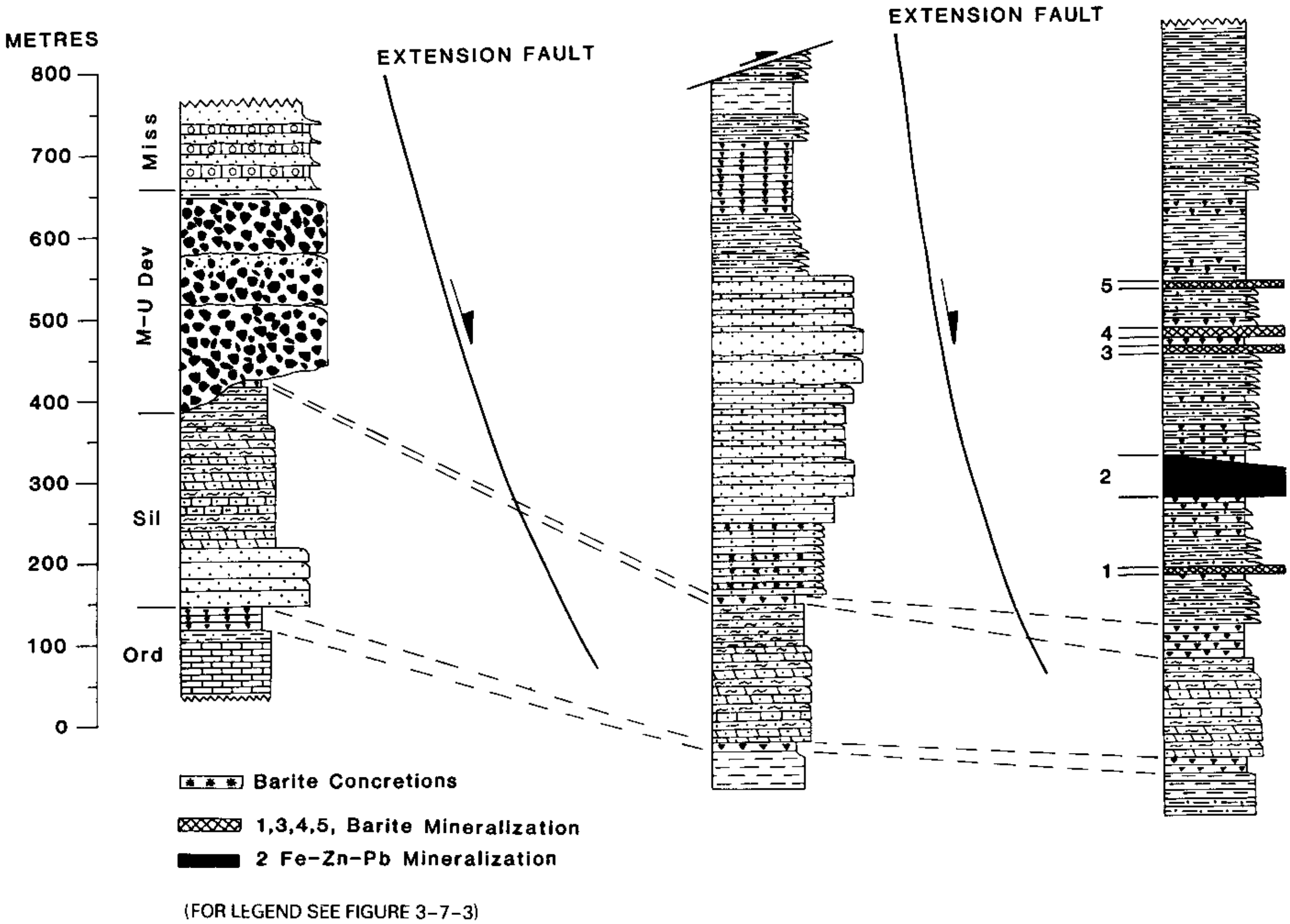

Figure 3-7-5. Detailed stratigraphic column of Devonian-Mississippian strata of the Gataga area.

LOWER EARN GROUP (MIDDLE TO LATE DEVONIAN)

The Road River Group is succeeded by a highly deformed sequence of Lower Earn Group (*sensu lato* after Gordey *et al.*, 1982) "black clastics". In the western part of the map area (Figure 3-7-2) the base of the Lower Earn Group is characterized by sheets and lenses of resistant thick-bedded chert pebble conglomerates and chert grits which interfinger eastwards with thin-bedded laminated siltstones and silt-banded argillites. The westernmost exposures of the Lower Earn Group are overlain by only a few tens of metres of fine-grained black argillites which are in turn overlain by the medium to thick-bedded crinoidal grainstones and sandstones of the Upper Earn Group.

In the eastern part of the map area the base of the Lower Earn Group is generally characterized by medium to thin-bedded chert-pebble grits and sandstones and local chert-pebble conglomerates. The conglomerates and grits are overlain by several hundred metres of recessive, unlaminated to thinly laminated silver-grey-weathering black argillites, cherty argillites and cherts which range in age from Frasnian to Fammenian (Orchard, personal communication, 1985). In the eastern part of the map area this late Devonian unit, informally called the Gunsteel Formation further to the south at the Cirque deposit (Jefferson *et al.*, 1983), contains stratiform barite-lead-zinc mineralization on at least three horizons and probably a further two horizons of stratiform barite mineralization (Figure 3-7-5). These horizons have been traced for 50 kilometres along strike and are complexly repeated by folding and thrust faulting.

UPPER EARN GROUP? (MISSISSIPPIAN)

This is the uppermost formation exposed in the map area and consists of a minimum of 70 metres of grey to black, medium to thick-bedded crinoidal grainstones, sandstones and siltstones with abundant shell debris which yield a Mississippian fauna (Gabrielse, personal communication, 1986). This unit is only found in the footwall of the westernmost major thrust fault in the map area (Figures 3-7-2 and 3-7-4) and the top of the unit is not preserved.

TECTONICS OF THE GATAGA AREA

The map area comprises four principal and distinct tectonostratigraphic packages which exhibit complex polyphase folding and thrust faulting (Figures 3-7-2 and 3-7-4).

Detailed structural analysis has indicated three deformation phases (McClay and Insley, 1986):

(1) An early cleavage phase of folding on northeast-trending axes. A local early cleavage is found around Phase 1 fold hinges.
(2) Dominant northwest-striking, northeasterly verging folding and thrusting with the accompanying development of a penetrative cleavage. The folds are tight to chevron style and generally plunge gently either to the northwest or to the southeast. All thrust faults are now steeply dipping and have been rotated into their steep attitude by movement on underlying thrusts.
(3) Late southwest to west-striking dextral reverse kink folding has produced minor folds, dilatant vein systems and minor reorientation of earlier structures.

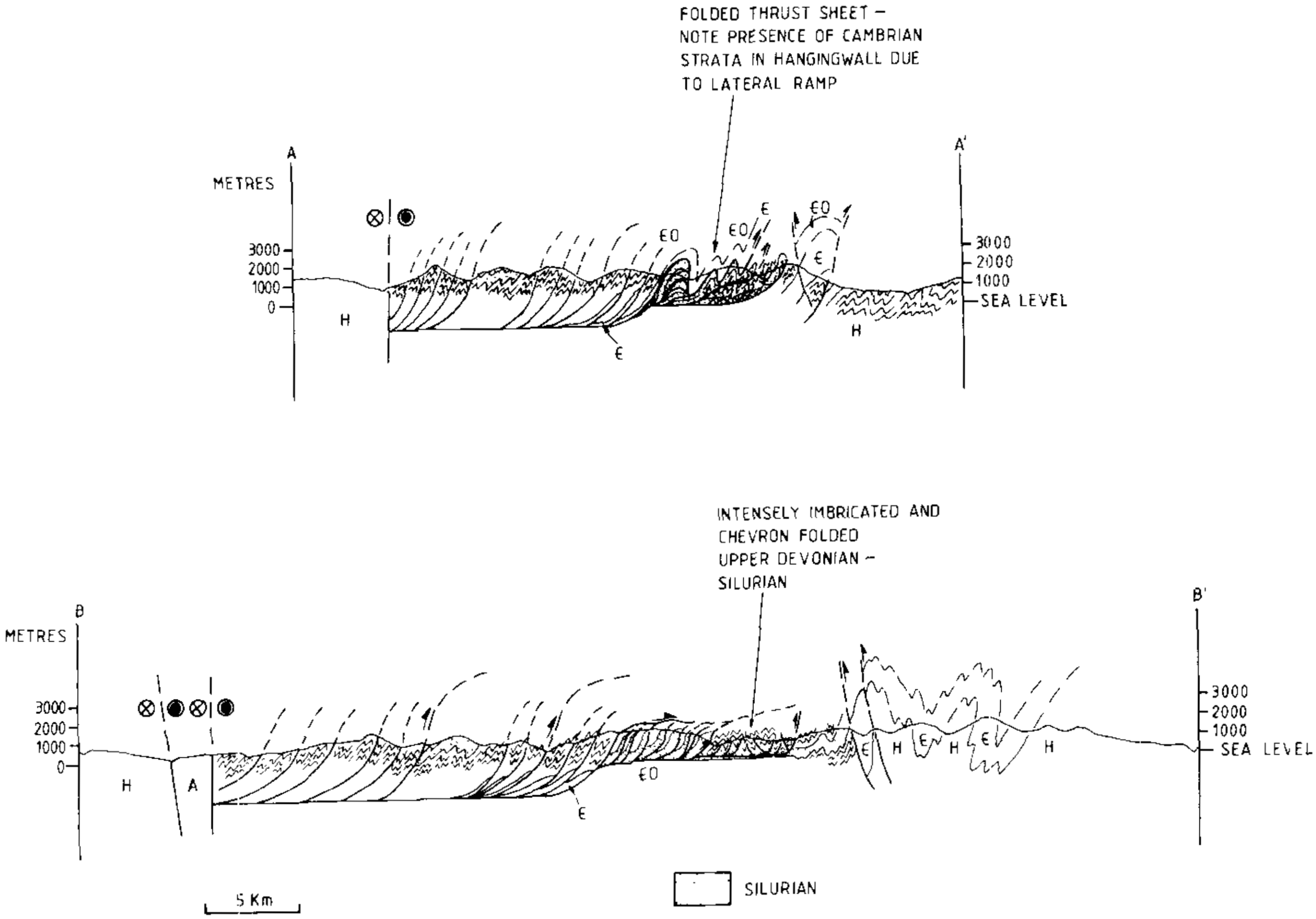

Figure 3-7-6. Cross-sections through the Gataga area.

In the western part of the map area the folds and thrusts show a northeasterly transport direction (that is, vergence northeast) whereas at the eastern boundary both northeast and southwest-verging folds and thrust faults are present. In the northern part of the area a large sheet of Cambrian strata has been thrust northeastwards over the recessive Ordovician through Devonian siliciclastics. Subsequent to emplacement this thrust sheet was folded by movement on underlying thrusts, giving rise to the complex map patterns in the northern part of the Gataga area (Figures 3-7-2 and 3-7-4).

MINERALIZATION

The Lower Earn Group siliciclastics of the Gataga area contain three to five intervals of stratiform barite (± zinc-lead) mineralization that can be mapped semicontinuously over a strike length of 50 kilometres (Figure 3-7-2). Within this mineralized interval (Figure 3-7-5) local lenses of sulphide enrichment have been the targets of exploration. Three occurrences of stratiform barite (± lead-zinc) mineralization have so far been identified, the Driftpile, Bear and Saint prospects (Figure 3-7-2). The most important is the Driftpile Creek deposit held by the Gataga Joint Venture. It consists of at least three stratiform intervals of barite-pyrite-galena-sphalerite mineralization. Preliminary biostratigraphic analysis using conodonts indicates a Frasnian to Fammenian (Late Devonian) age (M. Orchard, personal communication, 1985) for the deposits.

The barite mineralization is typically rhythmically interbedded massive, laminated and blebby barite and siliceous, cherty argillites over thicknesses from 5 to 50 metres. Detailed descriptions of the mineralization are given in McClay and Insley (1986).

In the northern part of the Gataga area the Rough prospect is an occurrence of vein-style mineralization (quartz, pyrite, ± galena and sphalerite) in cherty argillites, chert breccias and dolomitic siltstones. The mineralization can be traced over a strike length of 5 kilometres and occurs in the immediate footwall of a large thrust fault.

DISCUSSION AND CONCLUSIONS

Regional and detailed mapping of the Gataga area has confirmed the structural interpretations of the 1985 fieldwork (McClay and Insley, 1986) and has redefined the stratigraphy of the area.

Phase 1 deformation produces local zones of steep fold plunges and may be related to either syndepositional deformation during the mid-Devonian extension or to early thrust deformation during the emplacement of the large thrust sheets of Cambrian strata. Further analysis is required to resolve this problem.

The dominant Mesozoic thrusting and folding of Phase 2 deformation has produced both southwestward and northeastward tectonic transport on the margins of the Kechika trough. There is a strong lithostratigraphic control on deformation style with the massive competent carbonate units forming thick thrust panels whereas the fine-grained siliciclastics in the central fold and thrust belt are tightly folded, cleaved and faulted. This "palaeo-triangle zone" of ductile Road River and Earn Group rocks in the Kechika trough acted as a buffer zone between the two opposing thrust complexes to the northeast and southwest. Continued deformation on underlying "blind thrusts" beneath the exposed section rotated and steepened the thrust sheets at the present surface (Figure 3-7-6).

Phase 3 deformation may be interpreted in terms of a dextral shear couple associated with late Cretaceous dextral strike-slip faulting along the Rocky Mountain Trench (Gabrielse, 1985).

Within the Kechika trough, the Middle to Late Devonian Lower Earn Group siliciclastics thicken and coarsen westwards suggesting that they were deposited in extensional half-grabens. Further analysis of measured sections and of sedimentological data is needed to develop a tectono-sedimentary model for these units and for the stratiform mineralization found in the Devonian.

FUTURE RESEARCH

Future research will involve the palinspastic reconstruction of the Gataga map area involving the construction and restoration of balanced sections; determination of the detailed structural evolution of the area; analysis of the detailed sedimentology from measured sections; and geochemical and isotopic analysis of the stratiform mineralization. These techniques will be used to erect and test models for the tectonics, sedimentation and mineralization of this part of the Kechika trough.

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REFERENCES

Carne, R.C. and Cathro, R.J. (1982): Sedimentary Exhalative (Sedex) Zinc-Silver-Lead Deposits, Northern Canadian Cordillera, *Canadian Institute of Mining and Metallurgy*, Bulletin, Volume 75, pages 66-78.

Evanchick, C. (1985): Stratigraphy, Metamorphism, Structure, and their Tectonic Implications in the Sifton and Deserters Ranges, Cassiar and Northern Rocky Mountains, Northern British Columbia, Ph.D. Thesis, Queen's University, Kingston, Ontario.

Fritz, W.H. (1980): Two Cambrian Stratigraphic Sections near Gataga River, Northern Rocky Mountains, British Columbia, *in* Current Research, Part C, *Geological Survey of Canada*, Paper 80-C, pages 113-119.

Gabrielse, H. (1962): Kechika, British Columbia, *Geological Survey of Canada*, Map 42-1962.

——— (1985): Major Dextral Transcurrent Displacements along the Northern Rocky Mountain Trench and Related Lineaments in North-central British Columbia, *Geological Society of America*, Bulletin, Volume 96, Number 1, pages 1-14.

Gordey, S.P., Abbott, J.G. and Orchard, M.J. (1982): Devono Mississippian (Earn Group) and Younger Strata in East-central Yukon, *in* Current Research, Part B, *Geological Survey of Canada* Paper 82-B, pages 92-100.

Jefferson, C.W., Kilby, D.B., Pigage, L.C. and Roberts, W.J. (1983): The Cirque Barite-Lead-Zinc Deposits, Northeastern British Columbia, *in* Sangster, D.F. (editor), Sediment Hosted Stratiform Lead-Zinc Deposits, *Mineralogical Association of Canada* Short Course Notes, Volume 9, pages 121-140.

McClay, K.R. and Insley, M.W. (1986): Structure and Mineralization of the Driftpile Creek Area, Northeastern British Columbia (94E/16, 94F/14, 94K/4, 94L/1), *B.C. Ministry of Energy, Mines and Petroleum Resources*, Geological Fieldwork 1985, Paper 86-1, pages 343-350.

MacIntyre, D.G. (1981): Geology of the Akie River Ba-Pb-Zn Mineral District, *B.C. Ministry of Energy, Mines and Petroleum Resources* Preliminary Map Number 44.

——— (1983): Geology and Stratiform Barite Sulphide Deposits in Northeastern British Columbia, *in* Sangster, D.F. (editor), Sediment Hosted Stratiform Lead-Zinc Deposits, *Mineralogical Association of Canada*, Short Course Notes, Volume 9, pages 85-120.

Mansy, J.L. and Gabrielse, H. (1978): Stratigraphy, Terminology and Correlation of Upper Proterozoic Rocs in the Omenica and Cassiar Mountains, North Central British Columbia, *Geological Survey of Canada*, Paper 77-19, 17 pages.

Taylor, G.C. and Stott, D.F. (1973): Tuchodi Lakes Map-area, British Columbia, *Geological Survey of Canada*, Memoir 373.