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GEOLOGY OF THE NORTHEASTERN NIDDERY LAKE MAP AREA, EAST-CENTRAL YUKON AND ADJACENT NORTHWEST TERRITORIES

M.P. Cecile

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Cover Illustration
View looking north at thin imbricate thrusts within the Rogue Décollement Complex west of the study area (ISPG Photo 4460-1).

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GEOLOGY OF THE NORTHEASTERN NIDDERY LAKE MAP AREA, EAST-CENTRAL YUKON AND ADJACENT NORTHWEST TERRITORIES

ABSTRACT

The northeastern Niddery Lake map area is underlain by autochthonous North American strata. These include uppermost Proterozoic shallow- and deep-water strata, the edge of the Lower Cambrian Blackwater Platform and adjacent Selwyn Basin, Middle Cambrian to Silurian basin strata deposited on the Niddery submarine high, and Middle Devonian to Carboniferous strata deposited in the middle of a major foredeep clastic basin that stabilized at the end of the Paleozoic with a complex of shallow- and deep-water strata. Lower Paleozoic rocks include significant volumes of alkaline volcanic and volcanoclastic strata.

In this bulletin, twenty-seven mappable units in four different facies zones are identified and ten new formations within them described: Algae Lake, Old Cabin, Elmer Creek, Hailstone, Misfortune, Thor Hills, Hawthorne Creek, Heritage Trail, Keele Creek, and Fourway. The "tectonostratigraphic map unit" is defined for the first time.

The northeastern part of the Niddery Lake map area comprises three major structural complexes: Mackenzie Fold Belt, Rogue Décollement Complex, and Keele Thrust Belt. The Mackenzie Fold Belt contains open to tight folds and thrusts and is shortened by approximately 20 per cent. The Rogue Décollement Complex is shortened by more than 80 per cent and is made up of small folds with amplitudes three to five times their wavelength. In the complex, fold axes bend northwest in association with the northwest-trending Macmillan–Hess strike–slip fault system. The Keele Thrust Belt consists of stacks of gently dipping thrusts repeating Paleozoic strata, and is shortened by more than 50 per cent.

Upper Cretaceous Selwyn Plutonic Suite granite–granodiorite plutons intrude the deformed strata of the area, which are sub-greenschist facies. Most Conodont Colour Alteration Indices range between 4.5 and 5.5. The area includes fifteen economic mineral occurrences.

RÉSUMÉ

La portion nord-est de la région cartographique de Niddery Lake est occupée par des couches autochtones du continent nord-américain. Celles-ci appartiennent, entre autres, à des successions du Protérozoïque sommital déposées en eau peu profonde et en eau profonde; à une succession du Cambrien inférieur déposée à la bordure de la plate-forme de Blackwater et dans le bassin de Selwyn adjacent; à une succession de bassin du Cambrien moyen au Silurien déposée sur la hauteur sous-marine de Niddery; à une succession du Dévonien moyen au Carbonifère déposée au milieu d'un important bassin d'avant-fosse à sédimentation détritique qui s'est stabilisé à la fin du Paléozoïque, ce qui a donné lieu à la formation d'un assemblage complexe de couches d'eau peu profonde et d'eau profonde. Les roches du Paléozoïque inférieur comprennent des quantités importantes des roches volcaniques alcalines et de strates volcaniclastiques.

Dans le présent bulletin, on a délimité vingt-sept unités cartographiques appartenant à quatre zones de faciès différentes. Parmi celles-ci, dix nouvelles formations sont ici décrites : Algae Lake, Old Cabin, Elmer Creek, Hailstone, Misfortune, Thor Hills, Hawthorne, Heritage Trail, Keele Creek et Fourway. Le concept d'«unité cartographique tectonostratigraphique» est défini pour la première fois.

La portion nord-est de la région cartographique de Niddery Lake regroupe trois complexes structuraux majeurs : la zone de plissement de Mackenzie, le complexe de décollement de Rogue et la zone de chevauchement de Keele. La zone de plissement de Mackenzie renferme des plis ouverts à serrés ainsi que des failles de chevauchement qui témoignent d'un raccourcissement d'environ 20 pour cent. Le complexe de décollement de Rogue révèle un raccourcissement de plus de 80 pour cent et est formé de petits plis dont l'amplitude est de trois à cinq fois leur longueur d'onde. Dans le complexe, on observe une courbure vers le nord-ouest des axes de plis associée à la présence du système de failles de coulissage de Macmillan–Hess qui s'étire dans une direction nord-ouest. La zone de chevauchement de Keele se compose d'empilements de nappes de charriage légèrement inclinées dans lesquelles sont répétées les couches du Paléozoïque. Le raccourcissement y atteint plus de 50 pour cent.

Des plutons de granite-granodiorite de la Suite plutonique de Selwyn du Crétacé tardif se sont mis en place dans les couches déformées de la région, lesquelles ont été métamorphisées dans des conditions inférieures à celles du faciès des schistes verts. Les indices d'altération de la couleur des conodontes varient pour la plupart entre 4,5 et 5,5. Quinze indices minéralisés d'intérêt économique ont été localisés dans la région.

SUMMARY

The northeastern Niddery Lake map area covers a region where strata on the southwestern margin of the Blackwater Platform are transitional into Selwyn Basin. The Lower Cambrian of the Blackwater Platform is represented by a large area of shallow-water clastic and carbonate strata that covers most of the northern and eastern cordillera and interior plains to the Canadian Shield (Cecile et al., 1997). Selwyn Basin is an area now underlain by time-equivalent basin facies strata that extend across most of the southwestern part of the northern cordillera, underlain by autochthonous North America strata. From the Middle Cambrian to the Silurian, a marine rift, Misty Creek Embayment, located immediately northeast of the Niddery area, and a local submarine high, Niddery High, found in the study area, complicated the transition from Blackwater Platform to Selwyn Basin.

There are twenty-seven mappable formations and members constituting four different facies zones in the study area. Ten new formations and three new members are proposed. These are, from oldest to youngest: Algae Formation (Proterozoic), Senoah and Arrowhead Lake members (Narchilla Formation - Proterozoic–Cambrian), Keele Member (Gull Lake Formation - Cambrian), Old Cabin Formation or tongue (Cambrian–Silurian - a mappable volcanic unit crossing other stratigraphic boundaries but largely equivalent to and within the Gull Lake Formation), Elmer Creek Formation (Ordovician), Hailstone Formation (Lower–Middle Devonian), Misfortune Formation (Lower–Middle Devonian), Thor Hills Formation (Upper Devonian), Hawthorne Creek Formation (Mississippian), Heritage Trail Formation (Mississippian), Keele Creek Formation (Mississippian), and Fourway Formation (Pennsylvanian). All of these are in the Tsichu Group, which is here elevated from the informal Tsichu formation.

The latest Proterozoic strata underlying the area represent both shallow- and deep-water clastic and carbonate facies deposition: Algae Formation (shallow-water, carbonate), Senoah Member–Narchilla Formation (deep-water, clastic), and Backbone Ranges Formation (shallow-water, clastic). By the Early Cambrian, rocks in the southwest of the area were Selwyn Basin facies consisting of the Arrowhead Lake Member, Narchilla and Gull Lake formations (both deep-water, clastic), while in the northeast, they were Blackwater Platform (edge) facies consisting of upper Backbone Ranges (shallow-water, clastic) and Sekwi (shallow-water and transitional-to-basin, carbonate–clastic) formations. The paleogeography changed from the Middle Cambrian to Silurian, with deposition of anomalously thin basin strata on the Niddery High in the northeast of the study area (Hess River – clastic and carbonate, Rabbitkettle – carbonate, Duo Lake – clastic; all deep-water formations). Northeast of the Niddery High, the same basinal strata thicken toward a major rift basin (Misty Creek Embayment) that formed a prominent recess into the Blackwater Platform, which had stepped back to the northeast. Southwest of the Niddery High, Selwyn Basin facies strata continued to accumulate but were more argillaceous and cherty (upper Gull Lake, Elmer Creek, and Steel formations – all deep-water, clastic). During the Middle Silurian to Early Devonian the Niddery High was an area of nondeposition or erosion, but sediments continued to accumulate in parts of Misty Creek Embayment to the northeast of the study area (Cloudy Formation – carbonate; Cecile, 1982), and in Selwyn Basin in the southwest and south of the study area (Steel Formation – deep-water, clastic). In the Early and Middle Devonian, Blackwater platform (Grizzly Bear Formation – shallow-water, carbonate) was re-established in the northeast of the area. Deposition in the southwest consisted of transitional-to-basin, and basin facies (Hailstone and upper Sapper formations – deep-water and slope carbonate) and farther southwest Selwyn Basin facies (lower part of the Misfortune Formation – deep-water, clastic).

Middle Devonian to Carboniferous strata underlying the area record a major change in the tectonic framework of the Canadian Cordillera. These strata, in the northeastern Niddery Lake map area, represent the central part of a major, deep-water, foredeep clastic basin, with northeasterly and easterly sourced clastics on the northeast (deep-water clastics, Canol and Imperial formations), and locally and westerly derived deep-water clastics on the southwest (upper Misfortune and Thor Hills formations). By the Carboniferous this foredeep basin filled and/or stabilized, and deposition in the study area resulted in a complex of shallow-water clastic and carbonate rocks interstratifed with deeper water shale and limestone (Tischu Group), along with land areas marked by significant erosion of older strata.

Lower Paleozoic rocks, in particular Cambrian strata, include significant volumes of volcanic and volcaniclastic strata. These are alkali basalts and basanites, typical of extensional tectonic environments.

Strata in northeastern Niddery Lake map area are biostratigraphically controlled with more than 165 macro- and microfossil collections. The majority of ages are based on graptolites and conodonts, but a variety of other macrofauna have also been identified. This map area was the site of the first collections in Canada of the important trace fossil *Oldhamia*, which is an important index fossil for Lower Cambrian to earliest Middle Cambrian.

The tectonostratigraphic map unit is a pragmatic approach to mapping in a structurally complex area. It is here defined as an area of outcrop with complex structural repetition that contains more than 50 per cent of the formation from which it derives its name, and includes some outcrop of older and younger units repeated in fold noses or keels, or repeated on faults. The Elmer Creek and Steel formations, for example, can be mapped as separate stratigraphic units locally only at a 1:50 000 scale. In practice, most areas mapped as the Elmer Creek Tectonostratigraphic Unit are more than 80 per cent Elmer Creek Formation, and much more than 60 per cent of the Steel Tectonostratigraphic Unit is Steel Formation.

The northeastern part of the Niddery Lake map area includes three major structural domains: the Mackenzie Fold Belt, the Rogue Décollement Complex, and the Keele Thrust Belt. The Mackenzie Fold Belt consists of three zones which are, from northeast to southwest, the Devonian Zone, the Cambrian Zone, and the Selwyn Zone. All three zones are characterized by moderate-scale open to tight folds and high-angle thrusts. They differ in the character of strata-controlling structures, the level of fold detachment, and in the presence or absence of pervasive cleavage.

The Rogue Décollement Complex consists of locally detached, tight to isoclinal upright and overturned folds with amplitudes three to five times their wavelength, accompanied by small, locally detached thrusts. There are also steeply dipping zones composed of locally detached stacks of thin, imbricate thrusts. In chert units the folds are nearly concentric, and in shale and argillite the folds are incompetent. Shortening in the Rogue Décollement Complex is about 80 per cent (that is, to 20% of the original length).

In the Rogue Décollement Complex, axial trends of both smaller scale folds and the larger anticlinoria and synclinoria swing from southeast- to southwest-trending. This 'bending' of structure is accomplished with little to no change in the original fold attitudes, which have close to zero plunges, and is the basis for dividing this complex into north and south zones.

The swing in trend within the décollement complex is attributed to refolding associated with kilometre-scale to tens of kilometres-scale right lateral strike–slip displacement on the Macmillan–Hess Fault system, which is west-northwest-trending and found across the southern half of the Niddery Lake map area.

The Rogue Décollement Complex is detached at the base of the Lower Cambrian Arrowhead Lake Member, Narchilla Formation. Rocks below this level are folded into large, open anticlines and synclines with shortening of about 20 per cent. These deeper structures broadly fold the tight, complex structures of the Rogue Décollement Complex into major anticlinoria and synclinoria.

The Keele Thrust Belt southeast of the study area is characterized by imbricate stacks of thin thrust plates repeating Paleozoic strata, and is shortened more than 50 per cent. Thrusts in the Keele Thrust Belt are detached on the Rogue Décollement Surface, which is continuous with the Rogue Décollement Complex.

Intrusive rocks in the area include two large biotite–hornblende-bearing granodiorites (the Keele and Rogue plutons) and one small granodiorite body in the southeast. In addition there are three, small, circular stocks exposed northwest of Keele Pluton and one small granitic body north of Rogue Pluton. These plutons are part of the Selwyn Plutonic Suite, which comprises a distinctive group of inclusion poor, compositionally restricted granite and granodiorite intrusions ranging in age from 106 to 80 Ma. Both plutons and their satellites have large hornfels zones defined in host strata by drab, brown weathering colours, increased density and crystallinity, local skarn development and silicification. The hornfels forms circular zones one to two kilometres wide around the large plutons and up to 200 m wide around the small satellite bodies.

The northeastern Niddery Lake map area is within the zone of sub-greenschist facies, prehnite–pumpellyite zone metamorphism, with Conodont Colour Alteration Indices ranging from 3.0 to 6.0 (most values between 4.5 and 5.5).

There are eight known mineral occurrences, five locations with geochemical anomalies, two shallow subsurface exploration plays, and two claim groups with no specific reports on mineral occurrences in the study area. In addition, Devonian shales across the area host barite and some witherite and have been prospected for stratifrom Pb–Zn–Ag deposits. Lower Paleozoic diatremes and volcanics in the study area and immediately north and northeast of the area have been considered prospective for diamonds, but exploration has failed to demonstrate the presence of any true kimberlites.

SOMMAIRE

La portion nord-est de la région cartographique de Niddery Lake couvre une région où les couches de la bordure sud-ouest de la plate-forme de Blackwater font graduellement place à celles du bassin de Selwyn. Le Cambrien inférieur de la plate-forme de Blackwater est représenté par une vaste étendue de couches détritiques et carbonatées d'eau peu profonde qui couvre la majeure partie de la Cordillère septentrionale et de la Cordillère orientale ainsi que les Plaines intérieures, jusqu'à la bordure du Bouclier canadien (Cecile et al., 1997). Ce que l'on appelle aujourd'hui «bassin de Selwyn» consiste en une succession montrant des faciès de bassin. Les couches qui la constituent reposent sur les strates autochtones du continent nord-américain et sont des équivalents chronologiques des unités précédentes. Elles s'étendent à presque toute la portion sud-ouest de la Cordillère septentrionale. Du Cambrien moyen au Silurien, un rift sous-marin, le rentrant de Misty Creek, situé juste au nord-est de la région de Niddery Lake, et une hauteur sous-marine locale, la hauteur de Niddery, située dans la région à l'étude, ont rendu plus complexe la transition de la plate-forme de Blackwater au bassin de Selwyn.

Dans la région à l'étude, on a délimité vingt-sept unités cartographiques constituées de formations et de membres qui appartiennent à quatre zones de faciès différentes. De nouvelles appellations sont proposées pour dix formations et trois membres. De l'unité la plus ancienne à la plus récente, ce sont : la Formation d'Algae Lake (Protérozoïque), les membres de Senoah et d'Arrowhead (Formation de Narchilla - Protérozoïque–Cambrien), le Membre de Keele (Formation de Gull Lake - Cambrien), la langue ou Formation d'Old Cabin (Cambrien–Silurien -unité cartographique de roches volcaniques dont les contacts recoupent d'autres limites stratigraphiques, mais qui est en grand partie équivalente à la Formation de Gull Lake dans laquelle elle est incluse), la Formation d'Elmer Creek (Ordovicien), la Formation de Hailstone (Dévonien inférieur et moyen), la Formation de Misfortune (Dévonien inférieur et moyen), la Formation de Thor Hills (Dévonien supérieur), la Formation de Hawthorne (Mississippien), la Formation de Heritage Trail (Mississippien), la Formation de Keele Creek (Mississippien) et la Formation de Fourway (Pennsylvanien). Toutes ces unités appartiennent au Groupe de Tsichu, unité correspondant à la formation informelle de Tsichu dont on a élevé le rang.

Dans cette région, les couches déposées au Protérozoïque terminal sont formées de faciès détritiques et carbonatés qui témoignent d'une sédimentation aussi bien en eau peu profonde qu'en eau profonde (Formation d'Algae Lake [roches carbonatées d'eau peu profonde], Membre de Senoah–Formation de Narchilla [roches détritiques d'eau profonde] et Formation de Backbone Ranges [roches détritiques d'eau peu profonde]). Avant que ne débute le Cambrien précoce, se déposaient dans le sud-ouest de la région des faciès du bassin de Selwyn (Membre d'Arrowhead, formations de Narchilla et de Gull Lake [roches détritiques d'eau profonde]), tandis que dans le nord-est avait lieu le dépôt de faciès (de bordure) de la plate-forme de Blackwater (partie supérieure de la Formation de Backbone Ranges [roches détritiques d'eau peu profonde] et Formation de Sekwi [roches carbonatées-détritiques appartenant à des faciès d'eau peu profonde, ainsi qu'à des faciès de transition à des faciès de bassin]). Des modifications paléogéographiques se sont produites du Cambrien moyen au Silurien, ce qui s'est manifesté par le dépôt de couches de bassin d'une épaisseur anormalement faible sur la hauteur de Niddery dans le nord-est de la région à l'étude (faciès d'eau peu profonde des formations de Hess River [roches détritiques et carbonatées], de Rabbitkettle [roches carbonatées] et de Duo Lake [roches détritiques]). Au nord-est de la hauteur de Niddery, les mêmes couches de bassin montrent un épaississement important en direction d'un bassin d'effondrement majeur (rentrant de Misty Creek), qui forme une échancrure importante dans la plate-forme de Blackwater, laquelle montre à cette époque un mouvement de recul vers le nord-est. Au sud-ouest de la hauteur de Niddery, des unités affichant des faciès propres au bassin de Selwyn ont continué de s'accumuler, mais étaient plus argileuses et plus cherteuses (partie supérieure de la Formation de Gull Lake, Formation d'Elmer Creek et

Formation de Steel [roches détritiques d'eau profonde dans les trois cas]). Du Silurien moyen au Dévonien précoce, soit la sédimentation a cessé, soit il y a eu érosion sur la hauteur de Niddery. Cependant, les sédiments ont continué de s'accumuler dans certaines parties du rentrant de Misty Creek, au nord-est de la région à l'étude (Formation de Cloudy [roches carbonatées]; Cecile, 1982) et dans le bassin de Selwyn, dans le sud-ouest et le sud de la région à l'étude (Formation de Steel [roches détritiques d'eau profonde]). Au Dévonien précoce et moyen, la plate-forme de Blackwater s'est constituée à nouveau avec le dépôt de la Formation de Grizzly Bear (roches carbonatées d'eau profonde) dans le nord-est de la région. Au sud-ouest, la sédimentation a été caractérisée par le dépôt de faciès de transition-bassin et de faciès de bassin (Formation de Hailstone et partie supérieure de la Formation de Sapper [roches carbonatées d'eau profonde et de talus]) et encore plus loin au sud-ouest, par le dépôt de faciès du bassin de Selwyn (partie inférieure de la Formation de Misfortune [roches détritiques d'eau profonde]).

Les couches du Dévonien moyen au Carbonifère présentes dans la région témoignent d'une modification importante du cadre tectonique de la Cordillère canadienne. Dans le nord-est de la région cartographique de Niddery Lake, ces couches témoignent d'une sédimentation détritique en eau profonde dans la partie centrale d'un vaste bassin d'avant-fosse. Dans la partie nord-est de ce vaste bassin, se sont déposés des sédiments détritiques ayant leur source au nord-est (roches détritiques d'eau profonde des formations de Canol et d'Imperial), alors que dans la partie sud-ouest, les sédiments détritiques qui se déposaient en eau profonde provenaient de sources locales ou de sources situées à l'ouest (partie supérieure de la Formation de Misfortune et Formation de Thor Hills). Avant que ne s'amorce le Carbonifère, ce bassin d'avant-fosse était déjà comblé ou s'était stabilisé, de sorte que la sédimentation a donné lieu dans la région à la formation d'un assemblage complexe de roches détritiques et de roches carbonatées d'eau peu profonde qui sont interstratifiées avec des shales et des calcaires d'eau plus profonde (Groupe de Tischu). Au même moment, se déroulait dans les régions émergées une érosion importante des strates plus anciennes.

Les roches du Paléozoïque inférieur, en particulier celles du Cambrien, contiennent des volumes importants de couches volcaniques et volcanoclastiques. Il s'agit de basaltes alcalins et de basanites dont les caractéristiques sont propres aux lithologies des milieux tectoniques d'extension.

La biostratigraphie des couches présentes dans la portion nord-est de la région cartographique de Niddery Lake est bien encadrée par des collections paléontologiques qui comptent 165 macrofossiles et microfossiles. La majorité des âges ont été déterminés à l'aide des graptolites et des conodontes, mais on a identifié également divers autres macrofossiles. C'est dans cette région cartographique qu'ont été récoltées au Canada les premières collections de l'important ichnofossile *Oldhamia,* fossile caractéristique du Cambrien inférieur et de la base du Cambrien moyen.

L'unité cartographique tectonostratigraphique est utile à la cartographie de régions structuralement complexes. Selon la définition que nous en offrons dans la présente étude, elle correspond à une zone d'affleurement montrant une répétition de couches par un jeu complexe de structures tectoniques où un minimum de 50 pour cent des couches appartiennent à la formation qui donne son nom à l'unité. Elle renferme également des affleurements d'unités plus anciennes ou plus récentes qui sont répétées dans le nez ou la quille de plis ou le long de failles. Les formations d'Elmer Creek et de Steel, par exemple, ne peuvent être représentées en tant qu'unités stratigraphiques distinctes que dans des secteurs restreints sur les cartes à l'échelle de 1/50 000. Dans les faits, la plupart des secteurs rapportés à l'unité tectonostratigraphique d'Elmer Creek sur les cartes sont constitués à plus de 80 pour cent de couches de la Formation d'Elmer Creek, alors que l'unité tectonostratigraphique de Steel se compose pour sa part à beaucoup plus de 60 pour cent de couches de la Formation de Steel.

Dans la portion nord-est de la région cartographique de Niddery Lake, on reconnaît trois domaines structuraux majeurs : la zone de plissement de Mackenzie, le complexe de décollement de Rogue et la zone de chevauchement de Keele. La zone de plissement de Mackenzie comporte trois zones qui sont, du nord-est au sud-ouest, la zone dévonienne, la zone cambrienne et la zone de Selwyn. Ces trois zones sont caractérisées par des plis ouverts à serrés d'échelle moyenne et par des failles de chevauchement à angle élevé. Elles se différencient les unes des autres par la nature des structures qui régissent l'agencement des strates, le niveau des surfaces de décollement des plis et la présence ou l'absence d'un clivage pénétrant.

Le complexe de décollement de Rogue se compose de plis serrés à isoclinaux, droits à renversés, à charnière parfois isolée, dont l'amplitude est de trois à cinq fois leur longueur d'onde. Ces plis sont accompagnés de petits chevauchements, parfois isolés. On observe aussi dans le complexe des zones fortement inclinées qui se composent d'empilements, par endroits isolés, de minces écailles. Dans les unités cherteuses, les plis sont quasi concentriques, alors que dans les shales et les argilites, la déformation a produit des plis semblables. Dans le complexe de décollement de Rogue, le raccourcissement est d'environ 80 pour cent (cette zone ne montre donc plus que 20 % de sa longueur originale).

Dans le complexe de décollement de Rogue, les axes des petits plis aussi bien que ceux des grandes structures comme les anticlinoriums et les synclinoriums changent de direction, passant du sud-est au sud-ouest. Cette «courbure» des structures s'accomplit sans modification, ou si peu, de l'attitude des plis originaux dont le plongement est presque horizontal. Ce changement de direction des structures sert à diviser ce complexe en zones nord et sud. On l'attribue à un plissement ultérieur associé au coulissage dextre d'échelle kilométrique à décakilométrique survenu le long du système de failles de Macmillan–Hess, une importante entité structurale de direction ouest-nord-ouest qui traverse la demie sud de la région cartographique de Niddery Lake.

Le détachement du complexe de décollement de Rogue se situe à la base du Membre d'Arrowhead (Formation de Narchilla) du Cambrien inférieur. Les roches présentes sous ce niveau sont déformées en de vastes anticlinaux et synclinaux ouverts qui révèlent un raccourcissement d'environ 20 pour cent. Ces structures de plus grande profondeur reprennent les structures serrées à géométrie compliquée du complexe de décollement de Rogue pour former de vastes anticlinoriums et synclinoriums.

La zone de chevauchement de Keele, au sud-est de la région à l'étude, se caractérise par des empilements de minces nappes de charriage imbriquées dans lesquelles sont répétées les couches du Paléozoïque. Le raccourcissement à l'intérieur de cette zone s'élève à plus de 50 pour cent. Les failles inverses dans la zone de chevauchement de Keele se rejoignent en profondeur le long de la surface de décollement de Rogue, laquelle se situe dans le prolongement du complexe de décollement de Rogue.

Les roches intrusives de cette région appartiennent, entre autres, à deux vastes intrusions de granodiorite à biotite-hornblende (les plutons de Keele et de Rogue) et à un petit massif granodioritique, situé au sud-est. De plus, trois petits stocks circulaires affleurent au nord-ouest du pluton de Keele, ainsi qu'un petit massif granitique, au nord du pluton de Rogue. Ces plutons appartiennent à la Suite plutonique de Selwyn. Cette suite comprend un groupe d'intrusions caractéristiques de granite et de granodiorite qui affichent un éventail limité de composition, contiennent peu d'inclusions et présentent des âges se situant entre 106 et 80 Ma. Les deux gros plutons, ainsi que leurs intrusions satellites possèdent de vastes auréoles de cornéenne. Ces auréoles se manifestent dans les roches encaissantes par une couleur d'un brun terne sur les surfaces d'affleurement météorisées, une augmentation de la densité et de la cristallinité, la formation locale de skarns et une silicification. Les cornéennes forment des zones circulaires de un à deux kilomètres de largeur autour des vastes plutons et d'une largeur pouvant atteindre 200 m autour des petites intrusions satellites.

Dans la portion nord-est de la région cartographique de Niddery Lake, le métamorphisme s'est déroulé dans des conditions inférieures à celles du faciès des schistes verts, soit dans celles de la zone à prehnite-pumpellyite. Les indices d'altération de la couleur des conodontes varient de 3,0 à 6,0 et se situent surtout entre 4,5 et 5,5.

Dans la région, on a répertorié huit indices minéralisés, cinq secteurs présentant des anomalies géochimiques, deux zones d'intérêt à faible profondeur définies par forage et deux groupes de claims pour lesquels on ne recense aucun rapport faisant état de la présence d'indices minéralisés. En outre, les shales du Dévonien renferment un peu partout dans la région de la barytine et un peu de witherite et ils ont été la cible de travaux visant à découvrir des gîtes stratiformes de Pb–Zn–Ag. Des diatrèmes et des roches volcaniques du Paléozoïque inférieur dans la région à l'étude ainsi qu'au nord et au nord-est de celle-ci ont été des cibles d'exploration pour le diamant, mais on n'a pas identifié la présence de vraies kimberlites.

INTRODUCTION

The eastern part of the Northern Canadian Cordillera is underlain by autochthonous, easily distinguishable platform facies strata that have been foreshortened by thrusting and folding in a reasonably simple, well understood fashion. In the western part of the Northern Canadian Cordillera however, strata are mostly monotonous, commonly drab coloured basin facies with a much greater degree of structural complexity. Only in recent years have there been regional studies documenting the geology of this area in detail (Abbott, 1982; Abbott and Turner 1990a; Abbott and Roots, 1993; Gordey and Anderson, 1993; Gordey 1980, 1988, 1990, 1992; Cecile 1982; Cecile and Abbott 1992; Cecile and Norford, 1992, 1993; Roots and Brent, 1994; Roots et al. 1995a, b). In addition new constraints on the resolution of the structure and stratigraphy have been provided through the widespread application of conodont paleontology to the cordillera (see papers in Orchard and McCracken, 1991). There has also been considerable focus on the economic mineral deposits in the same rocks and a variety of outstanding papers on these deposits has been published recently (see papers in Morin, 1986 and in Abbott and Turner, 1990a).

In this study ten new formations and three new members are defined. They will provide the framework for mapping much of the remaining Selywn Basin and bordering platform-edge facies. In addition this study provides important insights into the internal geometry of structural domains found in Selwyn Basin, which indicate large-scale foreshortening and complex deformation. For instance, thin chert strata among incompetent shale and argillites show folds with amplitudes three times greater than wavelength and demonstrate extreme shortening. By comparison, underlying, thick, brittle Proterozoic strata are openly folded and apparently much less shortened.

Applying this new, detailed geological framework to known mineral deposits and on new plays should provide economic geologists with renewed incentives for exploring in northeast Niddery and surrounding areas. The southwest portion of map area 105-O (Niddery Lake) is host to several important mineral deposits; for example, the Tom and Jason lead–zinc–silver deposits, and the Macmillan Pass Tungsten deposit.

LOCATION

The northeastern Niddery Lake map area lies both in Yukon and the Northwest Territories, at the junction between the Mackenzie and Selwyn mountains. The south boundary of the area is 20 km north of the Macmillan Pass air strip on Canol Highway (Fig. 1, 2). In the late seventies and eighties, during a mineral exploration boom, casual helicopter charter and fixed wing air service were seasonally available at the airstrip. In recent years the nearest available fixed wing or rotary wing charters have been located in Ross River on the Canol Highway some 200 km to the south-southwest of the study area (Fig. 2). The Canol Highway is maintained by the Yukon government up to the boundary with the Northwest Territories. It is a narrow dirt road but is navigable in summer by most conventional vehicles including cars and recreational vehicles.

GEOLOGICAL SETTING

The northeastern Niddery Lake map area is underlain by rocks that were part of the autochthonous ancestral North America continental margin. The paleogeography of parts of this margin described in the following section was complex. Lower Cambrian and upper Lower to Middle Devonian strata show that the southwestern edge of the Blackwater Platform was situated across the map area, with shallow-water platform facies in the northeast and deeper water Selwyn Basin facies in the southwest. By contrast, Middle Cambrian to Silurian strata show a completely different paleogeography, spanning the submarine Niddery High over the middle of the area, but extending into a rift basin on the northeast (Misty Creek Embayment), and well into an outer miogeoclinal basin (Selwyn Basin) on the southwest (Fig. 1). During the Middle to Late Devonian the area was inundated by a complex, deep-water, foredeep clastic package with northeasterly derived strata on the northeast and westerly derived rocks in the southwest. In the latest Paleozoic, shoaling quartz arenite and limestone strata, representing varied facies, were deposited across the area.

Structurally, the northeastern part of the map area includes part of the Mackenzie Fold Belt on the northeast and the structural complexes of the Selwyn Mountains on the southwest. These variations in structural style are partly the result of variations in mechanical rock competency associated with the facies change discussed above. However, the attenuated succession of latest Proterozoic and lower Paleozoic shales and cherts was deformed into a distinctive highly foreshortened package known as the Rogue Décollement Complex.

There is also a variety of known mineral occurrences or anomalies indicative of mineral deposits found in the area. These fall broadly into two types: skarns with strategic or precious metals, and strata with demonstrated base metal potential.

PALEOGEOGRAPHIC FEATURES

Named paleogeographic features follow those of Cecile and Norford (1993) and are defined on the basis of their

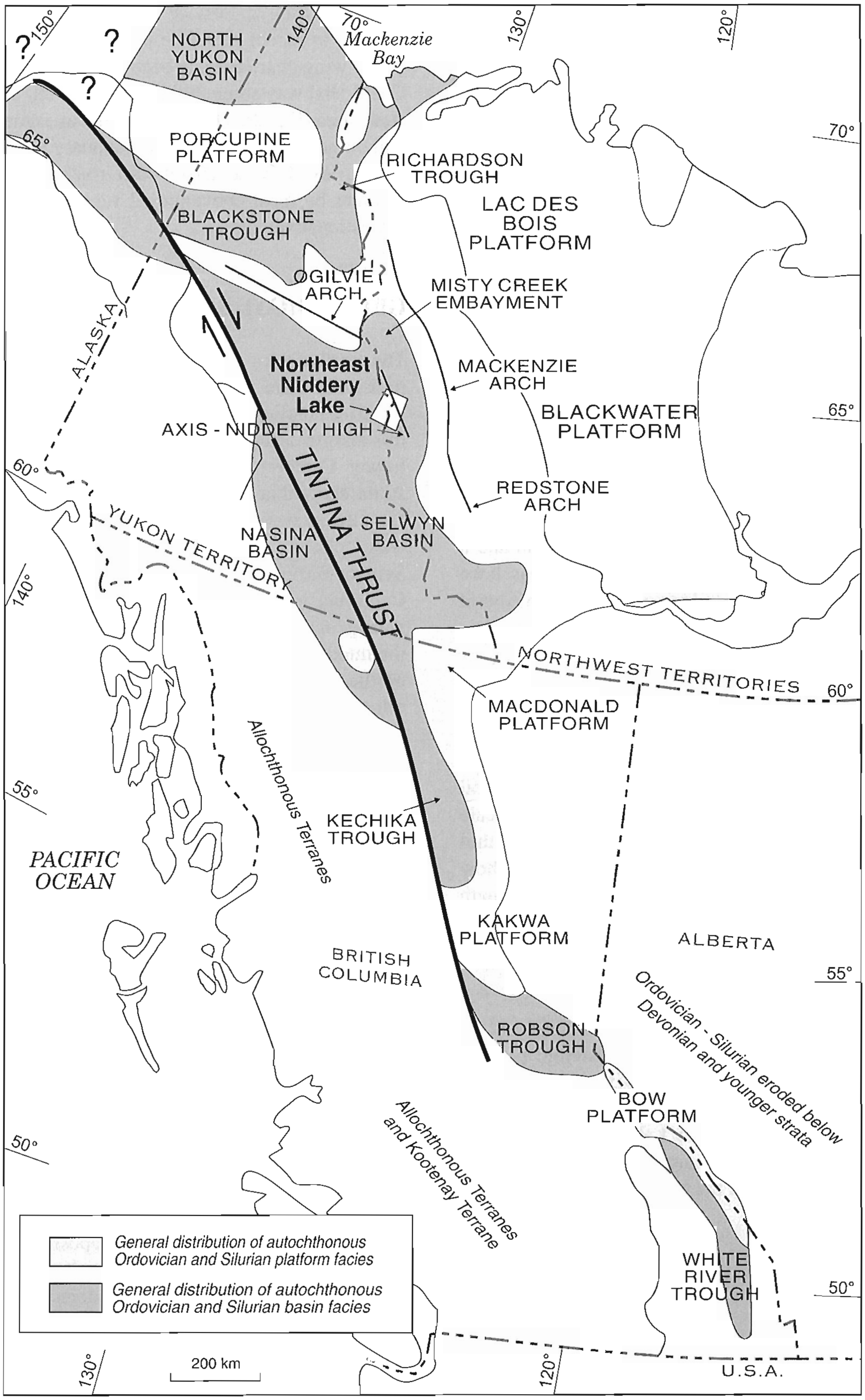


Figure 1. *Location of the northeastern Niddery Lake map area (105-O NE) with respect to general Ordovician–Silurian paleogeography (adapted from Cecile et al., 1997).*

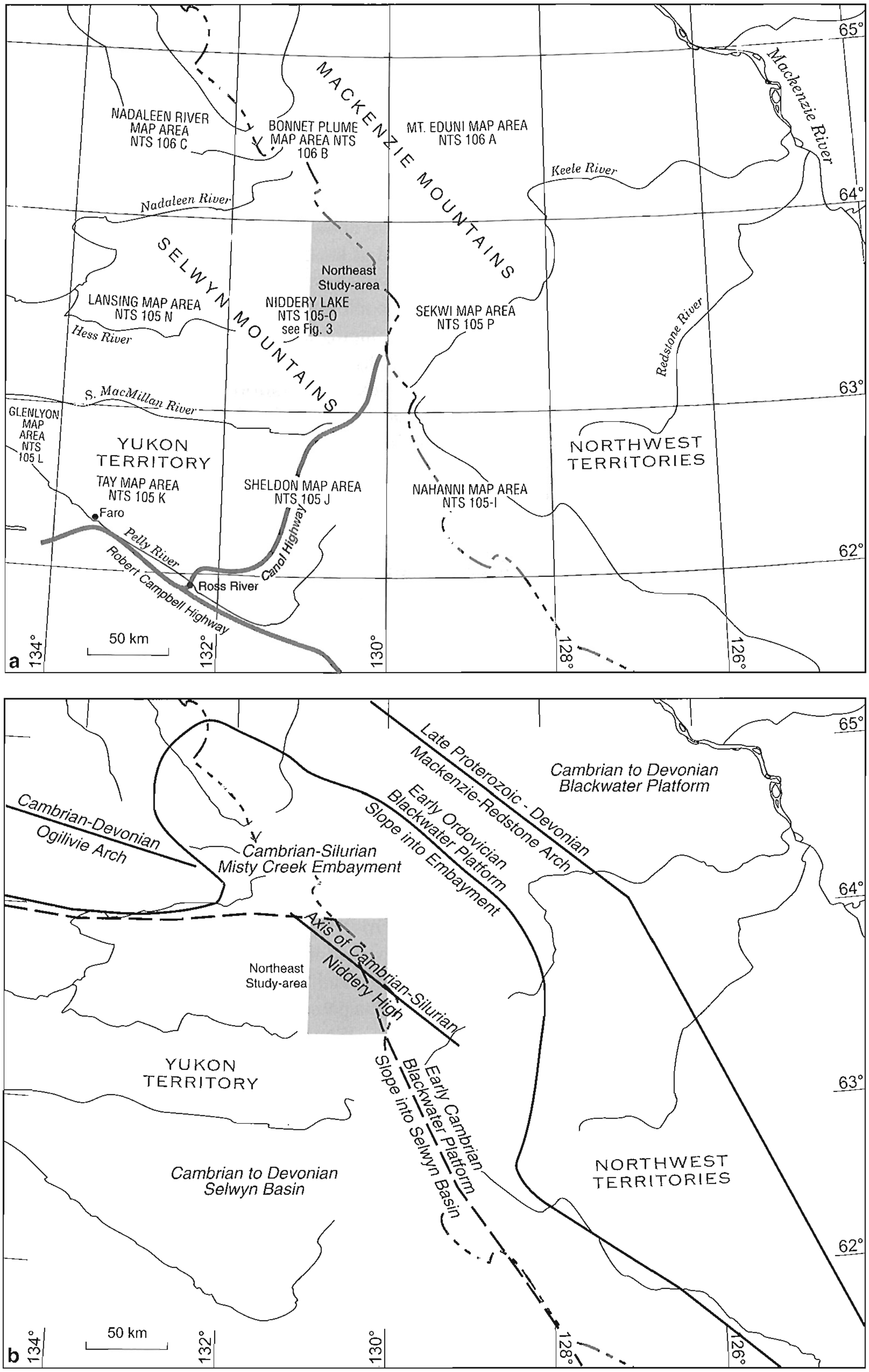


Figure 2. a) *Detailed location map showing the Niddery Lake map area, the northeast study area, and the Nahanni map area (Gordey and Anderson, 1993), which is an important reference area for stratigraphic names and comparisons.* ***b)*** *Major Late Proterozoic to Devonian tectonic and facies elements of the same area (from Cecile and Norford, 1993; and Gordey and Anderson, 1993).*

general lithofacies and inferred depositional environment. Basin, embayment and trough are areas underlain by shale, chert and thin-bedded limestone, and are interpreted as deep-water deposits. A platform is an area of thick-bedded dolostone and/or limestone with minor clastics interpreted as shallow-water deposits. An arch is an elongate, positive feature that underwent repetitive erosion, and can now be defined by thinning of strata and convergence of unconformities toward its axial zone. A high is similar to an arch, but not elongate, and a submarine high is defined by an attenuation in thickness of strata, due to diminished sediment supply and/or submarine erosion.

The study area encompasses several important paleogeographic features (Fig. 1, 2). From northeast to southwest these are: the southwestern edge of Blackwater Platform, the southwestern side of Misty Creek Embayment, the submarine Niddery High, and northeastern Selwyn Basin. The eastern end of Ogilvie Arch lies just north of the map area.

Blackwater Platform was a very large area of shallow-water carbonate deposition (Fig. 1). Lower Cambrian and Lower–Middle Devonian strata from the southwest edge of this platform now underlie the northeastern part of the study area.

The Misty Creek Embayment (Cecile, 1982) was a large, rectangular, marine rift that developed on the southwest edge of the Cambrian Blackwater Platform during the late Early Cambrian to Silurian. This rift was bounded on the southeast, northeast, northwest, and partly on the west by shallow-water, lower Paleozoic carbonate platform strata deposited on the western flank of the Mackenzie–Redstone Arch and eastern end of the Oglivie Arch (Fig. 1, 2). The open side of the embayment, on the west, is separated from Selwyn Basin by the submarine Niddery High, situated in the central part of the study area.

The Niddery High (Cecile and Norford, 1993; Cecile 1982) was a relatively short-lived feature that had two phases. Its first phase is defined by a thin succession of Middle Cambrian to Lower Silurian basinal shale and limestone. These thin strata contrast with very thick equivalent successions in Misty Creek Embayment to the northeast, and to attenuated chert and argillite in Selwyn Basin to the southwest. Shale and limestone accumulated on the high because it was generally above the level of carbonate compensation, whereas siliceous strata of the adjacent Selwyn Basin probably accumulated below the carbonate compensation depth. The second phase of the Niddery High was an Early Silurian to Devonian period of nondeposition or submarine erosion (see discussion on the Niddery High beneath the Hailstone Formation, p. 56). During this phase sediment continued to accumulate in Selwyn Basin. Misty Creek Embayment was filled during the Silurian and overstepped by Devonian carbonates (Cecile, 1982). Some Silurian strata and debris from Devonian platform carbonates are preserved on Niddery High.

The largest basin in the Northern Cordillera was Selwyn Basin (Fig. 2). The area of preserved Selwyn Basin strata is now 700 km long and up to 200 km wide. This area extends from about 60°N latitude northwest to the Alaskan border, and at least half of it is inferred to have been underlain by some form of attenuated continental crust on the basis of isotopic data (Armstrong, 1979). Its northern border was the beginning of shallow-water carbonate facies along the south flanks of the Ogilvie Arch; its eastern border was the Blackwater Platform in Early Cambrian and Early–Middle Devonian time, and the Niddery High during Middle Cambrian to Early Devonian time (Fig. 1). Strata in the southwestern part of the study area were deposited in Selwyn Basin.

PREVIOUS GEOLOGICAL WORK

The first significant geological study of the Niddery Lake map area, after early canoe reconnaissance (McConnell 1906; Keele 1906, 1910), started after construction of the Canol Road, which crosses the southeastern part of the Niddery Lake map area south of the study area (Fig. 3). Kindle carried out geological reconnaissance along the road in 1944 and 1945 (Kindle, 1946). Mineral explorationists immediately began exploring along the right-of-way. The Tom deposit was discovered a short time later (staked in 1951, Yukon Minfile, 1991).

In 1952 Wheeler (1954), mapping on horseback, traversed the northern Niddery Lake area, north of Emerald Creek and west of the Yukon Territory boundary. This work encompassed most of the southwestern and western study area. Wheeler divided rocks in the study area into large lithological packages of Proterozoic and Paleozoic age. He identified the Rogue and northern Keele plutons, and was the first to map what is herein named the Rogue Thrust. He also recognized large-scale structural variation across the area, as well as complex structure in the Rogue Décollement Complex.

In the late 1960s and early 1970s the Niddery Lake area was mapped during a helicopter reconnaissance project – Operation Stewart (Blusson and Tempelman-Kluit, 1970; Blusson, 1971, 1973). An open file map was compiled by Blusson and released in 1974. In the study area northeast of Selwyn Valley Blusson (1974) recognized the following units: the Lower Cambrian Backbone Ranges and Sekwi formations; the Road River Formation, in which all lower Paleozoic basin facies were included; undivided Paleozoic clastic rocks; Devonian carbonate; Devonian–Mississippian

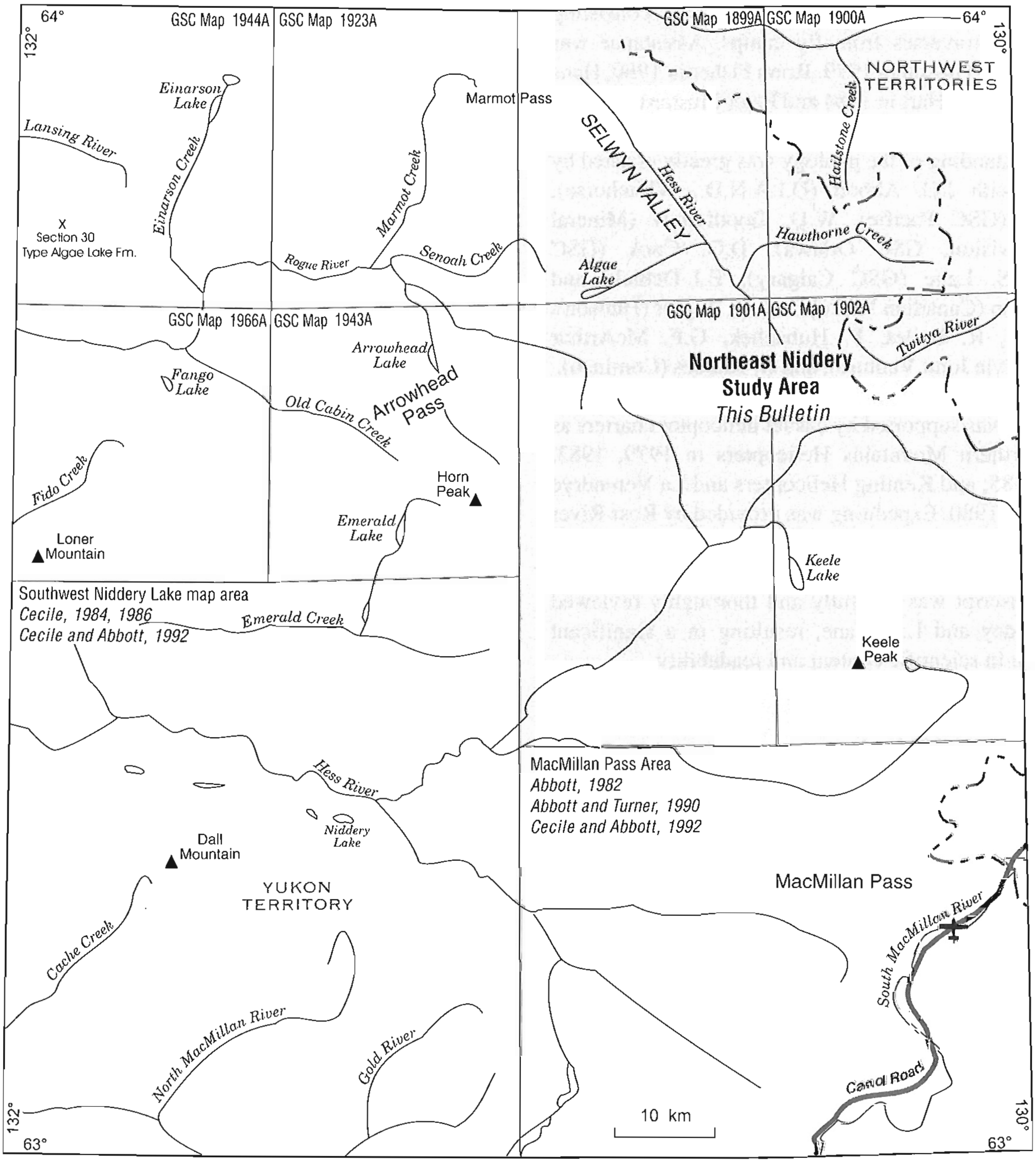


Figure 3. Geographic features of the Niddery Lake map area showing the location of the northeast study area, and references to geological reports for the rest of the map area. Separate Geological Survey of Canada bulletins are being prepared for the northwest and southwest portions and a Department of Indian Affairs report is being prepared by J.G. Abbott for the MacMillan Pass area.

clastic rocks; and Carboniferous–Permian quartz arenite and carbonate. He also mapped most of the major anticlines and faults, and some synclines in the northeast. Blusson recognized a major buried fault in the position of what is named here the Selwyn Valley Thrust.

Southwest of Selwyn Valley Blusson mapped the Rogue and Keele plutons and divided the stratigraphic succession into Proterozoic 'Grit Unit' and undivided Paleozoic (Ordovician to Mississippian) strata. Unlike Wheeler (1954), Blusson did not recognize a fault in the position of the Rogue Thrust.

ACKNOWLEDGMENTS

The geology of northeastern Niddery Lake map area discussed in this bulletin is based on fieldwork carried out by

M.P. Cecile in 1979, 1980, 1983, 1984, and 1985, consisting mainly of foot traverses from fly camps. Assistance was provided by Rob Gibsun in 1979, Brian Fisher in 1980, Hans Smit in 1983, Craig Hart in 1984 and Peter Mustard in 1985.

The understanding of the geology was greatly assisted by discussions with J.G. Abbott (D.I.A.N.D., Whitehorse), S.P. Gordey (GSC Pacific), W.D. Goodfellow (Mineral Deposits Division, GSC Ottawa), D.G. Cook (GSC Calgary), L.S. Lane (GSC Calgary), E.J. Debicki and B.T. Robertson (Canadian Nickel Co.), K. Taylor (Hudson's Bay Mining), R. Bailes, P. Hubachek, G.F. McArthur (Norcen–Ogilvie Joint Venture), and D. Rhodes (Cominco).

Fieldwork was supported by casual helicopter charters as follows: Northern Mountains Helicopters in 1979, 1983, 1984, and 1985; and Kenting Helicopters and La Verendrye Helicopters in 1980. Expediting was provided by Ross River Service in Ross River.

The manuscript was carefully and thoroughly reviewed by S.P. Gordey and L.S. Lane, resulting in a significant improvement in scientific content and readability.

STRATIGRAPHY

Introduction

The northeastern Niddery Lake map area (NTS 105-O) is underlain by Upper Proterozoic to upper Paleozoic strata that record multiple and complex facies changes (Table 1). These changes include the transition from the southwestern edge of the inner miogeoclinal Blackwater Platform into the outer miogeoclinal Selwyn Basin (Fig. 2).

In the latest Proterozoic, the area was part of a zone of shallow-water clastic and carbonate sediment deposition interstratified with sediments deposited in moderate- to deep-water environments. Lower Cambrian strata indicate that the northeast was a transitional zone from the Blackwater Platform into basin facies occupying the southwest of the area (Table 1, Fig. 2). Middle Cambrian to Silurian rocks in the central northeast Niddery map area were deposited on a submarine high (Niddery High). Farther northeast, off the high, the strata were transitional into a major rift basin (Misty Creek Embayment) that formed a large recess into the ancestral continental shelf (Fig. 2). Conversely, to the southwest and south of the high, these strata are transitional into attenuated and highly foreshortened Selwyn Basin rocks. During the Middle Silurian to Early Devonian the Niddery High was an area of nondeposition or erosion while adjacent basin areas continued to receive sediment. In the Early and Middle Devonian the northwest-trending Blackwater platform-edge was re-established with strata in the northeast by the shallow-water carbonate platform and strata in the southwest represented by Selwyn Basin facies. During the Middle Devonian to Early Mississippian, strata in northeastern Niddery map area record a significant change in the tectonic framework of the Canadian Cordillera with development of a major foredeep clastic basin. In the study area, northeastern sourced clastic strata were deposited on the northeast; westerly, as well as locally sourced, clastic strata accumulated to the southwest. The southwestern and local clastic strata are associated with a transpressional orogenic event, whereas the northeastern clastic rocks are from orogenic events in the Canadian Arctic Islands (see Gordey, 1988, 1992). By the end of the Paleozoic, sources for this foredeep basin began to stabilize and/or the basin filled and converted to an area represented by shallow-water clastic and carbonate rocks interstratified and laterally equivalent to strata of deeper water origin. Below these strata there is significant erosion of older rocks, indicating the presence of local land areas.

The preceding framework forms the basis for the stratigraphic descriptions that follow. Discussions of strata are grouped as follows: Upper Proterozoic clastic and carbonate strata; Lower Cambrian transitional to basin strata; Middle Cambrian to Silurian basin facies strata, on and adjacent to, the Niddery High; Lower to Middle Devonian platform-to-basin facies strata; Upper Devonian to Carboniferous foredeep clastic strata; and upper Paleozoic clastic and carbonate strata.

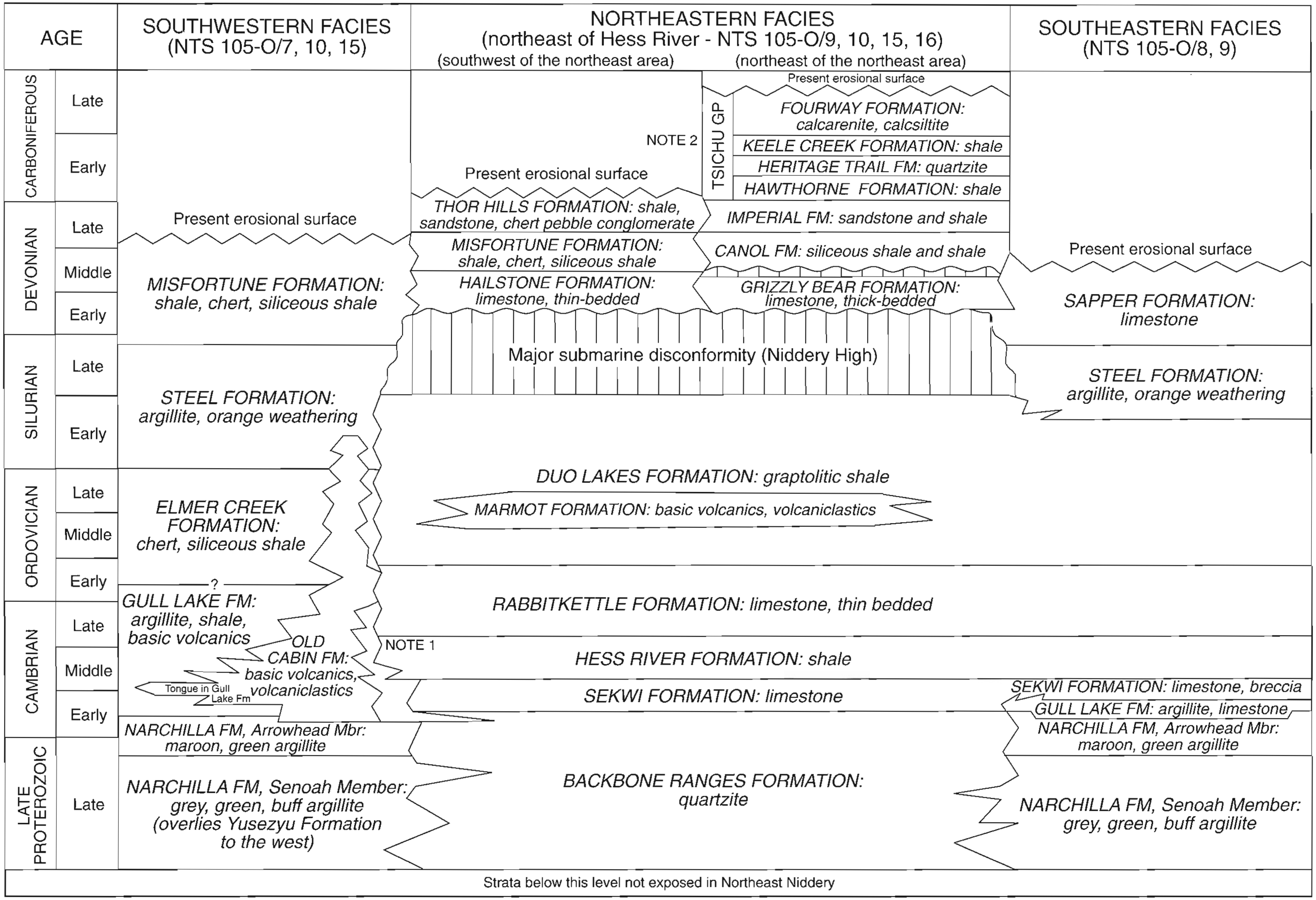
Recently, well documented and detailed stratigraphic subdivisions have been introduced for the edge of the Blackwater Platform and Selwyn Basin (Gordey and Anderson, 1993). This new stratigraphy was developed for the Nahanni map area, directly southeast of the Niddery Lake map area (Fig. 2). Correlation between the study area and the Nahanni map area extends the use of stratigraphic units about one third of the length of the eastern side of the Selwyn Basin and its adjacent platform and thus is likely to be useful throughout the whole region.

Upper Proterozoic clastics and carbonates (Hyland Group)

Formations representing Upper Proterozoic clastics and carbonates in northeast Niddery are, in ascending order, the Algae (new), and Narchilla formations (Fig. 4, 5). Just west of the northeast Niddery Lake map area the Algae Formation is underlain by the Yusezyu Formation of Gordey and Anderson (1993; Fig. 5). The Algae Formation is correlative with the limestone member of the type Yusezyu Formation (Gordey and Anderson, 1993). The Narchilla Formation is overlain by the Cambrian Gull Lake Formation, which is described in the following section (Fig. 5). The Yusezyu, Algae, and Narchilla formations comprise the Hyland Group of Gordey and Anderson (1993).

Table 1

General composition and relative ages of all formations found in the northeastern Niddery Lake map area



Note 1. A major unconformity is recognized by Gordey and Anderson (1993) below the Rabbitkettle Formation 60+ km southeast. This unconformity places Rabbitkettle Formation unconformably on both Gull Lake and Narchilla formations. No physical evidence was found for the unconformity in northeast Niddery and biostratigraphic control is too sparse to identify chronostratigraphic anomalies.
Note 2. See Figure 50 for additional units in the Tsichu Group.

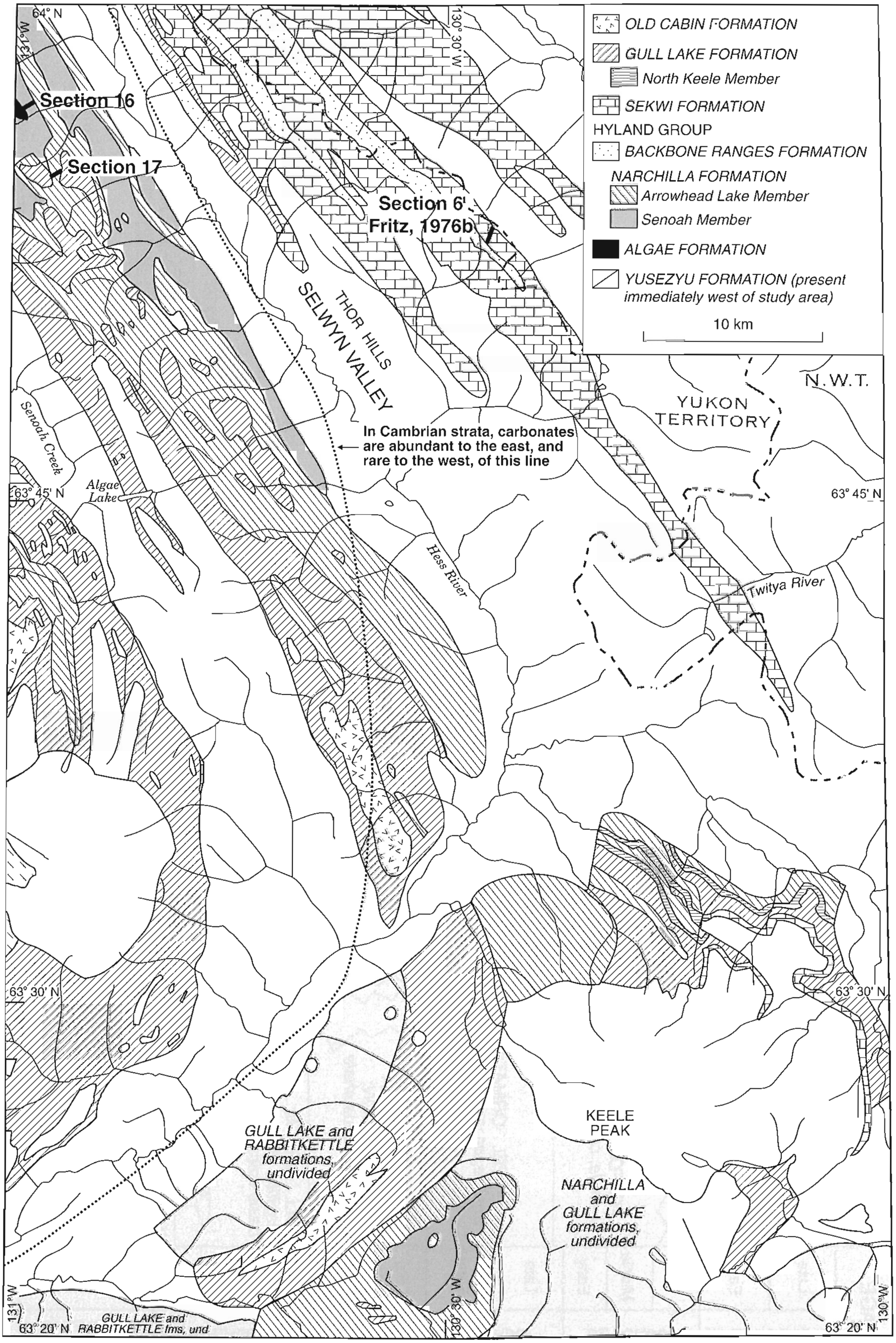


Figure 4. Distribution of Upper Proterozoic and Cambrian strata, northeastern Niddery Lake map area.

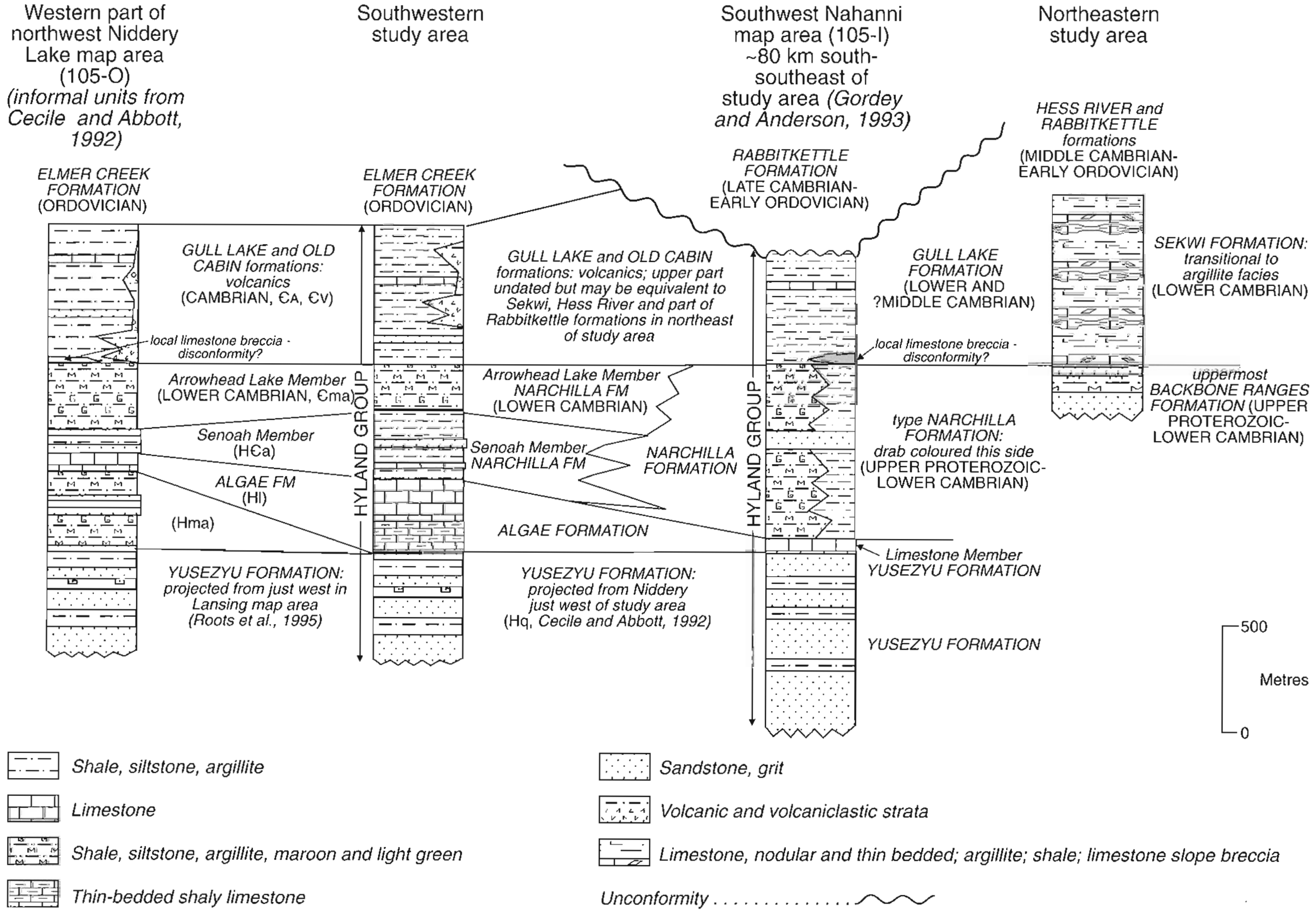


Figure 5. *Correlation of Upper Proterozoic and Cambrian Hyland Group, northeastern Niddery Lake map area (adapted from Gordey and Anderson, 1993).*

The type Narchilla Formation is divisible into three members. In the Niddery Lake map area it is divided into two mappable members, the Senoah Member (new) and the Arrowhead Lake Member (new).

The Senoah Member is approximately correlative with the lower and middle members of the Narchilla Formation of Gordey and Anderson (1993) and the Arrowhead Lake Member is approximately correlative with their upper member. The Senoah Member retains drab brown colours over most of the Niddery Lake map area and thus can be mapped separately from the bright maroon and green Arrowhead Lake Member. By contrast, over most of the Nahanni map area, all three members of the Narchilla Formation are characterized by maroon and pale green argillites, and in the type area, all three are drab coloured. The sandstone of the middle member and stratigraphic succession are the criteria used to distinguish the three in Nahanni area.

Algae Formation (new)

Type section and type area. The Algae Formation is named after Algae Lake, which is situated in the southwestern part of 105-O/15 about 20 km south of the type area (Fig. 3). The type section of the Algae Formation is located west of the study area in NTS 105-O/13 (base at UTM 356950 co-ordinates E and 7081400 N, top at 356900 E and 7081700 N Zone 9[1]; Fig. 3, 6a; map of Cecile, 1998c). The type section lies on the south side of a ridge of flat-lying strata at the center of the Little Lakes Anticline (Section 30 on map of Cecile, 1998c). The type area is immediately adjacent to the northwest part of the study area (northeastern 105-O/14 between UTM co-ordinates 401000 E, 7094500 N and 401500 E and 7093500 N, Fig. 3).

Lithology, thickness, and contacts. At the type section the Algae Formation is 266 m thick and is divisible into a lower member of flaggy to slabby limestone with minor chert and

[1]UTM co-ordinates are given using North American Datum, 1927.

argillite, and an upper member consisting of dolostone, arenaceous dolostone and arenaceous limestone with minor quartz grit (Fig. 6a). In the type area, immediately adjacent to the study area, the Algae Formation is approximately 200 m thick and is divided into a lower member of shaly limestone and an upper member of resistant limestone with dolostone and quartz arenaceous limestone (Fig. 6b). The underlying contact with the Yusezyu Formation is distinct and conformable at the type section and in the type area. The presence of a few limestone beds in the upper 10 m of Yusezyu quartzite at the type section suggests some gradational change in lithology (Fig. 6a).

Sedimentary features. The upper member is thick bedded, arenaceous and has large-scale crossbeds in the type area. The upper member also has intraclast conglomerates and is partly dolomitized. The lower member is thin bedded and shaly.

Age. The Algae Formation is correlatable to the upper limestone member of the Yusezyu Formation of Gordey and Anderson (1993; see below). These authors consider the upper Yusezyu limestone to be Late Proterozoic in age on the basis of trace fossils found beneath it and Lower Cambrian fossils found above it.

No age-diagnostic fossils were recovered from this formation. The only fossils found in the Algae Formation in the Niddery Lake map area were stromatolite biscuits. The biscuits were found in a single exposure west of the study area (UTM co-ordinates 380500 E, 7084500 N, Zone 9), and comprise low-amplitude, laterally linked hemispherical laminae with a low degree of vertical inheritance.

Distribution. The Algae Formation is found in the northwesternmost part of the study area, and west of the study area throughout the northwestern part of the Niddery Lake map area (Cecile, 1984b, 1997d, 1998 a,b,c, 1999; Unit HI of Cecile and Abbott, 1989, 1992). It is approximately 200 to 260 m thick over most of its outcrop area, but in the southwestern 105-O map area it thins to a few metres.

Correlation. On the basis of stratigraphic position and composition, the Algae Formation is considered a direct correlative of the limestone member at the top of the Yusezyu Formation of Gordey and Anderson (1993) in the Nahanni map area to the south-southeast of the study area (Fig. 2, 5).

Gordey and Anderson (1993) in turn correlated this upper limestone eastward with the middle carbonate member of the Backbone Ranges Formation, Blackwater Platform area (Fig. 2). Aitken (1989) previously disputed the correlation of the limestone unit at the top of Yusezyu Formation (Aitken's 'Grit' limestone; see also Aitken, 1984 and Fritz et al., 1984) with the middle carbonate member of the Backbone Ranges Formation and correlated it instead with the Risky Formation of Aitken (1989) in the central Mackenzie Mountains. The Risky Formation is an Upper Proterozoic carbonate unit found under a well-developed erosional surface beneath the Backbone Ranges Formation. The Risky Formation is in places overlain by the Ingta Formation, which also unconformably underlies the Backbone Ranges Formation. The Ingta is likely correlative with the Narchilla Formation, because it is at least in part Early Cambrian in age (Macnaughton et al., 1997) (see discussion on p. 22) in which case the Algae and Risky formations would be in similar stratigraphic positions.

In spite of this, both correlations have to be regarded as equivocal because the carbonate units cannot be precisely dated and have no unique features, and the correlation of Ingta to Narchilla is so far, only general.

Interpretation. Based on the presence of large-scale crossbedding, dominance of thick bedding, and extensive dolomitization, the upper member of the Algae Formation is considered to be of shallow-water marine origin. The lower member is thin bedded, shaly limestone and is considered deeper water or transitional to deeper water.

Narchilla Formation - Senoah Member (new)

Type localities. The type section of the Narchilla Formation (Gordey and Anderson, 1993) is in the Nahanni map area at 62°15.7'N, 129°13.2'W. The type section of the Senoah Member is Section 16, found on the northeastern limb of the Algae Anticline (Fig. 4) in northwest 105-O/15 (base at UTM co-ordinates 402050 E, 7093400 N and top at 402800 E, 7093450 N, Zone 9). The Senoah Member is named after Senoah Creek, which is about 18 km south of the type section (Fig. 3).

Lithology, thickness, and contacts. The type Narchilla is 828 m thick and can be divided into three members (Gordey and Anderson, 1993). The lowermost member sits directly on the upper Yusezyu limestone (correlative with the Algae Formation) and is composed of 341 m of dark blue-grey and pale green slate. The middle type member comprises 71 m of orange-grey weathering, fine grained quartz sandstone and siltstone in thin to thick beds. The upper member consists mostly of 416 m of dark blue-grey slate with rare laminae of green slate. In its central part is minor quartz sandstone. Its upper 75 m consist of pale green slate that becomes tan to buff weathering upward.

The Senoah Member at its type section consists of about 400 m of siltstone and shale with thick units of resistant quartzite and some granule quartzite (grit) and minor limestone beds. Seventy to 80 per cent of the succession is siltstone–shale, and 20 to 30 per cent is quartzite, with only

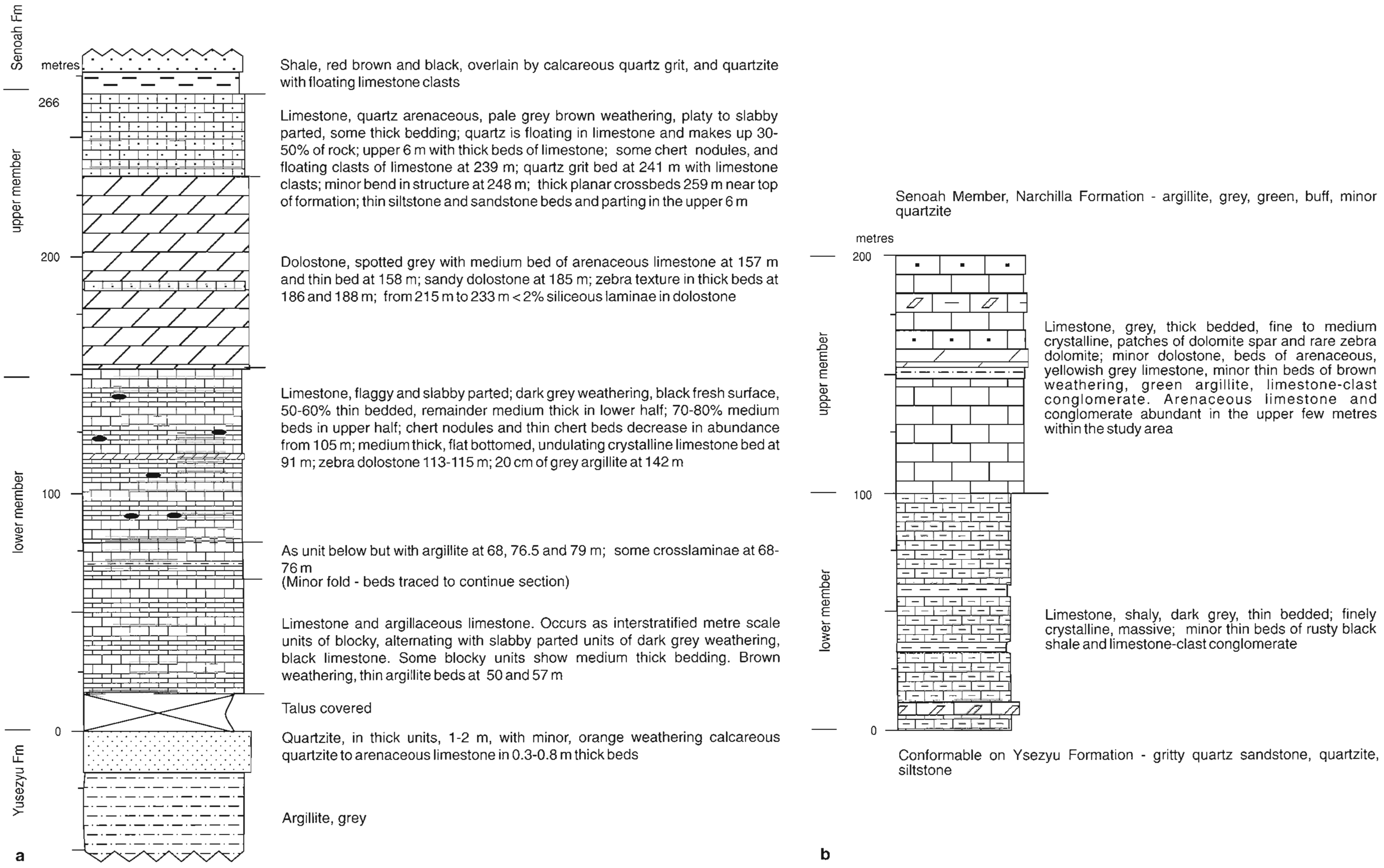


Figure 6. ***a)*** *Algae Formation, type section, located on the south side of a ridge of flat-lying strata in the center of the Little Lake Anticline, Einarson Creek map area (Section 30 on Cecile, Map 1944A). The type section is west of the study area in NTS 105-O/13 with the base at 356950 E and 7081400 N; top at 356900 E and 7081700 N, Zone 9.* ***b)*** *Algae Formation, schematic section based on traverse data in the type area, Algae Anticline. Type area just west of study area in NTS 105-O/14, between UTM co-ordinates 401000 E, 7094500 N and 401500 E, 7093500 N, Zone 9.*

1 to 5 per cent limestone (Fig. 7). A significant proportion of the type Senoah shale is grey-black; some is grey-blueish black with minor mauve coloration. In the upper part of the Senoah type section there are two, 20 m successions of quartzite divided by shale, which are potentially thinner lithological correlatives of Gordey and Anderson's (1993) type middle member. These thin quartzites are not mappable in the Niddery Lake map area (Cecile and Abbott, 1992).

The lower contact with the Algae Formation is conformable and distinct. However, the upper few metres of the Algae Formation in the area of the Senoah type section become arenaceous and the lower few metres of the Senoah Member, in the same area, are calcareous. The contact is marked where terrigenous clastics dominate over limestone. At the type section of the Algae Formation the contact is very distinct with some arenaceous limestones at the top of the Algae Formation changing abruptly to shale and calcareous quartzite grit with clasts of limestone (Fig. 6a).

Sedimentary features. Most sandstone beds are massive, some with load casts at their bases. Fine clastics are locally thin bedded and in one part of the Senoah type section show A–E Bouma-type bedding sequences.

Age. The Senoah Member is considered to be latest Proterozoic to Early Cambrian in age on the basis of stratigraphic position. The overlying Arrowhead Lake Member, Narchilla Formation, contains Early to early Middle Cambrian trace fossils and the underlying Algae Formation is considered Late Proterozoic in age.

Distribution. The Senoah Member outcrops extensively over the western part of the study area (maps of Cecile 1997b, c, d,); and throughout the northwestern part of the 105-O map area (Cecile, 1984a, 1998a, b, c, 1999; unit HЄa of Cecile and Abbott, 1989, 1992). Over most of the southern Niddery map area strata of this age are in the subsurface.

South of the Keele pluton, where structural repetitions and alteration make distinction of individual units impossible, the Senoah and Arrowhead Lake members, Narchilla Formation, and the Gull Lake Formation are grouped as one map unit (Fig. 4).

Correlation. The Senoah Member is considered to be correlative with the lower and middle members and possibly some of the upper member of the type Narchilla Formation of Gordey and Anderson (1993) in the Nahanni map area (Fig. 2, 5).

The differences between the Senoah and Arrowhead Lake members of the Narchilla Formation in the Niddery Lake map area and the three members of the Narchilla Formation in the Nahanni map area are colour and sandstone content.

In the Nahanni type section, and immediately surrounding area, drab blue-grey and green dominate fine clastic units in all three members, and the only distinguishing feature between the three is the sandstone of the middle member. Outside the type Narchilla in the Nahanni map area, all three members are maroon and green, and again, only the presence of the middle sandstone member allows the members to be distinguished.

By contrast, throughout the study area and most of the surrounding Niddery Lake map area, the Senoah Member retains its drab colours, and the overlying Arrowhead Lake Member is everywhere maroon and green. Thus in the Niddery Lake map area, the Narchilla Formation can be consistently mapped as two separate members on the basis of colour.

The Senoah Member has also been mapped in the Lansing map area west of Niddery Lake as the PNS by Roots et al. (1995a, b).

Gordey and Anderson (1993) correlated the type Narchilla Formation with the Upper Backbone Ranges Formation, and with a slope-facies equivalent of the Upper Backbone Ranges, the Vampire Formation (Fritz, 1982), in the central Mackenzie Mountains (Fig. 2). Aitken (1989) identified another potentially correlative unit of the Narchilla, the Ingta Formation, which unconformably underlies the Backbone Ranges Formation. This possible correlation is reviewed below.

Interpretation. The dominance of fine clastics, load casts, and (A–E) graded bedding indicates deposition from sediment gravity flows in moderate to deep water.

Narchilla Formation - Arrowhead Lake Member (new)

Type locality. The type section of the Arrowhead Lake Member is Section 17, NTS 105-O/15, with the base at UTM co-ordinates 404450 E, 7088200 N, and top at 404750 E, 7088950 N, Zone 9 (Fig. 4). Because the base of this section is faulted, a reference area for the base of the Arrowhead Lake Member is the first ridge less than a kilometre directly north of the type section.

Lithology, thickness, and contacts. The Arrowhead Lake Member in the Niddery Lake map area is typically a maroon and lime green weathering argillite; locally, blue-grey argillites are abundant in Arrowhead Lake Member outcrops. The type section of the Arrowhead Lake Member consists of 118 m of maroon and lime green argillite with minor quartzite (Fig. 8). Although the base of the type section is a fault, the total thickness is comparable to that

Figure 7. *Senoah Member, Narchilla Formation, type section, Algae Anticline. Section 16, 105-O/15 northwest; base at UTM co-ordinates 402050 E, 7093400 N; top at 402800 E, 7093450 N, Zone 9.*

estimated for complete sections at other localities within the study area.

The Arrowhead Lake Member in the study area rests conformably on the Senoah Member. The contact is distinct and marked by a generally abrupt change from maroon, lime green or blue-grey argillite typical of the Arrowhead Lake Member, into more drab siltstone or coarser clastic rocks of the Senoah Member (Fig. 7).

Sedimentary features. The Arrowhead Lake Member in the Niddery Lake map area is typically thin bedded, and some of the thin argillite beds are graded. Sandstones vary from massive to medium to thick bedded, are fine to coarse grained, and moderate to well sorted. Feeding traces and burrows are found in some beds.

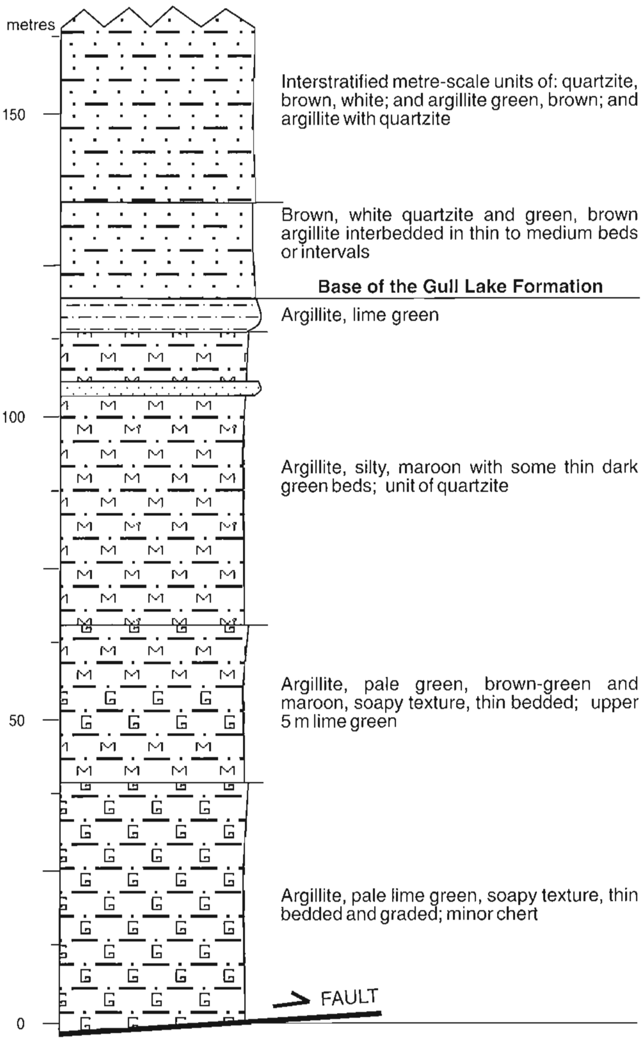


Figure 8. *Arrowhead Lake Member, Narchilla Formation, type section. Section 17, NTS 105-O/15, base at UTM co-ordinates 404450 E, 7088200 N; top at 404750 E, 7088950 N, Zone 9.*

Age. Gordey and Anderson (1993) considered the type Narchilla Formation Late Proterozoic to Early Cambrian in age. In the northeast Niddery Lake map area (Appendix 1) and throughout the Niddery Lake map area (Hofmann et al., 1994; Hofmann and Cecile, 1981) the Arrowhead Lake Member contains a variety of trace fossils, *Oldhamia* sp. being the most important. Hofmann et al. (1994) assigned the Arrowhead Lake Member trace fossil assemblages an Early Cambrian to early Middle Cambrian age.

Distribution. The Arrowhead Lake Member outcrops extensively in the western and southern parts of the study area (maps of Cecile 1997b, c, d,) and throughout the rest of the surrounding Niddery Lake map area (Cecile, 1984b, 1998 a,b,c, 1999; Ꞓma Unit of Cecile and Abbott, 1989, 1992) and map areas to the north, west and south of the Niddery Lake map area. As are strata of the Senoah Member, Arrowhead strata are in the subsurface over most of the southern part of the map area.

Correlation. The Arrowhead Lake Member is partly equivalent to the upper member of the type Narchilla in the Nahanni map area. It is also mapped in the Lansing map area west of Niddery Lake as the NA by Roots et al. (1995a, b).

As mentioned above, Gordey and Anderson (1993) correlated the type Narchilla Formation with the Upper Backbone Ranges Formation, and with a slope-facies equivalent of the Upper Backbone Ranges, the Vampire Formation (Fritz, 1982), in the central Mackenzie Mountains (Fig. 2). Aitken (1989) however, identified the Ingta Formation as another potentially correlative unit of the Narchilla. The Ingta unconformably underlies the Backbone Ranges Formation and is an apple green and purple-red shale and sandstone unit. At its type section the top of the Ingta yielded earliest Cambrian conodonts and latest Proterozoic to Cambrian trace fossils (Aitken, 1989).

The age range of the Ingta is the most important characteristic, because light green and purple-red or maroon colours are not a unique feature, and are not restricted to the potentially correlative Narchilla Formation. Colours are somewhat useful in continuous tracing of the Narchilla Formation in both the Nahanni and Niddery map areas, but they cannot be used for more distant correlation. As an example, in the west-central Niddery Lake map area, argillites below the Algae Formation are maroon and light green (Hma Unit of Cecile and Abbott, 1992). The possible age range however, is long and allows potential correlation of the Ingta with the Senoah and basal Arrowhead Lake members, but could even include all, or parts of, the Yusezyu and Algae formations, which are interpreted as latest Proterozoic in age.

Similar lithologies are found in the Barn and British Mountains (Ꞓa unit of Cecile 1988; Cecile and Lane, 1991; Lane and Cecile, 1989). There, however, the unit is 200 to 500 m thick and consists of both green and maroon argillites with quartzite and limestone. The maroon lithologies contain the trace fossil *Oldhamia* and resemble the Arrowhead Lake Member of the Narchilla Formation, whereas the green lithologies are more similar to the Gull Lake Formation. Maroon and green argillites with *Oldhamia* have also been reported from the Ogilive Mountains, Yukon (Thompson and Roots, 1982).

Interpretation. The Arrowhead Lake Member in Niddery Lake map area is considered to be a relatively deep-water unit on the basis of its graded bedding, and the dominance of fine grain size. Furthermore, the authors of reports on numerous occurrences of the trace fossil *Oldhamia* in western Europe and eastern and northwestern North America, all favour deep-water depositional environments for strata hosting *Oldhamia* (submarine fan and plain deposits). Modern traces resembling *Oldhamia* in pattern, but not size, have been photographed in deep ocean settings (Hofmann et al., 1994).

Lower Cambrian Blackwater Platform to Selwyn Basin (Backbone Ranges, Sekwi and Gull Lake formations)

In the northeast of the study area, Lower Cambrian formations comprise, in ascending order, the Backbone Ranges and Sekwi formations. These are interstratified shallow-water and deeper water facies that constitute the transition from the Blackwater Platform to Selwyn Basin. The Sekwi Formation is very argillaceous, and within it, deeper water facies are more abundant than shallow-water facies. Only the upper part of the Backbone Ranges Formation is exposed, and most of it consists of shallow-water, clean quartzites, with units of siltstone and shale.

In the southwest, Lower Cambrian strata comprise, in ascending order, the Arrowhead Lake Member, Narchilla Formation (described in previous section) and the Gull Lake Formation (Fig. 4). The Gull Lake Formation intertongues with, and is laterally equivalent to, local accumulations of volcanic strata of the Old Cabin Formation.

Northeastern facies - transition from Blackwater Platform

Backbone Ranges Formation

Type locality. The Backbone Ranges Formation was defined by Gabrielse et al. (1973). The type area is in the Backbone Ranges, Mackenzie Mountains (lower part at lat. 62°30'N, long. 127°11'W, upper part at lat. 62°31'N, long. 127°15'W, in the Glacier Lake map area). Fritz (1992) referred to this unit both as a formation and a group, but it has never been formally elevated to group status.

Lithology, thickness, and contacts. Only the upper 200 m or so of the Backbone Ranges Formation is exposed in the Niddery Lake map area. It consists of white, red-brown and minor grey or green quartzite and minor maroon siltstone. Some sandstones examined are fine to medium grained quartzites in blocky beds, well indurated, well sorted and with a silica cement. These strata are comparable to the higher strata of the type upper member of the Backbone Ranges Formation which consists of pink, purple, grey and brown quartz sandstone with minor purple, brown and maroon siltstone (Gabrielse et al. 1973). The base of the Backbone Ranges Formation is not exposed in the Niddery Lake map area.

Sedimentary features. The quartzites are fine to medium grained, and blocky. Internally the sandstone is massive or laminated.

Age. No fossils have been recovered from exposures in the Niddery Lake map area. Trace fossil burrows have been found in the upper Backbone Ranges Formation near the type area, and the overlying Sekwi Formation contains Lower Cambrian fossils. Because only the upper part of the formation is present in the Niddery area, the age of the exposures is assumed to be Lower Cambrian.

Distribution. The Backbone Ranges Formation is only found in the hinge zones of three anticlines – Middlecoff, Hawthorne and Porter (see Fig. 53 in section on Structure; Cecile 1997a, d).

Correlation. In the south and southwest of the study area the upper Backbone Ranges is either equivalent to some of the argillite and sandstone of the Senoah and Arrowhead Lake members, Narchilla Formation (Fig. 5, 9), or equivalent to parts of the Gull Lake (see previous discussion).

The Backbone Ranges Formation is part of a nearly continuous northwest-trending belt of Cambrian quartzite and carbonate found along the southwestern half of the Mackenzie Mountains. This area includes the type area of the Backbone Ranges Formation (see map of Wheeler and McFeely, 1991).

Interpretation. Limited exposure in the Niddery map area makes interpretation of this unit difficult. Aitken et al. (1973) considered the Backbone Ranges Formation to be a shallow-water unit, and Gabrielse et al. (1973) described the Backbone Ranges Formation as a unit of well-sorted quartz sandstone with a medial dolostone member, which is generally consistent with a shallow-water facies

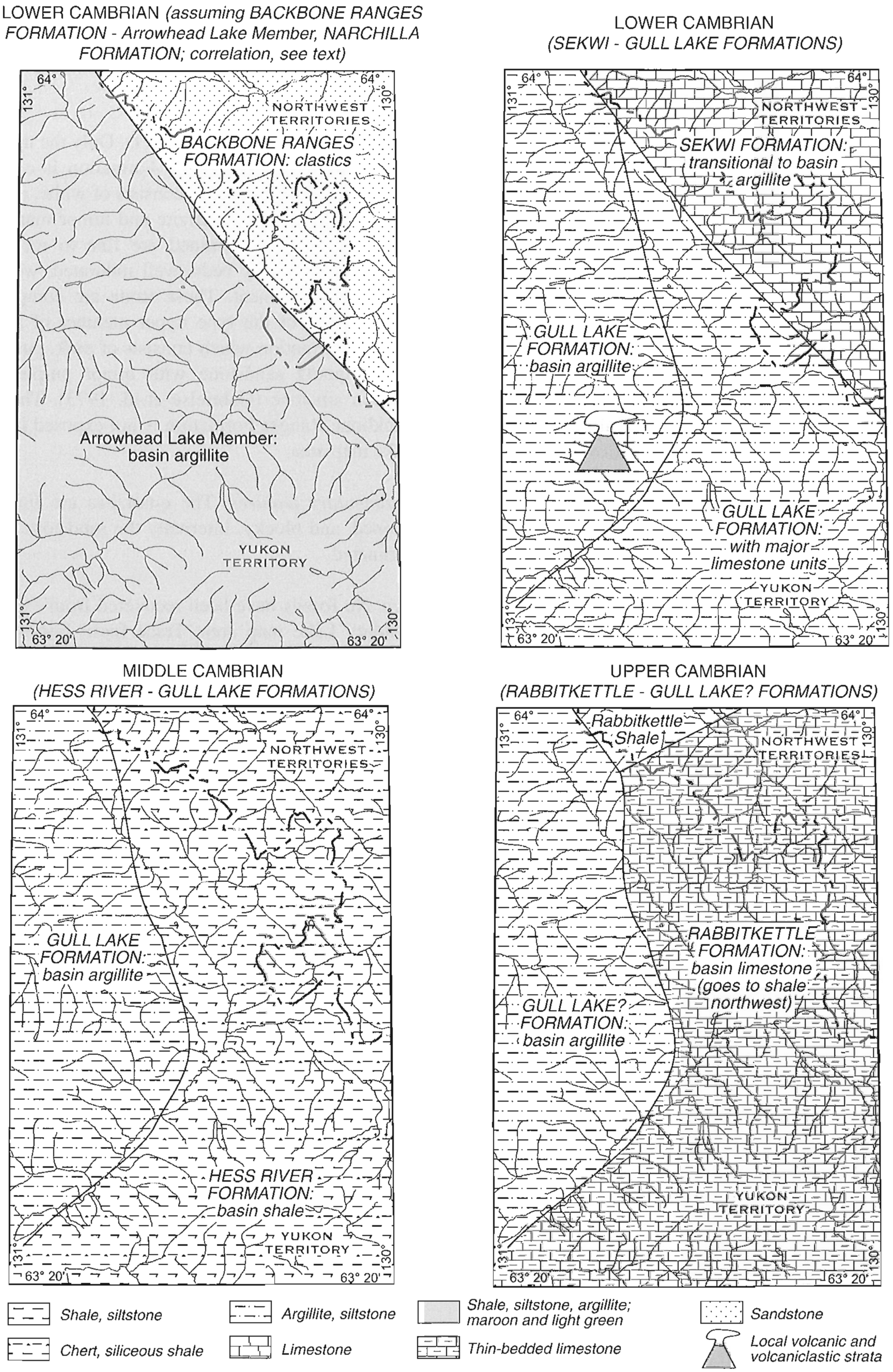


Figure 9. *Unrestored facies distribution of Cambrian strata. The arcuate facies boundary on the west side of the Sekwi, Hess, and Rabbitkettle maps may be an artifact of Mesozoic structure, with more eastward transport in the centre of the arc than to the south or north.*

interpretation. The exposures in the study area resemble the type Backbone Formation and are also interpreted as shallow-water facies.

Sekwi Formation

Type locality. The type locality is in the Sekwi Range, Mackenzie Mountains on a ridge immediately north of June Lake (lat. 63°33'N, long. 128°44'W) where the section is overturned (Hanfield, 1968).

Lithology, thickness, and contacts. The type Sekwi Formation consists of silty limestone, limestone, dolostone, arenaceous dolostone, calcareous shale and argillite. The intense orange, yellow, red, and grey weathering colours of the carbonates are a striking visual characteristic of the formation. Shales and argillite are also variegated. In the type section, a prominent shale member occurs in the middle of the formation. Variegated siltstones are also found at Hanfield's (1968) Section 5 near the southwestern limits of the Sekwi Formation in the central Mackenzie Mountains.

In the Niddery Lake map area the Sekwi Formation consists of silty and argillaceous limestone, limestone, dolostone, arenaceous dolostone, calcareous shale, and calcareous siltstone (Fig. 10). Carbonates primarily weather orange, yellow, red, and grey. Shales and argillite are also variegated. In northeast Niddery Lake map area the Sekwi can be divided into an upper dolostone and limestone member that is mappable in most Sekwi exposures ($Є_{SK2}$, Fig. 10), and a lower member consisting of a lower succession with limestone ($Є_{SK1a}$), overlain by shale, calcareous shale, thin bedded limestone, and argillite ($Є_{SK1b}$, Fig. 10). This three-fold division is similar to the type section, and to the central Mackenzie Mountains section referred to above. The lower contact with the Backbone Ranges Formation is not exposed in the study area, but appears to be conformable.

Sedimentary features. Limestone units are both thin bedded, and medium to thick bedded. Thin and commonly wavy bedding dominates the succession. A few thick units of centimetre-scale intraclast breccia and slump folds are also present. Laminae and small crosslaminae are the only other distinct sedimentary features. Trilobites are found both as complete, or nearly complete, specimens in calcilutites and as debris beds, composed mostly of appendages. Centimetre-scale limestone nodules are a prominent feature in some units.

Age. Fritz (1972, 1976a,b, 1981, 1992) assigned the Sekwi Formation to the Lower Cambrian, Upper Placentian and Waucoban stages (*Fallotaspis*, *Nevadella* and *Bonnia–Olenellus* zones). Among the collections of Fritz are trilobites, archeocyathids, inarticulate brachiopods, salterellids and a variety of ichnofossils. During mapping of the Niddery Lake map area some additional fauna were collected, all from the upper parts of the Sekwi Formation and all from the *Bonnia–Olenellus* Zone (Appendix 1).

Distribution. The Sekwi Formation is found on the limbs of the three large anticlines (Middlecoff, Hawthorne, and Porter), and forms the hinge zone of the faulted Border Anticline in the northeastern Niddery Lake map area (Fig. 4; Cecile 1997a, b, d).

Correlation to Selwyn Basin, transition to argillite. The Sekwi Formation is replaced to the southwest by the Gull Lake Formation. The transition from Sekwi Formation to Gull Lake argillites begins northeast of Selwyn Valley in the northern part of the study area (Fig. 4). Here a tongue of Gull Lake Formation can be mapped between the Backbone Ranges and the Sekwi formations (Fig. 4). In addition, westernmost study-area exposures of the Sekwi Formation, northeast of Selwyn Valley, are very argillaceous and carbonate units are thin bedded and contain slope breccias.

In the southeast, near Keele Peak, the Gull Lake Formation has mostly replaced typical Sekwi Formation strata, but has abundant thin beds of limestone and is overlain by a mappable tongue of thin Sekwi Formation. At the base of the Gull Lake Formation in this area is another thin mappable carbonate unit, the North Keele Member (Fig. 4).

The Sekwi Formation tongue is directly overlain by the Middle Cambrian Hess River Formation. A similar tongue of Sekwi Formation, this one containing archeocyathids, was recognized by Abbott (1983a) in the southeastern Niddery Lake map area. The lower Gull Lake North Keele Member is not well exposed but appears to be a distinct unit of thin bedded limestone, limestone conglomerate and breccia, which may or may not be a tongue of lower Sekwi Formation. It is only found northeast of Keele Peak (Fig. 4).

On the west side of Keele Peak, and southeast of Hess River, Cambrian strata are part of the Rogue Décollement Complex, within which structural complexity precludes mapping of individual units (map 105-O/07N2/3 and 10).

Correlation to Blackwater Platform. The Sekwi Formation is mapped as an important formation within a nearly continuous, northwest-trending belt of Cambrian quartzites and carbonates found along the southwestern half of the Mackenzie Mountains (see map of Wheeler and McFeely, 1991).

Interpretation. The Sekwi Formation in northeast Niddery Lake map area consists mostly of deep-water facies strata

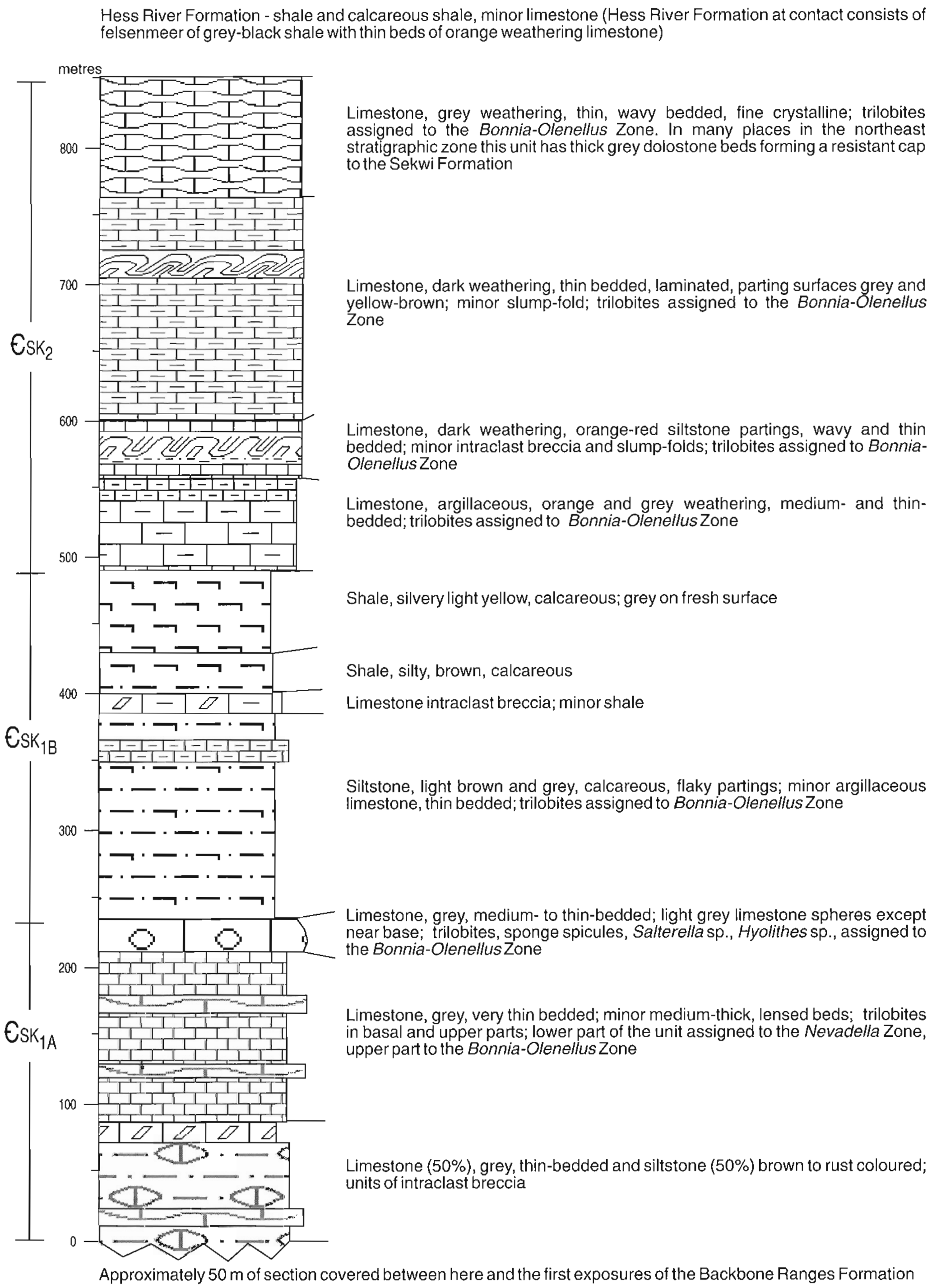


Figure 10. *Sekwi Formation, reference section. Redrafted and subdivided version of Section 6 measured by Fritz (1976b); NTS 105-O/16, UTM co-ordinates - composite section - middle and top in area of 429500 E, 7085000 N, and base in area of 430100 E, 7085250 N, Zone 9.*

with some shallow-water facies units. It is equivalent to shallow-water Sekwi Formation carbonates and clastics found on the southwest flank of the Mackenzie–Redstone Arch. It lies at the western edge of Lower Cambrian platform margin and is transitional to basin facies of the Selwyn Basin. The upper division of the Sekwi (ϵ_{SK2}) includes in many places thick beds of shallow-water dolostone, and the lower Sekwi (ϵ_{SK1a}) unit has some thick limestones, potentially of shallow-water origin (Fig. 10). The middle of the succession consists of thin bedded, shaly, deep-water or slope facies units. Intraclast breccias in limestone are interpreted as slope breccias where partly lithified calcilutites form large rip-up clasts during mass movement, or turbidite flow, downslope. Slump folds are also interpreted as being associated with mass movement downslope.

Southwestern facies - Selwyn Basin

Gull Lake Formation

Type locality. The type section of the Gull Lake Formation is in the Nahanni map area at lat. 62°23.4'N and long. 129°19.2'W (Gordey and Anderson, 1993).

Lithology, thickness, and contacts. At the Nahanni type section the Gull Lake Formation is divided into three members, from lower to upper: a discontinuous, basal, metre-thick unit of limestone conglomerate with archeocyathids; 662 m of orange-brown to rust-brown weathering slate and siltstone to fine grained sandstone; and 386 m of resistant, grey weathering, thick bedded bioturbated siltstone and mudstone.

In the study area, and the rest of the Niddery Lake map area (Cecile and Abbott, 1992), the Gull Lake Formation is approximately 400 m thick, and similar in composition to the Nahanni type section. It also includes a variety of minor, thin to thick stratigraphic units consisting of chert, shale, sandstone, grit and limestone. In addition, in many places it intertongues with beds of volcaniclastics or is interstratified with a mappable unit of volcanic rocks (Old Cabin Formation). In southeastern parts of the study area, as discussed previously, it has a poorly exposed basal unit, the North Keele Member, which is approximately 10 to 40 m thick and consists of thin bedded limestone and limestone conglomerate. The North Keele member rests directly on the Arrowhead Lake Member (Narchilla Formation), and is only known north of Keele Peak (Fig. 4).

The contact between the Arrowhead Lake Member, Narchilla Formation, and the Gull Lake Formation is distinct and conformable and defined by a colour change. As noted above, in the north Keele Peak area the lower boundary is the base of the North Keele Member.

Sedimentary features. The Gull Lake Formation consists mostly of thin bedded argillite with some graded beds. Sandstone units are generally clean and vary in grain size and sorting. Limestone units are commonly thin bedded, some contain intraclast breccias and others have small-scale, asymmetrical ripple crosslaminae.

Age. There are no fossil collections from within the study area, however immediately west of the study area, trace fossils were observed at several localities (Cecile, 1998a, c). These collections have been identified by H.J. Hofmann (*in* Norford et al., 1993) as consisting of the trace fossil *Planolites.* Also, immediately west of the study area, a single *Archeocyathid* was recovered from the Old Cabin Formation, which intertongues with the Gull Lake Formation (see Norford et al., 1993). The Gull Lake Formation in the study area is underlain by the Arrowhead Lake Member (Narchilla Formation) with trace fossils that range from Early Cambrian to earliest Middle Cambrian in age. It is overlain by Elmer Creek Formation, which is earliest Ordovician at the base. Because there are no known unconformities between the Gull Lake Formation and overlying and underlying units in the Niddery Lake map area, the Gull Lake Formation may represent a large part of the Cambrian Period.

Distribution. Southwest of the Sekwi–Backbone Blackwater Platform-edge the Gull Lake Formation outcrops over the entire study area (Cecile 1997b, c, d), as well as the remainder of the Niddery Lake map area (unit Ꞓa of Cecile and Abbott, 1992) and beyond into adjacent map sheets to the north, west, south and southeast.

Correlation. The Gull Lake Formation is directly correlative with the same unit in the Nahanni map area. To the northeast the Gull Lake Formation is equivalent to the Sekwi Formation and is very likely an argillaceous equivalent of the Hess River and basal Rabbitkettle formations. Gordey and Anderson (1993) noted that the Gull Lake Formation in the Nahanni area is a direct equivalent of the Sekwi Formation, and may be an argillaceous equivalent of the Middle Cambrian Rockslide and Avalanche formations of the Mackenzie Mountains. In the Nahanni area, however, the Upper Cambrian to Lower Ordovician Rabbitkettle Formation continues basinward as a mappable unit and is shown resting unconformably on the Gull Lake Formation (Gordey and Anderson, 1993).

The Gull Lake Formation is likely widespread over the entire Selwyn Basin, but its extent remains to be determined (Gordey and Anderson, 1993). Abbott (1992) has mapped Gull Lake Formation(?) strata in the northern Selwyn Basin about 200 km west of the study area, and Roots et al. (1995a, b) mapped the Gull Lake Formation in the Lansing map area west of Niddery Lake. A similar unit is also found in the Barn and British Mountains (a unit of Cecile 1988; Cecile and Lane, 1991; and Lane and Cecile, 1989). There, however, the unit is 200 to 500 m thick and consists of both green and maroon argillites with quartzite and limestone. The maroon lithologies contain the trace fossil *Oldhamia* (Hofmann et al., 1994) and resemble the Arrowhead Lake Member of the Narchilla Formation.

Interpretation. The Gull Lake Formation in the Niddery Lake map area is considered to be a relatively deep-water unit on the basis of its graded bedding, dominance of fine grain size, and its facies position (Fig. 9).

Old Cabin Formation (new)

Type locality. The type area of the Old Cabin Formation is a solitary mountain complex between Old Cabin Creek, after which it is named, on the south, and the Rogue River on the north (Fig. 3). This complex has a central peak of 2112 m at UTM co-ordinates 379450 E and 7067600 N, Zone 9, NTS 105-O/11. The mountain complex itself was described as the Old Cabin Massif by Hart (1986). Relief in the area is attributed to erosional resistance due to contact metamorphism associated with intrusion of a Cretaceous pluton. Some of the pluton is exposed on the east end of the 'massif'.

Lithology, thickness, and contacts. The type area of the Old Cabin Formation has been studied in detail by both Sarjeant (1983) and Hart (1986). Hart reported that strata here assigned to the formation are up to 500 m thick and consist of hyaloclastic breccias with lesser amounts of massive and pillowed flows, lapilli tuffs, epiclastics, sills, and dikes. Hart also noted that they show evidence of intense low-temperature hydrothermal alteration, with olivine and pyroxene pseudomorphed by hydrated phyllosilicates, quartz and carbonate.

In the type area the Old Cabin Formation overlies the Gull Lake Formation argillite with a sharp contact, and is directly overlain by the upper Lower Silurian to Lower Devonian Steel Formation. To the northwest of the Niddery Lake map area (Cecile and Abbott, 1992), however, the Old Cabin Formation is in direct contact with the top of the Arrowhead Lake Member, Narchilla Formation and laterally intertongues with the Gull Lake Formation. Outside the type area the formation either intertongues with and/or forms distinct units within the Gull Lake, Hess River, Rabbitkettle and Elmer Creek formations. In limited areas it is directly overlain by strata of the Lower to Upper Ordovician Elmer Creek Formation. In the study area most Old Cabin Formation units rest directly on the Gull Lake Formation and the upper contact is the modern-day erosion surface.

West of Keele Peak, the Old Cabin Formation occurs as a distinct unit within the Gull Lake Formation and at the same locality the Gull Lake Formation features numerous units and beds of volcanic rocks. The precise stratigraphic relations in this area are obscured by intense foreshortening, with small-scale detachments, within the Rogue Décollement Complex.

Chemistry. Several samples of Old Cabin Formation volcanics have been analyzed for major and rare earth elements (Goodfellow et al., 1995 - 'Niddery volcanics'). Goodfellow et al. characterized these volcanics as alkali basalts and basanites using a Zr/TiO_2 versus Nb/Y plot, and also showed that most fall in the within-plate alkali basalt field using a Nb–Zr–Y ternary diagram.

Age. The Old Cabin Formation volcanics are no older than the Arrowhead Lake Member (Narchilla Formation) and are as young as the basal Steel Formation. Thus they can range in age from Early Cambrian to Early Silurian. Over most of the area they are mainly found with the Cambrian Gull Lake Formation and the bulk of the volcanism is thought to be Cambrian. A single archeocyathid was identified within these volcanics by B.S. Norford (Norford et al., 1993).

Distribution. Mappable Old Cabin Formation volcanics are found in large synclinal structures and within the Gull Lake Formation in the western study area, (Fig. 4; Cecile 1997c, d), and throughout the northwestern Niddery Lake map area (Cecile, 1984b, 1998 a, b, c, 1999; Cecile and Abbott, 1989, 1992).

Correlation. Blusson (1974) mapped similar volcanic occurrences as 'Proterozoic' volcanics in adjacent Bonnet Plume (106 B) and Nadaleen (106 C) map areas, north and northwest of the Niddery Lake map area. The uppermost parts of the Old Cabin Formation are correlative with the Marmot Formation, which outcrops in the northeast of the study area, and over much of the Misty Creek Embayment to the north and northeast (Fig. 2; Cecile 1982; Goodfellow et al., 1995). Isolated occurrences of similar Cambrian and Lower Paleozoic volcanics are found throughout the Canadian Cordillera, and in Alaska (see Goodfellow et al., 1995).

Interpretation. The Old Cabin Formation volcanics represent discrete alkalic volcanic centres that are penecontemporaneous with deposition of the deep-water Gull Lake Formation, and to a lesser degree with the younger Elmer Creek and Steel formations. Most of the volcanics are probably of submarine origin – volcaniclastics, flows etc. With detailed study, shallow and subaerial facies may be identified around volcanic centres, but none were recognized during this study.

Middle Cambrian to Silurian basin stratigraphy and the Niddery High

During Middle Cambrian to Early Silurian time the central part of the study area received relatively thin sediment accumulations represented now by basin facies shale, calcareous shale, limestone and some chert. The stratigraphic units representing this time interval are, in ascending order, the Hess River, Rabbitkettle, and Duo Lake formations (Fig. 11). All these strata are only a few hundred metres in total thickness. By contrast, equivalent strata in the

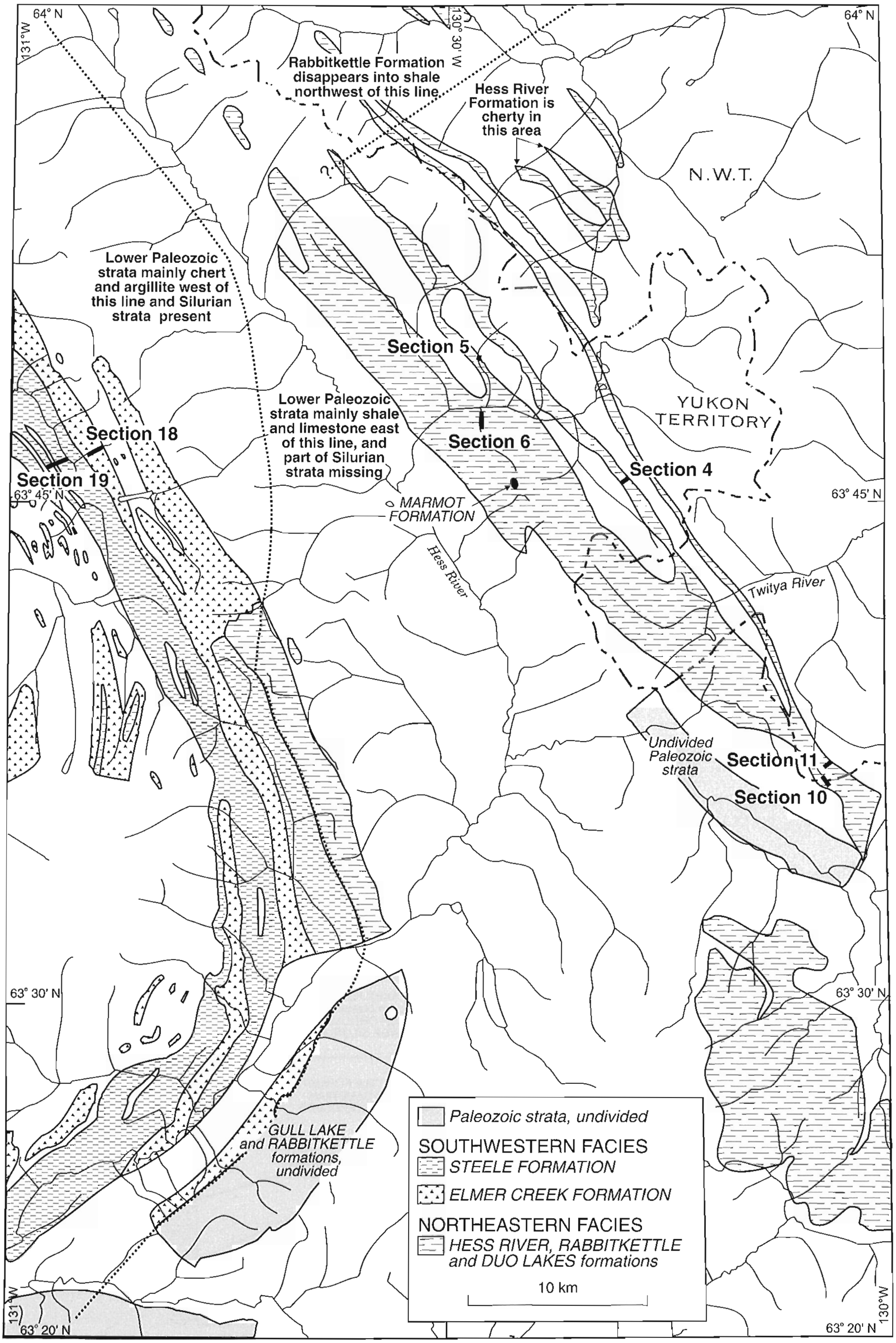


Figure 11. *Distribution of Middle Cambrian to Silurian strata, northeastern Niddery Lake map area.*

centre of the adjacent Misty Creek Embayment to the northeast (Fig. 2), are more than 3 km thick. The Hess River, Rabbitkettle, and Duo Lake formations are therefore interpreted as having been deposited on the Niddery High. In the far northeast of the area, the same strata in subsurface cross-section are interpreted as thickening into the Misty Creek Embayment to the northeast (see Fig. 54 in section on Structure; isopach maps of Cecile, 1982). Middle and Late Silurian strata are missing beneath the Early–Middle Devonian Hailstone Formation in the area of the Niddery High, and this is attributed to erosion or nondeposition associated with the high's ancestral relief (Fig. 2, 12; also see discussion on Hailstone Formation below).

In the west of the study area these lower Paleozoic strata are transitional from the Niddery High into Selwyn Basin (Fig. 12). Nearly all the limestone and most of the shale change southwestward from the high into time equivalent, thin, Middle Cambrian to Early Silurian Selwyn Basin argillite (Cambrian Gull Lake Formation, upper part) or chert (Elmer Creek Formation - new) facies units (Fig. 11, 12). In addition, the Lower Silurian part of the Duo Lake Formation, and the Middle and Late Silurian time interval missing on the Niddery High in the northeast, are represented in the west by the Steel Formation, a distinctive rusty orange weathering argillite unit (Fig. 11, 12).

These southwestern facies are considered to be strata of the Selwyn Basin proper. The dominance of chert and argillite and lack of limestone in comparison to the Niddery High are representative of deeper water facies.

Road River Formation or Group

Gordey and Anderson (1993) combined the Duo Lake and Steel formations into the Road River Group in accordance with the revised usage of Road River Formation of Gabrielse et al. (1973). In its type area the Road River Formation is composed of units similar in composition, biostratigraphy, and thickness to what we recognize as the Rabbitkettle, Duo Lake and Steel formations (Cecile and Morrow, 1981; Cecile, 1982; Cecile et al., 1982; Gordey and Anderson, 1993). In redefining the interpretation of Gabrielse et al. (1973), the type lower Road River Formation, a direct equivalent of the Rabbitkettle Formation, was excluded. Fritz (1985) attempted to resolve this problem by proposing that the base of the Road River 'Group' be placed at the base of Middle Cambrian strata in the type area of the Road River Formation and in the area of the Misty Creek Embayment, and then stepped upward to the top of Rabbitkettle in Selwyn Basin and areas farther south.

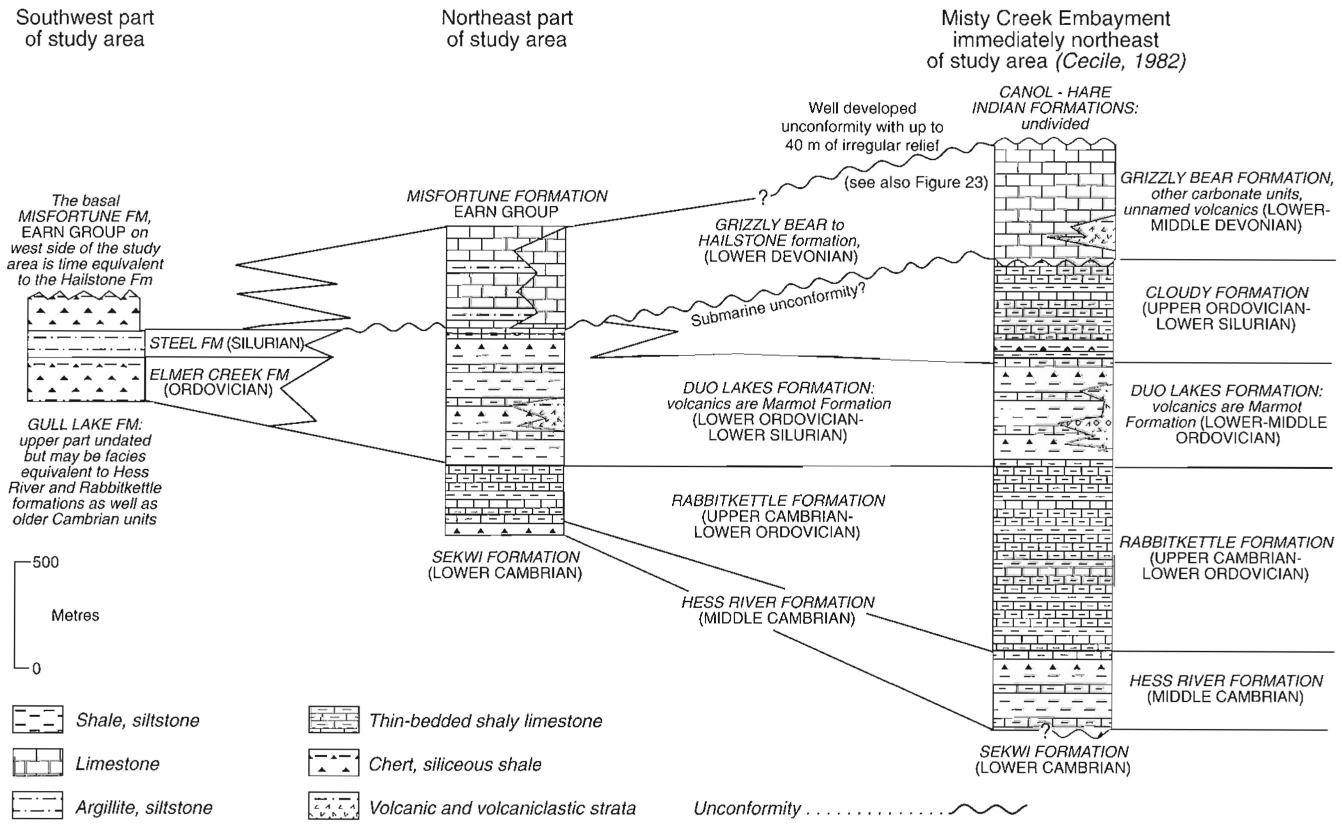


Figure 12. *Correlation of Middle Cambrian to Silurian strata, northeastern Niddery Lake map area.*

With new stratigraphic studies over the last twenty years we now understand what the type Road River is, and what its equivalents in Selwyn Basin are. We can also appreciate that the usage introduced by Gabrielse et al. (1973) was incomplete.

If the term Road River is to be extended to Selwyn Basin and elevated to group status it should include all equivalents of the type Road River Formation. In practice, however, this has not been done (e.g., Fritz, 1985; Gordey and Anderson, 1993). In addition, with the terms Rabbitkettle, Duo Lake, and Steel Formation now applied over a large part of the Selwyn and Mackenzie mountains, the usefulness of Road River as a group term is significantly diminished. Therefore in this study the term Road River Group is not used.

Northeastern facies - Niddery High

Hess River Formation

Type locality. The type section of the Hess River Formation is at lat. 62°42'N, long. 130°47'W in the Bonnet Plume (106 B) map area immediately north of the study area (Cecile, 1982). Section 5 is a reference section for the study area (Fig. 11, 13).

Lithology, thickness, and contacts. At its type section the Hess River Formation consists of 60 m of black shale overlain by 360 m of interbedded calcareous shale and argillaceous limestone, with minor barite and phosphate. In the centre of the Misty Creek Embayment the Hess River Formation is more than 1270 m thick, and in the northwest part of the embayment, where it includes a thick succession of quartz sandstone–shale flysch, 2530 m thick.

In the central study area the Hess River Formation outcrops on the Niddery High (Fig. 2). There it is between 38 and 115 m thick – less than one tenth the thickness in the adjacent Misty Creek Embayment (Fig. 13, 14). This thin succession consists of shale and calcareous shale with some thin bedded limestone. On the southwest limb of the Border Anticline (see Fig. 53 in section on Structure) in the northern part of the study area, partly exposed Hess River Formation is thin and anomalous. There it is apparently less than 40 m thick and composed dominantly of chert (see outcrops around UTM co-ordinates 433750 E and 7085950 N, Zone 9, NTS 105-O/16, Fig. 11).

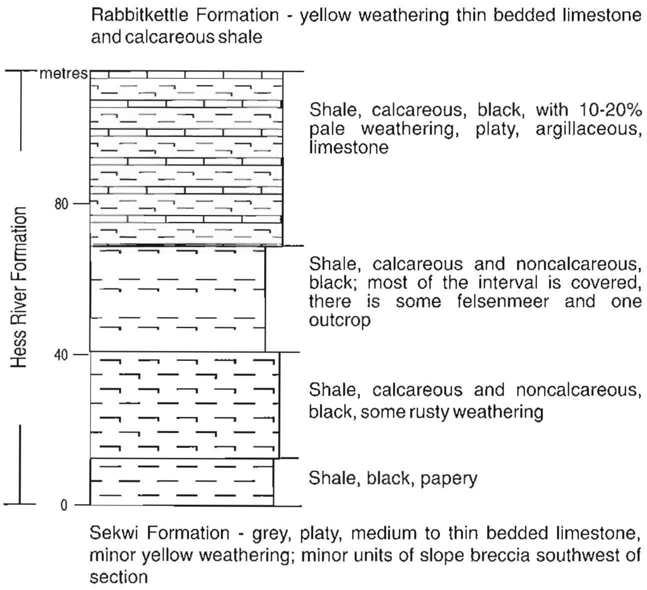


Figure 13. *Hess River Formation, reference section. Section 5, east limb of the Hawthorne Anticline, 105-O/16, base at UTM co-ordinates 428200 E, 7077150 N; top at 428400 E, 7077300 N, Zone 9.*

Figure 14. *Exposure of a relatively thick succession of Hess River Formation. Lighter coloured resistant beds are shaly limestone and darker recessive beds shale and calcareous shale (ISPG photo 1618-6).*

All contacts with the underlying Sekwi Formation are conformable and distinct. The contact is marked where shale is more abundant than limestone and can usually be placed to within a metre.

Age. In the study area the Hess River Formation is unfossiliferous and is dated tentatively as Middle Cambrian by its relative stratigraphic position. For example, the Sekwi Formation beneath the Hess River Formation is as young as late Early Cambrian and the oldest age in the overlying Rabbitkettle Formation is Early to Late Cambrian (Appendix 1).

In the Misty Creek Embayment the Hess River Formation ranges in age from latest Early Cambrian to latest Middle Cambrian and is diachronous with the top of the Sekwi Formation (Fritz et al., 1982; Cecile, 1982). The oldest Rabbitkettle age is Late Cambrian, Franconian, 117 m above the Hess River Formation. In addition, Late Cambrian, Dresbachian, fossils were identified from transitional Franklin Mountain Formation 141 m above the Hess River Formation (Fritz et al. 1982).

Distribution. The Hess River Formation outcrops across the eastern two thirds of the study area (Fig. 11; Cecile, 1997a, b, d). It is also mapped in the southeastern part of the Niddery Lake map area (Abbott, 1983a; Cecile and Abbott, 1992).

Correlation. The Hess River Formation is continuous into the Misty Creek Embayment to the north, east and southeast. The Hess River Formation is correlative with part of the Mount Cap Formation (glauconitic sandstone, shale, thin bedded limestone) found on the eastern side of the Mackenzie–Redstone Arch (Fig. 2). In the southern Mackenzie Mountains it is correlative with a platform dolostone succession (Avalanche Formation), and a basin or slope thin bedded limestone succession, which is a lateral equivalent of the dolostone (Rockslide Formation; Cecile, 1982). In the Nahanni map area the Avalanche Formation is transitional into the Rockslide Formation from the Blackwater Platform on the southeast to the Misty Creek Embayment on the northwest, respectively (Gordey and Anderson, 1993, their fig. 16). Farther northwest it is then transitional into the Hess River Formation in the Misty Creek Embayment.

In the western study area and western Niddery Lake map area the Hess River Formation is thought to be correlative with part of the Gull Lake Formation. Also, Middle Cambrian strata are not separately mappable in the southwestern part of the Nahanni map area (Selwyn Basin) where equivalent beds may also be included within the Gull Lake Formation (Gordey and Anderson, 1993).

Interpretation. The Hess River Formation is a deep-water facies unit consisting of shale with some thin bedded limestone. The variation in thickness in the study area may be a result of its diachronous relationship with the Sekwi Formation or may reflect subtle local relief at the time of deposition. The apparent local dominance of chert is anomalous.

Rabbitkettle Formation

Type area. The type area of the Rabbitkettle Formation is situated at the headwaters of the Rabbitkettle River in the southern Selwyn Mountains (Gabrielse et al., 1973). There is a reference section in the Misty Creek Embayment north of the study area at lat. 64°27'N and long. 130°52'W (Cecile, 1982). Section 6 is a reference for the Rabbitkettle Formation in the study area (Fig. 11, 15).

Lithology, thickness, and contacts. In the type area the Rabbitkettle Formation consists of about 1200 m of thin bedded limestone, silty limestone, and siltstone (Gabrielse et al., 1973). In the adjacent Misty Creek Embayment reference section, the Rabbitkettle Formation consists of 437 m of thin bedded silty limestone, limestone, carbonate breccia, shale and dolostone. In the centre of the Misty Creek Embayment it is more than 840 m thick (Cecile, 1982).

In the study area the Rabbitkettle Formation accumulated on the Niddery High and is relatively thin, ranging from 60 to 92 m thick. It consists of 70 to 80 per cent medium to thick beds of limestone alternating with 20 to 30 per cent medium to thick beds of shale (Fig. 15, 16).

The Rabbitkettle Formation is in distinct but conformable contact with the underlying Hess River Formation. The boundary is marked where limestone dominates over shale and can usually be placed to within a metre.

Sedimentary features. The Rabbitkettle Formation consists of thick (30–50 cm) couplets of yellow weathering, laminated limestone grading upward into shale (Fig. 17). The contact between the base of the limestone of one couplet and the underlying shale of another is sharp. In well weathered outcrop it appears that each lamina in the limestone portion comprises a surface of complex, bedding-parallel feeding traces (Fig. 18).

Age. In the study area the Rabbitkettle Formation is thought to be Late Cambrian to Early Ordovician in age. However fossils only partly constrain the age in this interval (Appendix 1). Most fossils collected indicate an Early Ordovician, Tremadoc to Arenig age. One collection gives a range of middle Arenig to Llanvirn and another, a range of Early to Late Cambrian.

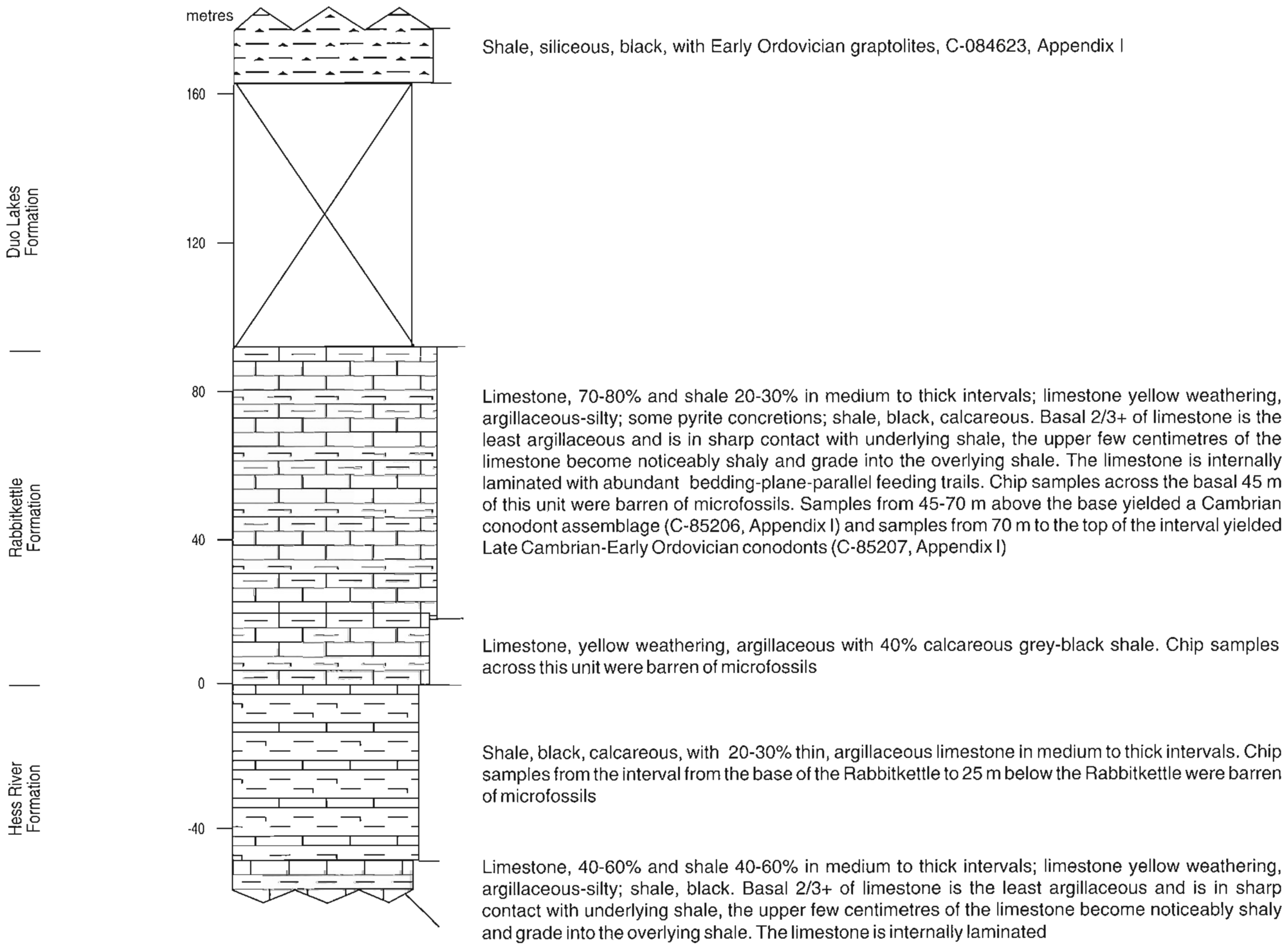


Figure 15. *Rabbitkettle Formation, reference section, west limb of Hawthorne Anticline. Section 6, 105-O/16, base at UTM co-ordinates 428000 E, 7074900 N; top at 427950 E, 7074500 N, Zone 9.*

The overlying Duo Lake Formation in the study area is as old as Early Ordovician, late Tremadoc, but is probably diachronous with the Rabbitkettle Formation, as it is in the adjacent Misty Creek Embayment (Cecile, 1982). The underlying Hess River Formation is inferred to be Middle Cambrian.

In the Misty Creek Embayment the base of the Rabbitkettle Formation is as old as Late Cambrian, Franconian. The top is as young as Early Ordovician, early Middle Arenig (Fritz et al., 1982).

Distribution. The Rabbitkettle Formation outcrops over the eastern two thirds of the study area and is missing or equivalent to the Gull Lake Formation argillites in the west (Fig. 11; Cecile 1997a, b, d).

Correlation. The Rabbitkettle Formation is continuous with the Rabbitkettle Formation of the Misty Creek Embayment to the north, northeast, east and southeast. It is correlative with the Rabbitkettle Formation of Gordey and Anderson (1993) in the Nahanni map area, which is similar in sedimentary features and composition to, but somewhat thinner than, the Rabbitkettle Formation found in the Misty Creek Embayment.

Named or unnamed map units similar in composition, lithology, facies, and age to the Rabbitkettle Formation are found throughout the Canadian Cordillera (Cecile and Norford, 1993). In the Richardson Mountains the equivalent unit is the lower part of the type Road River Formation (Cecile and Morrow, 1981). In the central Canadian Cordillera, the equivalent unit is the Kechika Formation or Kechika Group (Cecile and Norford, 1979; Cecile 1990). In the southern Canadian Cordillera, the equivalent unit is the McKay Group (Aitken and Norford, 1967).

Interpretation. The fine grain size and lack of shallow-water features indicates a deep-water environment. The most interesting feature of the Rabbitkettle Formation is the approximately one-half metre thick, graded limestone to calcareous shale couplets with sharp basal contacts. This

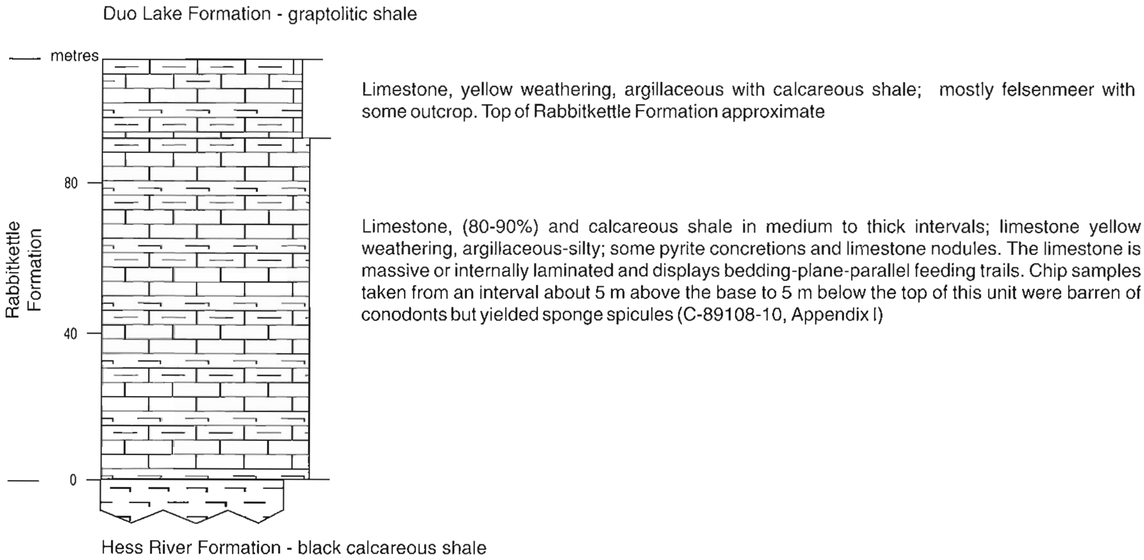


Figure 16. *Rabbitkettle Formation, Section 10. Base at UTM co-ordinates 446650 E, 7055050 N; top at 446700 E, 7054800 N, Zone 9.*

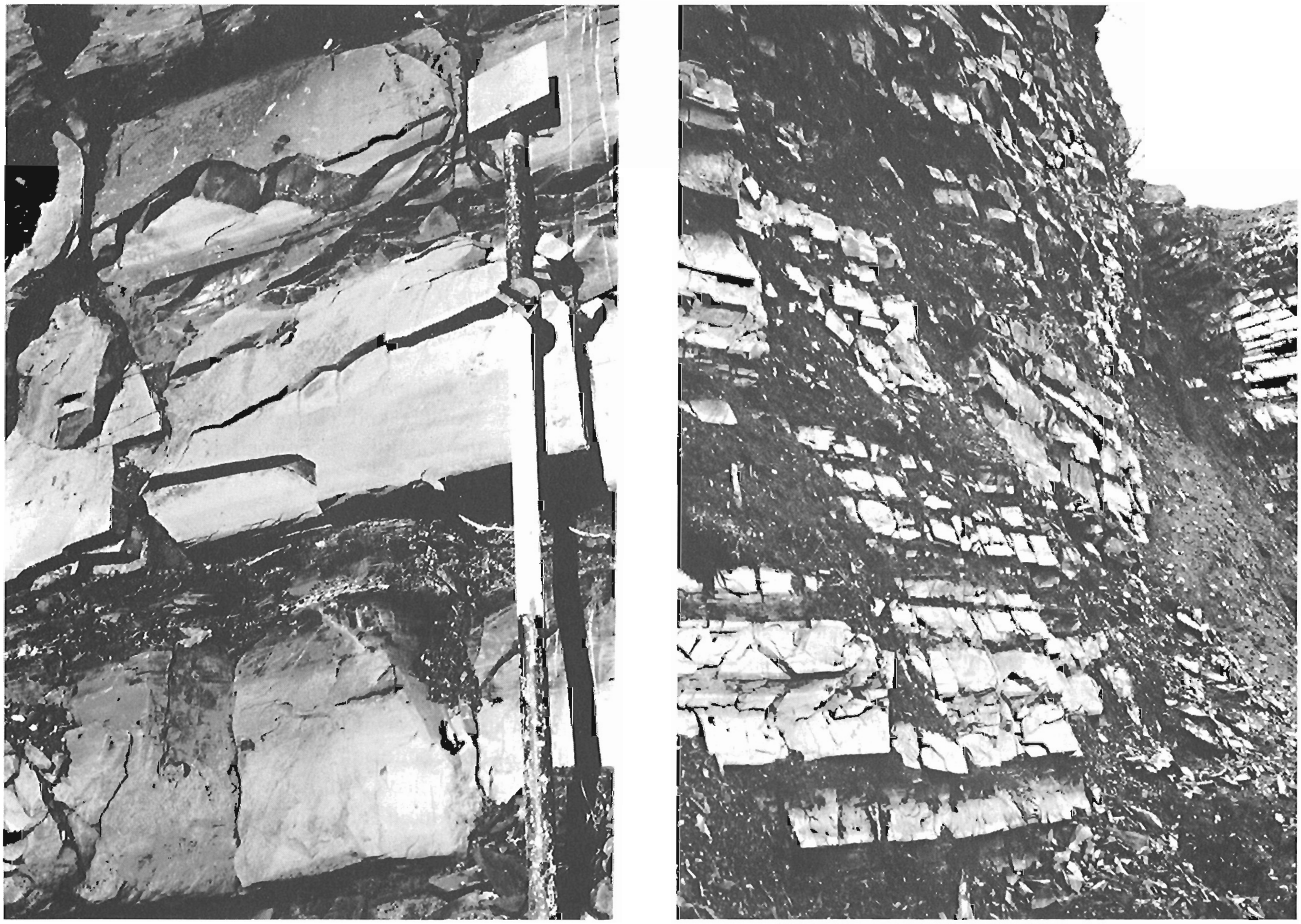


Figure 17. *Typical Rabbitkettle Formation of the northeast Niddery Lake study area. Each bed is a half-metre-thick graded limestone to calcareous shale couplet with sharp basal contacts (ISPG photos 1618-17, 20).*

Figure 18. *Slab of Rabbitkettle Formation showing abundant trace fossil trails on a bedding plane, a feature characteristic of the Rabbitkettle in the northeast Niddery study area (ISPG photo 1618-26).*

thickness and texture of beds is peculiar to the study area. In a thickness of 60 to 92 m there are about 180 couplets. Assuming a Late Cambrian to Early Ordovician age, and noting that there is no evidence of major erosional discontinuities, each couplet could represents 100 to 500 thousand years. Individual lamellae in limestone beds show abundant bedding-parallel trace fossil trails. In the Misty Creek Embayment, strata equivalent to each couplet comprise several tens to hundreds of metres of centimetre-scale limestone–shale rhythmites. Thus the study area couplets appear to represent, at a basic level, a systematic and recurring change in the rate of deposition of shale versus limestone over a period of time of about 100 to 500 thousand years. Also, the limestone accumulated slowly, allowing for extensive sediment bottom grazing on a lamellar scale.

Several factors could control the relative rate of shale versus limestone deposition: periodic submergence of the Mackenzie and correlative platforms, or deepening of the Misty Creek Embayment to cut off the carbonate supply; submergence tectonically or eustatically controlled; or periodic influx of fine clastics (shale) or conversely lime muds, controlled by climate, currents, winds, tectonics, or eustatic change.

Further systematic study of these rocks utilizing petrography, isotopes, and more precise biostratigraphy would narrow the range of possibilities and produce useful information on the origin of lower Paleozoic strata in the region.

Duo Lake Formation

Type locality. The type section of the Duo Lake Formation is in the Misty Creek Embayment at lat. 64°42'N and long. 130°47'W, (NTS106 B) immediately north of the Niddery Lake map area (Cecile, 1982).

Lithology, thickness, and contacts. In the type area the Duo Lake Formation is divided into two units, a basal, 240 m thick succession of thin bedded limestone and graptolitic shale, and an upper, 76 m thick unit of graptolitic siliceous shale and minor chert. Elsewhere in the Misty Creek Embayment the Duo Lake Formation is up to 415 m thick (Cecile, 1982).

In the study area the Duo Lake Formation consists of between 125 and 225 m of graptolitic, calcareous shale, shale, siliceous shale, minor dolomitic shale, and minor chert (Fig. 19–22). It has a distinct, conformable contact with the Rabbitkettle Formation that can be placed to within a metre, where a distinct change from limestone-dominated to shale-dominated strata occurs.

Sedimentary features. All strata are thin bedded or laminated and graptolitic.

Age. Graptolites collected from the Duo Lake Formation in the study area range in age from middle Early Ordovician (Late Tremadoc) to late Early Silurian in age. At least eight graptolite zones are represented in these collections (Appendix 1).

Distribution. The Duo Lake Formation outcrops over the eastern two thirds and the southern part of the study area (Fig. 11; Cecile, 1997a–d).

Correlation. The Duo Lake Formation is continuous north, northeast and east with Duo Lake Formation strata found in the Misty Creek Embayment. The upper Duo Lake Formation in the study area is also correlative with the Cloudy Formation in the Misty Creek Embayment. The Cloudy Formation is a distinctive succession of basin limestone and shale, that 'shales-out' to the southwest and merges into the study area with time-equivalent shaly facies of the Duo Lake Formation (Fig. 12).

The Duo Lake Formation is also mapped throughout the Nahanni map area (Gordey and Anderson, 1993) where it is very similar in composition and thickness to the Duo Lake Formation in the type area but has virtually no interbedded limestone.

The Duo Lake Formation is laterally correlative and intertongues with the Marmot Formation. The Marmot Formation is a mappable succession of volcanic strata that occurs as a lens within the Duo Lake Formation of the study area.

To the southwest, the Duo Lake Formation is correlative with, and transitional into chert of the Elmer Creek

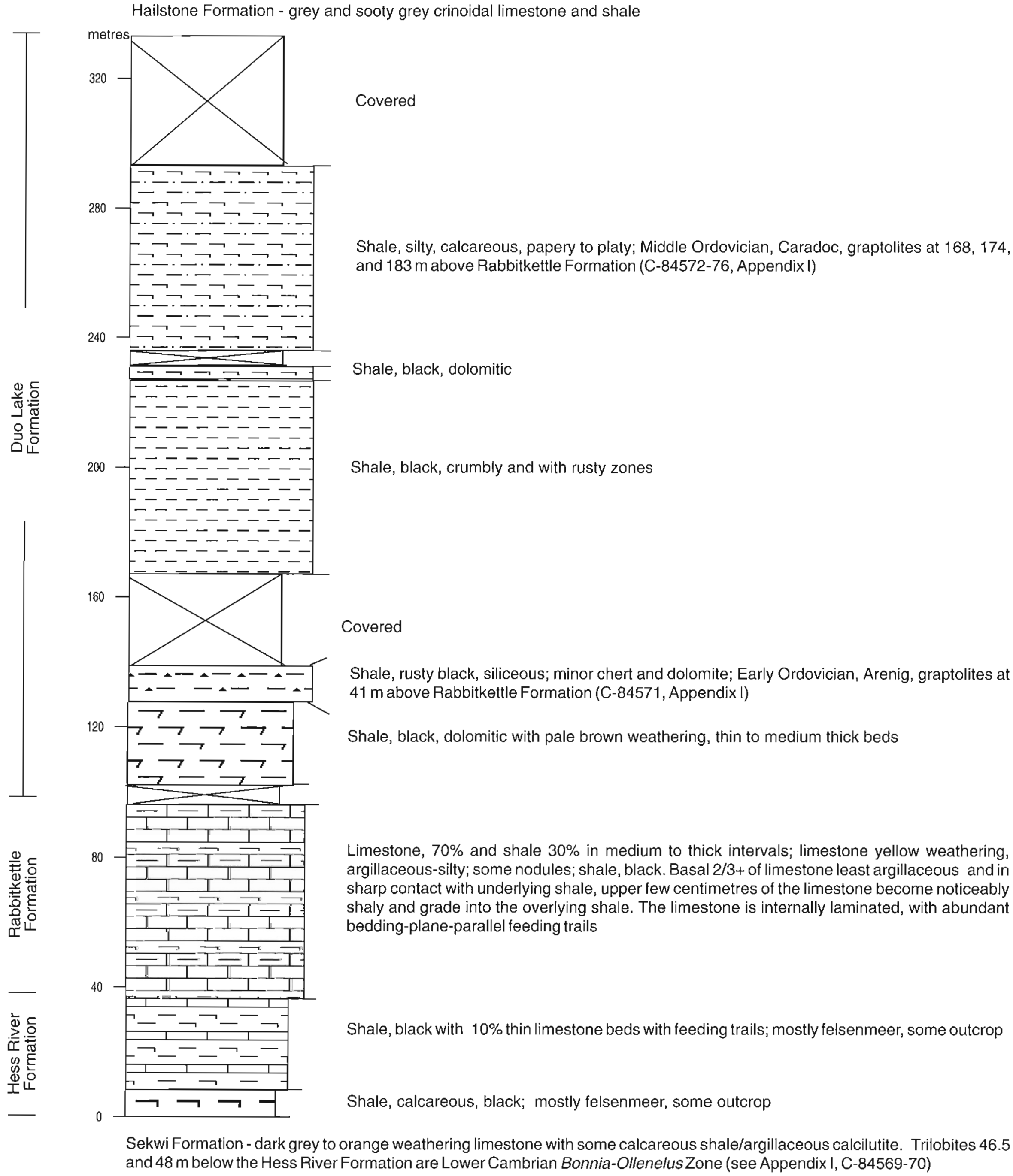


Figure 19. *Duo Lake Formation reference section and additional sections of Hess River and Rabbitkettle formations on the west limb of Middlecoff Anticline. Section 4, 105-O/16, base at UTM co-ordinates 437500 E, 7069850 N; top at 436850 E, 7069750 N, Zone 9.*

Formation, and argillite in the lower part of the Steel Formation (Fig. 11, 12).

Interpretation. Thin bedding, dominance of shale and chert, and presence of graptolites indicate that the Duo Lake Formation is a deep-water facies unit. The presence of calcareous shale and limestone indicates it is, however, above the level of the carbonate compensation depth. The southwesterly transition to chert of the Elmer Creek Formation reflects increasing water depth off the Niddery High into the Selwyn Basin proper.

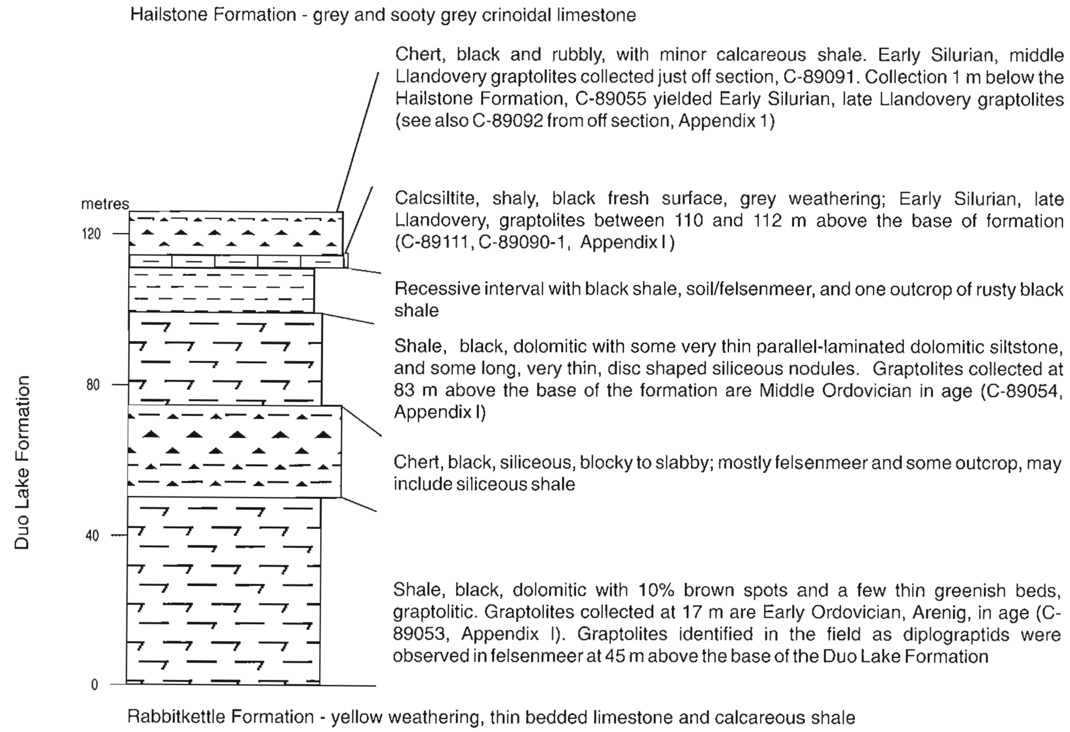


Figure 20. *Duo Lake Formation, reference section. Section 11, 105-O/9, base at UTM co-ordinates 448300 E, 7055300 N; top at 448350 E, 7055500 N, Zone 9.*

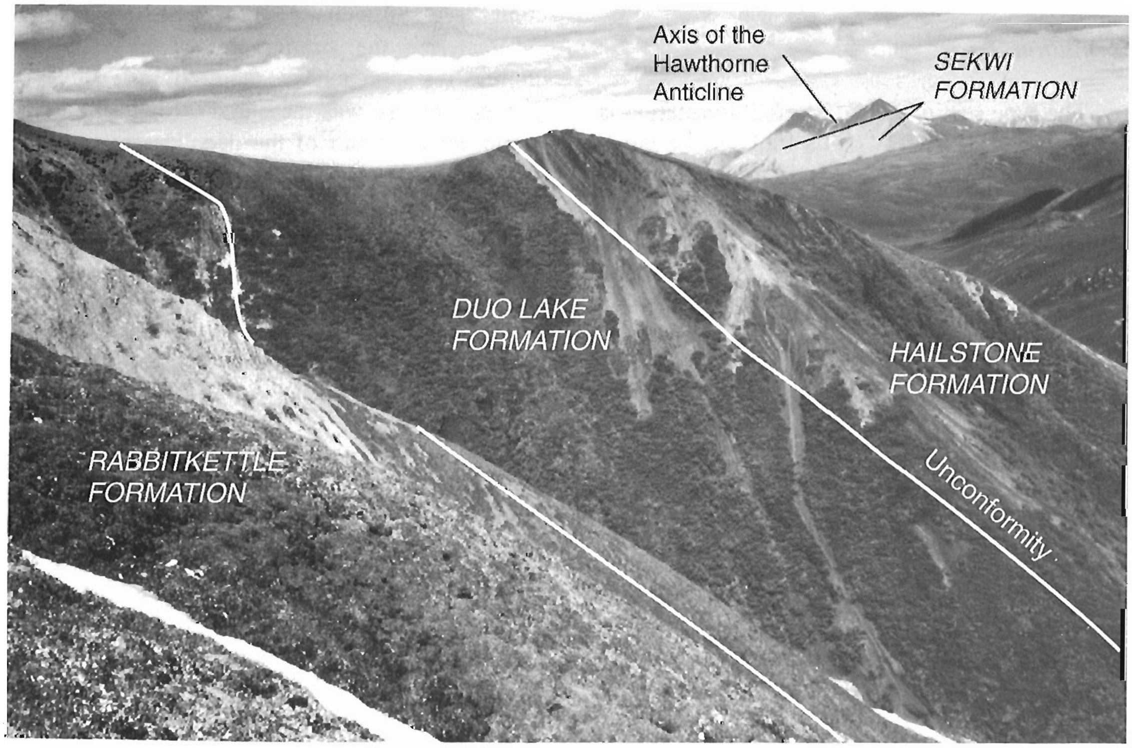


Figure 21. *View to the northwest of a ridge just northwest of Section 11 showing the Duo Lake Formation overlain by Hailstone Formation. The twin peaks in the right background are the upper Sekwi Formation. Each peak is an opposing limb of the Hawthorne Anticline, which plunges into the subsurface toward the left of the ridge in the foreground (ISPG photo 1666-1).*

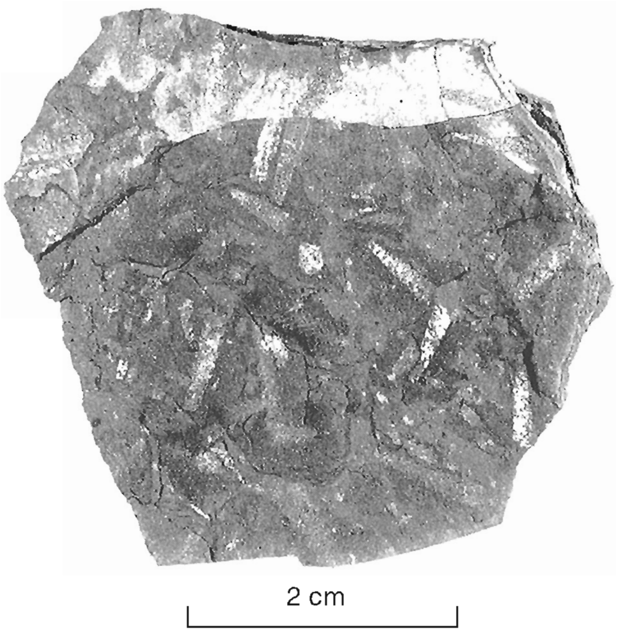


Figure 22. *Bedding plane surface showing typical biserial graptolites found in Duo Lake shale. In the centre of the photo is the outline of a* ***Dicellograptus****, the rest are various forms of* ***Diplograptidae*** *(ISPG photo 1628-3).*

Marmot Formation

Type locality. The type section of the Marmot Formation is at lat. 64°10'N and long. 130°20'W (NTS 106B) in the Misty Creek Embayment, immediately north of the study area (Cecile, 1982).

The type Marmot Formation is a mixture of volcanic and volcaniclastic strata. In the study area the Marmot Formation occurs as a single lens within the Duo Lake Formation (Fig. 11). At this locality it consists of a few tens of metres of cleaved breccia with a calcareous green matrix separating brown weathering, centimetre-scale, fine grained, basic volcanic clasts. The breccias resemble proximal volcanic vent breccias, and their compositions and association with graptolitic shale suggest they may be submarine, hyaloclastic breccias. However given the small outcrop area, evaluation of their origin is difficult. It is also possible that the breccias are part of a small, local, sub-volcanic intrusion. Because it is interstratified with the Duo Lake Formation, the lens is considered Ordovician to Early Silurian in age.

The Marmot Formation in the Misty Creek Embayment consists of alkalic potassic basanites, genetically associated with extensional tectonism (Goodfellow et al, 1995). If the breccias are not extrusive then they should be the same age or younger than the Duo Lake Formation.

Southwestern facies - Selwyn Basin

In the western third of the study area, and across the western and southwestern Niddery Lake map area (Cecile and Abbott, 1992), there is a marked change in the composition and stratigraphy of lower Paleozoic basin strata (Fig. 11, 12). Calcareous shales, shales, limestones, and minor chert of the Ordovician part of the Rabbitkettle Formation and the Duo Lake Formation, typical of the northeast, are here replaced by thin units of siliceous argillite and massive chert. This chert–argillite succession is distinctive and merits a new stratigraphic name, the Elmer Creek Formation. In addition, Middle and Upper Silurian strata, missing beneath a sub-Devonian submarine unconformity in the northeast part of the study area (Fig. 2, 12), are represented in the southwest by a thin succession of orange weathering argillites, the Steel Formation (Gordey and Anderson, 1993).

Measured type traverses, Rogue Décollement Complex

The Elmer Creek and Steel formations, in both the study area and the surrounding western Niddery map area, lie within the Rogue Décollement Complex (see Fig. 52, 53 in section on Structure). In the Rogue Décollement Complex shortening is intense (80%), and accommodated along numerous inter-stratal décollements. Because of composition and competency differences, strain varies widely from unit to unit (see Structure section). In order to restore and characterize the stratigraphy of units in this zone an innovative approach was required. Instead of a type section, a type traverse was measured through a nearly continuous exposure over part of the décollement complex (Fig. 23). Using biostratigraphy and lithological characteristics, together with distinct special features like bioturbation, rare limestone occurrences, and observations of actual structures, structural cross-sections were constructed along the traverses (e.g. Fig. 24). From the structural cross-sections, stratigraphic successions were established and a composite type section of the Elmer Creek Formation, as well as a reference section for the Steel Formation, were compiled.

Tectonostratigraphic map units

Although the stratigraphy can be locally resolved for the décollement complex, for practical mapping purposes, map units in the Rogue Décollement must include a mixture of formational units. Because of the dominance of shallow local detachments, large areas of the décollement complex are dominated by structural repetitions of one formation. To accommodate this circumstance the "tectonostratigraphic map unit" was established. A tectonostratigraphic map unit is here defined as an area of outcrop with complex structural repetition that contains more than 50 per cent of the formation from which it derives its name and includes some

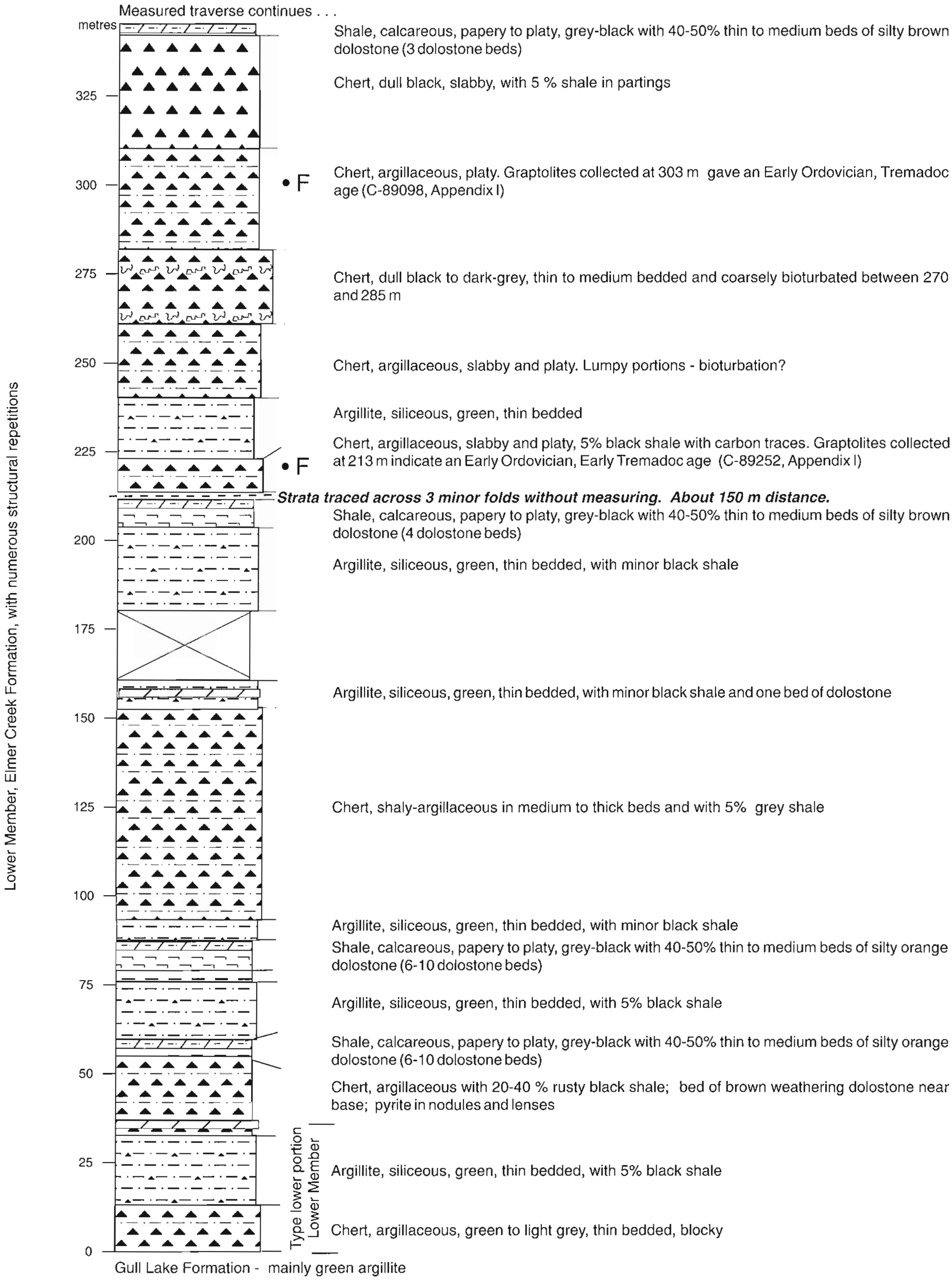


Figure 23. *Elmer Creek Formation, measured traverse. "F" marks fossil locations described in text. Traverse (Section 18) was measured in a creek bottom northwest of Algae Lake, 105-O/15, base at UTM co-ordinates 405950 E, 7075750 N; top at 405600 E, 7075100 N, Zone 9. Portions indicated are the parts used to construct the type composite section shown in Figure 25.*

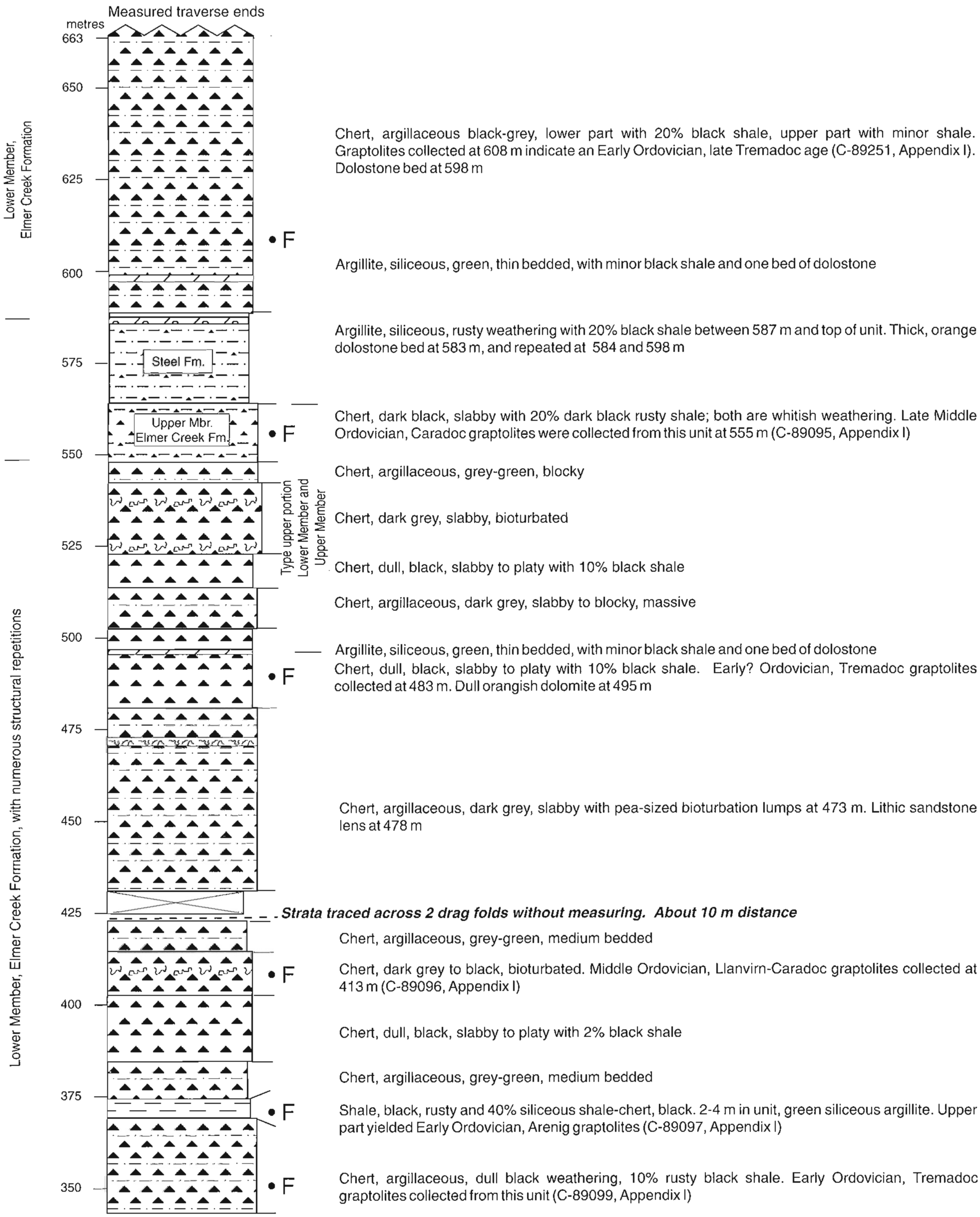


Figure 23. *Elmer Creek Formation, measured traverse continued.*

outcrops of older and younger units repeated in fold hinges or on thrust faults. In practice, most areas mapped in the study area as the Elmer Creek Tectonostratigraphic Unit are more than 80 per cent Elmer Creek Formation, and more than 60 per cent of the Steel Tectonostratigraphic Unit is Steel Formation (see following formation descriptions).

Elmer Creek Formation (new)

Type locality and measured traverse. The type measured traverse of the Elmer Creek Formation is Section 18 (Fig. 11, 23–25; Cecile, 1997d) which was measured in a creek bottom northwest of Algae Lake, in NTS 105-O/15. The traverse starts at UTM co-ordinates 405950 E, 7075750 N, and ends at 404600 E, 7075100 N, Zone 9. Figure 25 is a composite type section constructed from this traverse.

Lithology, thickness, and contacts. The Elmer Creek Formation can be divided into mappable upper and lower members in the study area. Without attempting to accommodate thinning or thickening due to strain, the total thickness of composite type section is 110 m. The massive cherts that comprise 30 to 50 per cent of the lower member can be demonstrated to have undergone minimal strain (see section on Structure). Because the traverse mostly crosses fold limbs (Fig. 24), the thickness is considered a minimum. True thickness may be 20 per cent to 100 per cent greater.

The lower member consists of a lower succession of pale green and drab grey siliceous argillite and argillaceous chert, with minor thin beds of brown dolostone. In the measured traverse dolostones in this position were observed as either a single bed or multiple beds. The association of the dolostone(s) with siliceous argillite, and the rare repetition of dolostone in the traverse, suggests that they are likely from a single or a similar stratigraphic position, and so one zone of dolostone is assumed. The upper part of the lower member is a 30 m thick, resistant, drab grey weathering succession of bioturbated chert (Fig. 26) and massive chert. It is assumed to be a unique unit and this is corroborated by observations, over the study area, of individual folds exposed in ridges and the presence of mainly Tremadocian, and one collection of Arenigian graptolites in this unit along measured traverse 18 (Fig. 24).

The upper member of the Elmer Creek Formation is a very distinctive succession of whitish weathering, dark black, siliceous shale and chert, usually containing biserial graptolites of Middle and Late Ordovician age. In the type composite section it is 17 m thick.

The Elmer Creek Formation is in distinct conformable contact with the Gull Lake Formation. The contact is defined where very siliceous argillite or chert dominate the succession and can usually be placed to within a few metres. The contact between the upper and lower members is sharp and distinct and is marked as a change from drab grey siliceous argillite on top of massive chert, to black weathering siliceous shale or chert.

Sedimentary features. The Elmer Creek Formation is generally thin bedded and laminated. It contains massive cherts with large, irregular, centimetre-scale bioturbation tubes (Fig. 26).

Age. The lower member contains graptolites and conodonts of Early Ordovician age, Early Tremadoc, Late Tremadoc and Arenig. Five separate graptolite zones are represented (Appendix 1).

The upper member contains graptolites and conodonts of Middle and Late Ordovician age, from the Llanvirn, Caradoc and Ashgill. At least four graptolite zones are represented (Appendix 1).

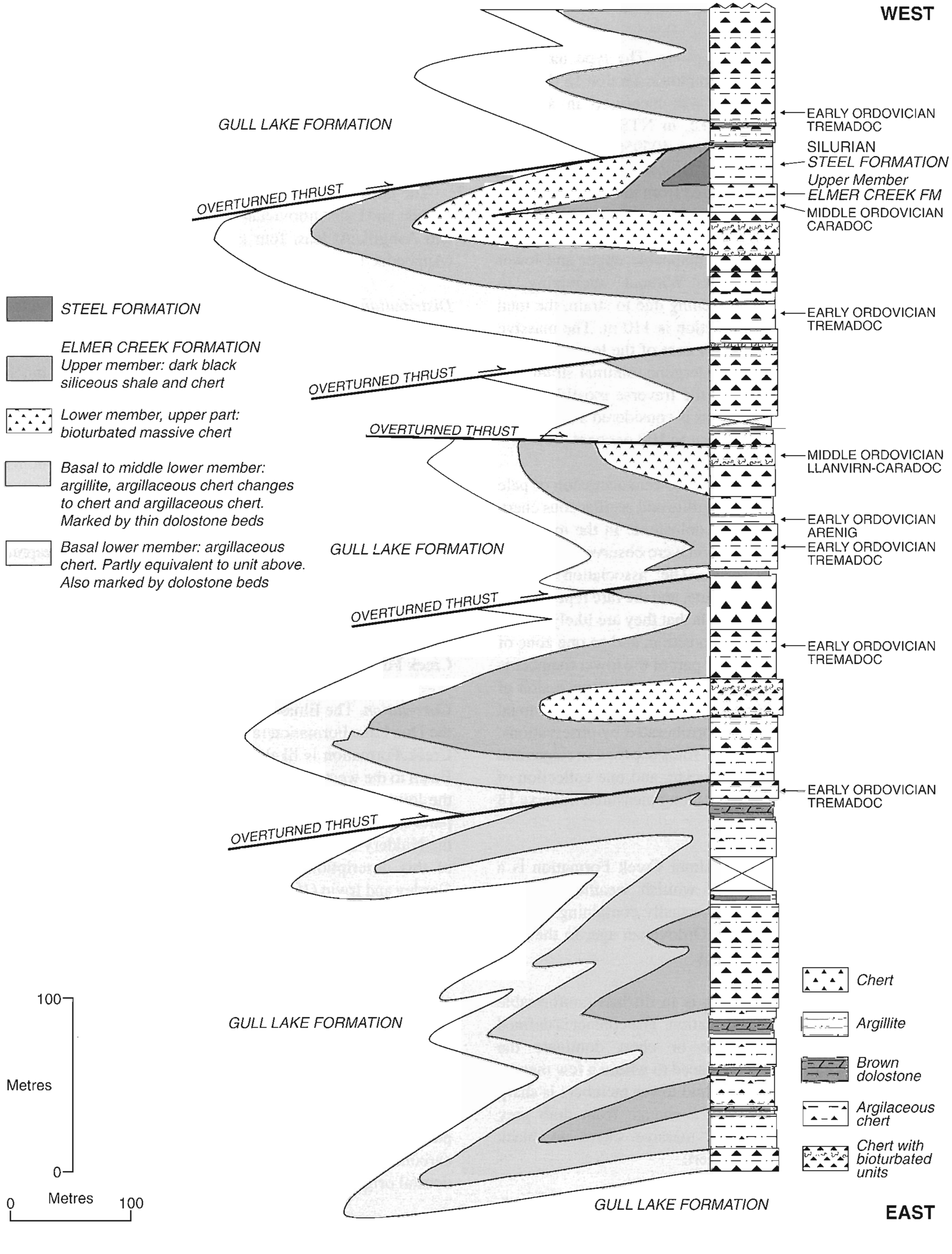
Distribution. The Elmer Creek Formation is found across the western one third of the map area (Fig. 11; Cecile, 1997c, d). It can also be mapped across the western and southwestern Niddery Lake map area (Cecile, 1998a, b, c, 1999) but it becomes increasingly difficult to map the two members separately southwestward (map units lmOc and muOc of Cecile and Abbott, 1989, 1992; Cecile, 1984c, 1986c). The upper member apparently thins, and thus is less commonly observed, to the southwest.

Elmer Creek tectonostratigraphic map unit. The Elmer Creek Formation can be mapped as a separate stratigraphic unit only locally at a 1:50 000 scale. In much of this study area the Elmer Creek Formation is mapped as the Elmer Creek tectonostratigraphic map unit (Cecile, 1997c, d). Most units mapped this way are more than 80 per cent Elmer Creek Formation.

Correlation. The Elmer Creek Formation is correlative with the Duo Lake Formation in the eastern study area. The Elmer Creek Formation is likely a widespread unit in the Selwyn Basin to the west and southwest. Outcrops of chert typical of the lower Elmer Creek member have been observed in the parts of the Sheldon, Tay and Lansing map areas that adjoin the Niddery Lake map area. In these three map areas, cherts of this description are included in the map unit OSr of Gordey and Irwin (1987), and OEC of Roots et al. (1995a, b). Similar strata are reported from the southern Ogilvie Mountains (map units OSDR3,4 of Abbott and Roots, 1993) and from the Barn and British Mountains (Oc unit of Cecile 1988; Cecile and Lane, 1991; and Oac unit of Lane and Cecile, 1989).

Interpretation. This unit is interpreted as a very deep-water deposit. The dominance of chert over shale and low carbonate content indicates slow deposition, mostly below the carbonate compensation depth. Carbonate, present in part of the unit, may reflect a relative drop in the level of carbonate compensation depth, or the carbonate may be of detrital origin.

Palinspastic restoration (see Structure section) of the Elmer Creek unit extends its distribution much farther west,


WEST
GULL LAKE FORMATION
EARLY ORDOVICIAN TREMADOC
SILURIAN
STEEL FORMATION
Upper Member
ELMER CREEK FM
MIDDLE ORDOVICIAN CARADOC
OVERTURNED THRUST
STEEL FORMATION
ELMER CREEK FORMATION
Upper member: dark black siliceous shale and chert
Lower member, upper part: bioturbated massive chert
Basal to middle lower member: argillite, argillaceous chert changes to chert and argillaceous chert. Marked by thin dolostone beds
Basal lower member: argillaceous chert. Partly equivalent to unit above. Also marked by dolostone beds
EARLY ORDOVICIAN TREMADOC
OVERTURNED THRUST
OVERTURNED THRUST
MIDDLE ORDOVICIAN LLANVIRN-CARADOC
EARLY ORDOVICIAN ARENIG
GULL LAKE FORMATION
EARLY ORDOVICIAN TREMADOC
OVERTURNED THRUST
EARLY ORDOVICIAN TREMADOC
EARLY ORDOVICIAN TREMADOC
OVERTURNED THRUST
100
Metres
0
GULL LAKE FORMATION
Chert
Argillite
Brown dolostone
Argilaceous chert
Chert with bioturbated units
0
Metres
100
GULL LAKE FORMATION
EAST

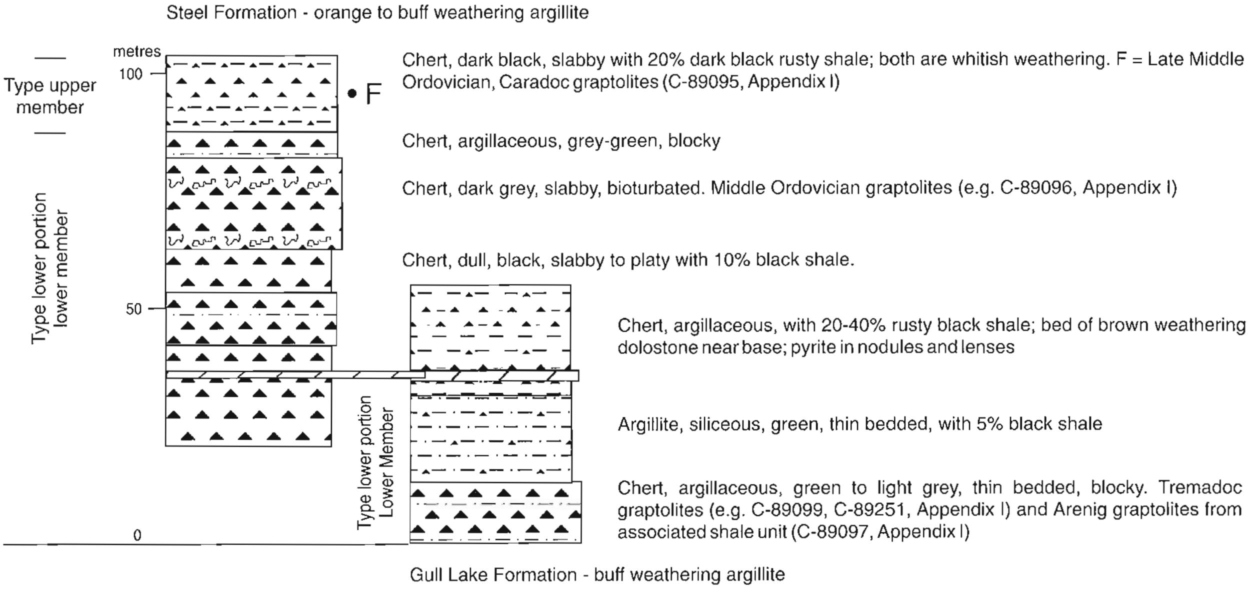


Figure 25. *Elmer Creek Formation, composite type section constructed from measured traverse shown in Figure 23.*

beyond the Niddery map area and across the width of the Selwyn Basin. This puts the western limits of this unit well into the realm of transitional to, and/or, possibly true, oceanic crust.

Steel Formation

Type locality and reference traverse. The type locality is in the Nahanni map area at lat. 62°19.5'N and long. 129°27.0'W (Gordey and Anderson, 1993). A reference traverse (Section 19) was measured in a creek bottom west-northwest of Algae Lake (105-O/15). The traverse starts at UTM co-ordinates 403800 E, 7074100 N, and ends at 401900 E, 7073400 N, Zone 9 (Fig. 27–29).

Lithology, thickness, and contacts. At its type section the Steel Formation is 143 m thick and consists of thin to thick bedded, siliceous, dark grey mudstone that weathers yellowish brown, dull olive grey, or dark yellowish brown; one ten-metre interval is a dark blue-grey siliceous argillite with dark, wispy laminae. Locally in the Nahanni area, a thin member of orange weathering, massive, grey-green dolostone is present.

In the study area, the reference section of the Steel Formation is 30 m thick and consists of rusty-orange weathering green argillite with a prominent, medium thick bed of bright orange weathering grey dolostone. Some shale and dark wispy laminae are also present. As noted previously, the thickness along the traverse is determined mostly across fold limbs and is therefore considered a minimum. Its true thickness may be 20 to 100 per cent greater. The Steel Formation is in distinct and conformable contact with the underlying upper member of the Elmer Creek Formation.

Sedimentary features. Thin bedding, wispy laminae and some feeding traces parallel to bedding are the most notable sedimentary features.

Figure 24. *Simplified cross-section of Elmer Creek Formation exposures along measured traverse of Section 18 (Fig. 23). Cross-section is constrained by the following observations: massive bioturbated cherts and pure cherts are found throughout the study area and in other measured traverses at or near the top of the lower member (e.g., Fig. 28a, b); siliceous argillite units are found throughout the study area near or at the base of the lower member; dolostone beds (dark, with dolomite symbol) are found in the middle of the lower part; the ridge immediately south of the traverse shows faulted-off synclines with the amplitude and wavelength of those shown in the interpreted cross-section. In ridge-side exposures in the study area, massive chert units show no more than 30 per cent variation in thickness between the limbs and noses of folds. This observation is reaffirmed by the fact that cherts with extensive bioturbation exhibit relatively little strain on either the limbs or noses of folds. In addition massive chert bed limbs are seen to close on one another, demonstrating that there are bedding plane detachments within the Elmer Creek Formation itself.*

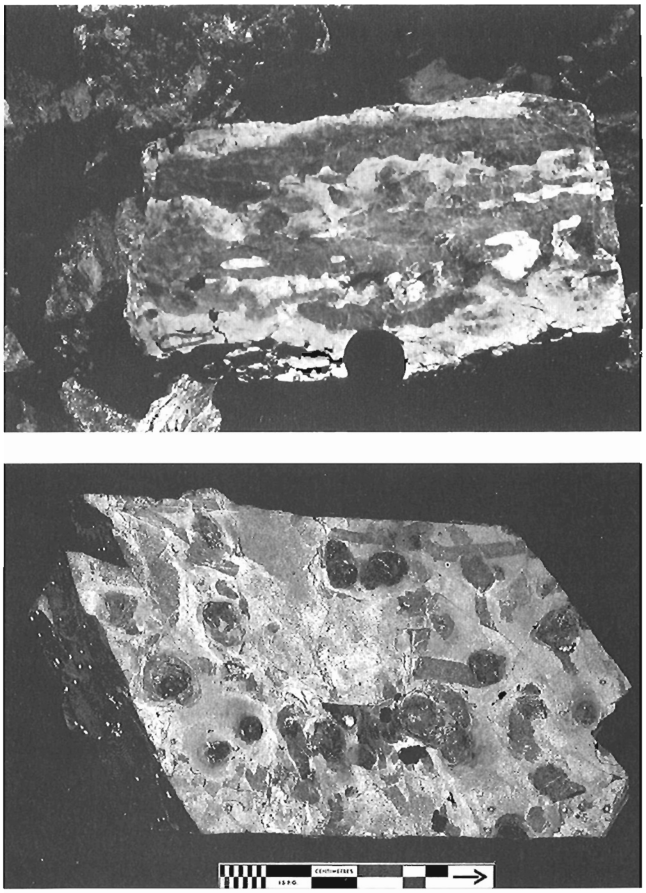


Figure 26. *Hand specimens showing typical centimetre-scale bioturbation found in the upper massive chert beds of the lower member, Elmer Creek Formation (ISPG photos 2019-5, 1618-10).*

Age. In the type area the Steel Formation contains Late Silurian, Ludlow fossils. The overlying basal Portrait Lake Formation contains Early Devonian graptolites and the underlying Duo Lake Formation uppermost Llandovery and mid Wenlock graptolites. Thus in its type area the formation may range in age from late Early Silurian (late Wenlock) to earliest Devonian (Gordey and Anderson, 1993).

In the study area the Steel Formation yielded abundant graptolites ranging in age from Early Silurian (late Llandovery) to Late Silurian (Fig. 30). At least five different graptolite zones are represented, ranging from late Llandovery through Wenlock, Ludlow and Pridoli (late Early Silurian to Late Silurian, Appendix 1). Misfortune Formation shale immediately above the Steel Formation yielded Early Devonian, Pragian graptolites, and therefore the top of the Steel Formation may be as young as earliest Devonian.

Distribution. The Steel Formation is found in the western one third of the study area (Fig. 11; Cecile, 1997c, d), and across the rest of the western (Cecile, 1998a, b, c, 1999) and southwestern Niddery Lake map area (Unit Sa of Cecile and Abbott, 1992; Cecile, 1984c, 1986c).

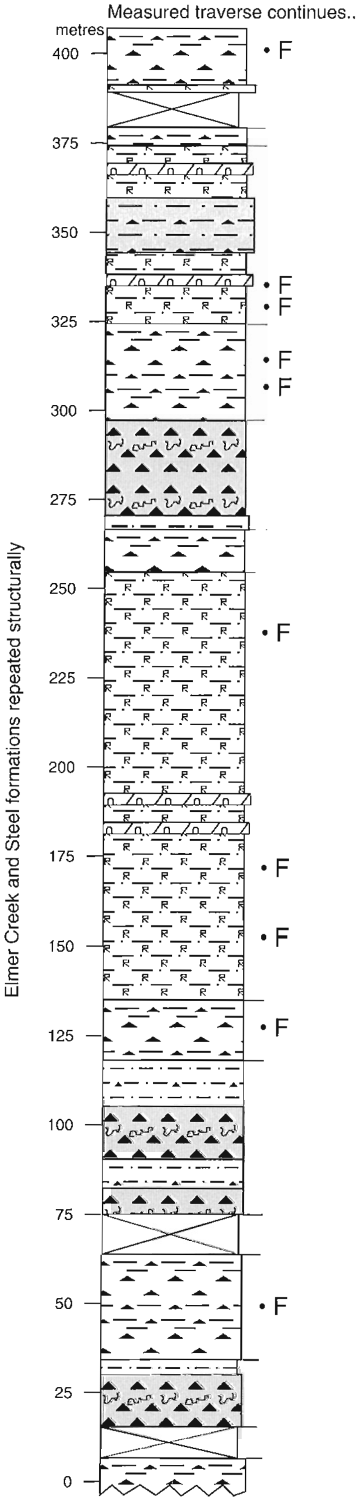
Steel tectonostratigraphic map unit. The Steel Formation can be mapped as a separate stratigraphic unit at a 1:50 000 scale only locally. However over most of the study area the Steel Formation is mapped as the Steel tectonostratigraphic map unit (Cecile 1997c, d). Most areas mapped this way are more than 60 per cent Steel Formation.

Correlation. The Steel Formation, like the Elmer Creek Formation, is probably a widespread unit of the Selwyn Basin to the west and southwest. It is mapped as the Steel Formation in the Sheldon Lake and Tay River map areas, which adjoin the Niddery Lake map area to the south and southwest (Gordey and Irwin, 1987). Steel Formation orange weathering argillites are mapped in the Lansing River map area to the west of the Niddery Lake map area (Roots et al., 1995a, b).

Orange weathering argillite and mudstone resembling the Steel Formation are known over a large part of the central and northern Canadian Cordillera (Cecile and Norford, 1993). An orange weathering Silurian argillite and carbonate unit is found in the upper part of the type Road River Formation, and throughout the rest of the Richardson Mountains (Sd unit of Cecile et al., 1982, 100–144 m thick). An orange weathering Silurian argillite unit is recognized in the British and Barn mountains (Sa Unit of Lane and Cecile, 1989; Cecile and Lane, 1991). In northeastern British Columbia a Siluro-Devonian orange weathering argillaceous dolostone and siltstone outcrops over a large part of the Kechika Trough (SD unit of Cecile and Norford, 1979). This SD unit is 275–500 m thick and Middle and/or Late Silurian in age, and may possibly range into the Early Devonian.

To the northeast the Steel Formation is partly equivalent to upper Duo Lake Formation (Fig. 31). Farther northeast in the Misty Creek Embayment it is partly correlative with the Cloudy Formation (basin limestone and shale) and to platform carbonates (Upper Ordovician to Lower Silurian Mt. Kindle and Upper Silurian to Lower Devonian Delorme formations). In the Nahanni map area it is partly correlative with the upper Duo Lake and Sapper formations (see Gordey and Anderson, 1993). In southeast Niddery Lake map area the Steel Formation is also partly correlative with the Duo Lake and Sapper formations (see Norford et al., 1993; Abbott, 1983a (his Sdl = Sapper Formation))

Interpretation. Thin bedding and lack of shallow-water features suggest deposition of the Steel Formation in relatively deep water.



Upper member, Elmer Creek Formation. Chert, 60-70% and remainder shale; both dark black, whitish weathering; minor green argillite 526-528 m (likely Steel Formation); pyrobitumen in fractures. Late Ordovician graptolites collected at 401 m (C-89262, Appendix I)

Steel Formation. Argillite, green-grey with distinct rusty weathering; minor argillaceous chert and black shale. Thick bed of orange dolostone at 338 m, repeated structurally at 368 m. Middle 15 m cherty. Early Silurian, late Llandovery graptolites collected between 335 and 336.5 m and Late Silurian, early Pridoli graptolites collected between 330-331 m (C- 89259-61, Appendix I)

Upper member, Elmer Creek Formation. Chert, 60-80% and remainder shale; both dark black, whitish weathering; minor green argillite. Late Ordovician, Ashgill graptolites collected at 308 m and Middle-Late Ordovician, Caradoc graptolites at 316 m (C-89069, C-89258, Appendix I)

Top of lower Elmer Creek Formation. Argillite, siliceous, and chert, argillaceous, followed by massive bioturbated chert, dull black and grey in medium to thick beds

Upper member, Elmer Creek Formation. Chert, 60% and shale 40%, both dark black, whitish weathering; minor green argillite

Steel Formation. Argillite, green-grey with distinct rusty weathering; minor argillaceous chert and black shale. Thick bed of orange dolostone at 182 m, repeated structurally at 191 m. Top 20 m well indurated. Late Silurian, Ludlow graptolites collected at 152 m, Late Silurian, early Pridoli graptolites collected at 173 m, and Late Silurian Ludlow graptolites collected at 243 m (C-89256-7, C-89068, Appendix I)

Upper member, Elmer Creek Formation. Chert and shale, dark black, rusty. 60-70% chert in first ten metres, 90% chert through rest of unit. Late Ordovician, Caradoc-Ashgill graptolites were collected at 120 and 128 m (C-89254-5, Appendix I)

Top of lower Member, Elmer Creek Formation. Units of chert, massive, thick bedded, bioturbated; some thin beds; and units of argillite, siliceous argillite, dark grey, platy

Upper member, Elmer Creek Formation. Shale, and chert, dark black, rusty in thin intervals. Middle Ordovician, Caradoc graptolites were collected at 46 m (C-89253, Appendix I)

Top of lower member, Elmer Creek Formation. Chert, massive, thick bedded, bioturbated; some thin beds. Upper 4 m, siliceous argillite, dark grey, platy

Upper member, Elmer Creek Formation. Shale, and chert, dark black, rusty in thin intervals

Figure 27. *Steel Formation, measured traverse. "F" marks fossil locations described in adjacent text. Traverse (Section 19) was measured in a creek bottom west-northwest of Algae Lake, NTS 105-O/15, base at UTM co-ordinates 403800 E, 7074100 N; top at 401900 E, 7073400 N, Zone 9. Portions indicated are used to construct the reference section shown in Figure 29 (arrows indicate upward stratigraphic direction)..*

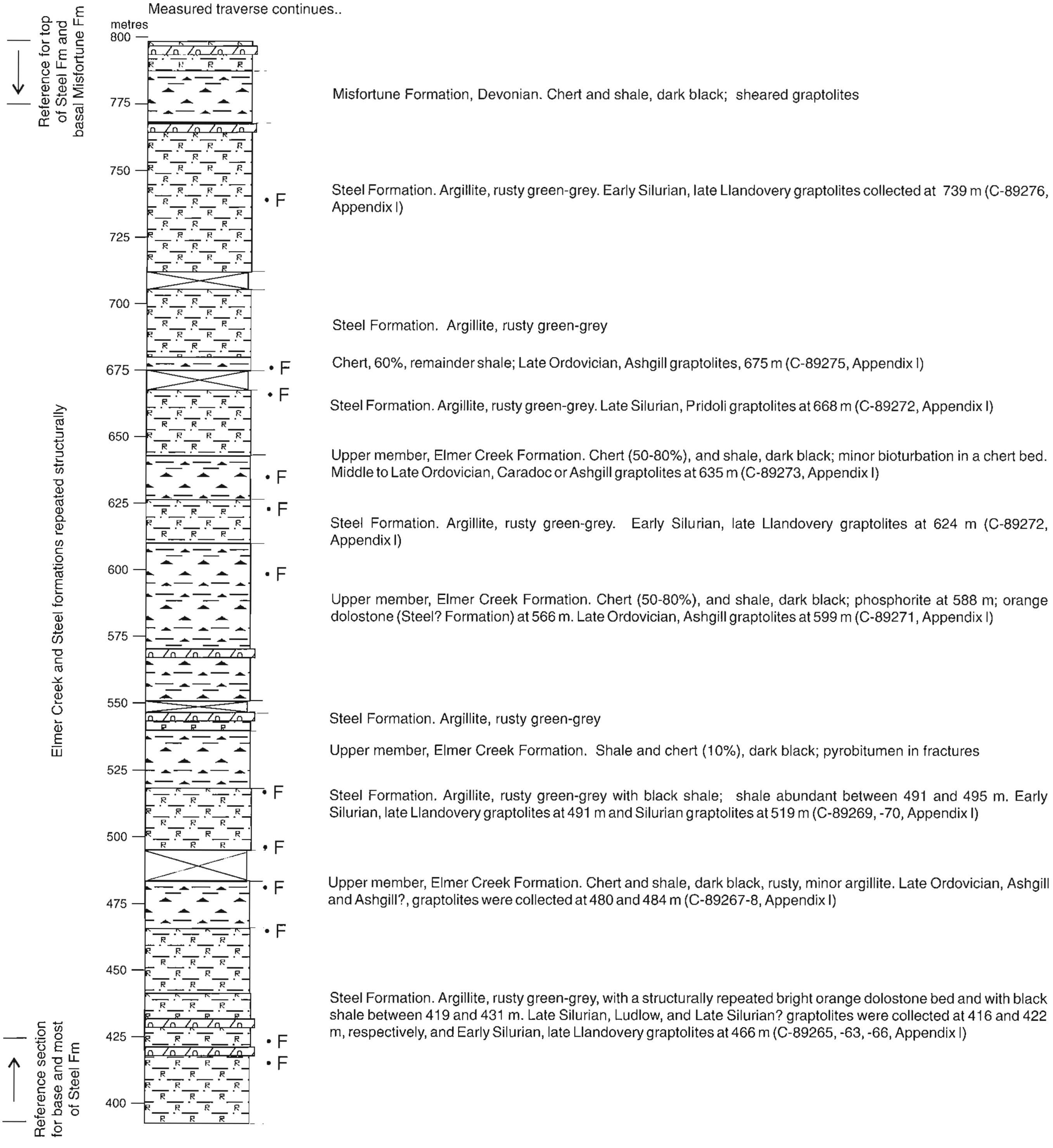


Figure 27. *Steel Formation, measured traverse continued.*

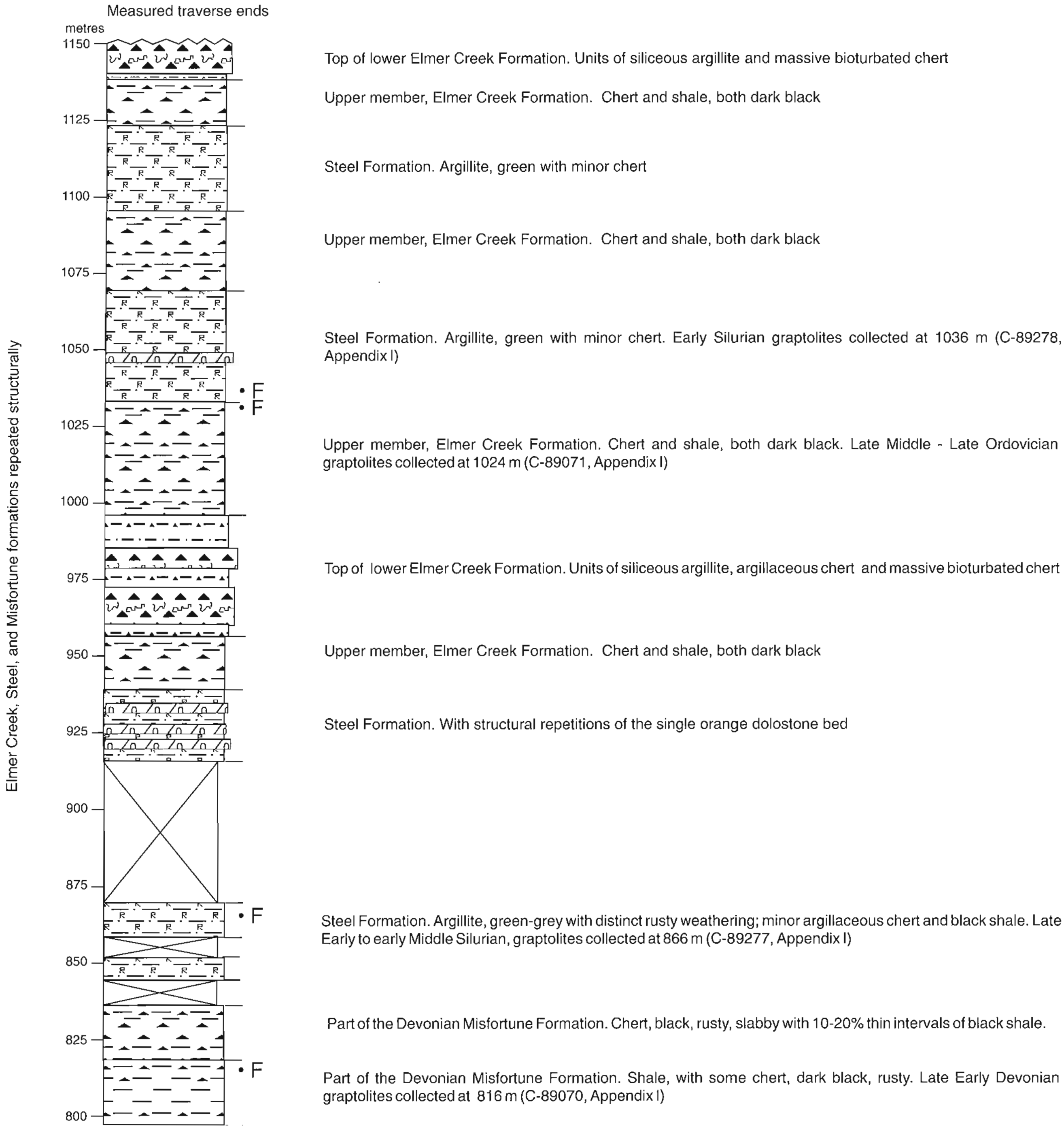


***Figure 27.** Steel Formation, measured traverse continued.*

Lower to Middle Devonian Blackwater Platform to Selwyn Basin stratigraphy

In the Early to Middle Devonian a distinct Blackwater Platform margin was established in the northeastern part of the study area (Fig. 31–33). This carbonate platform, represented by the Grizzly Bear Formation, outcrops in the northeasternmost corner of the study area and is transitional west and southwest into Selwyn Basin slope and basin facies, represented by the Hailstone Formation (new). From the north the facies transition line trends south and then southeasterly, where it continues into the adjoining Sekwi map area (Fig. 31).

Figure 28 (cont.)

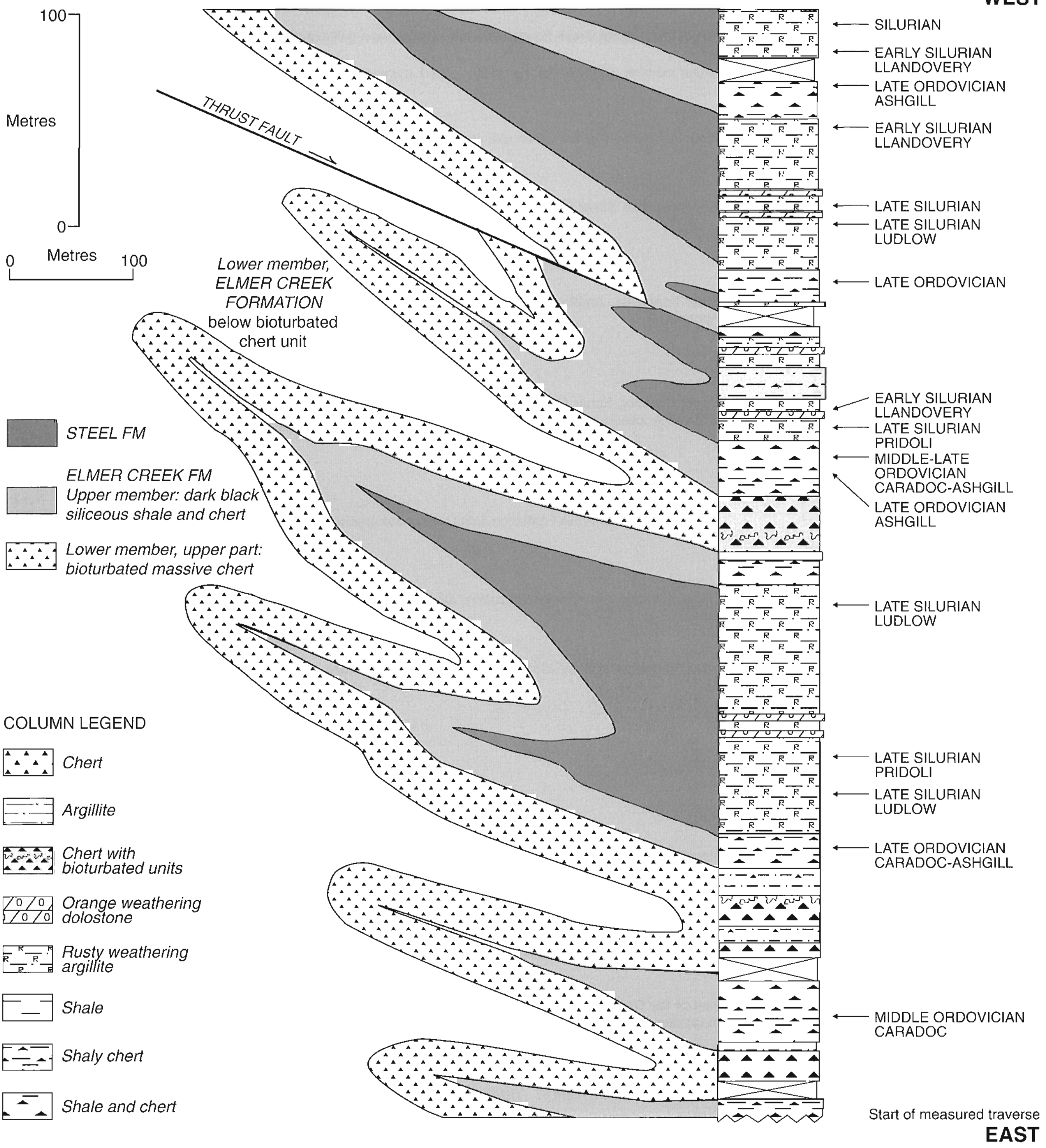


Figure 28. *Simplified structural cross-section, Steel and Elmer Creek formation exposures along measured traverse (Section 19; Fig. 27). The cross-section is constrained by distinctive lithologies and associated graptolites: bioturbated chert at the top of the lower member of the Elmer Creek Formation; distinctive whitish weathering black shale and chert, with Middle to Late Ordovician graptolites, of the upper member of the Elmer Creek Formation; rusty-orange-weathering green argillite, with Silurian graptolites, of the Steel Formation. The section is schematic and based on actual observations of fold amplitudes and wavelengths exposed in ridges in the study area. The massive bioturbated chert of the lower Elmer Creek Formation has been observed to close on itself in synclines, thus detaching from the upper member of the Elmer Creek Formation as shown (Fig. 56).*

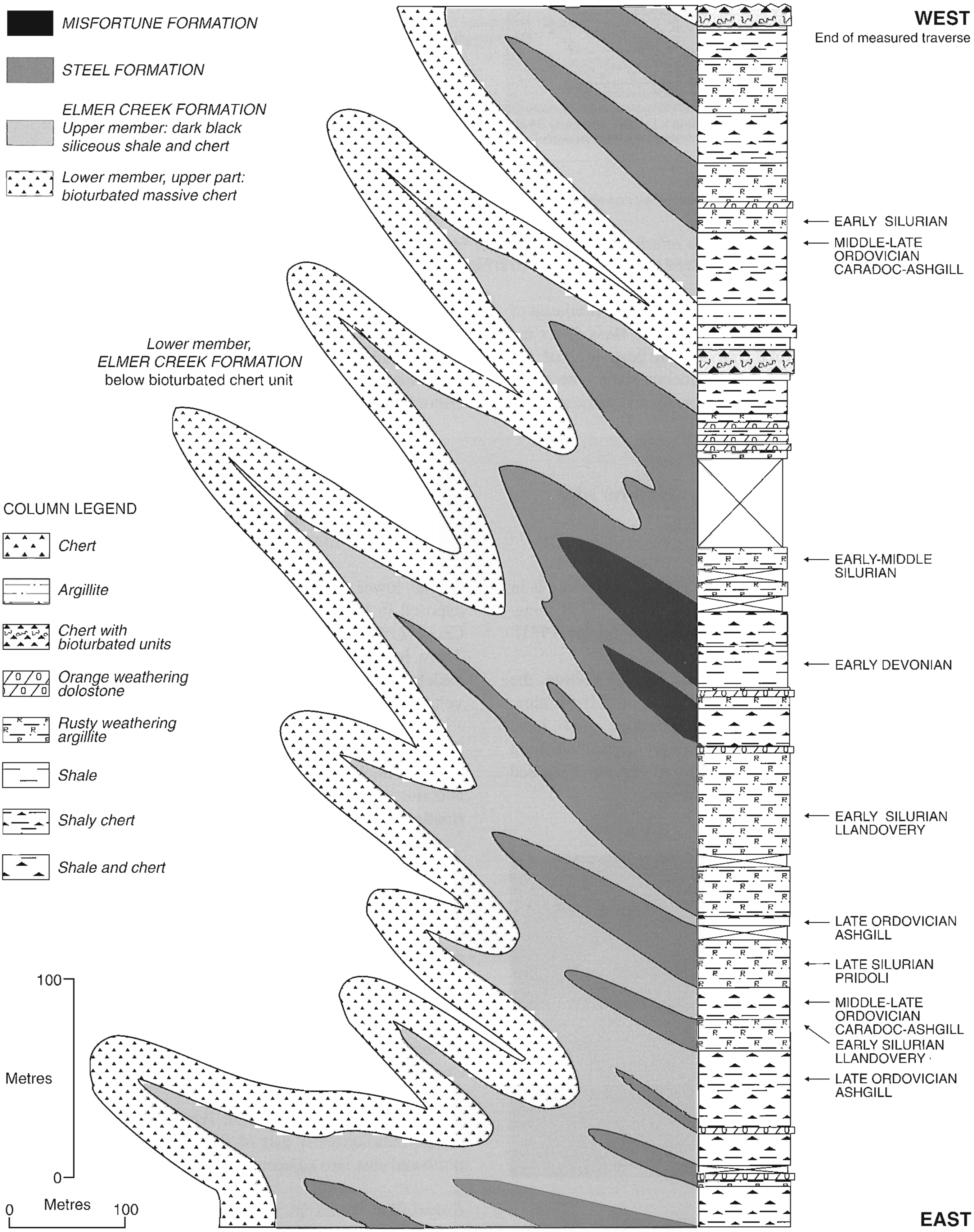


Figure 28. *Simplified cross-section, Steel and Elmer Creek formation exposures along measured traverse continued.*

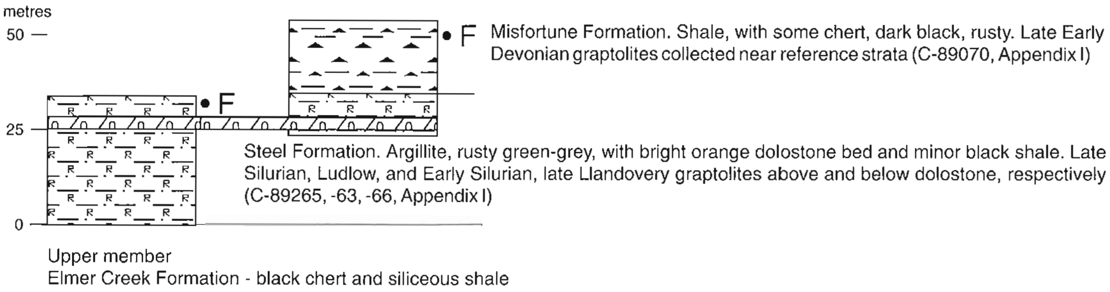


Figure 29. *Composite reference section for Steel Formation and base of the western Misfortune Formation constructed from portions shown in Figure 27.*

Hailstone Formation outcrops are found only northeast of the Hess River (Fig. 32). Southwest of the Hess River the Hailstone Formation is time equivalent to part, or all of, the Misfortune Formation chert and siliceous shale with some carbonate. The Misfortune Formation (new) is described in the following section.

Northeastern facies - Blackwater Platform edge

Grizzly Bear Formation

Type locality. The Grizzly Bear Formation type section is in the southern Mackenzie Mountains at lat. 62°42'N, long. 127°50'W (Gabrielse et al., 1973; Hills and Gabrielse, 1981).

Lithology, thickness, and contacts. At its type section, the Grizzly Bear Formation consists of 256 m of cliff forming, massive, light grey weathering limestone and local dolostone. The upper 152 m are coarsely crystalline, light grey weathering, black and grey, thick to very thick bedded crinoidal limestone and coarse calcarenite.

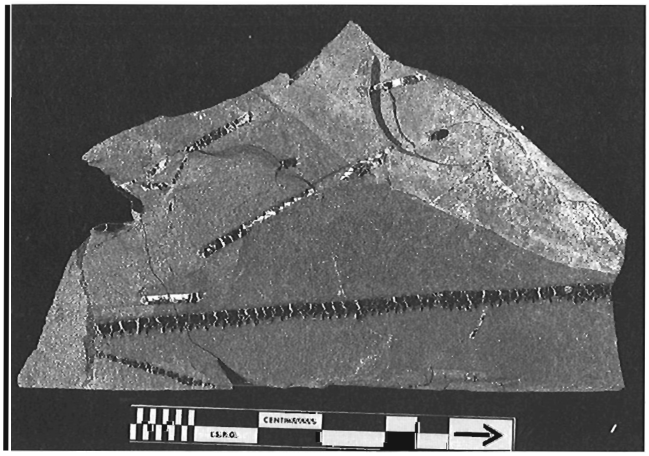


Figure 30. *Bedding plane view of a hand specimen (~10 x 15 cm) of Steel Formation argillite showing pieces of monograptids and a cyrtograptid preserved in three dimensions (ISPG Photo 1628-5).*

In the study area the Grizzly Bear Formation is very similar to the upper part of the type section. It consists of white weathering, white and grey, massive, thick to very thick bedded crinoidal limestone (Fig. 34). Among the crinoid ossicles is a form with twin axial canals (see *Age*).

Although the base of the Grizzly Bear Formation is not exposed in the study area, topographic relief along the axis of a gently plunging syncline, in the northeasternmost part of the area, indicates that the Grizzly Bear Formation is greater than 150 to 200 m thick.

The lower part of the Grizzly Bear Formation is not exposed in the study area. It is exposed at Section 17 of Cecile (1982) a few kilometres north of the study area. There, however, the massive crinoidal limestone, containing ossicles with twin axial canals, are interstratified with volcaniclastic strata.

Sedimentary features. The Grizzly Bear Formation is massive, thick to very thick bedded, and coarse crystalline. It contains some corals, stromatoporoids, and bryozoans floating in crystalline cement and crinoidal bioclastic debris.

Age. Collections of solitary and colonial corals, bryozoans, stromatoporoids, and crinoid ossicles, many with twin axial canals, give a late Early to early Middle Devonian age (upper Emsian to lowermost Eifelian stage; Appendix 1). The crinoid ossicles with twin canals are identified as *Gasterocoma*? *bicaula*, which according to Norris (1985) has the time range noted above. *G.*? *bicaula* has also been collected from outcrops at the the basal Grizzly Bear Formation a few kilometres to the north at Section 17 of Cecile (1982).

Distribution. The Grizzly Bear Formation is found only in the northeasternmost part of the study area but continues north and east into adjacent map areas (Fig. 32).

Correlation. From its type area Gabrielse et al. (1973) considered the Grizzly Bear Formation to both overlie the Arnica Formation and to be partly laterally equivalent to it. Gordey and Anderson (1993, fig. 27) correlated the Grizzly

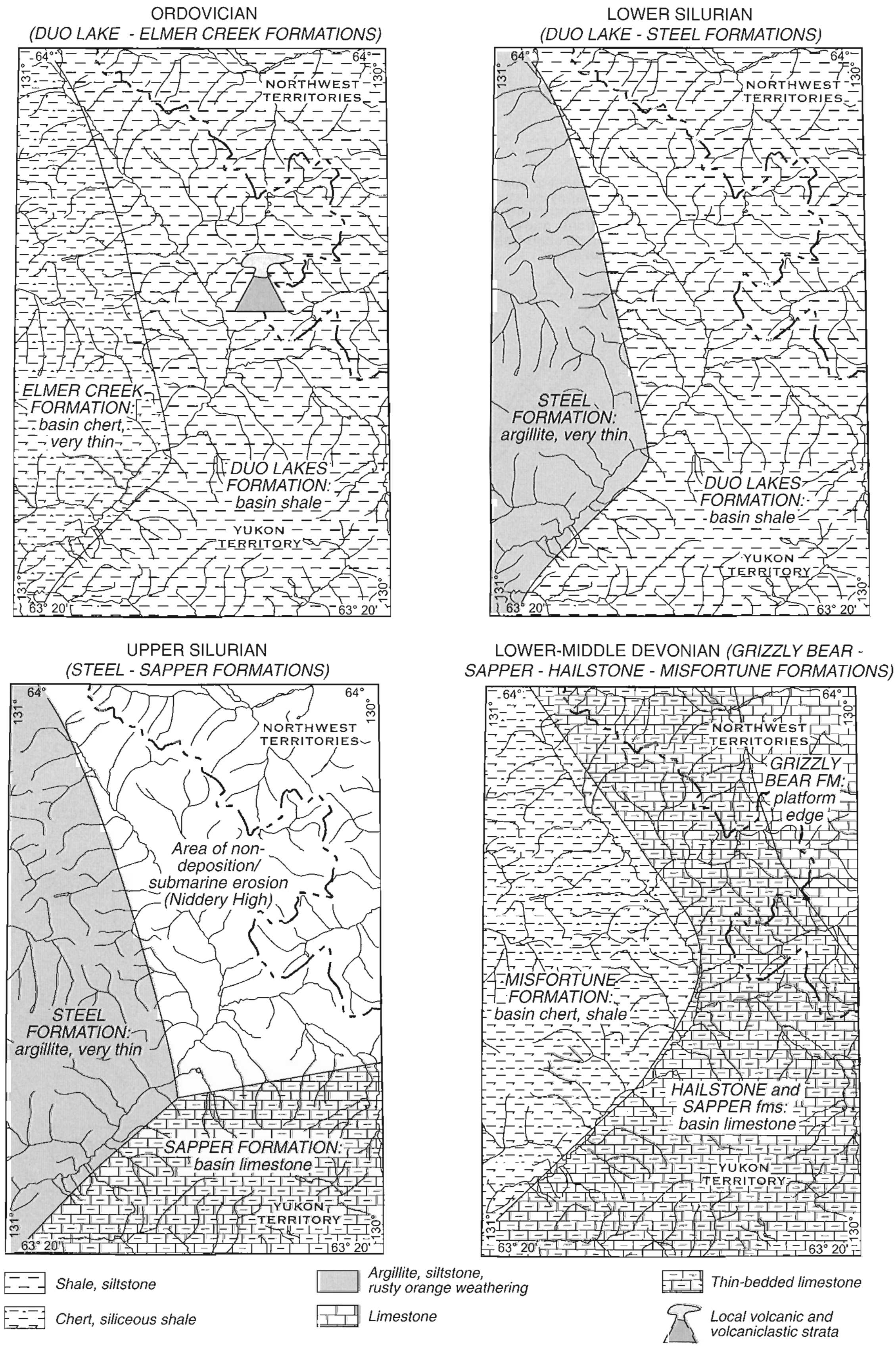


Figure 31. *Unrestored facies distribution of Ordovician to Lower Devonian strata. The arcuate facies boundary on all maps may be an artifact of Mesozoic structure, with more eastward transport in the centre of the arc than to the south or north.*

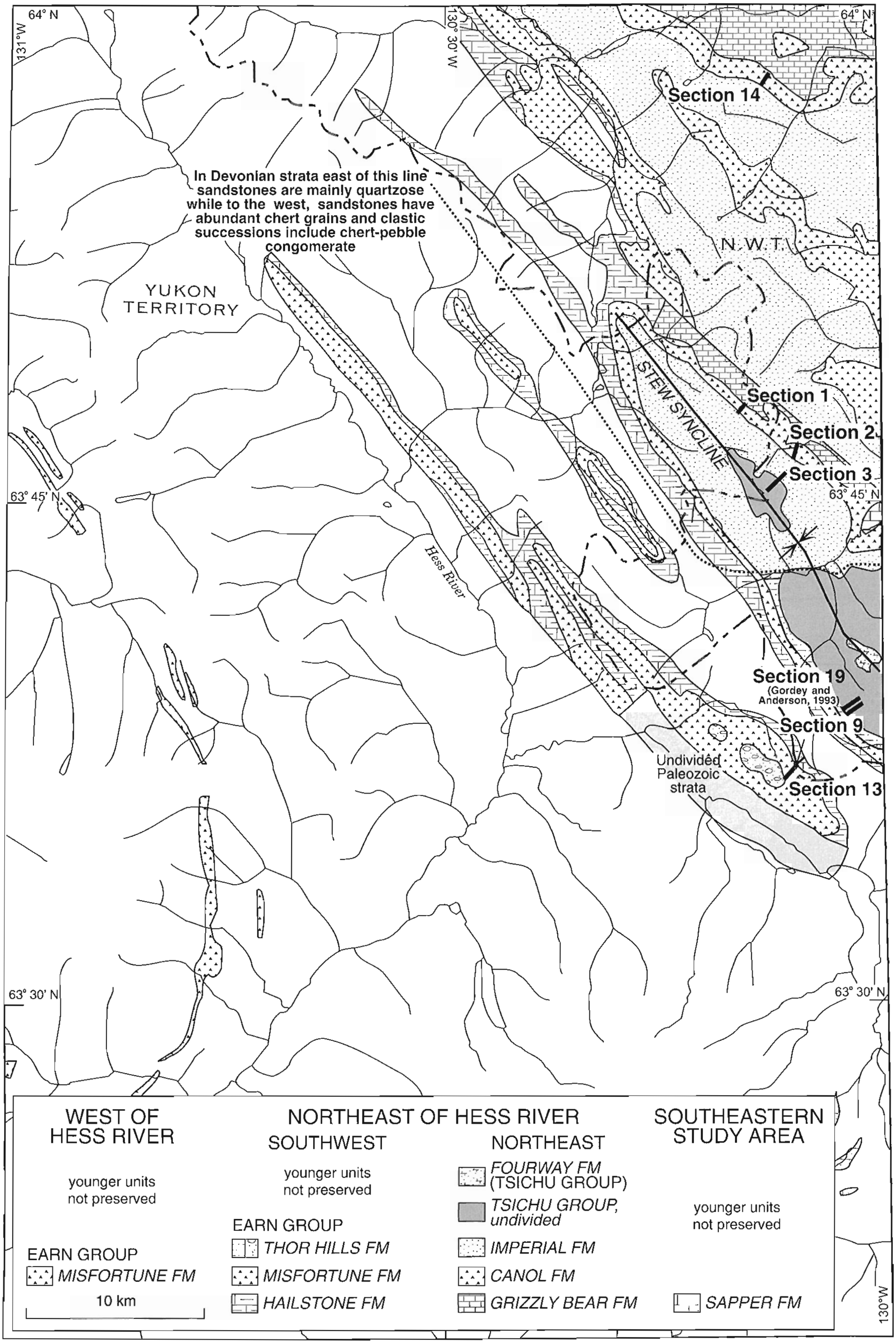


Figure 32. *Distribution of Devonian and Carboniferous strata, northeastern Niddery Lake map area.*

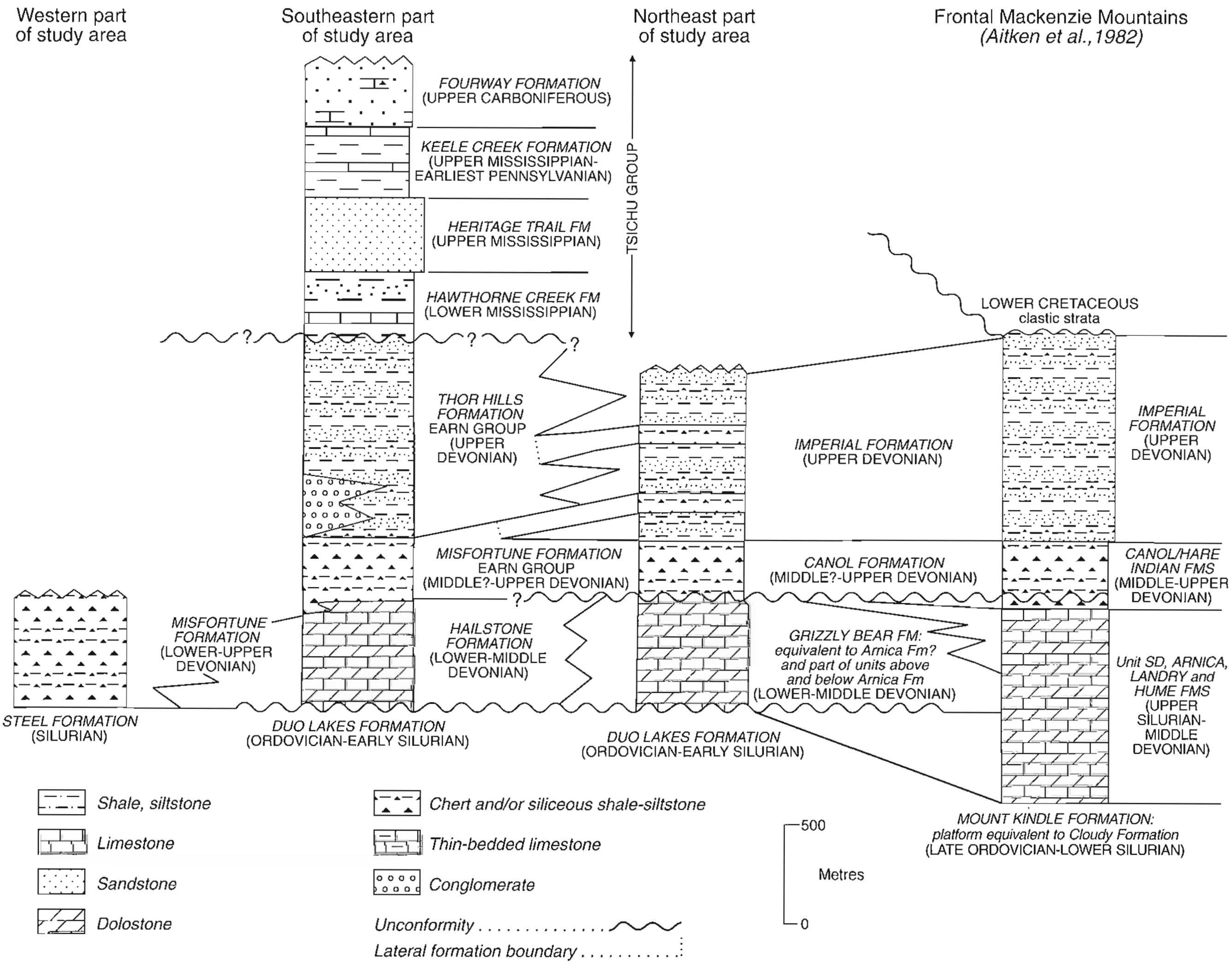


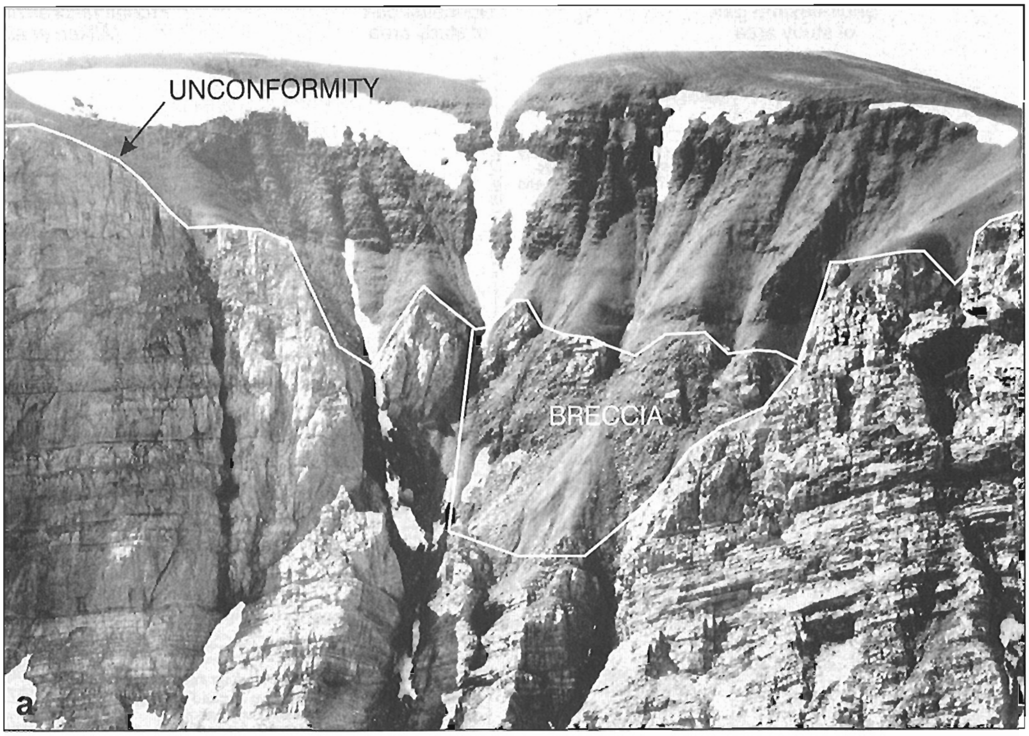
***Figure 33.** Correlation of Lower Devonian to Upper Carboniferous strata of the northeast Niddery Lake map area.*

Bear Formation in the Nahanni map area with the top of the Sombre Formation, the Arnica Formation, and most of the overlying Natla Formation, on the basis of detailed conodont zonation.

The Grizzly Bear Formation can be traced northward to Section 17 of Cecile (1982). At this location it is part of map unit SDc of Blusson (1974), which outcrops over the eastern Bonnet Plume and southwestern Mt. Eduni map areas (Fig. 2). The SDc unit is continuous to the southeast with a variety of Silurian to Devonian carbonates (map units 20 to 25 of Blusson, 1971) which outcrop along the eastern side of the Sekwi map area (Fig. 2). Using Gordey and Anderson's correlations the Grizzly Bear would be mainly correlative with Blusson's Unit 22 (Arnica Formation) and possibly with parts of the underlying Unit 21 (Sombre Formation), and the overlying Unit 23 (Landry Formation). Blusson's units 21 to 23 are on trend to the south with the Grizzly Bear Formation of the northeastern Nahanni map area (Gordey and Anderson, 1993).

In the Nahanni map area the Grizzly Bear Formation is a 150 to 200 m thick succession of thin to medium thick beds of crinoidal limestone. Many of the Nahanni Grizzly Bear Formation crinoid ossicles have twin canals, and the formation is dated as late Early to early Middle Devonian (Gordey and Anderson, 1993). Gordey and Anderson (ibid.) correlated their Grizzly Bear Formation directly with the type Grizzly Bear Formation in the adjoining Glacier map area.

Immediately adjacent to the study area Blusson (1971) grouped Silurian to Devonian carbonates into map units 22c and 22d. Unit 22c is to the north, and is described as primarily dolostone. Unit 22d outcrops south of, and is continuous with, unit 22c. Unit 22d is described as light grey



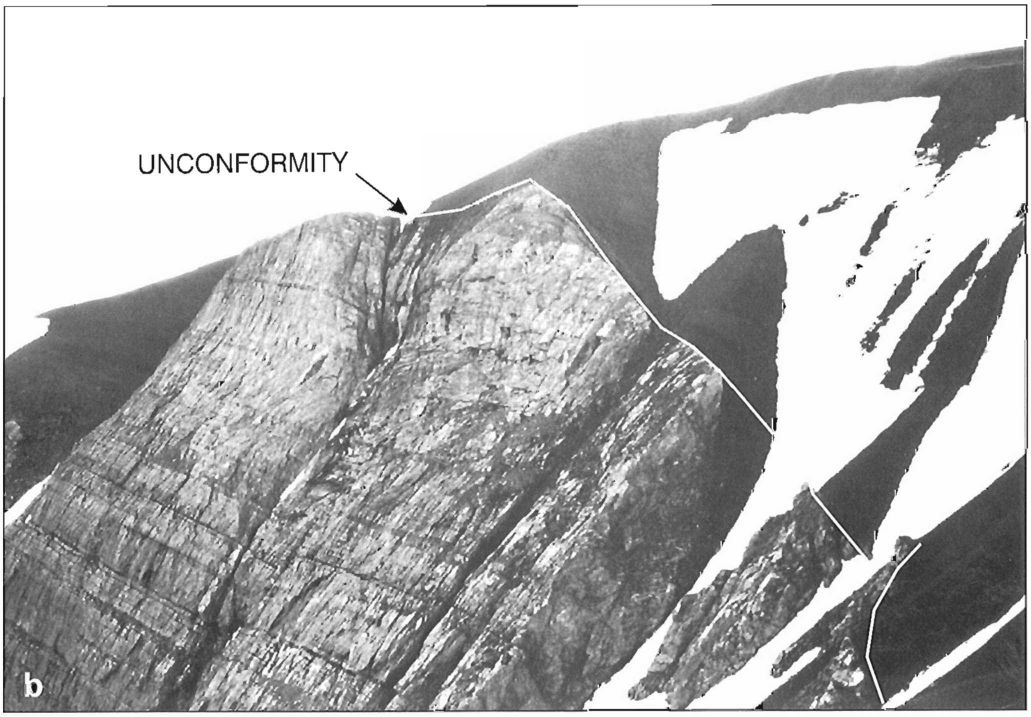


Figure 34. *Cliff exposure of the Grizzly Bear Formation just northwest of Section 14. The Canol Formation (dark) is draped across an irregular erosional surface with several metres of relief (ISPG photos **a** - 4300-1, **b** - 4277-1). No obvious sandstones or conglomerates were found on the surface at Section 14. However in Photo **a** there appears to be a local breccia unit under the shale, and there is a basal, one-metre-thick shale breccia on top of the Grizzly Bear Formation at the base of Section 1 farther to the southwest. Photo **b** is the area to the left of photo **a**.*

weathering, thin bedded crypto-crystalline limestone. Both unit 22c and 22d are on trend and nearly continuous with outcrops of the Grizzly Bear Formation of the study area. Unit 22d, by description, is therefore likely to be largely if not entirely Grizzly Bear Formation, and parts of 22c, a dolomitic equivalent.

To the west and southwest the Grizzly Bear Formation platform strata are correlative with the Hailstone Formation slope and basin facies strata. Farther southwest the Grizzly Bear and Hailstone formations are correlative with the Misfortune Formation basinal chert and siliceous shale (Fig. 12, 32, 33).

Interpretation. The Grizzly Bear Formation is interpreted as having been deposited on a shallow-water platform on the basis of its thick bedding, fossil content, and bioclastic debris.

Southwestern facies - Selwyn Basin

Hailstone Formation (new)

Type locality. The type locality of the Hailstone Formation (Fig. 35) is immediately north of the study area in the Bonnet Plume (106-B/01) map area. The section was measured across an outcrop on the east side of a tributary of the Middlecoff River at UTM co-ordinates 426600 E, 709850 N, Zone 9. At the type section the base of the section is not exposed. A reference locality for the base of the Hailstone Formation is given below in the section on Contacts. Hailstone Formation is named after Hailstone Creek in the northeast of the study area (NTS 105-O /16).

Lithology, thickness, and contacts. At its type section the Hailstone Formation consists of approximately 70 m of 80 to 90 per cent calcareous black shale with medium thick beds

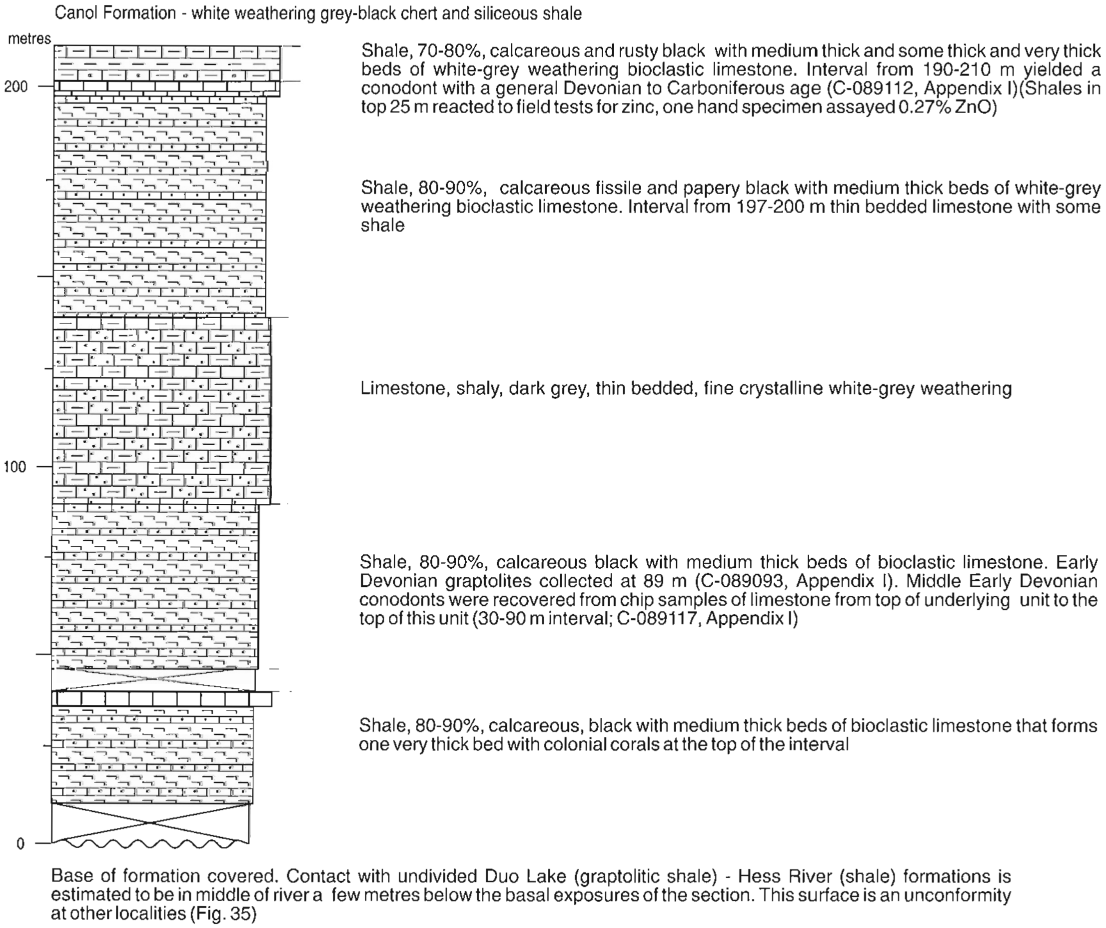


Figure 35. *Hailstone Formation type section, measured on the east side of a tributary to the headwaters of the Middlecoff River in NTS 106B/1, centred around UTM co-ordinates 426600 E, 7098500 N, Zone 9.*

of grey-white weathering bioclastic limestone at the base; followed by a middle unit of 50 m of grey to white weathering, thin bedded limestone; and finally by 70 m of black shale with medium thick beds of grey-white weathering bioclastic limestone (Fig. 35). Interestingly, the upper 25 m has rusty shales and reacts to field tests for zinc. One specimen assayed 0.27% ZnO.

The Hailstone Formation is a recessive unit and is typically represented by metre-scale outcrops of resistant limestone. Because it is recessive it is possible that all limestone-dominated outcrops are at the position of the middle limestone unit, or the uppermost shale with bioclastic limestone found at the type section (Fig. 35). In most of these outcrops the limestone is crystalline, fine to medium grained, shaly, and commonly contains some bioclastic crinoid material including ossicles with twin canals. Coarse conglomerate–breccia beds of older, shallower water facies were observed at the base and within the Hailstone Formation.

The lower contact of the Hailstone Formation is generally not exposed. However at the contact reference locality (UTM 432100 E, 7089450 N, Zone 9; NTS 105-O/16), noted above, it is disconformable. At this locality the base of the Hailstone Formation is a 1 m thick conglomerate/breccia bed (Fig. 36). The large clasts are shallow-water limestone with early Early Devonian, early Lochkovian fossils (C-89106, Appendix I). The conglomerate/breccia bed rests directly on the Duo Lake Formation chert with Early Silurian, late Llandovery graptolites (C-89062, Appendix I).

Sedimentary features. The Hailstone Formation is generally thin bedded. It contains bioclastic limestone beds, and some thick breccia-conglomerate beds.

Age. Most fossil collections from the Hailstone Formation range in age from late Early Devonian (Pragian) to early Middle Devonian (earliest Couvinian, earliest Eifelian; Appendix 1). However conglomerate clasts indicate older ages. They are interpreted as having been eroded from older platform strata to the east. One breccia conglomerate bed, 100 m above the Duo Lake Formation, yielded late Silurian fossils (C-89105, Appendix 1). By comparison, chip samples from 30 to 90 m at the type section indicate a late Early Devonian or younger age (Fig. 35). Conglomerate clasts immediately above the Duo Lake Formation at the reference locality for the base of the Hailstone yielded fossils of an early Early Devonian age (early Lochkovian; early Gedinnian, C-89106, Appendix 1). At another locality two collections indicate different ages. One is from macrofauna from outcrop and gives an early Early Devonian age (late Lochkovian, late Gedinnian, C-89051, Appendix 1). The other is from felsenmeer derived from the same outcrop and gives a late Early Devonian, Pragian age (C-89052, Appendix 1).

Distribution. The Hailstone Formation is known to outcrop only in the northeast part of the study area and to extend north into the adjacent 106B/01 map area (Fig. 32).

Correlation. The Hailstone Formation is a basin-and-slope facies correlative to the Grizzly Bear Formation to the northeast. In the southwest it is correlative with chert and siliceous shale of the Misfortune Formation (see description of the Grizzly Bear Formation for correlations with the Mackenzie Mountains). It is also time equivalent to parts of the Sapper Formation, a silty limestone and shale unit mapped in the south part of the study area (see following section) and the southern Niddery Lake map area (Sdl unit of Cecile and Abbott, 1992) and in the Nahanni map area (Gordey and Anderson, 1993).

Interpretation. The Hailstone Formation is a deeper water debris fan derived from the Grizzly Bear platform carbonates. Exposures near the Grizzly Bear outcrops tend to have more conglomerate and bioclastic limestone than those farther southwest.

Niddery High (bare and eroded beneath the Hailstone Formation)

Middle Silurian to early Early Devonian aged strata are missing between the Duo Lake and Hailstone formations over most of the study area (Fig. 31), whereas time-equivalent deep-water mudstone (Steel Formation) accumulated in Selwyn Basin in the western part of the area. In the southern part of the area, time-equivalent deep-water limestone and shale (Sapper Formation) were deposited in Selwyn Basin (Fig. 31). Farther east, in the Mackenzie Mountains, this period of time is represented by platform carbonate facies (see Grizzly Bear Formation, Correlation). To the north the erosional or nondepositional surface extends into Misty Creek Embayment but Recent erosion and lack of data make it difficult to assess its original extent.

This surface of erosion or nondeposition is coincident with, and thus a continuation of, the Niddery High. In older strata the high is defined by the thinness of shale and limestone basin facies units in comparison to their counterparts to the northeast in the Misty Creek Embayment.

As noted above, at the base of the Hailstone Formation there is a metre-thick, poorly sorted, angular to subrounded, coarse conglomerate/breccia composed of clasts of early Early Devonian age, which rests directly on the top of the Early Silurian graptolitic Duo Lake Formation. The presence of such coarse material on what was otherwise a surface of nondeposition is problematic. It may represent a far-travelled debris flow that made it up onto this surface or indicate proximity of a carbonate platform that has since been removed by erosion.

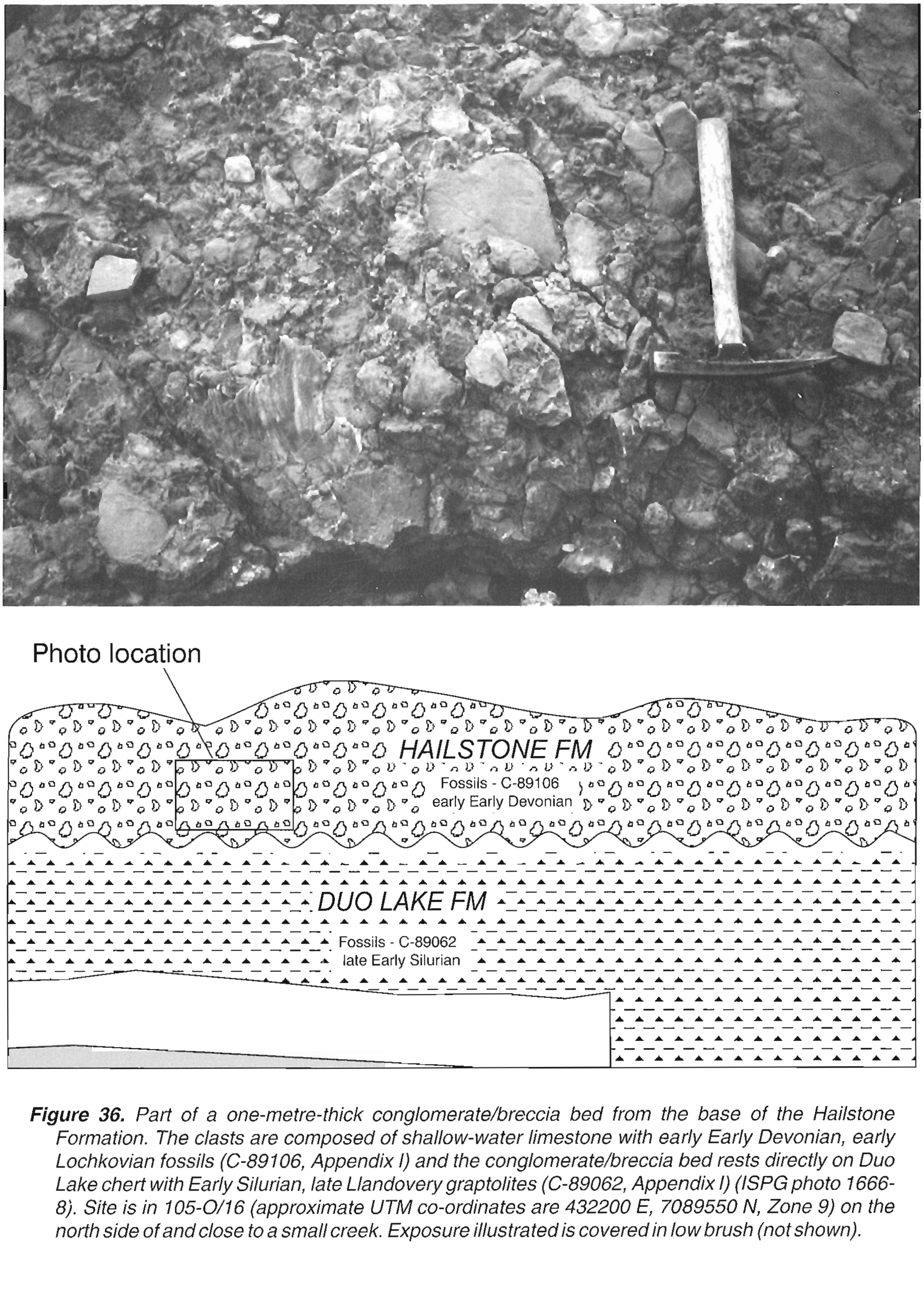


Figure 36. *Part of a one-metre-thick conglomerate/breccia bed from the base of the Hailstone Formation. The clasts are composed of shallow-water limestone with early Early Devonian, early Lochkovian fossils (C-89106, Appendix I) and the conglomerate/breccia bed rests directly on Duo Lake chert with Early Silurian, late Llandovery graptolites (C-89062, Appendix I) (ISPG photo 1666-8). Site is in 105-O/16 (approximate UTM co-ordinates are 432200 E, 7089550 N, Zone 9) on the north side of and close to a small creek. Exposure illustrated is covered in low brush (not shown).*

By late Early Devonian however, the Grizzly Bear platform margin had been established on the eastern side of the area, and Selwyn Basin (Hailstone Formation) had been re-established over the site of the high.

Sapper Formation

In the southeastern part of the study area there is a distinct Silurian to Early Devonian limestone succession found above the Steel Formation (map 105-O/08N2/3, 09). This unit was mapped by J.G. Abbott (pers. comm., 1993) as the Sapper Formation of Gordey and Anderson (1993; Fig. 32).

The Sapper Formation is a succession of thin bedded, dark grey to orange weathering limestone and silty limestone. Its type section is in the Nahanni map area at lat. 62°42'N and long. 128°25.6'W (Gordey and Anderson, 1993). In its type area it is highly diachronous and ranges in age from Late Ordovician to Middle Devonian. In the study area Early Devonian, Pragian graptolites have been recovered from the Sapper Formation (Appendix 1). Elsewhere in the Niddery Lake map area the Sapper Formation ranges from as old as Late Silurian, Ludlow to Middle Devonian, Emsian (Norford et al., 1993)

Devonian to Carboniferous clastics - foredeep basin

In the Middle Devonian, the northern Canadian Cordillera underwent a major change in its tectonic and sedimentary history. The pattern of Blackwater carbonate platform facies to the east, flanked by Selwyn Basin deep-water shales, cherts and limestones to the west, was replaced by fine to coarse grained clastic strata deposited in a classic foredeep basin setting (see Gordey, 1988; Gordey, 1992). The eastern half of this foredeep basin is defined by quartzitic coarse clastic and associated fine grained clastic strata (Canol, Imperial and other formations) sourced from mainly northeastern areas. The western half is defined by quartz–chert–lithic coarse clastic and associated fine grained clastic strata (Misfortune and Thor Hills formations), sourced mainly from western areas.

The boundary between eastern and western facies of the foredeep basin is situated in the study area. This boundary runs southeasterly from the north part of the study area and then turns east into the Sekwi map area (Fig. 32).

Northeastern facies - eastern foredeep basin

Canol Formation

Type locality. The type section is situated at the Mackenzie Mountain front at lat. 65°10'30"N and long. 128°46'30"W (Bassett, 1961).

Lithology, thickness, and contacts. At its type section the Canol Formation consists of 23 m of dark grey to black, yellow and rusty-brown weathering, siliceous, thin bedded, fissile and predominantly noncalcareous shale (Bassett, 1961; Chi and Hills, 1981). The shales contain ironstones. In the Norman Wells area the Canol Formation is reported to be as much as 120 m thick (Bassett, 1961).

In the study area the Canol Formation consists of between 182 and 440 m of thin bedded, white weathering, black, siliceous shale and some papery black shale, with minor limestone nodules and rare beds of thin bedded limestone and sandstone (Fig. 37–40). At a reference section in the

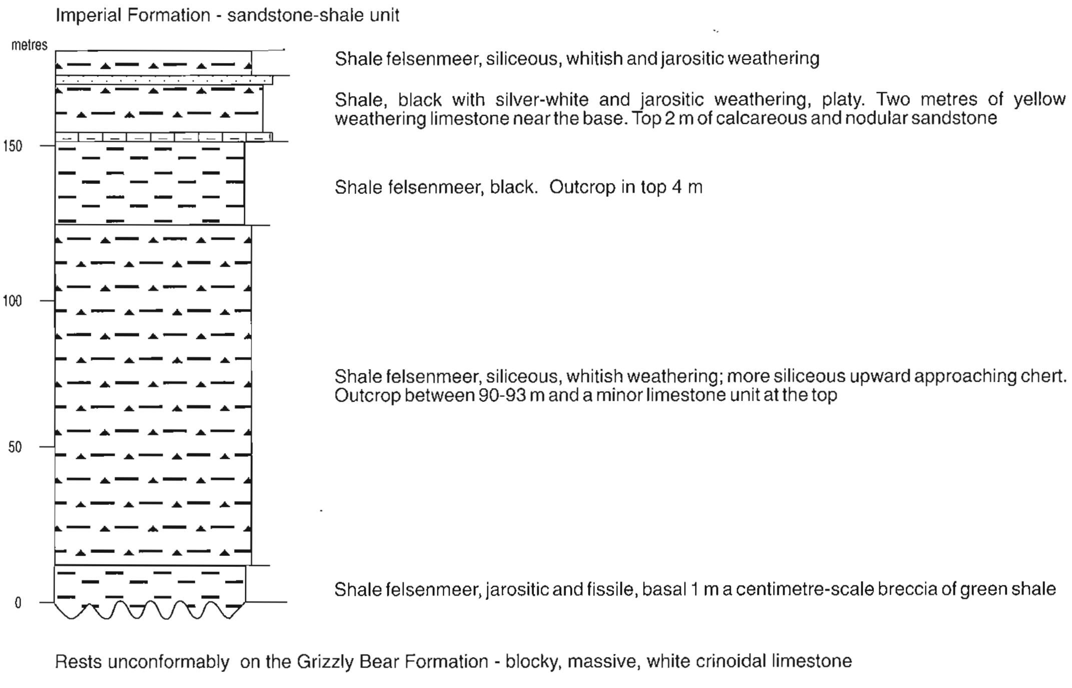


Figure 37. *Canol Formation, section 1 on the northeast limb of the Stew Syncline, 105-O/16. Base at UTM co-ordinates 443900 E, 7074200 N; top at 443750 E and 7074100 N, Zone 9.*

Figure 38. *Canol Formation, section 2 on the northeast limb of the Stew Syncline, 105-O/16. Base at UTM co-ordinates 446500 E, 7072450 N; top at 446450 E and 7071800 N, Zone 9.*

study area the Canol can be divided into a mappable, lower, recessive, shaly member and an upper, resistant, cherty member (Section 14, Fig. 39; Cecile, 1997a). Here the basal Canol Formation contains sandstone and a lens of chert pebble conglomerate.

In the frontal Mackenzie Mountains the Canol Formation rests disconformably on a variety of older units: the Kee Scarp, Hare Indian and Hume formations (see Chi and Hills, 1981).

In the study area the Canol Formation rests unconformably on the Grizzly Bear Formation (Fig. 34). At Section 1 (Fig. 37) the base of the Canol Formation consists of a one metre thick breccia of centimetre-scale green shale

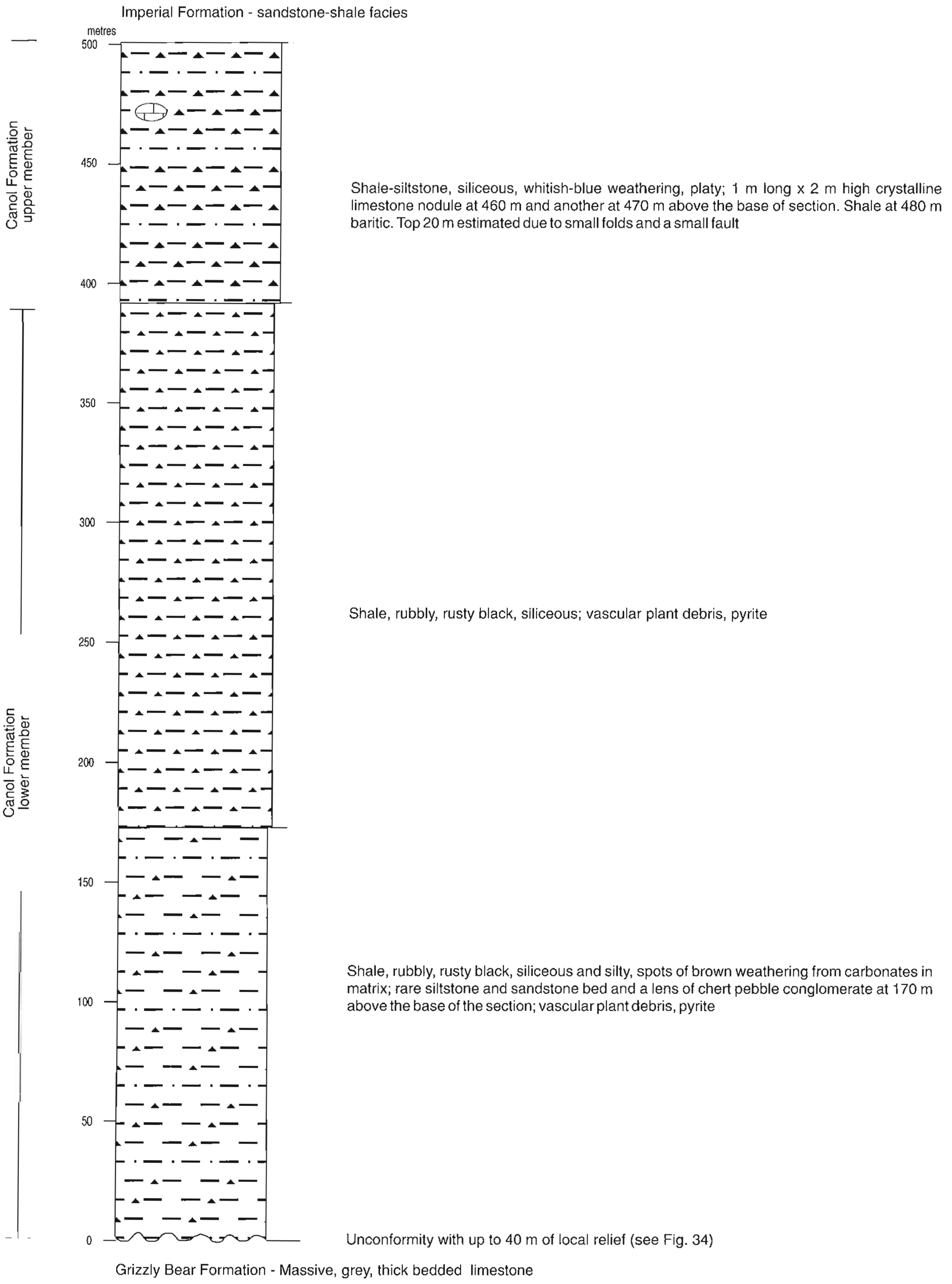


Figure 39. *Canol Formation, reference section. Section 14, 105-O/16 northeast, base at UTM co-ordinates 445300 E, 7092950 N; top at 444800 E and 7092600 N, Zone 9.*

fragments resting directly on the Grizzly Bear Formation. Northwest of Section 14 (Fig. 34) the Canol Formation fills in an irregular erosional surface with about 40 m of relief.

Sedimentary features. The Canol Formation is thin bedded and contains abundant limestone, and in places ironstone and barite nodules (Fig. 41).

Age. The type section of the Canol Formation is Late Devonian, Frasnian (Chi and Hills, 1981).

One collection of conodonts from the Canol Formation in the study area also indicated a Late Devonian age (Appendix 1). Using the ages of overlying and underlying units, the Canol Formation in the study area may range from early Middle to Late Devonian. The underlying Grizzly Bear Formation is as young as early Middle Devonian (lowermost Eifelian) and a lower shale unit in the overlying Imperial Formation yielded conodonts of Late Devonian (early Famennian) age.

Distribution. The Canol Formation is found only in the northeastern part of the study area (Fig. 32). Here it can generally be divided into a lower, recessive and more shaly member, and an upper, resistant and more siliceous member.

Correlation. The Canol Formation correlates with the type Canol Formation along the Mackenzie Mountain Front. It is mapped as a separate unit, or included with the Hare Indian Formation in much of the northern Mackenzie Mountains where it varies in thickness from 85 to more than 92 m (e.g., Aitken and Cook, 1974; Aitken et al., 1982). Just north of the map area, Blusson (1974) mapped a similar unit at the base of the Imperial Formation, which he labeled 'Besa River Formation'. East of the study area in the Sekwi map area, Blusson (1971) mapped a unit (26a) that is mostly silvery blue weathering siliceous shale and chert, and which is contiguous with the Canol Formation in the study area. Blusson (ibid.) noted that the basal part of Unit 26a had local bands of chert pebble conglomerate, fine grained quartzite and light coloured chert. Blusson's units 26b and 26c are correlated with the Imperial Formation and possibly part of the Tsichu Group (see following).

The Nahanni map area lies within the western part of the foredeep basin and neither the Canol nor Imperial formations are recognized in that area (see following). The equivalent unit there is part of the Portrait Lake Formation.

The Canol Formation is continuous to the southwest with the Misfortune Formation (see Misfortune Formation, *Correlation*).

Figure 40. *View of the Canol Formation (dark) overlying the Grizzly Bear Formation (light) in the core of a gentle open syncline. View is to the northeast across the Middlecoff River, toward an area north of the Canol reference section (Figure 39; ISPG photo 1618-4).*

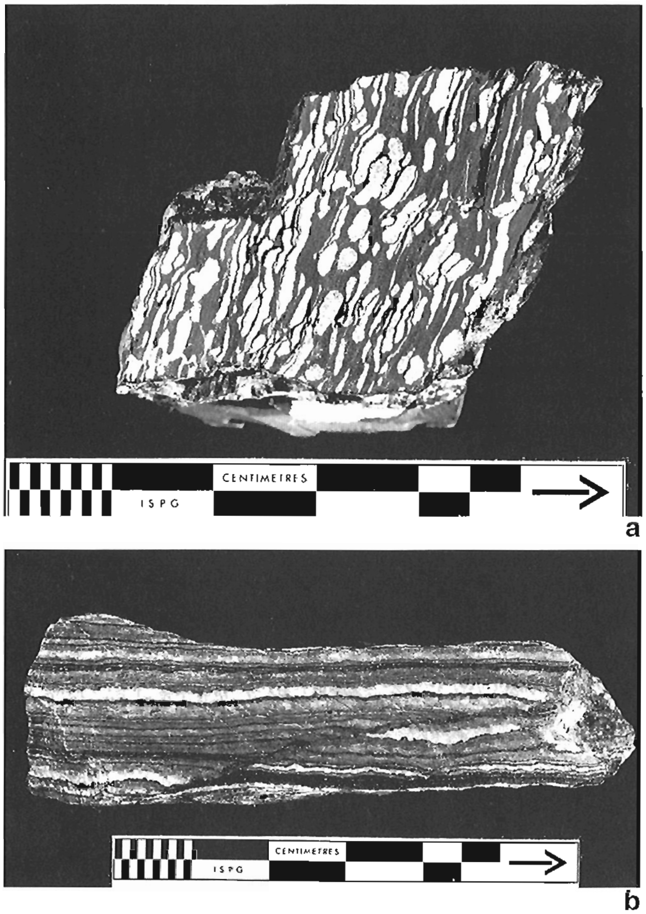


Figure 41. *Hand specimens showing two forms of barite occurrence typical of the upper Canol and Misfortune formations and siliceous shale units found in the Imperial and Thor Hills formations.* ***a)*** *Elongate, centimetre-scale nodules in shale.* ***b)*** *Laminated barite with little interstratified shale, which forms thin to thick beds in the shale (ISPG photos 2019-1, 3). Large, round, metre-scale, massive black barite nodules also occur in the Upper Canol Formation.*

Interpretation. Both the Canol and Misfortune formations are interpreted as deep-water, organic rich shales deposited during the early stage of foredeep basin development ('starved-basin facies').

Imperial Formation

Type locality. The type section of the Imperial Formation is on the Imperial River at the Mackenzie Mountain front at lat. 65°07'N and long. 127°51'W (Hume and Link, 1945; Bassett, 1961).

Lithology, thickness, and contacts. The type Imperial Formation consists of 468 m of green sandstone and green sandy shale with minor limestone and calcareous sandstone, overlain by 138 m of soft, dark coloured shale interbedded with sandy and grey-brown, fossiliferous limestone beds.

In the study area the Imperial Formation is a more than 400 m thick succession consisting of units of rhythmically bedded brown quartzose sandstone and brown weathering black shale interstratified with members of shale and siliceous shale (Fig. 42, 43).

Variations in sandstone and shale form metre-scale units. Some of these units have sandstone and shale in equal abundance whereas others are sandstone dominated (Fig. 42). In the mixed units, sandstones form thin, medium-thick and thick beds, and the shales form thin to medium-thick beds.

Figure 42. *Cliff-side exposure of rhythmically bedded Imperial Formation sandstone and shale. Resistant beds are sandstone and the recessive beds shale. Many of the beds are interpreted as turbidites (see Fig. 44) (ISPG photo 1618-28).*

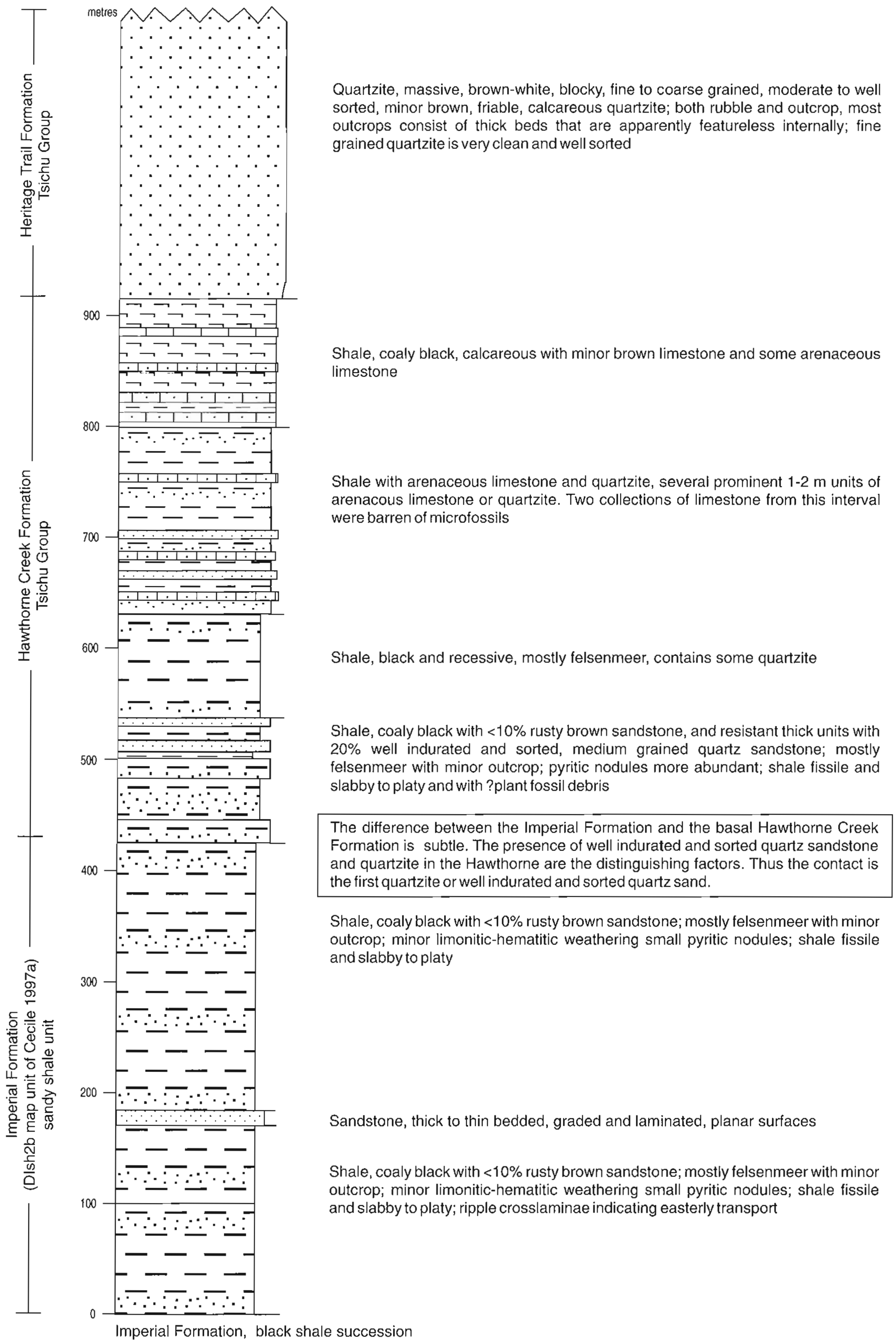


Figure 43. *Upper part of the Imperial Formation and lower part of the Tsichu Group. Section 3, NTS 105-O/16, northeast limb to centre of the Stew Syncline; base at UTM co-ordinates 445250 E, 7070850 N; top at 444150 E, 7069500 N, Zone 9.*

Interstratified with the sandstone–shale units are two mappable members of whitish weathering siliceous grey shale and grey-black shale (DIsh1, DIsh2a, Cecile, 1997a, b) that resemble the Canol Formation in lithology and appearance, and one mappable unit of black shale with some sandstone (DIsh2b; Cecile, 1997a, b).

In the study area, the Imperial Formation is in sharp and conformable contact with the underlying Canol Formation. The change is from the whitish weathering siliceous shale of the Canol Formation into the brown weathering sandstones and shales of the Imperial Formation.

Sedimentary features. In the study area, the Imperial Formation is rhythmically bedded, has graded beds and flute casts (Fig. 42, 44). Small-scale, asymmetrical ripples, representing twenty-nine paleocurrent directions, were measured at three localities. Corrected for bed tilt they indicate a distinct southwesterly direction of transport (all values between 170 and 260°; mean at approximately 220°). At section 3 (Fig. 43) a few unmeasured asymmetrical ripples showed easterly transport directions.

Age. The lowest sandstone-shale unit of the Imperial Formation contains vascular plant debris (Appendix 1). The lowermost shale member of the Imperial Formation (DIsh1, Cecile, 1997a, b) yielded conodonts from limestone nodules of late Late Devonian (early and middle Famennian) age (Appendix 1). The Imperial Formation is conformably overlain by the Tsichu Group, the base of which is dated in the study area as early Early Mississippian (early to middle Tournaisian) (Appendix 1).

The lowermost Imperial shale unit also contains ammonoids (C-128331, Appendix 1). The ammonite

Figure 44. *Underside of a slab of Imperial Formation sandstone showing well developed flute marks typical of turbidites (ISPG photo 1618-2).*

Ponticeras cf. *P. Tschernyschewi* has been identified by W.W. Nassichuk from Upper Devonian strata at the TOM lead–zinc deposit in the southeastern part of map area 105-O.

Distribution. The Imperial Formation outcrops in the northeastern part of the study area (Fig. 32). It is continuous with similar units in the adjacent Sekwi (units 26b, c of Blusson 1971) and Bonnet Plume (DMs unit, Blusson, 1974) map areas (Fig. 2).

Correlation. To the north, northwest, east and southeast, the Imperial Formation outcrops over vast areas of the Northwest Territories and Yukon. To the southwest it is directly correlative with the Thor Hills Formation of the Earn Group, as defined in the study area.

The transition to the Thor Hills Formation is relatively abrupt. Across a single river valley, a mappable, complex, Imperial succession converts directly to a time correlative and homotaxial, approximately 300 to 400 m thick succession of Thor Hills Formation, consisting dominantly of black shale with some sandstone (Fig. 32; Cecile, 1997a, b).

Interpretation. The Imperial Formation in the study area is interpreted as a mainly distal turbidite succession on the basis of rhythmic bedding, graded bedding and flute casts. The quartzose composition of the turbidites suggests it is a deeper water continuation of the more shallow-water, northeasterly sourced Imperial Formation to the north and east of the study area (Gordey, 1988).

Gordey (1988) divided the Upper Devonian of the northern Cordillera into a coarse proximal Imperial facies (northern Yukon) and fine grained 'Besa River' facies. The Imperial Formation of the study area lies near the southern edge of the coarse grained Imperial facies. Fossils in the Imperial Formation are a mixture of marine fossils and conodonts along with vascular plant debris. The plant debris is interpreted as having being transported into the area from distant sources. The depositional site is considered marine on the basis of conodont-bearing limestone nodules and the presence of ammonoid debris.

The abrupt transition of the Imperial Formation into the shale and sandstone of the Thor Hills Formation is interpreted as representing the change of a wedge-shaped lobe of deep-water Imperial turbidites into a mainly shale-dominated part of the central foredeep basin (Fig. 32, 33). Immediately southwest of this area the Thor Hills Formation contains a thick succession of chert pebble conglomerate derived from source areas in the western part of the foredeep basin.

Southwestern facies

Earn Group

The type area of the Earn Group is northeast of the Tintina Fault, in northeastern Glenlyon (105 L) map area, more than 150 km west-southwest of the study area (Fig. 2). The term was proposed by Campbell (1967) for a mixed assemblage of chert, conglomerate and limestone. Since then it has been generally applied to an informal map unit known as the Devono–Mississippian 'black clastics', a clastic succession consisting of chert and lithic sandstones and chert pebble conglomerate that is widely recognized across Selwyn Basin and the Kechika Trough.

Gordey and Anderson (1993) extended the Earn Group designation to the east side of Selwyn Basin (Nahanni map area) where they divided it into two formations. Their lower formation is the Portrait Lake, which consists of a succession of Lower to Upper Devonian, gun-blue weathering siliceous shale and chert with local beds and units of chert quartzarenite and wacke, pebbly mudstone, and chert-pebble conglomerate. The upper formation is the Prevost, which unconformably overlies the Portrait Lake and consists of a succession of brown weathering shale and thick members of sandstone and chert conglomerate.

Underlying a large portion of the southwestern and southern study area are "black clastics" similar in age and lithology to the Earn Group. These strata differ from the Portrait Lake and Prevost formations of Gordey and Anderson (1993), in that neither an unconformity nor a distinct Prevost Formation are recognized. After some discussion between the author, S.P. Gordey (pers. comm., 1994), and J.G. Abbott (pers. comm., 1994) it was decided that it was best to proceed with a separate nomenclature for the study area. Thus the Earn Group in the northeast Niddery Lake map area consists of two formations, the Misfortune and the overlying Thor Hills. These two units are generally equivalent to Gordey and Anderson's Portrait Lake Formation (see Fig. 50 at the end of this section). Gordey and Anderson (1993) recognized Prevost Formation in southeastern Niddery Lake map area. However the unit they designated as Prevost? is identical to the Hawthorne Creek Formation, which is defined and included here in the Tsichu Group because it contains quartzite and limestone (see Fig. 50 at the end of this section).

Type Earn and Tsichu groups

Campbell (1967) recognized four map units in the type Earn Group. In ascending order, these are: Map-Unit 10 – mainly dark grey or black chert; Crystal Peak Formation – characterized by massive chert pebble conglomerate; Kalzas Formation – dark grey to black fetid limestone; and Map-unit 13 – chert, quartzite, argillite, and minor limestone.

The Kalzas Formation overlies the Crystal Peak Formation and yielded lower Mississippian macrofauna. A thin limestone unit believed to underlie the Crystal Peak is also lower Mississippian, thus the Crystal Peak Formation and Kalzas are both lower Mississippian. A single collection from Map-unit 13 indicated a late Paleozoic age, possibly Pennsylvanian. In the study area, and in the Nahanni area, the Earn Group includes significant amounts of immature clastics, mainly chert clasts, whereas the overlying Tsichu Group (see following) does not contain immature clastics and includes quartzite and limestone. Earn Group strata in both the study area and the Nahanni map area are mainly Devonian in age and may range into the lower Mississippian. Tischu Group strata in the study area and Nahanni map area are early Mississippian, and range up to early Pennsylvanian in age (Appendix 1; Gordey and Anderson, 1993). Thus based on lithology and relative ages it is likely that the type Earn Group, in Glenlyon map area, is equivalent to both the Nahanni map area Earn Group and Tsichu formation (informal) of Gordey and Anderson (1993). This division is continued here because of the distinct lithological difference between Earn and Tsichu strata, and the Tsichu is upgraded to group status (see following).

Misfortune Formation (new), Earn Group

Type locality. The type section of the Misfortune Formation is Section 13 in map area 105-O/9 (Fig. 45). The base of the section is at UTM co-ordinates 446000 E, 7055800 N, and the top at 445500 E and 7054550 N, Zone 9. The Misfortune Formation is named after Misfortune Lake in the southeastern Bonnet Plume Lake map area, west-northwest of the study area.

Lithology, thickness, and contacts. The Misfortune Formation is continuous with and very similar to the Canol Formation. On the northeast, like the Canol, it can be divided into an upper and lower member. At the type section the lower member consists of 170 m of black shale with limonitic weathering and minor siltstone. In the upper part of the lower member are 10 to 20 per cent lithic sandstone with chert, quartz, and argillite clasts. The upper member is a more resistant whitish weathering, black siliceous shale with minor (centimetre to metre scale) lithic sandstone and chert pebble conglomerate. In the northeast of the study area, Misfortune Formation lithologies are similar to the type section but become more siliceous and contains chert successions to the southwest.

Like the Canol Formation the Misfortune Formation contains minor carbonate and barite in small and large lenses, and nodules. The lower contact with the Hailstone

Formation is sharp and conformable, and diachronous to the west (Fig. 33).

Sedimentary features. The Misfortune Formation is thin-bedded, and sandstone beds are moderately sorted.

Age. In the northeast the Misfortune Formation is dated by stratigraphic position as probably in the range of early Middle to Late (Famennian) Devonian (see Canol Formation, Age, for details).

To the southwest, where shales equivalent to the Hailstone Formation merge into the Misfortune Formation, the base of the Misfortune Formation is middle Early Devonian (Pragian). Conodonts from within the formation indicate an early Middle Devonian (early Eifelian) age (Appendix 1).

Distribution. The Misfortune Formation outcrops in the central and western study area (Fig. 32; Cecile, 1997a, b, c, d). It is also recognized across northwest Niddery Lake map area (Cecile, 1998a, b, c, 1999) and is likely represented by the Dsh1b, lDl, and Dmc units of Cecile and Abbott (1989, 1992).

Correlation. The Misfortune Formation is continuous with the Canol Formation. The lateral boundary between the two is defined by the nature of the overlying clastic succession. The underlying shales are Canol Formation where they are overlain by quartzose sandstones of the Imperial Formation, and Misfortune Formation where overlain by Thor Hills Formation. This is done to underline the differences between the two clastic packages. In addition real differences develop to the west, where the Misfortune Formation is diachronous and comprises siliceous shale equivalent to the Canol Formation as well as siliceous shale equivalent to the Hailstone Formation. The Misfortune Formation has more beds and units of lithic sandstone and chert pebble conglomerate than the Canol Formation (Fig. 45).

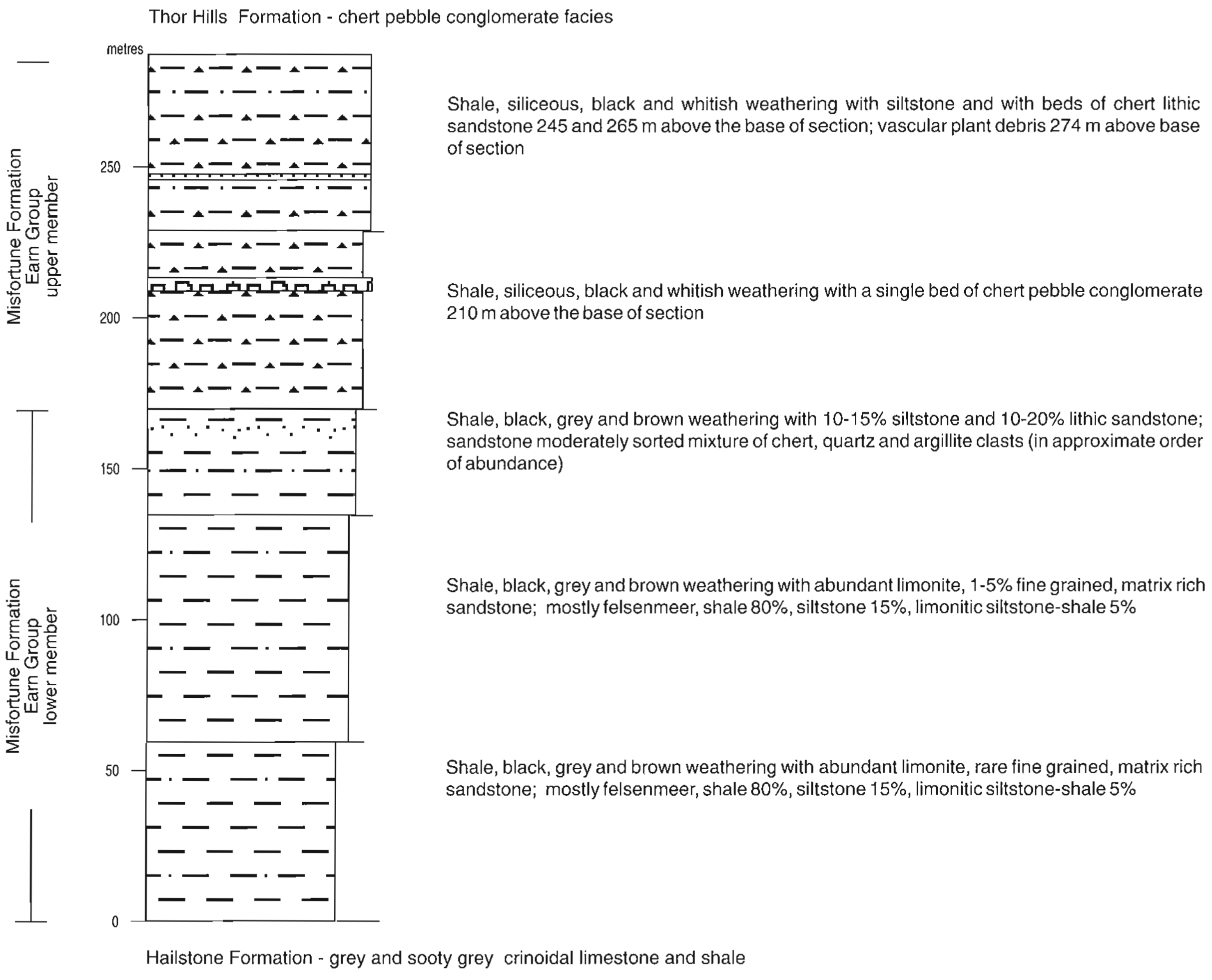


Figure 45. *Misfortune Formation, type section. Section 13, 105-O/9, base at UTM co-ordinates 446000 E, 7055800 N; top at 445500 E, 7054550 N, Zone 9.*

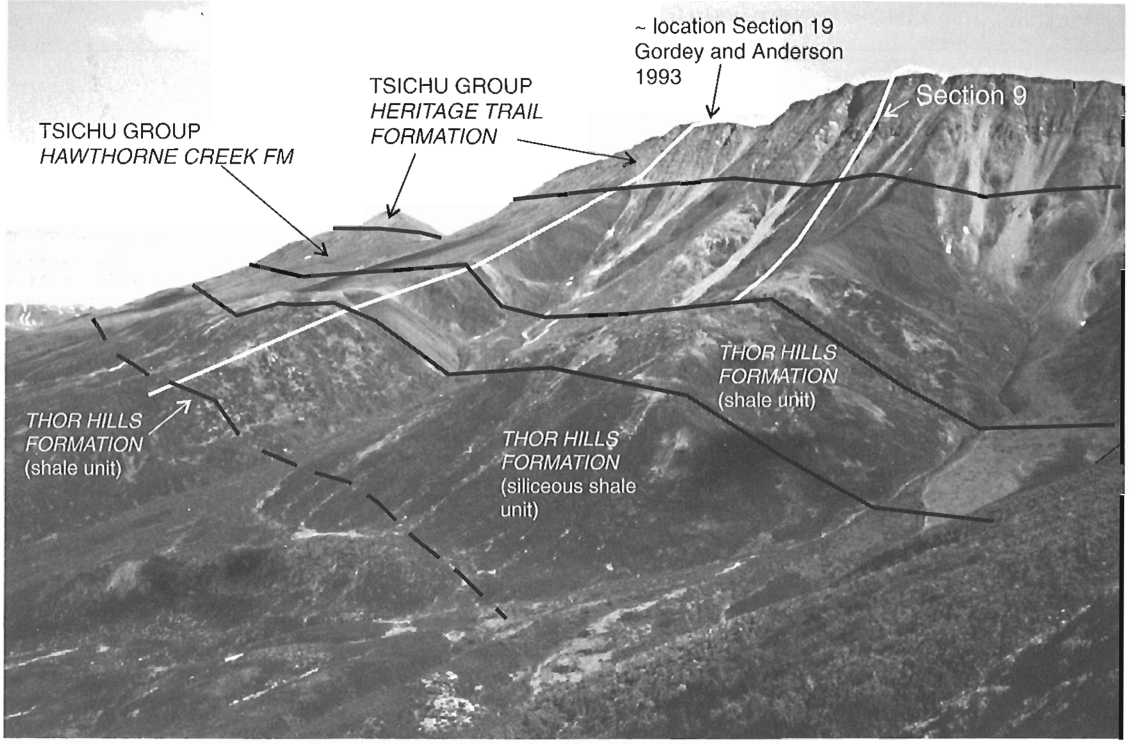


Figure 46. *View northeast of Section 9 (this manuscript) and Section 19 of Gordey and Anderson (1993). Upper cliff-forming ridge is the Heritage Trail Formation, Tsichu Group. Its highest point is 2093 m, a peak situated in NTS sheet 105-O/9 at UTM co-ordinates 449400 E and 7057800 N, Zone 9 (ISPG photo 1618-27). The basal part of Section 19 of Gordey and Anderson (1993) is the type section of the Thor Hills Formation (see Fig. 47).*

To the southeast, south, and southwest the Misfortune Formation is correlated with a basal shale, siliceous shale, or chert unit found at the base of most sections of the lower Earn Group of Gordey et al. (1982, fig. 13.2). Section D of Gordey et al. (1982), located in southeast Niddery Lake map area, was subsequently established as the type Portrait Lake Formation (Gordey and Anderson, 1993). The Misfortune Formation is homotaxial with, and lithologically similar to, the basal 90 m of the lower member of the type Portrait Lake Formation in southeast Niddery.

Cecile and Abbott (1992) also recognized mappable, but discontinuous, correlative units of the Misfortune Formation in the western and southern Niddery Lake map area (map-units Dsh1b, lDl, DMc map-units).

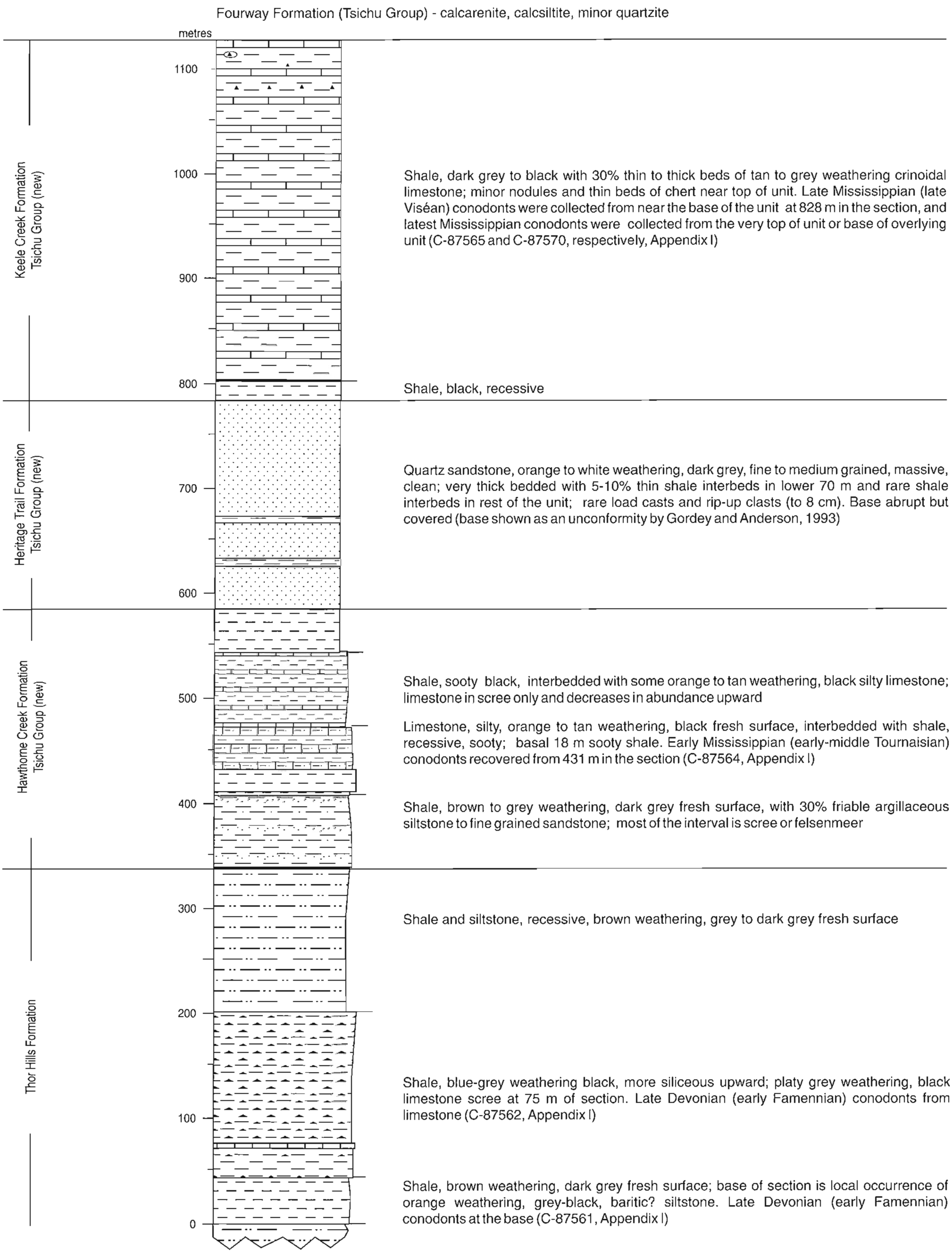
Interpretation. Both the upper Misfortune and Canol formations are interpreted as deep-water, organic-rich shales deposited during the early stage of foredeep basin development ('starved-basin facies').

Thor Hills Formation (new), Earn Group

Type locality. The type locality is in the eastern study area (Fig. 46, 47, Section 19 of Gordey and Anderson, 1993) with the base of the type section at UTM coordinates 450300 E and 7058600 N (map area 105-O/09; Fig. 32). The formation is named after the Thor Hills in NTS 105-O /15.

Lithology, thickness, and contacts. The Thor Hills Formation in its type area is estimated to be 340 to 440 m thick. The basal 100 to 200 m of the type section is covered. Above the covered interval are three distinct units that together total about 340 m. The lowest is a 40 m thick succession of brown weathering, dark grey shale. The middle unit is a 160 m thick succession of blue grey weathering, black shale, with a bed of thin grey limestone, that becomes more siliceous upward. The upper unit is a 140 m thick recessive succession of brown weathering, grey to dark grey shale and siltstone. Outside the type area the Thor Hills Formation consists of black rusty shale and siliceous shale with 10 to 20 per cent brown sandstone containing minor grey argillite and beds of chert pebble conglomerate. In southeast 105-O/9 (Cecile, 1997b) the Misfortune Formation is directly overlain by a thick succession of chert pebble conglomerate and chert lithic sandstone. These strata are mapped as Thor Hills conglomerate.

The basal contact of the Thor Hills Formation is not exposed at the type section. A reference area for the basal contact is in the hinge zone of the Hawthorne Syncline


Fourway Formation (Tsichu Group) - calcarenite, calcsiltite, minor quartzite
metres
1100
1000
900
800
700
600
500
400
300
200
100
0
Keele Creek Formation
Tsichu Group (new)
Heritage Trail Formation
Tsichu Group (new)
Hawthorne Creek Formation
Tsichu Group (new)
Thor Hills Formation
Shale, dark grey to black with 30% thin to thick beds of tan to grey weathering crinoidal limestone; minor nodules and thin beds of chert near top of unit. Late Mississippian (late Viséan) conodonts were collected from near the base of the unit at 828 m in the section, and latest Mississippian conodonts were collected from the very top of unit or base of overlying unit (C-87565 and C-87570, respectively, Appendix I)
Shale, black, recessive
Quartz sandstone, orange to white weathering, dark grey, fine to medium grained, massive, clean; very thick bedded with 5-10% thin shale interbeds in lower 70 m and rare shale interbeds in rest of the unit; rare load casts and rip-up clasts (to 8 cm). Base abrupt but covered (base shown as an unconformity by Gordey and Anderson, 1993)
Shale, sooty black, interbedded with some orange to tan weathering, black silty limestone; limestone in scree only and decreases in abundance upward
Limestone, silty, orange to tan weathering, black fresh surface, interbedded with shale, recessive, sooty; basal 18 m sooty shale. Early Mississippian (early-middle Tournaisian) conodonts recovered from 431 m in the section (C-87564, Appendix I)
Shale, brown to grey weathering, dark grey fresh surface, with 30% friable argillaceous siltstone to fine grained sandstone; most of the interval is scree or felsenmeer
Shale and siltstone, recessive, brown weathering, grey to dark grey fresh surface
Shale, blue-grey weathering black, more siliceous upward; platy grey weathering, black limestone scree at 75 m of section. Late Devonian (early Famennian) conodonts from limestone (C-87562, Appendix I)
Shale, brown weathering, dark grey fresh surface; base of section is local occurrence of orange weathering, grey-black, baritic? siltstone. Late Devonian (early Famennian) conodonts at the base (C-87561, Appendix I)

northwest of the type section north and south of Hawthorne Creek (Cecile, 1997a, b). In this area, the hinge zone of the syncline shows several areas where there is a distinct and conformable contact with the underlying Misfortune Formation. The basal contact is defined where the whitish weathering chert and siliceous shale of the Misfortune Formation change to brown weathering dark shale, or conglomerate and sandstone of the Thor Hills Formation.

Sedimentary features. Thor Hills Formation sandstone and conglomerate exhibit medium to poor sorting, and clasts are subrounded to angular. The sandstone is matrix rich and interstratified with shale. The shale is black, rusty and commonly siliceous.

Age. In the study area the Thor Hills Formation is unfossiliferous and is dated as Late Devonian on the basis of stratigraphic position. It overlies the Misfortune Formation, which is as young as late Late Devonian (early Famennian, Appendix 1), and is overlain by the Tsichu Group, the base of which is early early Mississippian in age (Hawthorne Creek Formation, Appendix 1). The Thor Hills conglomerate is underlain by the Misfortune Formation, but its upper part is eroded and missing. This opens up the possibility that the conglomerate may be younger than the rest of the Thor Hills Formation. However, direct correlation is considered likely because in the southern Niddery Lake map area Middle to Late Devonian chert-pebble conglomerate units are homotaxial with successions of shale and sandstone (Cecile and Abbott, 1992).

Distribution. The Thor Hills Formation outcrops in the central study area southwest of correlative Imperial Formation exposures (see Fig. 32). It is recognized in parts of the western (Cecile, 1998b, 1999) and southern Niddery Lake map area as the Dsh1, Dcg and DMsh2 map units of Cecile and Abbott (1992, 1989). These map units are laterally equivalent to a variety of other lateral clastic facies variants in other parts of the Niddery map area (DMss, DMsc, Dmcs, DMc units, Cecile and Abbott, 1992).

Correlation. The Thor Hills Formation in the study area is equivalent to some of the Portrait Lake Formation of Gordey and Anderson (1993), which outcrops across the central to northwestern part of the Nahanni map area (Fig. 50, 51). In the Niddery Lake map area the lower 90 m of the Portrait Lake Formation measured by Gordey and Anderson (1993) is equivalent to the Misfortune Formation (see Correlation, Misfortune Formation). The Thor Hills Formation is time correlative and homotaxial with the Imperial Formation in the study area, and in the northern Canadian Cordillera. It may also be equivalent to most of the Prevost Formation as mapped in the Nahanni area (S.P. Gordey, pers. comm., 1995). However the unit Gordey and Anderson (1993) designated as Prevost? in Niddery Lake map area is considered to be compositionally closer to units of the overlying Tsichu Group (includes quartzite and limestone) and thus is included with the Tsichu Group as the Hawthorne Creek Formation.

Interpretation. The Thor Hills Formation is interpreted as a deep-water clastic facies that was deposited in the western part of the late Paleozoic foredeep basin (see Gordey, 1988). The composition of the coarser facies and paleocurrents indicate westerly source areas (see Gordey, 1988; Gordey and Anderson, 1993). Two source areas for western foredeep basin clastic material are identified within a few kilometres of the study area. One is in southeastern Lansing map area, where Upper Devonian strata equivalent to the Misfortune and Portrait Lake formations rest unconformably on Proterozoic strata equivalent to the Yusezyu Formation (see Roots et al., 1995b). The second is in southwestern Niddery Lake map area where Upper Devonian equivalents of the Misfortune and Portrait Lake formations rest unconformably on a variety of units of Cambrian to Silurian age (see Cecile, 1984c, 1986c; Cecile and Abbott, 1992).

Upper Paleozoic carbonates and clastics

Tsichu Group

Gordey and Anderson (1993) introduced the term Tsichu formation (informal) for a succession of quartzites, interbedded shales and carbonates, and carbonates. No type section was proposed and the unit was considered informal, pending further study. Gordey and Anderson (ibid., their section 19) measured a section through what they considered to be the Tsichu formation in the southeastern part of this study area (Fig. 46, 47). Here they assigned the name Tsichu formation to a succession of lower Mississippian quartzite, a succession of lower to upper Mississippian shale and limestone, and to a unit of Pennsylvanian carbonates. An unnamed succession of shale and siltstone with limestone

Figure 47. *Type section of the Thor Hills and Keele Creek formations (Tsichu Group). This section is Section 19 of Gordey and Anderson (1993). Section 9, type Hawthorne Creek and Heritage Trail, was measured on a parallel ridge (see Fig. 46, 48). The base of this section is at UTM co-ordinates 449100 E, 7057450 N; top at 449400 E, 7057800 N (2093 m peak on map), NTS105. Section 19 of Gordey and Anderson is revised here as follows: the Tsichu formation is elevated to Tsichu Group; their Portrait Lake Formation and the lower stratigraphic unit of the Prevost? Formation are assigned to the new Thor Hills Formation; the remaining units of their Prevost? Formation are assigned to the new Hawthorne Formation, basal Tsichu Group. Compare with Figure 49.*

below the quartzite was considered to be Earn Group, Prevost? Formation, but is here included in the new Tischu Group (Hawthorne Creek Formation). The Tsichu Group as used herein is mostly equivalent to the upper type Earn Group (see preceding discussion on *Type Earn and Tsichu groups*).

Type section - group and formations. The Tsichu formation is formally elevated to group status. The type section for the group and most of its formations is on the southwest limb of the Stew Syncline, and consists of three parts (Fig. 46–49, 53). The first part, for the Hawthorne Creek and Heritage Trail formations, has UTM co-ordinates as follows: base at 449100 E, 7057450 N, top at 449400 E, 7057800 N (2093 m peak on map; NTS 105-O/09), and the second part, for the Keele Creek Formation, has its base at UTM co-ordinates 450300 E, 7059150 N and its top at 450300 E, 7058600 N, Zone 9 (adopted directly from Section 19b of Gordey and Anderson, 1993). The Fourway Formation is only found in one ridge, on the eastern margins of the study area (ridge around UTM co-ordinates 449900 E and 7059900 N, Zone 9; Fig. 32).

The type section of the Caribou Pass Formation (Fig. 49) is a section adopted directly from Gordey and Anderson (1993, their section 18 - "Tsichu limestone"), and is located 60 km southwest of the Stew Syncline section, in the North Macmillan Fold Belt (see Fig. 53 in Structure section). The base of the section is at UTM co-ordinates 404000 E, 7020000 N, and the top at 403500 E, 7018500 N, Zone 9, just outside the study area in southwestern 105-O/07 map area.

The Hawthorne Creek Formation is named after Hawthorne Creek north of the type section (Fig. 3). The Heritage Trail Formation is named after the 'Canol Heritage Trail' which runs through the adjacent Sekwi map area. Keele Creek is a geographic feature to the west of the type section (Fig. 3). The Caribou Pass Formation is named after Caribou Pass in the adjacent Sekwi map area. The Fourway Formation is named after Fourway Pass in the Bonnet Plume map area north of the study area. Tsichu Group is named after the Tsichu River, which has its headwaters near the type section and runs through the adjacent Sekwi map area.

Hawthorne Creek Formation (new), Tsichu Group

Lithology, thickness, and contacts. The type Hawthorne Creek Formation consists of two units: a lower, 200 m thick succession of black shale with minor quartzite and siltstone, and an upper, 130 m thick succession of black calcareous shale with medium to thick beds of yellow weathering limestone (Fig. 48).

The type Hawthorne Creek Formation rests conformably on the Thor Hills Formation. The two units are distinguished on the basis of their associated sandstone composition. The Thor Hills Formation contains chert lithic sandstone and chert pebble conglomerate, and units of siliceous shale, and the Hawthorne Creek Formation contains quartz sandstones in its basal unit and limestones in its upper unit. The Thor Hills Formation is not well exposed at this section.

Age. The Hawthorne Creek Formation at its type section is early Mississippian in age. One conodont collection at the base of the type section yielded early early Mississippian (early to middle Tournasian) conodonts, and another collection higher in the type section (250 m) yielded Early Mississippian (probably Viséan) conodonts (Appendix 1).

Distribution. The Hawthorne Creek Formation outcrops in the southeast hinge zone of the Stew Syncline (Fig. 32; see maps of Cecile 1997b) and continues into the adjacent Sekwi map area to the southeast.

Correlation. In the North Macmillan Fold Belt, along the southern part of the Niddery Lake map area the Hawthorne Creek Formation is considered to be correlative with map unit DMsh2a of Cecile and Abbott (1992). This map unit and the Hawthorne Creek Formation are apparently homotaxial. The DMsh2a map unit is 200 to 400 m thick and is characterized by the presence of 30 to 50 per cent thin beds of laminated to crosslaminated quartzite.

At the type section (North Macmillan Fold Belt) of the Caribou Pass Formation (Tsichu Group), the Hawthorne Creek Formation is missing, either through facies transition or erosion (Fig. 49).

In the adjoining Sekwi map area it is directly correlative with the top of Unit 26 of Blusson (1971).

Heritage Trail Formation (new), Tsichu Group

Lithology, thickness, and contacts. The type Heritage Trail Formation consists of 220 m of massive to blocky, buff to grey-white quartzite. The basal 30 m is dark coloured and has some shale matrix. There are rare, thin, shaly beds, shale chips beds, and calcareous quartzite beds (Fig. 48).

The type Heritage Trail Formation has a sharp but apparently conformable contact with the underlying Hawthorne Creek Formation.

Age. The Heritage Trail Formation at its type section is unfossiliferous but is dated as probably early Mississippian on the basis of relative stratigraphic position. A conodont collection from the upper part of the underlying Hawthorne Creek Formation yielded early Mississippian (probably Viséan) conodonts (Appendix 1). Also Gordey and Anderson (1993, their Section 18; Fig. 49) reported an early

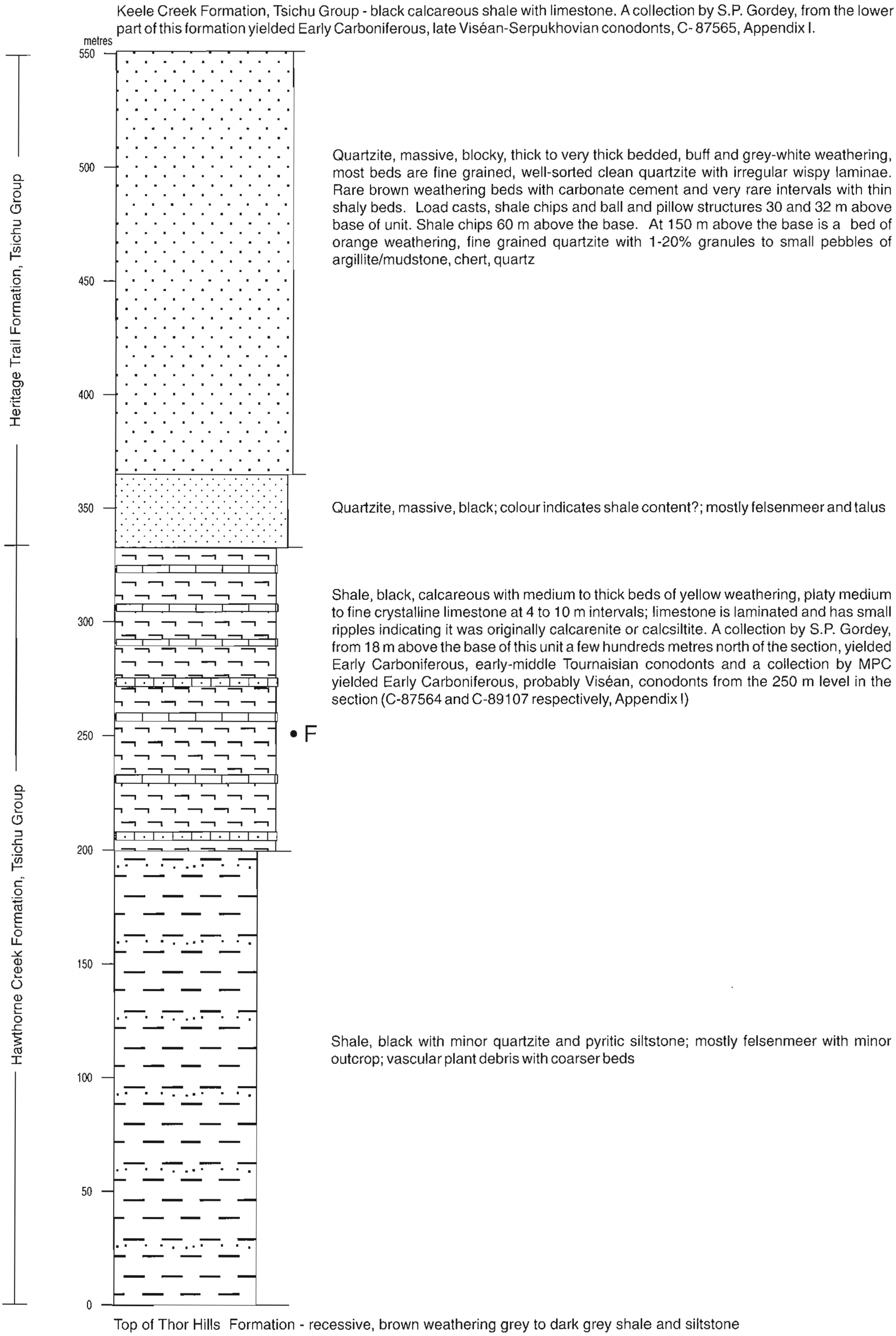


Figure 48. *Hawthorne Creek and Heritage Trail formations, Tsichu Group, type section. Section 9, NTS 105-O/9, southwest limb of the Stew Syncline; base at UTM co-ordinates 449100 E, 7057450 N; top at 449400 E, 7057800 N (2093 m peak on map).*

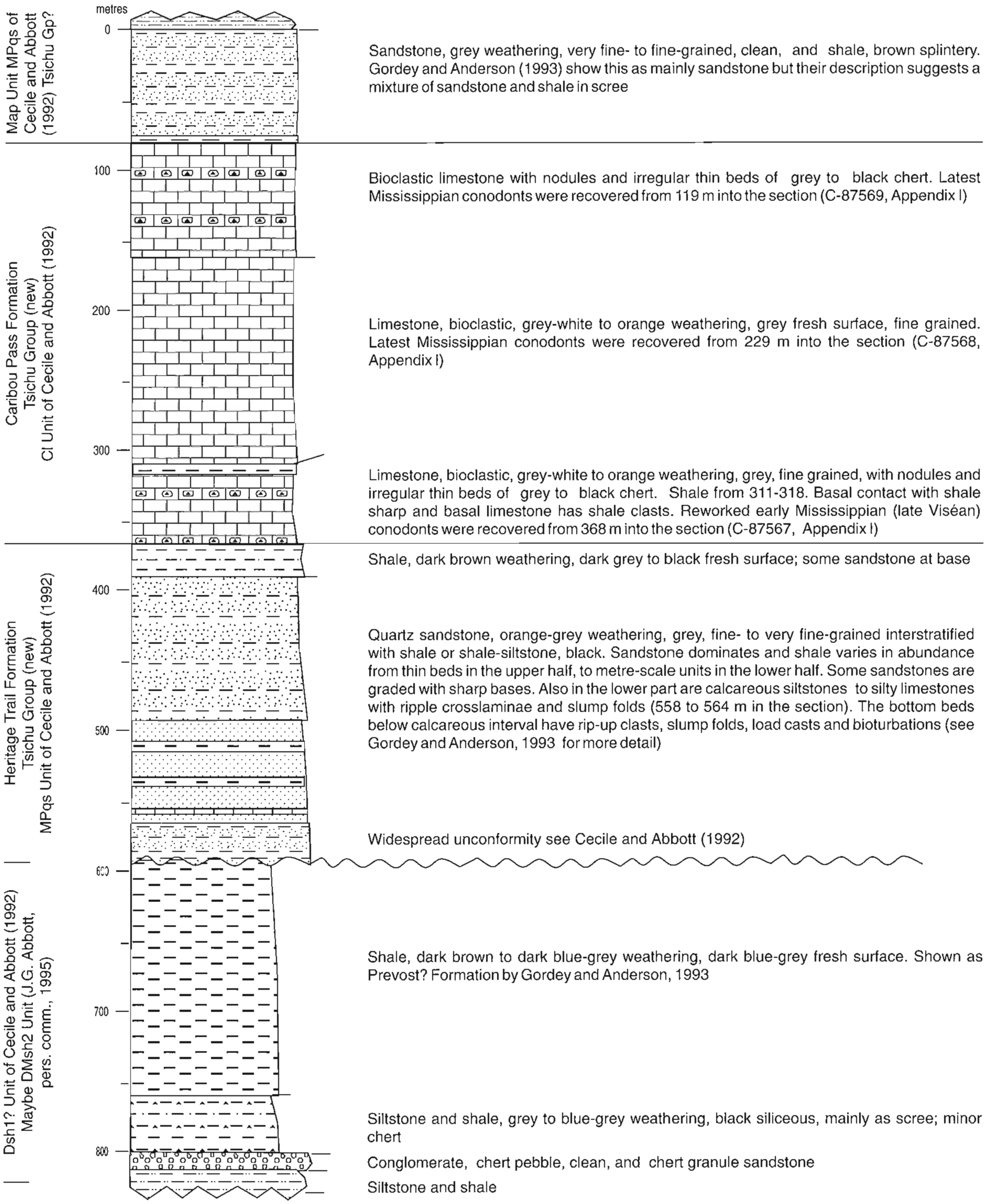


Figure 49. *Type section of the Caribou Pass Formation, Tsichu Group. This section is taken directly from Gordey and Anderson's (1993) Section 18 in NTS 105-O/7 just southwest of the study area. The section is overturned. The base is at UTM co-ordinates 404000 E, 7020000 N; top at 403500 N, 7018500 N, Zone 9. Note that the Hawthorne Creek Formation is missing, but it is not certain whether it is missing through lateral facies changes or erosion. There is good evidence for an unconformity directly beneath the Heritage Trail Formation in this section. Mapping of Cecile and Abbott (1992) shows most of the Thor Hills Formation is missing in the North Macmillan Fold Belt in this area (see Fig. 50).*

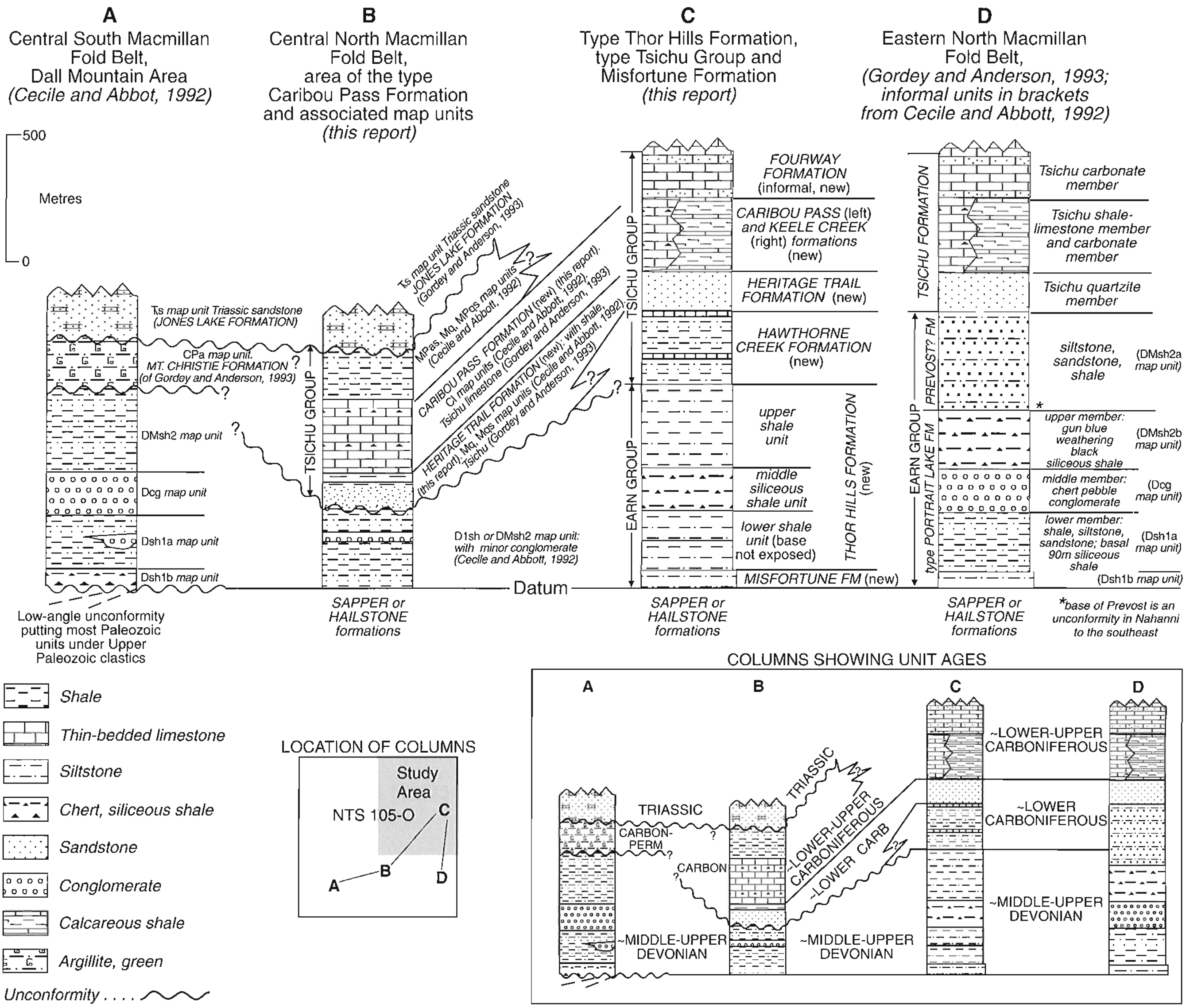


Figure 50. *Correlation chart showing the relations between the Thor Hills Formation as used in study area, type Tsichu Group and its formations, usage of Gordey and Anderson (1993), and map units of Cecile and Abbott (1992) in the Macmillan Fold Belt.*

Carboniferous (late Viséan) age from the base of the Caribou Pass Formation, which overlies the Heritage Trail Formation southwest of the study area. These fauna are apparently reworked (C-87567, Appendix I) and condonts from the rest of the the Caribou Pass Formation are latest Mississippian in age (Appendix 1).

The overlying type Keele Creek Formation has yielded conodonts from its base that are late Mississippian to earliest Pennsylvanian in age (Appendix 1).

Distribution. The Heritage Trail Formation outcrops in the southeast hinge zone of the Stew Syncline in NTS 105-O/9 (Fig. 32; Cecile, 1997b) and continues into the adjacent Sekwi map area to the southeast.

Correlation. In the Macmillan Fold Belt along the southern part of the Niddery Lake map area, the Heritage Trail Formation is directly correlated to the Mq and lower MPqs map units of Cecile and Abbott (1992) that underlie the Caribou Pass Formation. Strata also mapped as MPqs by Cecile and Abbott (1992) overlie the type Caribou Pass Formation (Fig. 49). This is the only exposure of this undated upper Mpqs. It cannot be correlated with the Heritage Trail Formation because the top of the Caribou Pass Formation is latest Mississippian. Thus this unit is a younger, late Paleozoic or possibly even Triassic clastic unit.

In the adjoining Sekwi map area it is directly correlative with Unit 27 of Blusson (1971).

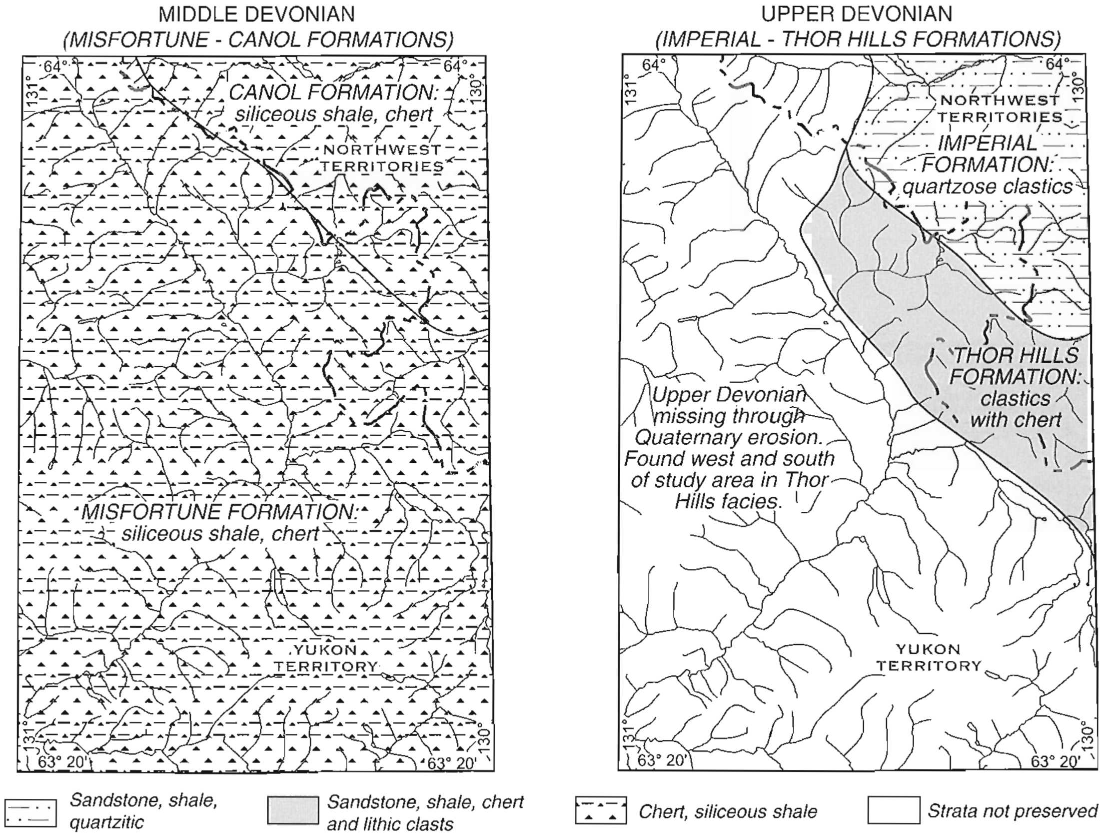


Figure 51. *Facies distribution of Devonian clastic strata.*

The Heritage Trail Formation is correlated with the Mattson Formation of the southeasternmost Mackenzie Mountains, which is similar in age and composition (Richards et al., 1981).

Keele Creek Formation (new), Tsichu Group

Lithology, thickness and contacts. The type Keele Creek Formation consists of 345 m of 70 per cent dark grey to black shale interstratified with 30 per cent thin to thick beds of crinoidal grey limestone. There are minor thin beds and nodules of chert near the top (Fig. 49). The type Keele Creek Formation is in sharp contact with, and conformable with, the Heritage Trail Formation.

Age. The Keele Creek Formation is late Mississippian to early Pennsylvanian in age. A collection near the base of the type section yielded late Mississippian (late Viséan) to latest Mississippian (early Namurian) conodonts (Appendix 1). At the top of the formation, right at the boundary with the overlying Fourway Formation, a collection yielded conodonts of early Pennsylvanian (late Namurian) age.

Distribution. The Keele Creek Formation outcrops in the southeast hinge zone of the Stew Syncline (Fig. 32; Cecile, 1997a, b) and continues into the adjacent Sekwi map area to the southeast.

Correlation. In the Macmillan Fold Belt along the southern part of the Niddery Lake map area the Keele Creek Formation is correlative with the Caribou Pass Formation and map unit Cl of Cecile and Abbott (1992). The Caribou Pass Formation and Cl map units are shallow-water carbonate facies equivalents of the more basinal Keele Creek Formation.

In the adjoining Sekwi map area it is directly correlative with Unit 28 of Blusson (1971).

Caribou Pass Formation (new), Tsichu Group

Lithology, thickness, and contacts. The type Caribou Pass Formation consists of 288 m of grey-white to orange weathering, fine grained bioclastic limestone with chert nodules and shale in the basal and upper parts (Fig. 49).

The type Caribou Pass Formation rests conformably on the shales at the top of the Heritage Trail Formation. It is conformably overlain by an unnamed succession of quartzite and argillite similar in composition to the underlying Heritage Trail Formation and mapped as the MPqs unit by Cecile and Abbott (1992) and as the Cp map unit by Abbott (1983a)

Age. The Caribou Pass Formation at its type section yielded three collections of conodonts. The first, near the base, gave an early Mississippian (Viséan) age, but these fauna are considered to be reworked. The second, from the middle of the type section, gave a latest Mississippian (Serpukhovian) age. The third, near the top of the succession, also gave a latest Mississippian (Serpukhovian) age (Appendix 1).

Distribution. The Caribou Pass Formation outcrops in the north-central part of the North Macmillan Fold Belt in NTS map areas 105-O/6, 7 (see Fig. 53 in section on Structure).

Correlation. The Caribou Pass Formation is a facies correlative of the Keele Creek Formation (this volume). In its type area, the North Macmillan Fold Belt, it is correlative with Cl map unit of Cecile and Abbott (1992) and replaces the Cl unit of Abbott (1983a).

Fourway Formation (new), Tsichu Group

Type locality, lithology, thickness, and contacts. The Fourway Formation is known only from one ridge peak area, which is its type locality (Fig. 32). Here it consists of more than 220 m of siliceous and white to buff calcarenite and calcisiltite, with minor quartzite (see top unit, Section J2 of Gordey et al., 1982). It is in sharp, but conformable, contact with shales and limestones of the upper Keele Creek Formation.

Sedimentary features. The Fourway Formation is silicified but appears to have at least some thick bedding.

Age. One very good collection of conodonts from the base of the Fourway Formation gives an early Pennsylvanian (Bashkirian) age (C-87570, Appendix 1). A single conodont from 40 m above the base indicated an older, Mississippian age, and is either inherited or will be revised (C-89101, Appendix 1). There are no age determinations for strata higher in the section so the unit is considered to be Pennsylvanian and possibly younger.

Correlation. There are no rocks of this age in the Mackenzie Mountains to the north and east. In the Selwyn Mountains, S.P. Gordey (pers. comm., 1995) reported bedded cherts of the Mt. Christie Formation (Pc unit of Gordey and Irwin, 1987) from the Tay River and Sheldon Lakes map areas south and southwest of Niddery, which are early Pennsylvanian to Late Permian in age. The Mount Christie Formation is also thought to occur in western Niddery Lake (Cpc(A) unit of Cecile, 1999) and to the west in Lansing map-area (Cpc unit of Roots et al. 1995a, b).

In the immediately adjoining Sekwi map area it is directly correlative with Unit 29 of Blusson (1971).

At the Fourway Formation type locality, Gordey and Anderson (1993; Section 19) measured a section at the base of the Fourway Formation and identified it as their Tsichu formation carbonate member. However their Tsichu carbonate member is the Caribou Pass Formation, which is older (late Mississippian) and a time and facies equivalent of the Keele Formation, Tsichu Group (this report).

Tsichu Group - Interpretation

Formations of the Tsichu Group represent a complex paleogeography featuring both shallow-water limestone and clastics and deeper water facies. The Heritage Trail, Fourway and Caribou formations are all interpreted as the products of shallow-water environments because of the dominance of limestone and bioclastic material and/or clean quartzite. The Hawthorne and the Keele Creek formations are interpreted as deeper water deposits that accumulated on the peripheries of shallow-water units.

Recent tuffas and hot spring

Seven, small, calcareous tuffa deposits and one small spring, discharging hot water, were found during mapping in the study area (Cecile, 1997a, c, d). All deposits are likely the products of discharge of calcium-carbonate-rich ground-waters driven by montane hydrostatic systems.

Four of the tuffas fall close to a northeast-trending line in the west-central map area 105-O/16 (Cecile, 1997a). Along this line, two are situated over the Sekwi Formation, one over the Hailstone Formation and the other over the Duo Lake formation. They all occur in or close to, northeast-trending creeks on either side of the Northwest Territories and Yukon boundary among mountains of moderate relief. Their northeast alignment suggests the possibility of structural control. However, there are no documented faults on this trend, therefore if structurally controlled, the system would likely be a fracture system or a fault with no detectable offset.

STRUCTURE

Introduction

The Niddery Lake map area was deformed mainly by convergent orogenesis between Late Triassic and Late Cretaceous time. Structures over most of the area have consistent northwest strikes, and folds have simple, low-angle plunge variations. This suggests dominance of a single deformation event. Convergent deformation is demonstrated by the bulk of strata being shortened by between 20 and 80 per cent. The youngest supracrustal strata deformed and preserved are Late Triassic, early Norian, in age (Norford et al., 1993, collection C-89946 of J.G. Abbott identified by M.J. Orchard from NTS 105-O/2). This provides an older limit to the age of deformation. No strata younger than early Late Triassic are known in the Niddery Lake map area, thus the age of deformation may be younger. Most deformed rocks are cleanly cut by Late Cretaceous plutons, one of which, the Emerald Lake Pluton (NTS 105-O/11; Cecile, 1998b), is dated as 92–91 Ma (early Late Cretaceous, Smit et al., 1985; Smit, 1984), and this provides the youngest limit for the age of major deformation. This deformation event thus will be referred to as the Columbian Orogenesis, following the usage of Stott et al. (1993, p. 413–414).

There are some structures that do not conform to the dominant Columbian structural trends and patterns – opposed facing directions for structures and bending of fold axes in the horizontal plane are examples – and they indicate either modification by later deformation and/or local structural peculiarities.

The bending of fold axes is considered evidence of post-Columbian deformation. A set of strike–slip faults, the MacMillan–Hess River Fault System (Fig. 52; Abbott, 1985; Abbott and Turner, 1990b; Cecile and Abbott, 1992; Roots et al., 1995a), runs east and southeast through southern Niddery Lake map area. These faults are spatially associated with a continuous reorientation of fold axes trends from northwest to southwest and finally west (Fig. 53 shows the change to southwest in the study area; the full range of change can be seen on the map of Cecile and Abbott, 1992). In addition, structures wrap around a small pluton between faults in this system, indicating post-intrusion rotation (Cecile 1984c, NTS 105-O/6). These faults are thought to have a post 92–91 Ma or Laramide component of deformation. They are likely associated with major mid-Cretaceous to Eocene transcurrent faulting along the Tintina–Northern Rocky Mountain Trench (Roddick, 1966; Gabrielse, 1991).

There is also evidence of older Paleozoic tectonic activity. Devonian growth faults associated with tilting and regional truncation of older Paleozoic strata are known from several places in the Niddery Lake map area (Fig. 50; Cecile, 1984c, 1999; Cecile and Abbott, 1992). This deformation was accompanied by basic volcanism (Cecile, 1984c) and is likely locally extensional. Regionally, Devonian tectonism is transpressional. In addition to that there are numerous unconformities among upper Paleozoic and Triassic strata suggesting local uplift (Fig. 50). Devonian growth faults have the same orientation as the younger, MacMillan–Hess River Fault System and much of the erosional truncation is spatially tied to the same fault system. This implies that the MacMillan–Hess River Fault System may be a long-lived structural feature of the area.

Evidence for most of the pre- and post- Columbian deformation is outside the study area and will be discussed only where relevant in the following sections.

MAPS

Although there are figures illustrating structures in this volume, the following discussion of is best augmented by the geological maps available separately from this bulletin (Cecile, 1997a, b, c, d).

STRUCTURAL DIVISIONS

The study area in the northeastern part of the Niddery Lake map area includes three main structural domains identified on the basis of dominance of folds or thrusts and the degree and scale of deformation. These are: the Mackenzie Fold Belt, the Rogue Décollement Complex and the Keele Thrust Belt (Fig. 52, 53).

Mackenzie Fold Belt

The Mackenzie Fold Belt consists of three zones which are, from northeast to southwest, the Devonian, the Cambrian, and the Selwyn zone (Fig. 53, 54). All three zones are characterized by moderate-scale open to tight folds and high-angle thrusts. They differ in the character of strata-controlling structures, level of fold detachment, and in the presence, or absence, of pervasive cleavage. The Selwyn and Cambrian zones are divided by a major structure, the Selwyn Valley Thrust, which is also coincident with a major physiographic feature, the broad, northwest-trending Selwyn Valley.

Devonian Zone

The Devonian Zone is an area of dominantly open folds with thrusts where mainly Devonian strata are exposed at the surface. Devonian strata consist of the following: greater than 200 m of thick bedded limestone (Grizzly Bear

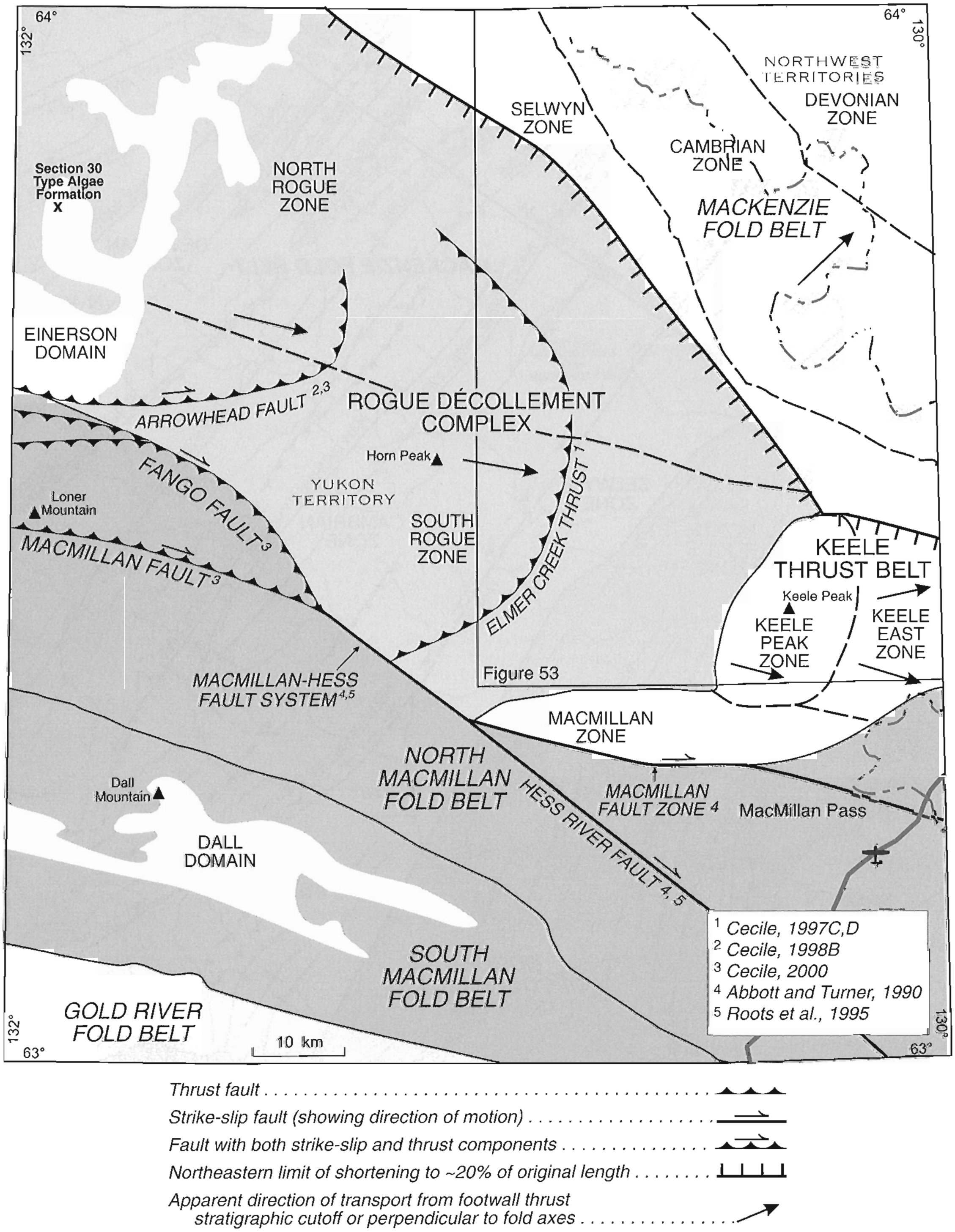


Figure 52. *Major structural features of the Niddery Lake map area (105-O) with the study area shown (Fig. 53). Based on the geology of Cecile and Abbott (1992) and Cecile (1997a, d, 1998a, d).*

Formation) that thins and becomes more shaly westward (Hailstone Formation), aproximately 400 m of Canol Formation shale, and more than 400 m of Imperial Formation sandstone and shale.

Description of individual structures. Mappable large anticlines and synclinoria in this zone are, from northeast to southwest: Northeast Anticline, Northeast Synclinorium, Territories Anticline, and Territories Synclinorium.

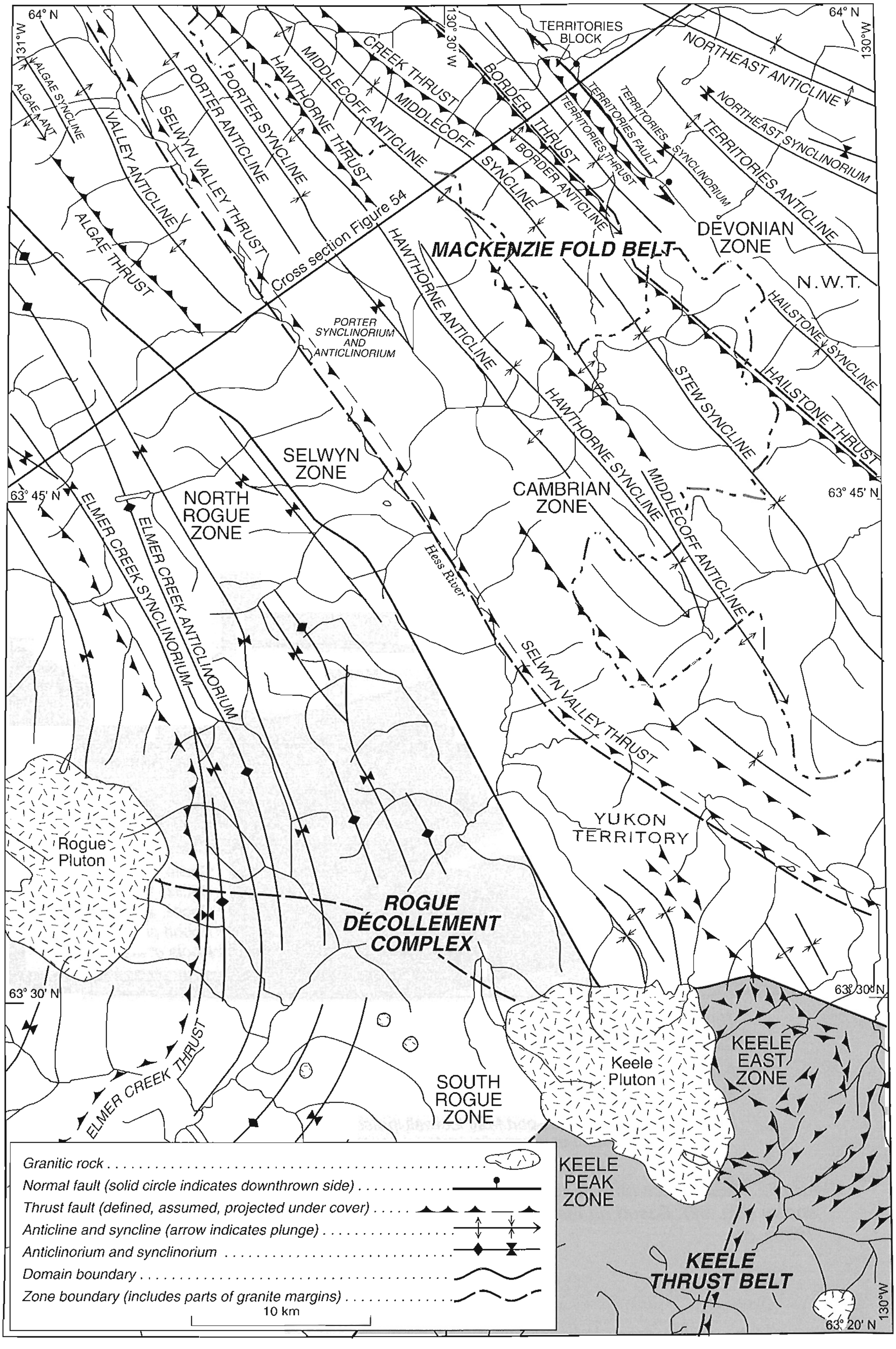


***Figure 53.** Major structural features of the northeastern Niddery Lake map area. Based on the geology of Cecile (1997a–d).*

Mappable faults are the Territories Normal Fault and the Territories Thrust. The southwestern boundary of the zone is defined by the Border and Hailstone thrusts. Within synclinoria are some smaller scale mappable synclines: Northeast Syncline, Territories Syncline and Hailstone Syncline, and unnamed folds (Fig. 54; Cecile, 1997a).

The Northeast Anticline is a large, open, upright fold that exposes Devonian platform carbonates in its hinge zone. It is flanked on the northeast by an open, unnamed syncline with Canol Formation shale in its hinge zone. The Northeast Synclinorium is a broad, symmetrical structural depression with at least three, minor, upright synclines and anticlines. The largest is the Northeast Syncline, which is a narrow feature defined by a shale unit within the Imperial Formation. The Territories Anticline is a major upright fold that extends along strike across most of the map area, and is cored by the Canol Formation. In the study area all folds plunge southeasterly except for the Territories Anticline, which plunges northwesterly, opposite to the general trend. In the northwest the Canol Formation plunges below the Imperial Formation, and immediately southeast of the map area the anticline opens and is cored by the Devonian Grizzly Bear Formation carbonates. The Territories Synclinorium is another broad, symmetrical structural depression with several smaller syncline–anticline pairs. Within the Territories Synclinorium are at least two mappable structures. The first, the Territories Syncline, is a narrow feature defined by fold cores of an Imperial Formation shale unit. The second, Hailstone Syncline, is a larger, upright structure extending halfway across the southwestern part of the zone. The Hailstone Syncline plunges to the southeast, where it is cored by a relatively complete succession of the Imperial Formation.

A peculiar feature of this zone is a block of rocks confined by the Territories Normal Fault and the Territories Thrust, herein referred to as the Territories Block. This block and its bounding faults are about 8 km long. The faults are peculiar in that they comprise a westward-directed thrust on the southeast side, and a northeast-side-down extensional fault.

The southwestern boundary of the Devonian Zone is defined by the Border and Hailstone thrusts. The Border Thrust is a minor, high-angle thrust on the northeastern margin of the Border Anticline, and terminates southeastward between the Territories Synclinorium and the northwest end of the Hailstone Thrust. The Hailstone Thrust is a steep fault that trends toward the Border Anticline but does not directly connect with it. The Hailstone Thrust places the Devonian Grizzly Bear Formation platform carbonate in the hanging wall, on the west, over the Canol and Imperial formation clastic rocks in the footwall. In the map area the thrust is more than 15 km long and its maximum stratigraphic offset is approximately 500 m.

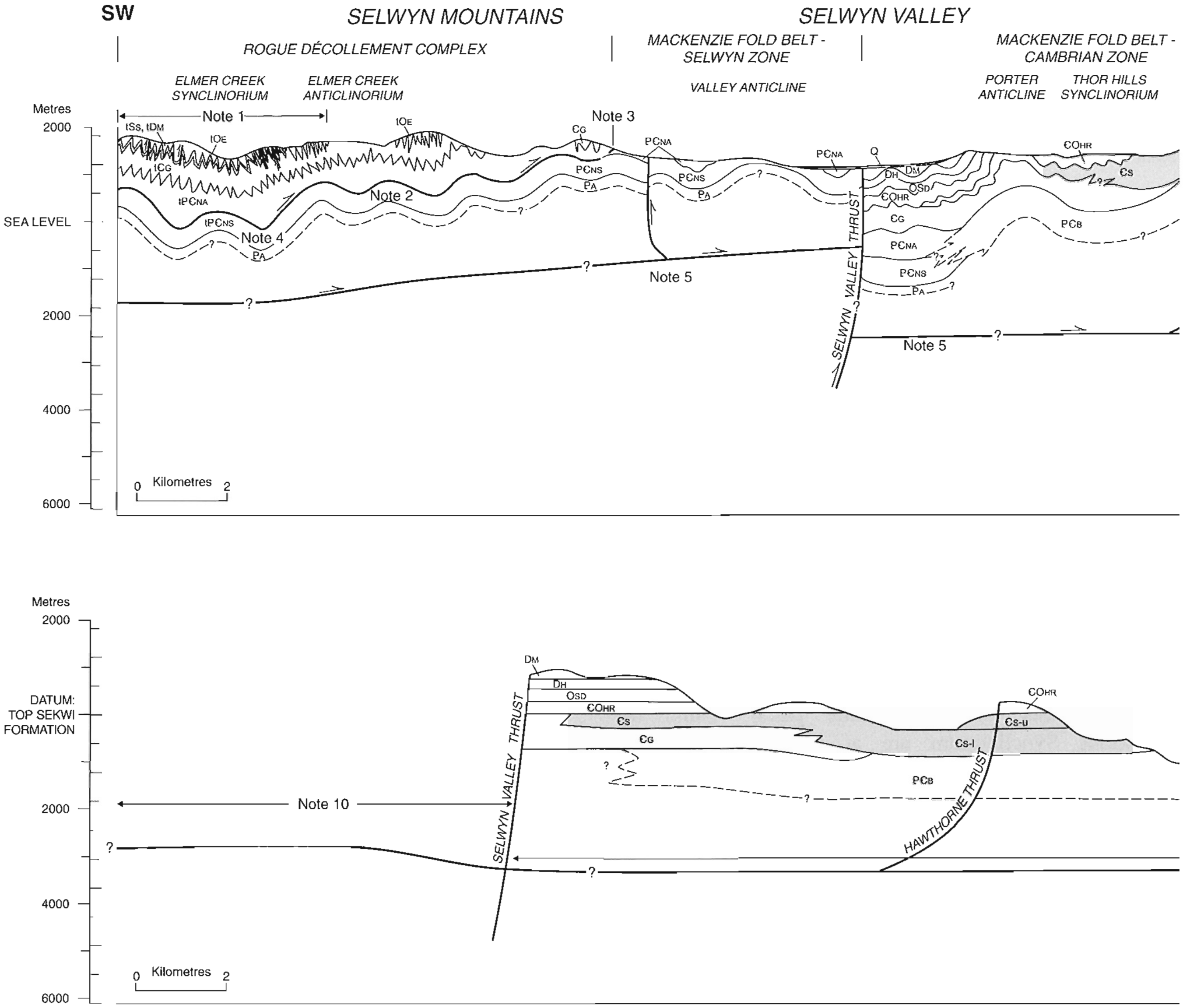
Analysis. Three scales of folds are found in this zone. The largest are the Northeast and Territories anticlines and synclinoria with wavelengths of approximately 10 km. Based on scale, these structures are likely controlled by a combination of the competent Devonian strata together with underlying competent Cambrian strata (see Fig. 55). On an intermediate scale are the narrow Northeast, Territories and Hailstone synclines, which have kilometre-scale wavelengths and are found within the synclinoria. The smallest scale folds have wavelengths of a metre to tens-of-metres and are found throughout the synclinoria. Based on scale, all medium and small structures within the synclinoria must detach within the Devonian clastic succession and would be controlled by the more competent Imperial Formation sandstones (Cecile, 1997a).

In cross-section (Fig. 54) the geometry of structures at the level of the competent Cambrian strata in this zone is based on projecting stratigraphic thicknesses from surface to depth. Cambrian strata exposed up-plunge in adjacent map areas on the northwest and southeast (Blusson, 1971, 1974) show folds similar to those shown in the section and those found in the Cambrian Zone.

Poles to bedding planes show that the basic structures form a simple, broad, fold girdle with an average shallow southwest plunge (Fig. 55). Shortening across this zone is in the order of 20 per cent using bed length only (Fig. 54). Layer-parallel shortening cannot be measured but when taken into account it could double the amount of shortening (Hobbs et al., 1976).

The opposing plunge of the Territories Anticline is an interesting anomaly, but like many other structural features is likely due to displacement transfer. In addition, all folds found in the study area are, on a regional-scale, doubly plunging. In fact throughout the Canadian Cordillera there are regional-scale (tens of kilometres) structural culminations that are doubly plunging to the southeast and northwest. Doubly plunging elongate folds are common in thrust belts (Dixon and Tirrul, 1991). In experiments of Dixon and Tirrul (1991) folds propagate by nucleation of new, elongate, periclinal folds ahead of older, higher amplitude folds. Small-scale folds grow in amplitude and hinge-line length simultaneously until they encounter other propogating folds. The result is an en echelon array of elongate periclines.

The overturned nose of the Border Anticline is likely controlled by dispacement tranfer, as it lies between the ends of the northeast-verging Hailstone, and southwest-verging Territories, thrusts.



Note 1 Detailed structure here based on measured traverses (see Fig. 24 and 28).

Note 2 Folds of this scale and size observed north of section. Thinning of the PЄNA tectonic unit over PЄNS and older unit anticlines observed west of section.

Note 3 Rogue Décollement displacement inferred to dissipate to zero.

Note 4 Rogue Décollement surface inferred from the observation that strata above are shortened to 20% of their original length while strata below the décollement are shortened to 60-80% of their original length.

Note 5 Area from the Porter Synclinorium west is a zone with multiple detachments. The top of the PЄNA correlates approximately with the top of the ЄS. A simple projection of the Mackenzie Fold Belt detachment places it at 2 km depth. Continuing that depth to the other side of the Selwyn Valley Thrust indicates an offset on the fault. If this is correct then the Selwyn Valley Thrust would detach at an even greater depth. This is consistent with calculations of Cecile and Cook (1991) which show a fundamental basal regional detachment at 18 km below the one shown here. There are many other possible interpretations including bringing the detachment to surface at the Selwyn Valley Thrust and running the deeper detachment continuously across the Selwyn Valley area, or running the eastern detachment at its present level, detaching the Selwyn Valley Thrust from it.

Note 6 Faults are steeply dipping at surface. They are projected to the basal detachment in this cross-section only to show a probable connection. The nature of such a connection cannot be determined. The faults may root higher or lower than the detachment shown here.

Note 7 Fold detachment level based on excess-area calculation (right) reduced by 20%. Calculation assumes normal stratigraphic thickness below synclines.

Note 8 Many factors may cause stepdown of detachment eastward. Examples: pre-existing relief on the detachment surface; repetition of sub-Sekwi strata below an upper detachment; offset on faults that extend below this detachment.

Note 9 Detachment lowered to 3+ km because of increased fold wavelengths at surface.

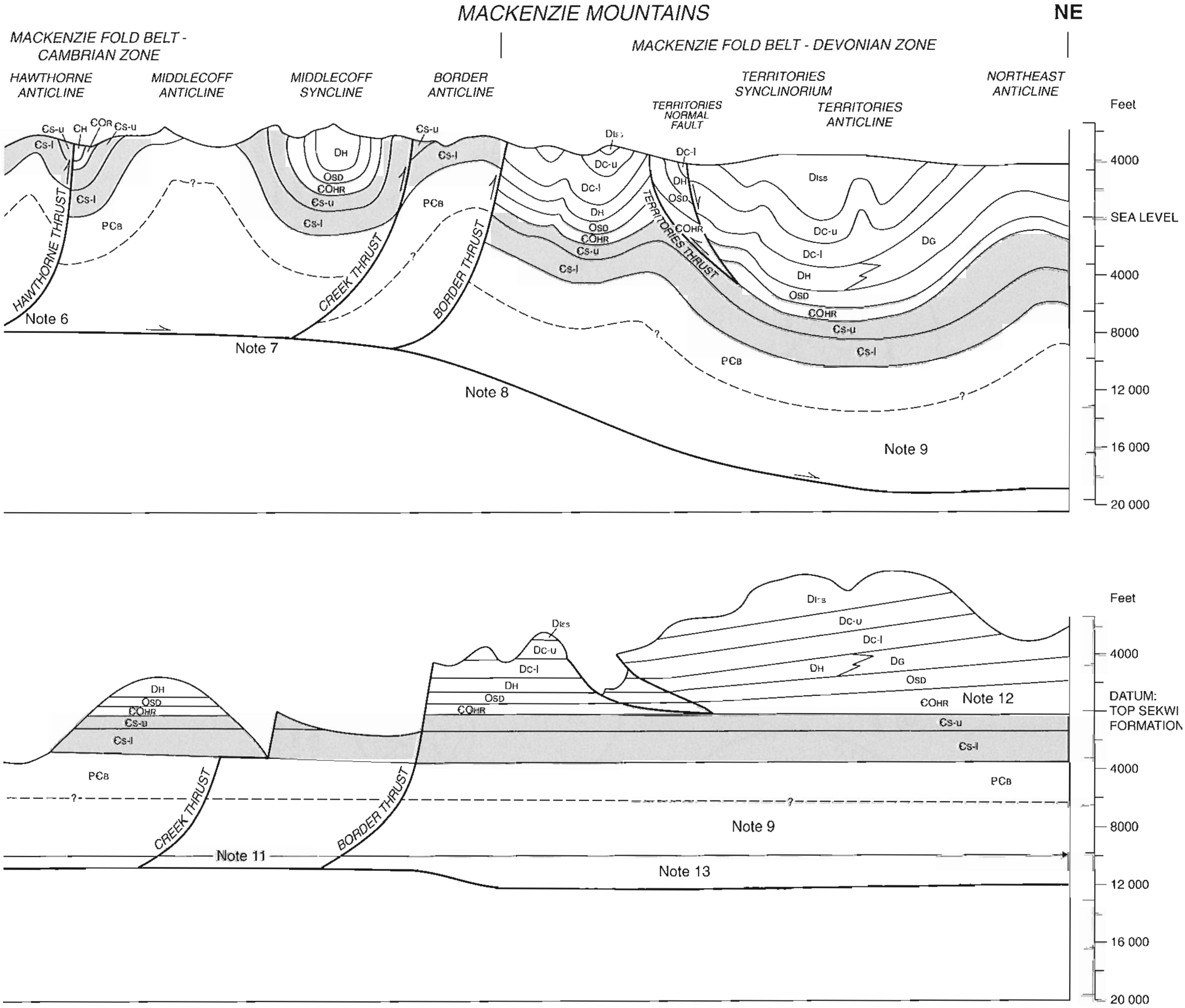
Note 10 Shortening beyond this point is estimated only. Strata above the Rogue Décollement, up to the point where it dissipates to zero, restored by ~80%. Strata below the décollement, and everything east of its zero point, restored by ~20%.

Note 11 Restored length is 36 km (20%).

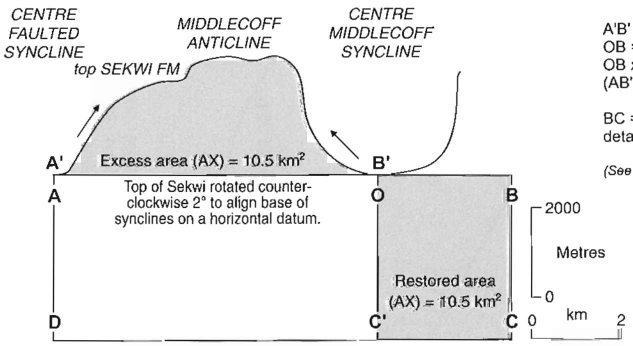
Note 12 Thickening of OSD and ЄOHR toward the northeast reflects the appearance of the Misty Creek Embayment. The base of PЄB is the base of known stratigraphy.

Note 13 Stratigraphy unknown. Probably includes various upper Proterozoic units: Rapitan Group, Coppercap-Redstone formations and part of the Little Da Group.

Figure 54. *Composite structural cross-section across northeastern Niddery Lake map area (from cross-section A-A' and B-B' on maps of Cecile (1997a, d) with excess area calculation for sub-Cambrian level of fold detachment).*



EXCESS AREA CALCULATION



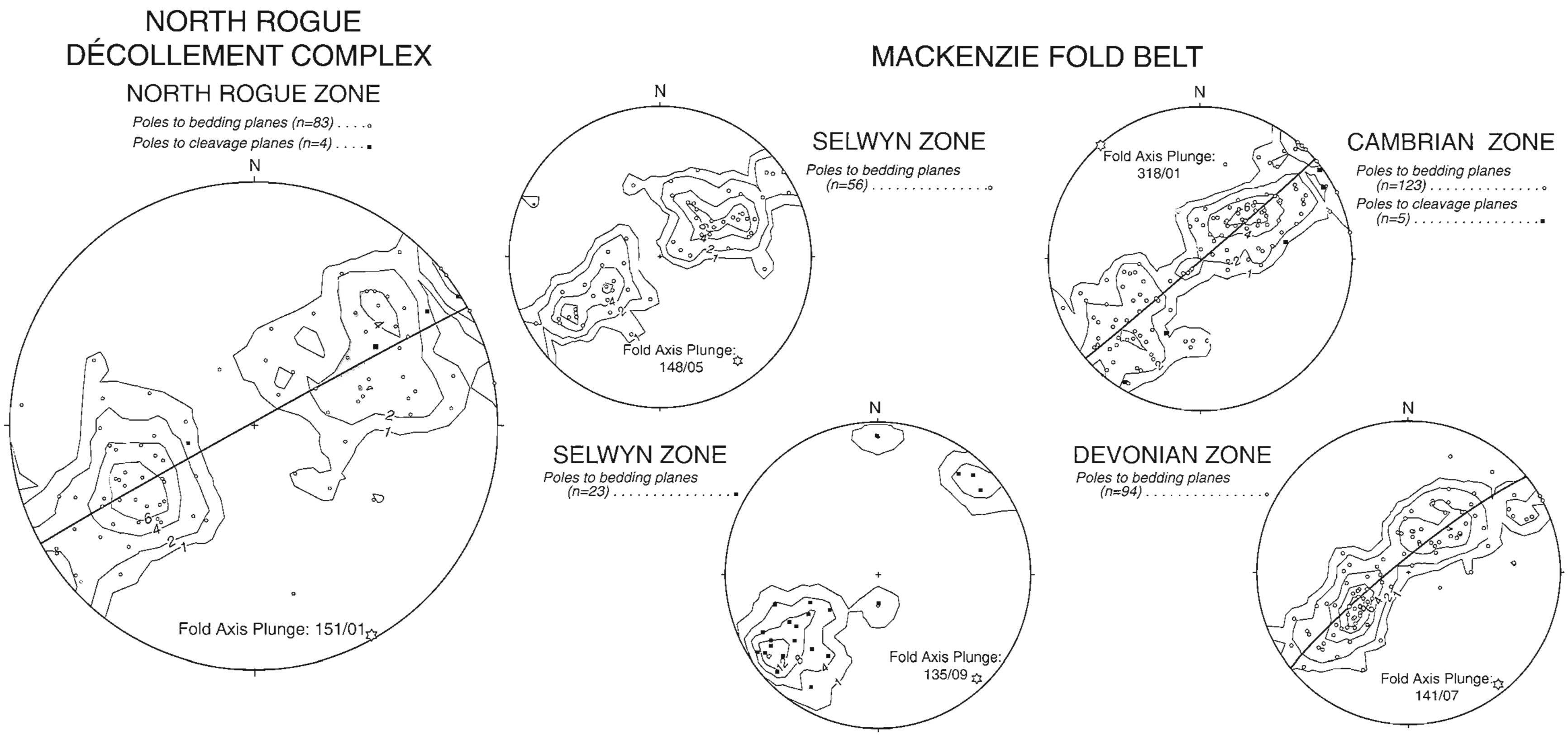
A'B' = AB = 10.0 km
OB = AB - AO = 3.0 km
OB x BC = AX = 10.5 sq. km
(AB', AO and AX - measured directly)

BC = AX/OB = Stratigraphic depth to detachment below synclines = 3.5 km

(See Hossack, 1979 for methods)

Calculated depth to detachment is 3.5 km. However this could be an overestimate because it does not account for pre-buckling, layer-parallel shortening of the Sekwi Formation (incompetent strata would buckle and thicken during layer-parallel shortening (Dixon and Tirrul, 1991)) and other factors like compaction losses (Hossak, 1979). To accommodate for this, the depth in the cross-section has been arbitrarily reduced by 20% of the calculated value. **Thus the depth to the detachment below the top of the restored Sekwi Formation is estimated to be 2.8 km under the Middlecoff Anticline.**

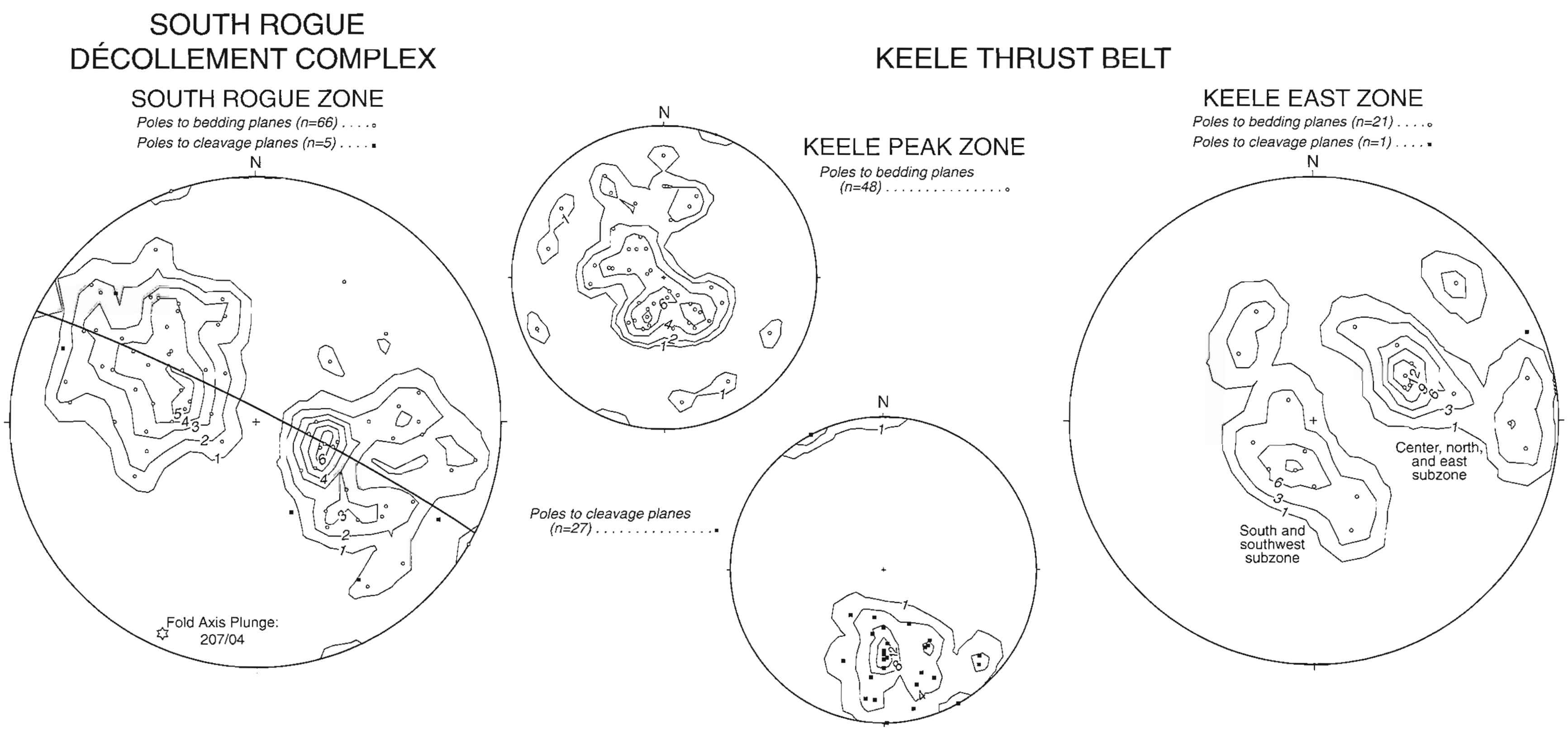
Figure 54. *Composite structural cross-section across northeastern Niddery Lake map area continued.*



A. Poles to bedding and cleavage planes, Rogue Décollment Complex, North Rogue Zone. In the field there are at least two scales of folding defined by Elmer Creek Formation cherts. The first are shallowly detached tens of metre-scale folds which are tight to isoclinal. These smaller folds are refolded into open, kilometre-scale anticlinoria and synclinoria.

B. Poles to bedding and cleavage planes, Selwyn Zone, Mackenzie Fold Belt. Cleavage planes are slightly fanning and mainly dip steeply to the northeast. In the field this zone is characterized by kilometre-scale folds that plunge gently southeast.

C. Poles to bedding and cleavage planes, Cambrian and Devonian zones, Mackenzie Fold Belt. Patterns demonstrate upright folds that gently plunge to the southeast in the Devonian and are near horizontal in the Cambrian. In the field these folds are kilometre-scale and are open to tight, and upright. In the Devonian Zone, smaller scale folds appear in synclinoria and anticlinoria, as shallower detachments begin to develop.



D. Poles to bedding and cleavage planes, Rogue Décollment Complex, South Rogue Zone. In the field there are two scales of folding defined by Elmer Creek Formation cherts. The first consists of shallowly detached tens of metre-scale folds that are tight to isoclinal. These smaller folds are refolded into open, kilometre-scale anticlinoria and synclinoria. The southwestward swing in trends from the North Rogue Zone is the result of bending of fold axes in the horizontal plane in association with right-lateral strike motion on the Macmillan-Hess fault system.

E. Poles to bedding and cleavage planes, Keele Thrust Belt Keele Peak Zone. Strata in this area are continuous with the basal Rogue Décollment Complex, below the level of the tightly folded Elmer Creek Formation cherts. There are no distinctive units at this level to illustrate structural geometry. Poles to bedding indicate relatively flat dips, whereas cleavage poles indicate flattening on steeply northwest-dipping planes. The probable method of foreshortening is thrust repetition.

F. Poles to bedding and one cleavage plane, Rogue Décollment Complex, Keele East Zone. Poles to bedding indicate relatively flat dips consistent with flat thrust structures found in this zone. Poles fall into two subzones that correspond to map position indicated. For both subzones there is a weak pattern suggesting folding about a southwest-trending axis, which is consistent with swings in thrust fault trends in the zone.

Figure 55. *Lower hemisphere stereonet plots of poles to bedding and cleavage for northeastern Niddery Lake map area. Stereonets are arranged in order of geographic position with north at the top and east on the right. Compare with zone positions on Figures 52, 53.*

Cambrian Zone

The Cambrian Zone is characterized by open folds with wavelengths of approximately 5 km, and high-angle thrusts. The level of exposure across the zones varies from Cambrian, in the hinge zones of anticlines, to Devonian in synclines. Fold structures are mainly controlled by thick, competent, Cambrian quartzite (Backbone Ranges Formation) and carbonate (Sekwi Formation) units, which together are thought to be close to 2000 m thick (Fig. 54). In cross-section (Fig. 54) the geometry of structures at the level of the competent Cambrian strata is upright open to approximately box shaped folds.

Only the upper Backbone Ranges Formation is exposed in the map area. The exposed part is more than 200 m thick and consists mainly of massive quartzite and siltstone. The overlying Sekwi Formation is a 900 m thick mixed succession of thick and thin bedded carbonates, calcareous shale and argillite (Fig. 10). When foreshortened this mixture of lithologies could result in a blend of similar and concentric folds. There is little evidence of significant strain in Sekwi strata, but there is likely to be some minor variation in thickness of the Sekwi Formation from fold limbs to fold hinges. Folds are thought to be mainly controlled by the underlying quartzites and thick units of competent carbonates and thus are close to concentric in general overall form.

Poles to bedding planes from this zone show that the basic structures form a simple, broad girdle to northwest-trending folds with essentially no plunge (Fig. 55). Southeasterly plunges are apparent from map patterns in the study area (Fig. 53; Cecile, 1997a, b, d). As noted earlier, however, these folds are part of a regional doubly plunging structural culmination and most measurements are from fold limbs. Shortening using bed length across this zone is on the order of 20 per cent and, as noted earlier, layer-parallel shortening is not measurable and could double this value (Fig. 54).

The Cambrian strata can be used to estimate depth to detachment (Fig. 54). The top of the competent Cambrian succession (top of Sekwi Formation) is considered to be a relatively unstrained surface that can be used to calculate the depth of detachment following the excess area method (Hossack, 1979). There is a more precise method of calculating detachment depth using multiple stratigraphic surfaces (Epard and Groshong, 1993). However, well controlled, multiple, independent stratigraphic surfaces cannot be precisely defined in this succession without seismic or drill hole control.

The depth of detachment determined by Hossack's method, with some consideration for layer-parallel shortening, is about 2.8 km below the top of the restored Sekwi Formation. If Proterozoic and Cambrian strata exposed in the Mackenzie Mountains approximately 80 km to the northeast extend under the study area, then the detachment would be located somewhere in the interval extending from the upper Little Dal Group, through the Coppercap–Redstone formations to the lower Rapitan Group. It is hypothesized that the Plateau Thrust, in the central Mackenzie Mountains, detaches on a gypsum unit in the upper Little Dal Group (Cecile and Cook, 1981; Cecile et al., 1982).

Anticlines, synclines, thrusts, and synclinoria. There are four large anticlines cored by competent Cambrian strata and four synclines cored by Devonian strata. From northeast to southwest these are: Border Anticline, Stew Syncline, Middlecoff Syncline, Middlecoff Anticline, Hawthorne Syncline, Hawthorne Anticline, Porter Syncline, and Porter Anticline (Fig. 4, 54).

There are five, major, named thrusts and two unnamed thrusts in the zone. Named thrusts are, from northeast to southwest: Border Thrust, Creek Thrust, Lakes Thrust, and, forming the boundary between the Cambrian and Selwyn zones, the Selwyn Valley Thrust.

Border Anticline, Border Thrust, and Creek Thrust. The Border Anticline is a large structure exposed in the northeast of the Cambrian Zone (Fig. 54; Cecile, 1997a). It is cut on the northeast by the Border Thrust and on the southwest by the Creek Thrust. The Border Thrust is steep, small and northeasterly directed; it disappears into the nose of the Border Anticline. The Creek Thrust also has a short strike length and disappears southeastward where Cambrian strata of the Border Anticline plunge below Devonian rocks. The Border Anticline opens to the northwest where is becomes anticlinorial, with smaller open folds within it. To the southeast it plunges below Devonian strata. The southeast termination is peculiar in that it is steeply overturned, facing southwest.

Middlecoff and Stew synclines. The Middlecoff Syncline is an open syncline with steeply dipping limbs. It is near box-like in cross-section. It is cored by the Devonian basinal Hailstone Formation, which is vertically dipping in several places. The Middlecoff Syncline trends toward, but is not continuous with the Stew Syncline. The two are joined enéchelon by a hypothetical anticline (Cecile, 1997a).

The Stew Syncline is a broad, open, southeast-plunging fold that contains strata as young as Pennsylvanian. The southwest limb of the syncline is the site of abrupt facies changes where Imperial Formation units change to Thor Hills Formation (Earn Group) southerly across the valley of the Twitya River (Cecile, 1997b).

Middlecoff Anticline and Lakes Thrust. The Middlecoff Anticline is a large, shallowly southeast-plunging anticline cored by the Backbone Ranges and Sekwi formations. The anticline is upright and closed (Fig. 54), and cuts the eastward-directed Lakes Thrust, in the center of the study area. The Lakes Thrust is moderately west-dipping, less than 10 km long and has a displacement of only a few tens of metres (Cecile, 1997a).

Hawthorne Syncline. The Hawthorne Syncline is a narrow, upright, short, doubly plunging fold cored by Devonian carbonates and clastics. The youngest clastics are Earn Group, Thor Hills Formation. This syncline extends across the central part of the map area. To the northwest it trends into the Hawthorne Thrust and to the southeast it ends along with the Hawthorne Anticline (Cecile, 1997a, b, d).

Hawthorne Anticline and Hawthorne Thrust. The Hawthorne Anticline is a narrow, mostly upright open fold exposing Cambrian strata in its hinge zone across most of the map area. It plunges southeasterly and ends in the southeast along with the Hawthorne Syncline. Along its southeastern end it is overturned to the northeast.

The northeastern limb of the Hawthorne Anticline is cut by the Hawthorne Thrust in the northern part of the area. The Hawthorne Thrust is more than 15 km long and places Cambrian lower Sekwi strata over upper Sekwi strata and lower Paleozoic basinal facies, a displacement of about 1000 m (Fig. 54). The thrust merges with the Hawthorne Syncline to the southeast. At its southeast termination lower Paleozoic rocks in the footwall are vertically dipping along a 5 km segment of the fault.

Porter Anticline, Syncline, Anticlinoria, and Synclinoria. The southwesternmost structures in the Cambrian Zone are a pair of narrow, upright, southeast-plunging folds that diverge southeastward into anticlinoria and synclinoria. Together all of these structures extend from the northwest for less than half the distance across the map area. The Porter Anticline is cored by Backbone Ranges and the Sekwi Formation, and the Porter Syncline has lower Paleozoic Hess River and Rabbitkettle formations as the youngest units in its core. The anticlinoria and synclinoria are both in a poorly exposed area with numerous small-scale folds repeating the Hess River and Rabbitkettle formations.

Southwesterly and southeasterly through the Porter structures, Cambrian strata thin, become more shaly, and are transitional into argillite facies, which are dominant in the southwest. Thus the transition southeast of the Porter Anticline and Syncline into the Porter Anticlinorium and Synclinorium is attributed to development of higher level detachments associated with the change to more shaly facies.

Fault characteristics. The majority of faults in this zone are thought to be high-angle thrusts or reverse faults for the following reasons: they are associated with compressional structures, they mainly dip to the west, follow bedding for long distances along strike, and consistently show older over younger hanging wall/footwall relationships.

Selwyn Valley and Selwyn Valley Thrust

The Selwyn Valley Thrust forms the southwestern boundary of the Cambrian Zone. Its presence beneath surficial deposits is inferred from the relatively low stratigraphic level of exposure southwest of the Selwyn Valley (Proterozoic and Lower Cambrian) when compared to exposures northeast of the valley (Lower Cambrian to Devonian; Fig. 54).

The Selwyn Valley Thrust is situated in the center of the physiographic Selwyn Valley. This physiographic feature forms a prominent, 90 km long linear trench in the northern Cordillera. Because of the Selwyn Valley's length, and also because most rocks on either side differ in gross facies, it was hypothesized to be the southern extension of a major strike–slip fault system, the Richardson–Hess fault system (Eisbacher, 1982, 1983). However, analysis of the geology along this 'fault system' indicates that only a maximum of about 10–20 km of right lateral separation is permissible (Cecile, 1984a), and in fact no strike–slip displacement is necessary. There is no direct unequivocal evidence of strike–slip movement along the fault.

The Selwyn Valley Thrust is situated approximately along the position of the shale-out of Lower Cambrian strata – for example, the Backbone Ranges and Sekwi formations change laterally to parts of the Narchilla and Gull lake formations (Fig. 4, 5, 54) across Selwyn Valley. However this transition starts northeast of Selwyn Valley, and an intermediate facies with the Keele Member, the Gull Lake Formation, is exposed around Keele Pluton in a direct line with Selwyn Valley.

The Selwyn Valley is interpreted as the approximate location of a major facies transition that has undergone small-scale thrust movement (+/- small-scale strike–slip) and is not the result of structural juxtaposition of different facies (Cecile, 1984a).

Selwyn Zone

The Selwyn Zone is characterized by similar folds, minor thrusts, fanning pervasive cleavage, and moderate shortening in the order of 20 per cent using bedding length (layer-parallel shortening could double this value; Fig. 54).

The zone includes three named folds in the northwest of the zone: Valley Anticline, Algae Syncline, and Algae Anticline. All these folds continue and open to the north, into the adjacent Bonnet Plume map area. There is one major named thrust, the Algae Thrust. In the south there are several, mappable, unnamed narrow anticlines, synclines and thrusts. Some of these structures extend for 5 to 10 km (Cecile, 1997b, c, d). The boundary of the Selwyn Zone with the Rogue Décollement Complex is defined as the line across which shortening increases rapidly from approximately 20 to aproximately 80 per cent within Cambrian argillite facies.

Description of structures. The Valley Anticline is an open fold that extends from the Selwyn Valley northwest beyond the edge of the map area. It is cored by the lower Senoah Member (Narchilla Formation), which consists of about 400 m of siltstone and shale with thick units of resistant quartzite, grit, and limestone. The Valley Anticline is upright over most of the map area but to the northwest it overturns to the southwest.

The Algae Syncline is a relatively tight fold with Cambrian argillite in its hinge zone. It is found only in northwest of map area 105-O/15. It is upright in the southeast and overturned facing southwest in the north. The Algae Syncline truncates against the Algae Thrust to the south.

Only the nose of the Algae Anticline is exposed in the northwest of the map area. It is an open, upright, southeast-plunging fold with Proterozoic clastic and carbonate strata in its hinge zone (Algae and Yusezyu formations). The Algae Anticline is part of a small, regional, doubly plunging culmination exposing similar strata in north-central 105-O map area and in the Bonnet Plume (106B) map area to the north (Blusson, 1974).

The Algae Thrust is a westward-directed, steeply dipping fault with the Narchilla Formation in the hanging wall and Narchilla and overlying Gull Lake formations in the footwall. The fault is 15 km long and has a small stratigraphic separation of less than 400 m.

There is nothing distinctive about folds in the south part of this zone that justifies naming individual structures. They are open, upright, have subhorizontal to shallow southeast plunges, and can be mapped for several kilometres. Anticlines are cored by the Narchilla Formation and synclines by Cambrian argillite of the Gull Lake Formation.

Thrusts in the far southeast of the zone and north of the Keele Pluton differ from thrusts in the rest of the Mackenzie Fold Belt in the study area. They are moderately west dipping and stacked in a closely spaced array (Cecile, 1997b). These faults are continuous with faults in the Keele Thrust Belt.

Poles to bedding planes form a girdle to northwest-trending folds with a plunge of five degrees southeast. Poles to cleavage planes form a similar girdle and are anomalous in that they show a predominance of shallow northeast dips.

Rogue Décollement Complex

Structures in this domain consist of tight to isoclinal upright and overturned folds with amplitudes that are three to five times their wavelength, accompanied by small, local thrusts (Fig. 56; Cecile 1983, 1986b). In addition there are zones with steeply dipping, shallowly detached stacks of thin imbricate thrusts (Fig. 57). In chert units the folds are nearly concentric, whereas in shale and argillite they have an incompetent (similar) style. Shortening in this zone is about 80 per cent (that is, to 20% of the original length, Fig. 54).

These tight folds and imbricate faults lie above a relatively shallow detachment that is broadly refolded into large-scale, open and upright anticlinoria and synclinoria. These broader structures are related to a detachment at a deeper level (Fig. 54). The axes of the smaller scale folds and larger anticlinoria and synclinoria bend in a horizontal plane about a steeply south-southeast-plunging fold axis. This results in a continuous swing in structural trends, and map units, from northwest- to southwest-trending. The axial surfaces are bent without any change in plunge between the Rogue and Keele plutons (Fig. 53). This change in structural trend is the basis for division of this complex into north and south zones.

Rogue décollement

There is one major décollement surface in the Rogue Décollement Complex, situated at the base of the Arrowhead Lake Member, Narchilla Formation. In the northwestern part of the Niddery Lake map area (Cecile, 1998a, b, c, 1999; Cecile and Abbott, 1992) four large anticlines expose the Yusezyu, Algae, and Narchilla formations. In these anticlines there is a marked change in the structural style and degree of foreshortening between the Proterozoic to (?) Lower Cambrian strata and overlying lower Paleozoic strata. The Proterozoic to (?) Lower Cambrian Yusezyu, Algae and lower Narchilla formations (Senoah Member) are deformed in simple, large, open, upright folds with shortening similar to that of the Mackenzie fold-Belt (~20%). In contrast, the overlying upper Narchilla (Arrowhead Lake Member) Gull Lake, Elmer Creek, Steel, and Misfortune formations, which make up the Rogue Décollement Complex, show intricate internal deformation and extreme shortening. This décollement surface is here named the Rogue Décollement.

Because strata above and below the décollement surface are concordant, the surface itself must be folded into large-

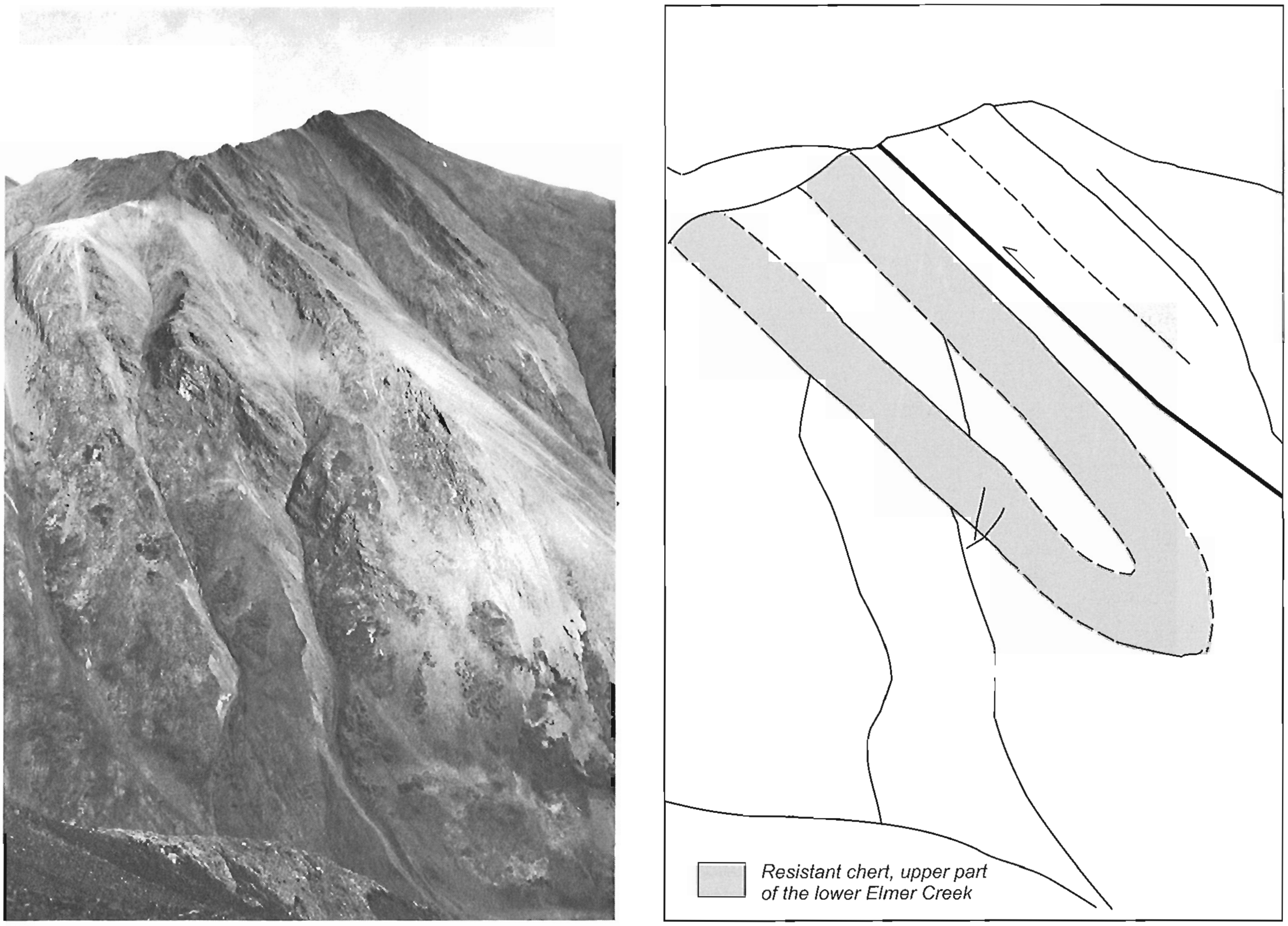


Figure 56. *Ridge-side exposure of a faulted syncline cored by the upper part of the lower Elmer Creek Formation. Note the core is an argllaceous chert and the overlying upper Elmer Creek and Steel Formation have been squeezed out of the core. Resistant chert is illustrated but all the ridge is Elmer Creek Formation (ISPG photo 1618-11).*

scale anticlinoria and synclinoria. Thus the Rogue Décollement surface is shown as folded on the regional cross-section (Fig. 54).

Measured traverses and internal structure of the Rogue Décollement Complex

The Rogue Décollement Complex is highly shortened along multiple, stacked, inter-stratal detachments. The amount of internal strain varies widely from unit to unit; it is generally low in cherts and high in argillites. In order to restore and characterize the structure and internal composition of stratigraphic units in this zone a unique approach was required. Two traverses were measured through nearly continuous exposures of lower Paleozoic chert, argillite and shale, across part of the décollement complex (Fig. 23, 27). Structural cross-sections were constructed along the traverses, using biostratigraphy, lithological characteristics, special features and observations of actual structures (Fig. 24, 28).

Tectonostratigraphic units

Although individual stratigraphic units can be resolved and locally mapped within the Rogue Décollement Complex, for general mapping purposes, map units in the complex are a structural mixture of formational units. Thus within the décollement complex "tectonostratigraphic map units" were established (see preceeding sections on stratigraphy for definitions). Fortunately, because of the presence of multiple detachments, most tectonostratigraphic units in the study area are dominated by one formation or the other.

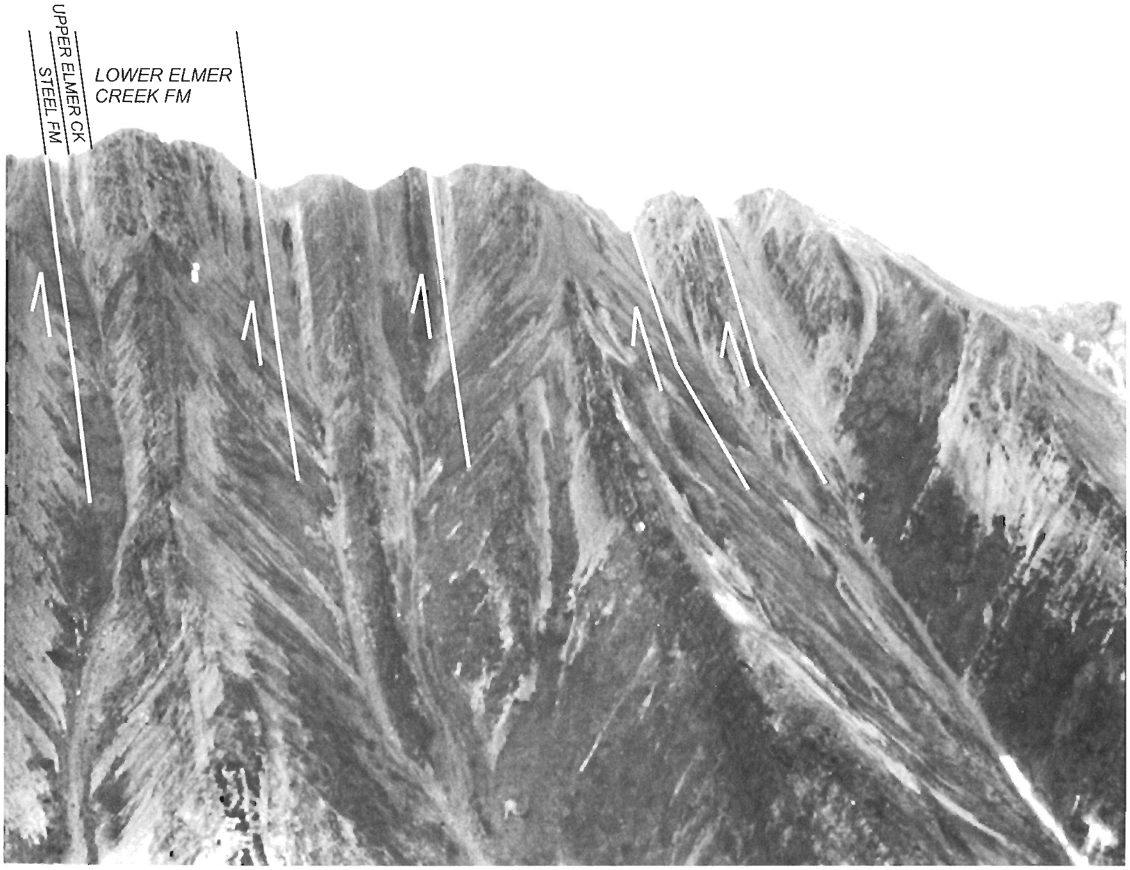


Figure 57. *View looking north at thin imbricate thrusts within the Rogue Décollement Complex west of the study area. There are five resistant ridges forming small ridge peaks. Shoulders down the sides of the ridge are all repeats of the lower member of the Elmer Creek Formation, and the recessive zones are the upper member of the Elmer Creek Formation and the Steel Formation. Each forms an asymmetrical stratigraphic package with tops to the left. Thus the portion of the ridge in the photo is composed of at least five, east-dipping, overturned, thin thrust panels. The overturning is likely associated with the later formation of larger anticlinoria and synclinoria (ISPG photo 4460-1).*

The bioturbated and massive chert at the top of the lower Elmer Creek Formation is a particularly important unit. Given the thinness of the chert and its position between ductile shale it is likely to have undergone mostly buckling and minor, layer-parallel shortening. This unit can be traced around fold noses where it shows very little change in thickness (maximum strain observed is ≤30%). The length of this unit, through and across folds and faults, therefore gives an approximation of the original extent of the unit before deformation, less 30 per cent. Noting that fold amplitudes in the chert are three to five times greater than wavelength, then across the Niddery Lake map area alone this unit restores westward by a distance of more than 200 km. This represents shortening to approximately 20 per cent of the original undeformed length.

Anticlinoria, synclinoria, and fabric data. There are several anticlinoria and synclinoria in the Rogue Décollement Complex. The anticlinoria are mainly cored by the Gull Lake and Elmer Creek formations and the synclinoria by the Steel Formation, with lesser exposures of the underlying Elmer Creek and overlying Misfortune formations. Some of the synclinoria in the South Zone are cored by Old Cabin Formation volcanics.

Only two of these features, the Elmer Creek Anticlinorium and Elmer Creek Synclinorium, are named. These two features are important because they are crossed by the measured traverses (Fig. 24, 28), thus their internal geometry is well known. In addition, numerous individual small-scale folds can be mapped within these features (Cecile, 1997c, d). They are also typical of other anticlinoria and synclinoria in that both are broad, upright and open, and have a very gentle southeast plunge in the north, and southwest plunge in the south. Individual small-scale folds and thrusts are overturned to the west and to the east within the larger anticlinoria and synclinoria. The overturning is likely a result of secondary rotation.

Poles to bedding plane plots essentially outline the basic geometry of anticlinoria and synclinoria (Fig. 55) with an average girdle indicating northwest-trending folds with a very shallow southeast plunge in the North Rogue Zone and southwest plunge in the South Rogue Zone.

Elmer Creek Thrust

The Elmer Creek Thrust is an arcuate, 30 km long, northwest-trending fault that extends southwesterly beyond the map area (Fig. 52, 53; Cecile and Abbott, 1992). Its hanging wall comprises mainly Gull Lake Tectonostratigraphic Map Unit, although locally Elmer Creek Tectonostratigraphic Map Unit outcrops close to the trace of the thrust. In addition, in the central part of the thrust, a small zone of Narchilla Formation, Arrowhead Lake Member makes up about 2 km of the basal hanging wall. The footwall, over the central one third of the fault, is composed of Misfortune Tectonostratigraphic Map Unit, and, over most of the remaining footwall area, by the Steel Tectonostratigraphic Map Unit.

The length and stratigraphic separation of this feature suggests detachment at a deep level. The presence of the Arrowhead Lake Member, Narchilla Formation, in the hanging wall, places the detachment a least as deep as the base of the Rogue Décollement.

The Elmer Creek Thrust abuts the Hess–Macmillan strike–slip fault system at a high angle (Cecile and Abbott, 1992). The complex pattern of footwall cut-offs (Cecile, 1997c) suggests it is out-of-sequence, postdating the formation of anticlinoria and synclinoria. The presence of the oldest hanging wall strata in the middle of the thrust suggests it was generally eastward-directed. It is likely a late feature related to right-lateral strike–slip displacement on the Macmillan–Hess fault system. The Rogue pluton cleanly cuts structures in the hanging wall of the thrust and thus must postdate emplacement of the thrust.

Keele Thrust Belt

The Keele Thrust Belt, in the southeast of the study area, is characterized by a mappable stack of thin, imbricate thrust sheets repeating Paleozoic strata, with an accumulated shortening estimated to be more than 50 per cent. Exposure allows for definition of several thrusts with offset, but it is not good enough to allow for refinement of individual structures in precise detail (Cecile, 1997b).

The Keele Thrust Belt can be divided into the Keele Peak and Keele East zones in the study area, and the Macmillan Zone, south and outside the study area (Fig. 52, 53). The basic difference between the zones is level of exposure and thrust arrangement. In the Keele East Zone, individual thrusts are outlined by identifiable lower Paleozoic map units (Cecile, 1997b). In the Keele Peak Zone the level of exposure is entirely within argillites of the Narchilla and Gull Lake formations (Cecile, 1997b, c). Furthermore, the contact aureole around the Keele pluton has converted most of these strata to a single brown colour, making it impossible to map individual units and define structures. Poles to bedding plane plots in the Keele East Zone show two area sets of single-point maximum distribution, indicative of structure with planar bedding. This is shown by a limited range of attitudes consistent with the geometry of thrusts with some folding (Fig. 55).

On the basis of a clustered bullseye pattern of poles to bedding, the Keele Peak Zone is thought to be a zone of mainly thrusting (Fig. 55). The Keele Peak Zone is structurally continuous with the Rogue Décollement Complex. Both the complex and the Keele Peak Zone share the Rogue Décollement surface. There is a large anticline cored by the Senoah Member of the Narchilla Formation exposed in the western Keele Peak Zone (Cecile 1997b,c). The Senoah part of the anticline forms a simple and open structure with small-scale shortening, whereas the overlying Arrowhead Lake Member and Gull Lake Formation are highly shortened and complexly deformed.

Other parts of the Keele Thrust Belt also likely share the Rogue Décollement surface. The oldest strata exposed in the hanging wall of thrusts in this zone belong to the Arrowhead Lake Member, Narchilla Formation.

Effects of the Macmillan–Hess strike–slip system

The Macmillan–Hess strike–slip fault system trends west-northwesterly across the southern Niddery Lake map area and central and northern Lansing map area (Roots et al., 1995a, b). Abbott and Turner (1990b) and Roots et al. (1995a, b) interpreted this as a right-lateral strike–slip fault system. A right-lateral sense of displacement is supported by the horizontal bending of Rogue Décollement Complex fold axes around a steeply southeast-plunging fold-axis (drag effect, Fig. 53).

The younger out-of-sequence Elmer Creek Thrust and a similar thrust found farther west, the Arrowhead Thrust (Cecile, 1998b, 1999), are probably related to this strike–slip system (Fig. 52). The Arrowhead fault can be directly tied in to strike–slip faults (Fig. 52). The length and complexity of the fault system and the association of large thrusts suggest it has displacements of tens of kilometres.

The Macmillan–Hess strike–slip fault system clearly cuts and postdates Upper Triassic strata. In addition one small pluton in the middle of the Niddery Lake map area lies within the fault system. Swings in structural trends around this pluton suggest that it may have been rotated during a period of fault movement. This means that motion on the fault system could be post-Triassic to possibly as young as Tertiary.

The orientation and length of the fault and the range in possible ages indicate that it may connect west with the Tintina Fault system. A likely link with the Tintina Fault to the west is the Dawson Fault (see map of Wheeler and McFeely, 1991). The Dawson Fault apparently ends in the west in the Dawson map area, very close to the Tintina Fault (Thompson and Roots, 1982) and in the east, it apparently ends in Nash Creek map area (Abbott, 1990). It has been mapped as a thrust, featuring basinal strata on the south overthrust northward onto platform strata on the north (Abbott, 1990; Thompson and Roots, 1991). The marked juxtaposition of basinal strata up on platform strata across this fault is peculiar and quite abrupt. It is possible that this thrust has had or has a strike–slip component of displacement and links into the McMillan–Hess strike–slip system.

INTRUSIVE ROCKS

There are two large plutons – Keele and Rogue – and one small intrusive body in the southeast part of the area. In addition there are three, small, circular stocks exposed northwest of Keele Pluton and one small granitic body north of Rogue Pluton.

Mesozoic granites in Selwyn Basin have recently been reported on by R.G. Anderson (Anderson, 1982; Gordey and Anderson, 1993). They are known as the Selwyn Plutonic Suite (Gordey and Anderson, 1993). Selwyn Plutonic Suite rocks are "a distinctive group of inclusion poor, compositionally restricted granite and granodiorite intrusions" ranging in age from 106–80 Ma (Gordey and Anderson, 1993, p. 73). Three types are found: 1) with widespread common hornblende, and with or without biotite; 2) with biotite and rare hornblende; and 3) with biotite and muscovite.

The Keele Pluton is an 8 to 10 km (in diameter) circular intrusion. The Rogue Pluton is 6 to 10 km in diameter and slightly ovoid. Based on scattered sampling, both plutons are coarse crystalline, equigranular granite to granodiorite with a few per cent of ubiquitous biotite and hornblende (Type 1, Selwyn Plutonic Suite). The Rogue Pluton shows wide variation in the proportions of hornblende versus biotite; it also has some quartz-poor phases (10-20%). In places, in both plutons, centimetre-scale rectangular to ovoid megacrysts of potassium felspar float in a coarse crystalline, equigranular groundmass. Both plutons have adjacent hornfels zones, 1 to 2 km across, which are defined in host strata by drab brown colours, increased density and recrystallization, local skarn development, and silicification.

There are three small circular stocks exposed northwest of the Keele Pluton. Each stock is 400 to 800 m in diameter and has a 100 to 200 m altered halo. The southwesternmost of these stocks is a biotite granite or granodiorite.

A small granitic body (3 km in diameter) in the southeast part of the area was mapped by Abbott (1983a) and was not examined during this study. This intrusion is described as a biotite quartz monzonite (Kelvin Claims, Yukon Minfile, 1991).

The Keele and Rogue plutons and their satellitic intrusions spatially correlate with a large, regional, positive magnetic anomaly that runs from south of Rogue River in the west, easterly through several large and small plutons with hornfelses in the central Niddery Lake map area, continues east and southeast through the Rogue Pluton, the Keele satellites, the Keele Pluton, farther southeast through the Mactung Pluton, and into the Macmillan Pass area. The magnetic anomalies can be associated with the plutons and surrounding altered zones (compare geological map of Cecile and Abbott, 1992 to Niddery aeromagnetic map, Geological Survey of Canada, 1969). The continuity of the magnetic anomalies and plutonic rocks suggests that Rogue and Keele plutons, and plutons and stocks to the west and southeast are part of a larger family of intrusions that may have common subsurface links. In terms of magnetic expression the Keele Pluton and surrounding hornfels are weakly anomalous in comparison to other plutons on this trend.

Skarns, veins in hornfels, and igneous rocks in and around the Keele and Rogue plutons and their satellites account for nearly half the mineral showings in the northeast Niddery Lake map area (Fig. 58).

REGIONAL METAMORPHISM

Outside the hornfels zones there are no known occurrences of chlorite and other minerals indicative of the first stages of greenschist facies metamorphism. Conodonts, however, have CAI (Conodont Alteration Indices - see Rejebian et al., 1987) of 3 to 6 (most in the range 4.5–5.5 and equivalent to Ro value of >1.5) indicating temperatures beyond the oil window and thus on the high end of diagenesis (Appendix 1). Read et al. (1991) included the study area in the a sub-greenschist facies, prehnite–pumpellyite zone.

ECONOMIC GEOLOGY

Introduction

The Niddery Lake map area is host to two large and important mineral deposits that will likely be exploited when economic conditions are favourable. The first is a tungsten deposit known as Mactung (Atkinson, 1986; Atkinson and Baker, 1990; Dick 1976; Dick and Hodgson, 1979, 1982; Gerstner et al., 1989; Harris, 1976; Morin 1986; Yukon Minfile, 1991, 1994). The second is the Tom and Jason stratiform zinc–lead–silver deposits (Bailes et al., 1987; Carne, 1976, 1979a,b, 1982; Gardner, 1983; Gardner and Hutcheon, 1985; Goodfellow et al., 1989; Goodfellow and Rhodes, 1990; McClay, 1984; McClay and Bidwell, 1987; Morin, 1986; Turner, 1984, 1985, 1987, 1989, 1990; Turner and Einaudi, 1986; Turner et al., 1989; Winn and Bailes, 1987). There are also significant potentially mineable barite deposits like the Tea deposit (also know as Samovar - Yukon; Lydon et al., 1985; Yukon Minfile, 1991, 1994).

In the northeastern 105-O map area there are eight known mineral occurrences; five locations with geochemical anomalies; two, untested, shallow subsurface exploration plays; and two claim groups with no reports (see Yukon Minfile, 1991, 1994; Cecile 1997a, b, c, d). In addition, Devonian shales across the area host barite, and locally witherite and norsethite. Lower Paleozoic diatremes and volcanics in the northeast study area and immediately north and northeast of the area have been considered prospective for diamonds but don't have the right indicator mineralogy (Rob Carne, Archer-Cathro, pers. comm. 1995; Goodfellow et al., 1995, Godwin and Price, 1986).

Geochemical anomalies

Three lead–zinc–silver geochemical anomalies were initially staked by Canadian Nickel company in the northeast of the study area. These were Prospecting (53), Hess (14), and Duet (38) in the northeastern part of the study area (Fig. 58, numbers from Yukon Minfile, 1991). Zinc anomalies were found by field tests ("zinc-zap") during mapping in the Devonian Misfortune Formation shale, near Elmer Creek (east of Loc. 31, Fig. 58), and at at several stratigraphic levels through the type section of the Hailstone Formation (Hailstone) just north of the map area (Fig. 58, 35). The Hailstone anomaly assayed at 0.27% ZnO over 20 m (Cecile, 1981). No mineralization has been reported at any of these localities.

The Duet zinc anomaly is represented by two localities in an area underlain by Sekwi, Hess River, Rabbitkettle, Duo Lakes and Hailstone formations from the nose of the Hawthorne Anticline into the hinge zone of the Hawthorne Syncline. The Hess silver anomaly plots within Hailstone Formation shales and limestones near the contact with the Duo Lakes Formation on the nose of the Border Anticline. The Prospecting anomalies are within the area of Devonian sandstone and shale units of the Imperial Formation. The Prospecting anomalies are considered to simply reflect high background values for the underlying Devonian clastics (Yukon Minfile, 1991). High silver values were attributed to the Hailstone Formation limestone (referred to as 'Natla' in the Yukon Minfile, 1991).

Mineral occurrences

There are eight specific mineral occurrences identified in the study area. One (unnamed - northwest study area) is simply copper staining on Algae Formation limestone (Fig. 58). The rest are potentially more significant and are described individually. The following reports are mainly extracted from the Yukon MinFile (1991, 1994) supplemented with field information gathered during fieldwork.

Ursa claims

The mineralization was discovered during field mapping in 1980 by Cecile (1981). It was subsequently staked by Noranda in August of 1981 and again by Kennecott Canada Inc. in July of 1991 (Yukon Minfile, 1994).

The mineralization observed by Cecile (1981) is in the Lower to Middle Devonian Misfortune Formation limestone interstratified with black shale. Mineralization consists of witherite and norsethite ($BaMg(CO_3)_2$ with traces of copper staining that occur as thin beds in limestone. This is the only known occurrence of norsethite mineral in Canada at the time of publication.

Van Angeren

Minor pyrite and molybdenite were found in quartz–feldspar veins within the northern Rogue granite near its contact with Rogue Décollement Complex strata. It was staked by Agip in September of 1979 (Yukon MinFile, 1991, #105-O 031, lat. 63°37'N, long. 130°54'W).

Rogue

Gold-bearing pyrrhotite, pyrite, and minor chalcopyrite, molybdenite, galena, and sphalerite were found in quartz veins that extend 20 to 30 m into the Rogue Pluton, and 110 to 200 m into adjacent host strata of the Rogue Décollement Complex. Disseminated sulphides were also found in host strata, commonly concentrated in fold hinges. Contact alteration extends for more than two kilometres, and

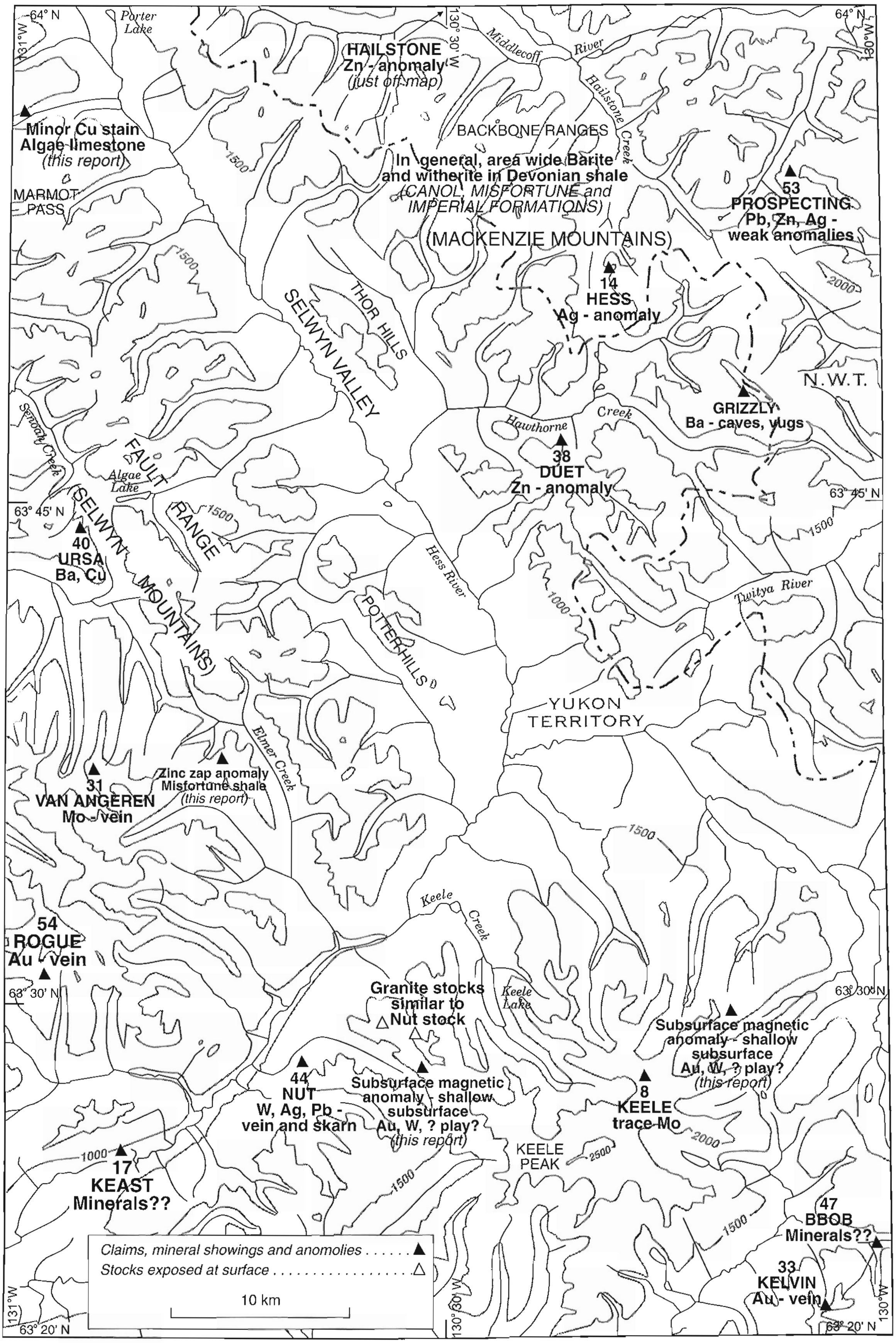


Figure 58. *Claims, mineral showings and anomalies in northeastern Niddery Lake map area. Numbers and locations are from the Yukon Minfile (1994).*

silicification for more than a kilometre from the granite contact. The property was staked by Nebex Resources in July of 1990 (Yukon MinFile 1994, # 105-O 054, 63°31'N, 130°57'W).

Nut

Three types of mineralization occur in a contact breccia zone around a biotite granite–granodiorite stock west of the Keele Pluton. The stock is circular, 400 m in diameter, and surrounded by a contact breccia up to 100 m wide. The breccia is fractured and reworked and may be the result of fluid streaming. The breccia and hornfels are developed in complexly deformed, undivided, lower Paleozoic Hess River Formation and Rabbitkettle Formation shale and limestone of the Rogue Décollement Complex. The north part of the stock may intrude Elmer Creek Formation chert (Cecile, 1997c). The breccia and adjacent strata have been altered for up to 1 km from the contact with the stock. In the hornfels are three zones with pyrrhotite–pyroxene skarn lenses up to several metres wide and with accessory chalcopyrite, scheelite, galena and arsenopyrite. A second type of mineralization is quartz–sericite veins up to 12 cm wide near the margin of the stock. These contain galena, arsenopyrite, sphalerite, and chalcopyrite. The third type of mineralization is disseminated galena in the breccia – one galena vein was found on the property (Yukon MinFile 1991, #105-O 044, lat. 63°28'N, long. 130°40'W).

Keele

Discovered by the Geological Survey of Canada (Garrett, 1971), the showing consists of a trace of molybdenite in a tourmaline vein within the Keele Pluton. It has not been staked (Yukon MinFile 1991, #105-O 008, lat. 63°27'N, long. 130°6'W).

Kelvin

Gold-bearing quartz–arsenopyrite veins were found in altered, undivided Narchilla and Gull Lake formations within 100 m of a small Cretaceous pluton. The gold-bearing veins parallel the contact with the pluton, are 10 to 20 cm wide, pinch and swell and extend for strike lengths up to 325 m. Veins perpendicular to the contact contained quartz and tourmaline but no gold. Gold was found as native gold and in arsenopyrite. Claims were staked by Kelvin Energy in July of 1980, restaked by Agip in 1982 and allowed to lapse after 1990 (Yukon MinFile 1991, #105-O 044, lat. 63°28'N, long. 130°40'W).

Grizzly barite

Several large caves and vugs exposed in Grizzly Bear limestone in southeast 105-O/16 (Fig. 58; Cecile 1997a) are lined with barite (Cecile, 1981, 1986a). One cave was several metres in diameter and had a 2 to 4 cm crystalline barite lining.

Subsurface tungsten–precious metal play

The Nut claims are tungsten, silver, lead veins, and skarn associated with a small stock west of Keele Peak. There are two similar stocks northeast of, and close to, the Nut claims (Fig. 58). All three show a strong magnetic anomaly pattern (Geological Survey of Canada, 1969; Garrett, 1968). Two strong magnetic anomalies similar in size, shape and intensity occur around the Keele Pluton periphery but have no known outcrops of igneous rocks. One is found immediately northeast of the Keele Pluton within the area of the Keele Thrust Belt. The other occurs east of the Nut claims and immediately south of the two stocks outcropping to the northwest of the Keele Pluton (Fig. 58). It is possible that either or both anomalies may indicate the presence of other small stocks with a completely preserved altered zone just under the surface. The altered zone, however, would be complete and include the overlying cap. In both cases the host rocks are shales and limestone like those at the Nut claims, and similar to the host rocks at the Mactung tungsten deposit located just south of the area (Atkinson and Baker, 1986, 1990).

Thus although these are 'wildcat' plays, their proximity to known mineral deposits, like Mactung (Atkinson, 1986; Atkinson and Baker, 1986) which is considered to have major tungsten reserves (Anonymous, 1981), justifies exploration through detailed geophysical work and shallow diamond-drilling.

Ultrabasic diatremes and volcanics, and diamonds?

The Northern Canadian Cordillera hosts numerous small mafic diatremes associated with potassic basalts (Goodfellow et al., 1995; Cecile and Norford, 1992, 1993; Cecile 1982). One of the diatremes, Mountain Diatreme, situated just northeast of the map area, reportly yielded microdiamonds and kimberlite-type heavy minerals (Godwin and Price, 1986). However, sampling and bulk sampling by at least two companies of the Mountain Diatreme, other diatremes in the region, and nearby volcanics, failed to recover a single diamond or more than a trace of kimberite-type heavy minerals (Rob Carne, Archo, Cathro and Associates, pers. comm., 1995). The volcanic rocks and diatremes sampled are part of a suite of potassic, basic igneous rocks, most of which are found in or around the Misty Creek Embayment.

The study area and the rest of the Niddery Lake map area host a similar suite of potassic basaltic volcanics and volcaniclastics located outside the Misty Creek Embayment within Selwyn Basin and on the Niddery High (Cecile and Norford, 1992, 1993), and which are mostly Cambrian in age. The poor results from the Misty Creek Embayment may or may not carry through to this area. Thus the volcanics in the study area and the rest of the Niddery Lake map area south and west, may still be associated with small, basic intrusives with diamond potential.

In the study area volcanics are found in three general localities. The first, northeast of Selwyn Basin, is a small pod of rocks mapped as volcanic breccia of the Marmot Formation (southwest 105-O/16; Cecile 1997a). This body of rocks was interpreted as extrusive in the field, but re-examination of field notes suggests this determination was equivocal. Many basic diatremes are found in direct association with volcanic rocks as small intrusives, tens of metres in diameter (Rob Carne, pers. comm., 1995). The second occurrence consists of Cambrian to Silurian Old Cabin Formation volcaniclastics and volcanics found over a large part of eastern 105-O/10 (Cecile, 1997c). The third occurrence consists of a variety of beds and units of volcanic rocks found south and east of the Nut claims (units in Gull Lake Formation and mappable Old Cabin Formation volcanics; Cecile 1997c).

Stratiform base metal potential

Another mineral exploration play in the study area comprises the potential stratiform base metal deposits associated with upper Paleozoic clastic units. The well known Tom and Jason zinc, lead, silver, and barite deposits found in the southeastern Niddery Lake map area are hosted in black clastic rocks of the Devonian–Mississippian Earn Group (Yukon MinFile, 1991). They are also in a peculiar sedimentary and tectonic setting. They lie within the Macmillan Fold Belt and are associated with local conglomerates, Devonian volcanics, and commercial barite deposits (Abbott and Turner, 1990a).

Earn Group strata (Misfortune and Thor Hills formations) are found in the northeast study area together with their lateral equivalents, the Canol and Imperial formations. The Thor Hills Formation includes an area of mappable conglomerate (southwest 105-O/09; Cecile 1997b), and beds of conglomerate are found elsewhere in the Misfortune, Canol and Thor Hills formations. There are no known Devonian volcanics and these strata are part of the Mackenzie Fold Belt.

The Misfortune, Canol and Imperial formations all host barite and some witherite nodules. The nodules are both large (metre-scale) and small (centimetre-scale). Nodules of this age and type found in the northern Cordillera are enriched in heavy isotopes, suggesting sedimentary–diagenetic recycling (Cecile et al., 1983). Similar barite occurrences and deposits of commercial size are found alone or in association with base metal deposits elsewhere in the Canadian Cordillera (Abbott et al., 1986).

Thus although the northeastern study area may differ from Tom and Jason in that there are no volcanics or widespread conglomerate, the stratigraphy and facies, and the widespread presence of barite, favour the possibility of significant lead, zinc, silver, and barite deposits in the study area.

The most interesting stratigraphic target may be the Lower to Middle Devonian Hailstone Formation, which shows metal anomalies in more than one place (Hailstone and Hess). This formation is laterally time equivalent to the Misfortune Formation farther southwest. The Misfortune Formation is host to the Ursa mineralization and to one zinc zap anomaly. Neither the Hailstone nor the Misfortune Formation are well exposed in the area and a geochemical program targeting their interpreted outcrop area could be productive.

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APPENDIX 1

PALEONTOLOGICAL IDENTIFICATIONS (NORTHEASTERN NIDDERY LAKE MAP AREA N.T.S. 105-O AND IMMEDIATELY ADJACENT MAP AREAS)

Introduction

Stratigraphic units are organized from oldest to youngest. Identifications under one stratigraphic unit are arranged by C-number in increasing order.

Keys to abbreviations:

GSC loc. C-128329 - Geological Survey of Canada location number. NOTE: for citation purpose the GSC locality number should be used.

(BSN) - Initials of paleontologist who identified fossils and assigned an age.

UTM (e.g., 426120 m E, 70966940 m N, Zone 9) metric co-ordinates, N.A.D. 27 (North American Datum, 1927). Users wishing to visit field sites should purchase Canadian 1:50 000-scale topographic maps with the UTM grid. Because these maps are not marked with longitudes and latitudes, values calculated by this method are often in error and therefore not used.

NTS 105-O/15 - National Topographic System 1:50 000-scale map number.

Collected by - All collections by M.P. Cecile[1] unless specifically noted under this title. When a name is noted, the number with the collectors name is keyed to addresses below.

Contributing paleontologists

- BSN - B.S. Norford[1]
- DEJ - D.E. Jackson[4]
- MJO - M.J. Orchard[2]
- WHF - W.H. Fritz[6]
- GSN - G.S. Nowlan[1]
- RST - R.S. Tipnis[5]
- TTU - T.T. Uyeno[1]
- AWN - A.W. Norris[1]
- HJH - H.J. Hofmann[7]
- EWB - E.W. Bamber[1]
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Upper Proterozoic–Lower Cambrian Arrowhead Lake Member, Narchilla Formation

GSC loc. C-84632 (HJH) - Arrowhead Lake Member, Narchilla Formation

411150 E 7074550 N; Zone 9, NTS 105-O/15

Oldhamia flabellata Aceñolaza & Durand
Oldhamia radiata Forbes
Planolites sp.
Helminthoidichnites sp.

Age: Probably Early Cambrian
Remarks: Location N3 of Hofmann and Cecile (1981), updated by Hofmann et al., (1994).

GSC loc. C-89067 (HJH) - Arrowhead Lake Member, Narchilla Formation

403200 E 7082600 N; Zone 9, NTS 105-O/15

Oldhamia flabellata Aceñolaza and Durand
Oldhamia? *wattsi* (Sollas) n. comb.
Helminthoidichnites sp.

Age: Probably Early Cambrian
Remarks: Location N1 of Hofmann and Cecile (1981), updated by Hofmann et al. (1994).

GSC loc. C-89076 (HJH) - Arrowhead Lake Member, Narchilla Formation

409500 E 7076500 N; Zone 9, NTS 105-O/15

Oldhamia radiata Forbes
Planolites sp.

Age: Probably Early Cambrian
Remarks: Location N2 of Hofmann and Cecile (1981), updated by Hofmann et al. (1994).

Lower Cambrian
Gull Lake Formation

GSC loc. C-237738 (GSN) - Tectonized Gull Lake Formation

422500 E, 7036200 N; Zone 9, NTS 105-O/07

Barren

GSC loc. C-237739 (GSN) - Undivided Gull Lake and Rabbitkettle formations

420000 E, 7037600 N; Zone 9, NTS 105-O/07

Fragment of phosphatic platy material.

Lower Cambrian
Sekwi Formation

GSC loc. C-84569 (WHF) - Sekwi Formation, 46.5 m below the Hess River Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Ogygopsis batis? (Walcott)

Age: Early Cambrian, *Bonnia–Olenellus* Zone
Remarks: This and C-84570 resemble *Ogygopsis batis* in all respects except for the lack of small, anterolateral, pygidial spines.

GSC loc. C-84570 (WHF) - Sekwi Formation, 48 m below the Hess River Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Ogygopsis batis? (Walcott)

Age: Early Cambrian, *Bonnia–Olenellus* Zone (see remarks above).

GSC loc. C-84616 (WHF) - Sekwi Formation

437450 E, 7070200 N; Zone 9, NTS 105-O/16

Ogygopsis sp.
Olenellus laxocules? Fritz

Age: late Early Cambrian *Bonnia–Olenellus* Zone

GSC loc. C-84617 (WHF) - Sekwi Formation

437300 m E, 7070350 N, Zone 9 - N.T.S. 105-O/16

Bonnia sp.
Olenellus sp.
Perissopyge sp.

Age: late Early Cambrian *Bonnia-Olenellus* Zone

GSC loc. C-84624 (WHF) - Upper Sekwi Formation

432200 E, 7080350 N; Zone 9, NTS 105-O/16

Bonnia sp.
Kutorgina sp.
Olenellus sp.

Age: late Early Cambrian *Bonnia–Olenellus* Zone

GSC loc. C-89066 (WHF) - Uppermost Sekwi Formation

425800 E 7096950 N; Zone 9, NTS 105-O/15

Goldfieldia sp.
cf. *Oryctocara* sp.

Age: Upper part of the Early Cambrian *Bonnia–Olenellus* Zone

Middle Cambrian
Hess River Formation

GSC loc. C-85203 (RST) - Hess River Formation, chips from interval 25 m below to base of the Rabbitkettle Formation

Section 6. Base at 428000 E, 7074900 N; top at 427950 E, 7074500 N; Zone 9, NTS 105-O/16

Barren of microfossils

Undivided Cambro–Ordovician tectonic Map Unit - tOu

GSC loc. C-237725 (BSN) - t$Є_{H,R}$ map unit

418250 E, 7037750 N; Zone 9, NTS 105-O/07

dichograptid fragment
Glyptograptus sp.
Pterograptus sp.

Age: Early Middle Ordovician, Llanvirn, *P. tentaculatus* Zone to *P. decoratus* Zone

Cambro–Ordovician Rabbitkettle Formation

GSC loc. C-85202 (RST) - Rabbitkettle Formation, chips over an interval 17-42 m above the Hess River Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Barren of microfossils

GSC loc. C-85204 (RST) - Rabbitkettle Formation, chips across interval 0 - 20 m above the Hess River Formation

Section 6. Base at 428000 E, 7074900 N; top at 427950 E, 7074500 N; Zone 9, NTS 105-O/16

Barren of microfossils

GSC loc. C-85205 (RST) - Rabbitkettle Formation, chips across interval 20 - 45 m above the Hess River Formation

Section 6. Base at 428000 E, 7074900 N; top at 427950 E, 7074500 N; Zone 9, NTS 105-O/16

Barren of microfossils

GSC loc. C-85206 (RST) - Rabbitkettle Formation, chips across interval 45–70 m above the Hess River Formation

Section 6. Base at 428000 E, 7074900 N; top at 427950 E, 7074500 N; Zone 9, NTS 105-O/16

"*Prooneotodus*" spp. ?

Age: Early to Late Cambrian. See Tipnis and Chatterton (1979)

GSC loc. C-85207 (RST) - Rabbitkettle Formation, chips across interval 70–92 m (top of formation) above the Hess River Formation (see C-84623 for first age in overlying Duo Lake Formation)

Section 6. Base at 428000 E, 7074900 N; top at 427950 E, 7074500 N; Zone 9, NTS 105-O/16

Oneotodus spp. and/or *Phakelodus tenuis* (Müller) ? (few broken specimens)

Age: Late Cambrian - Early Ordovician if the cones are oneotodids. See Tipnis and Chatterton (1979)

GSC loc. C-85208 (RST) - Rabbitkettle Formation, chips over an interval 42–60 m above the Hess River Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982).

Phakelodus tenuis Mueller (individual specimens and clusters) + other phosphatic microfossils

Age: Early to Late Cambrian. See Tipnis and Chatterton (1979)

GSC loc. C-89108 (RST) - Rabbitkettle Formation, chips over 10–30 m interval above the Hess River Formation

Section 10. Base at 446650 E, 7055050 N; top at 446700 E, 7054800 N; Zone 9, NTS 105-O/09

Barren of microfossils

GSC loc. C-89109 (RST) - Rabbitkettle Formation, chips over 30–50 m interval above the Hess River Formation

Section 10. Base at 446650 E, 7055050 N; top at 446700 E, 7054800 N; Zone 9, NTS 105-O/09

Barren of conodonts, some sponge spicules

GSC loc. C-89110 (RST) - Rabbitkettle Formation, chips over 50–70 m interval above the Hess River Formation

Section 10. Base at 446650 E, 7055050 N; top at 446700 E, 7054800 N; Zone 9, NTS105-O/09

Barren of conodonts, some sponge spicules

GSC loc. C-89977 (MJO) - Rabbitkettle Formation at the contact with the Duo Lake Formation

447700 E, 7031450 N; Zone 9, NTS 105-O/08

Conodont taxa: CAI: 5
"*Scolopodus*" *quadratus* Pander 1856 (1)
acodiform element (1)
Drepanodus arcuatus Pander 1856 (1)
Paroistodus? sp. (1)

Age: Early Ordovician
Remarks: Pohler and Orchard (1990, table 8).
Collected by: J.G. Abbott[3]

GSC loc. C-089990 (BSN) - Rabbitkettle Formation

450880 E, 7030340 N; Zone 9, NTS 105 P/05

Adelograptus? sp.

Age: probably Early Ordovician, probably Tremadoc to earliest Arenig.
Collected by: J.G. Abbott[3]

GSC loc. C-128327 (BSN) - Rabbitkettle Formation

445150 E, 7030850 N; Zone 9, NTS 105-O/08

Dictyonema? sp.

Age: Late Cambrian to Carboniferous

GSC loc. C-128338 (GSN) - Rabbitkettle Formation

445150 E, 7030850 N; Zone 9, NTS 105-O/08

Drepanodus arcuatus Pander (12)
Variabiloconus bassleri Furnish (3)
Rossodus manitouensis Repetiski & Ethington (31)
acodontiform elements indeterminate (2)

Age: Early Ordovician, early to mid Canadian; late Tremadoc *R. manitouensis* Zone; CAI 3

GSC loc. C-128339 (GSN) - (?)Rabbitkettle Formation

441550 E, 704110 N; Zone 9, NTS 105-O/08

Microzarkodina sp. (2)

Age: Early to early Middle Ordovician (middle Arenig to Llanvirn); CAI 5

GSC loc. C-237721 (BSN) - (?)Rabbitkettle Formation

446550 E, 7034150 N; Zone 9, NTS 105-O/08

indeterminate debris of spines and/or echinoderm columnals

Age: Phanerozoic

GSC loc. C-237726 (BSN) - Rabbitkettle Formation

443550 E, 703380 N; Zone 9, NTS 105-O/08

dichograptid fragment
Clonograptus? sp.
Kiaerograptus? sp.
Pendeograptus? sp.

Age: Early Ordovician, middle Tremadoc to early Arenig

GSC loc. C-237740 (GSN) - Rabbitkettle Formation

444750 E, 7035350 N; Zone 9, NTS 105-O/08

Ansella cf. *jemtlandica* Lōfgren (8)
Cordylodus horridus Barnes and Poplawski (3)
Drepanodus arcuatus Pander (4)
Histiodella holodentata Ethington and Clark (1)
Oepikodus? n. sp. (36)
Periodon aculeatus Hadding (12)
Protopanderodus sp. (9)
indeterminate denticulate Sb elements (3)

Age: early Middle Ordovician (late Whiterockian; Llanvirn); CAI 4

Ordovician–Silurian Duo Lake Formation

GSC loc. C-84571 (BSN) - Duo Lake Formation, 41 m above the Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Caryocaris sp.
"Acrograptus" cf. *A. gracilis* Törnquist
Didymograptus sp.
D. cf. *D. bifidus* Hall
Phyllograptus sp.
Sigmagraptus sp.
Tetragraptus spp.

Age: Early Ordovician, Arenig, *D. bifidus* Zone

GSC loc. C-84572 (BSN) - Duo Lake Formation outcrop, 168 m above Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9 NTS 105-O/16 (Section 25 of Cecile, 1982)

Climacograptus ex gr. *C. bicornis* (Hall)
Dicellograptus sp.
Dicranograptus sp.

Age: Middle Ordovician, Caradoc, *C. bicornis* Zone to *O. quadrimucronatus* Zone

GSC loc. C-84573 (BSN) - Duo Lake Formation outcrop, 174 m above Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Climacograptus ex gr. *C. bicornis* (Hall)
Dicellograptus sp.
Dicranograptus sp.
Orthograptus sp.

Age: Middle Ordovician, Caradoc, *C. bicornis* Zone to *O. quadrimucronatus* Zone

GSC loc. C-84574 (BSN) - Duo Lake Formation felsenmeer, 174 m above Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Climacograptus ex gr. *C. bicornis* (Hall)
Dicellograptus sp.
graptolite fragments

Age: Middle Ordovician, Caradoc, *C. bicornis* Zone to *O. quadrimucronatus* Zone

GSC loc. C-84575 (BSN) - Duo Lake Formation outcrop, 183 m above Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

inarticulate brachiopod
Climacograptus ex gr. *C. bicornis* (Hall)
Dicellograptus 2 spp.
Dicranograptus aff. *D. contortus* Ruedemann
D. cf *D. nicholsoni* Hopkinson
Glyptograptus? sp.
Orthograptus sp.

Age: Middle Ordovician, Caradoc, *C. bicornis* Zone

GSC loc. C-84576 (BSN) - Duo Lake Formation felsenmeer, 183 m above Rabbitkettle Formation

Section 4. Base at 437500 E, 7069850 N; top at 436850 E, 7069750 N; Zone 9, NTS 105-O/16 (Section 25 of Cecile, 1982)

Climacograptus sp.
Orthograptus sp.

Age: Middle or Late Ordovician

GSC loc. C-84615 (BSN) - Duo Lake Formation

438050 E, 7071500 N; Zone 9, NTS 105-O/16

Climacograptus ex gr. *C. bicornis* (Hall)

Age: Middle or Late Ordovician, Caradoc to Ashgill

GSC loc. C-84619 (BSN) - Duo Lake Formation

433600 E, 7083800 N; Zone 9, NTS 105-O/16

Dicellograptus so.
Orthograptus sp.

Age: late Middle or Late Ordovician

GSC loc. C-84623 (BSN) - Duo Lake Formation, 80–88 m above Rabbitkettle Formation

427950 E, 7074050 N; Zone 9, NTS 105-O/16

Caryocaris sp.
Clonograptus? sp.
Didymograptus spp. (pendant and horizontal forms)
Isograptus sp.

Age: Early Ordovician, probably *I. victoriae* Zone to *P. tentaculatus* Zone

GSC loc. C-89053 (BSN) - Duo Lake Formation, 17 m above the Rabbitkettle Formation

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

Caryocaris sp.
Dichograptus? sp.
Didymograptus 2 spp. (extensiform)
Phyllograptus anna Hall
Tetragraptus approximatus Nicholson
T. cf. *T. quadribrachiatus* (Hall)
Pendeograptus fruticosus (Hall) 3 and 4 stiped forms

Age: Early Ordovician, Arenig, high in *P. fruticosus Zone*

GSC loc. C-89054 (BSN) - Duo Lake Formation, 83 m above the Rabbitkettle Formation

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

Amplexograptus? sp.
Climacograptus ex gr. *C. bicornis* (Hall)
Dicellograptus sp.
Dicranograptus sp.
Glossograptus sp.

Age: Middle Ordovician, early Caradoc, *C. bicornis* Zone

GSC loc. C-89055 (BSN) - Duo Lake Formation, 1 m below the contact with the overlying Hailstone Formation (slope facies) along strike from section 11

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

inarticulate brachiopod
Glyptograptus? sp.
Monograptus 3 spp.
M. cf. *M. exiguus* Nicholson

Age: Early Silurian, probably early late Llandovery

GSC loc. C-89060 (BSN) - Duo Lake Formation, felsenmeer

428000 E, 7089550 N; Zone 9, NTS 105-O/16

diplograptid
Climacograptus sp.
Dicellograptus? sp.
Gymnograptus sp.

Age: late Middle Ordovician, Caradoc

GSC loc. C-89061 (BSN) Lower Duo Lake Formation

432100 E, 7089450 N; Zone 9, NTS 105-O/16

Caryocaris sp.
Adelograptus? sp.
Clonograptus 2 spp.
Paradelograptus antiquus (Hall)
Paradelograptus? cf. *P. pritchardi* (Hall) sensu Jackson non Cooper
Tetragraptus cf. *T. quadribrachiatus* (Hall)

Age: Early Ordovician, early Arenig, *T. approximatus* Zone but perhaps a mixed collection with the underlying *P. antiquus* Zone

GSC loc. C-089062 (BSN) - Duo Lake Formation

432100 E, 7089450 N; Zone 9, NTS 105-O/16

Diversograptus cf. *D. runcinatus* Lapworth
Glyptograptus? sp.
Monograptus aff. *M. denticulatus* Törnquist
M. spp.

Age: Early Silurian, middle Llandovery or earliest late Llandovery

GSC loc. C-89064 (BSN) - Duo Lake Formation

422500 E, 7093100 N; Zone 9, NTS 105-O/15

Dicellograptus sp.
Leptograptus? sp.
Orthograptus sp.
O. cf. *O. calcaratus* (Lapworth)

Age: late Middle or Late Ordovician, Caradoc or Ashgill

GSC loc. C-89065 (BSN) - Duo Lake Formation

427450 E, 7097500 N; Zone 9, NTS 105-O/16

Climacograptus sp.
Dicellograptus 2 spp.
Leptograptus? sp.
Orthograptus? sp.

Age: Middle or Late Ordovician, late Llanvirn to Ashgill

GSC loc. C-89083 (BSN) - Duo Lake Formation at transition to the Elmer Creek Formation

415200 E, 7061100 N; Zone 9, NTS 105-O/10

bryozoan, echinoderm and brachiopod debris

Age: Ordovician or younger

GSC loc. C-89085 (BSN) - Duo Lake Formation

416950 E, 7061800 N; Zone 9, NTS 105-O/10

Clonograptus? sp.
Didymograptus 2 spp. (extensiform)
D. cf. *D. bifidus* Hall
Goniograptus sp.
Phyllograptus cf. *P. anna* Hall

Tetragraptus cf. *T. serra* (Brogniart)

Age: Early Ordovician, late Arenig, *D. bifidus* Zone

GSC loc. C-89090 (BSN) - Duo Lake Formation, 110–111 m above the Rabbitkettle Formation

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

indeterminate biserial and uniserial(?) graptolites

Age: Ordovician or Silurian

GSC loc. C-89091 (BSN) - Duo Lake Formation, just off section 11 ~112–114 m above the Rabbitkettle Formation

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

Climacograptus sp.
Monograptus spp.
Rastrites sp. or *M.* ex gr. *M. triangulatus* (Harkness)

Age: Early Silurian, middle Llandovery

GSC loc. C-89092 (BSN) - Duo Lake Formation (along strike from section 11)

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

Monograptus sp.
M. cf. *M. exiguus* Nicholson
M. cf. *M. turriculatus* (Barrande) or cf. *M.* ex gr. *M. spiralis* (Geinitz)
Retiolites sp.

Age: Early Silurian, late Llandovery, probably early late Llandovery

GSC loc. C-89111 (TTU) - Duo Lake Formation, 111 m above the base

Section 11. Base at 448300 E, 7055300 N; top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

"*Neoprioniodus*" *planus* Walliser
Walliserodus sp.
Dapsilodus sp.
(?)*Ozarkodina confluens* (Branson & Mehl) (?)alpha morphotype of Klapper & Murphy (1975)

Age: late Llandovery, late Early Silurian; probably *inconstans* Zone

GSC loc. C-89988 (BSN) - Duo Lake Formation

454250 E, 7032150 N; Zone 9, NTS 105-P/05

Cyrtograptus sp.
Monograptus spp.
M. ex gr. *M. spiralis* (Geinitz)
Retiolites sp.

Age: Latest Early Silurian, latest Llandovery, *M. spiralis* Zone or *C. sakmaricus–C. laqueus* Zone

Collected by: J.G. Abbott[3]

GSC loc. C-108195 (BSN) - Duo Lake Formation

452150 E, 7033000 N; Zone 9, NTS 105 P/05

Dichograptus sp.
Tetragraptus sp.

Age: Early Ordovician, Arenig, *P. fruticosus* Zone to *I. victoriae* Zone

Collected by: J.G. Abbott[3]

GSC loc. C-108196 (BSN) - Duo Lake Formation, about 5 m above the Rabbitkettle? Formation

450800 E, 7033600 N; Zone 9, NTS 105 P/05

Dichograptus sp.
Didymograptus (*Expansograptus*) sp.
Holmograptus? sp.

Age: Early Ordovician, Arenig, *P. fruticosus* Zone to *I. victoriae* Zone

Collected by: J.G. Abbott[3]

GSC loc. C-128326 (BSN) - Duo Lake Formation

447950 E, 7039950 N; Zone 9, NTS 105-O/08

Clonograptus sp.
Didymograptus? sp.
Tetragraptus sp.
T. aff. *T. approximatus* Nicholson

Age: Early Ordovician, probably early Arenig

GSC loc. C-128328 (BSN) - Duo Lake Formation

441400 E, 7041300 N; Zone 9, NTS 105-O/08

Clonograptus sp.

Age: Ordovician, Tremadoc to Llanvirn

GSC loc. C-128329 (BSN) - Duo Lake Formation

441950 E, 7041400 N; Zone 9, NTS 105-O/08

Climacograptus sp.
Orthograptus sp.

Age: Ordovician, Caradoc to Ashgill

GSC loc. C-128330 (BSN) - Duo Lake Formation

442500 E, 7035600 N; Zone 9, NTS 105-O/08

Clonograptus sp.

Age: Ordovician, Tremadoc to Llanvirn

GSC loc. C-237727 (BSN) - Duo Lake Formation

443350 E, 7033750 N; Zone 9, NTS 105-O/08

inarticulate brachiopod
Arachniograptus sp.
Climacograptus sp.
Dicellograptus ssp.
Glyptograptus? sp.
Orthograptus sp.
O. cf *O. truncatus abbreviatus* Elles and Wood
O. cf *O. socialis* (Lapworth)

Age: Late Ordovician, Ashgill, *O. quadrimucronatus* Zone to *D. ornatus* Zone

Lower–Middle Ordovician lower member, Elmer Creek Formation

GSC loc. C-84562 (RST) - lower member, Elmer Creek Formation (dolostone bed)

406250 E, 7072750 N; Zone 9, NTS 105-O/15

"*Oneotodus*" *nakamuri* Nogami
Oneotodus spp.

Age: latest Cambrian to Early Ordovician, Tremadoc

GSC loc. C-84564 (RST) lower member, Elmer Creek Formation

412450 E, 7069000 N; Zone 9, NTS 105-O/10

Protopanderodus spp. (includes specimens similar to *Paltodus bassleri* (Furnish s.f.))

Age: Early Ordovician; the nature of the cones (including their ornamentation) suggests a late Tremadoc to early Arenig age

GSC loc. C-84629 (BSN) - lower member, Elmer Creek Formation

407250 E, 7072700 N; Zone 9, NTS 105-O/15

Caryocaris sp.
Clonograptus sp.

Age: Early or Middle Ordovician, Tremadoc to Llanvirn

GSC loc. C-84631 (BSN) - lower member, Elmer Creek Formation

407950 E, 7073000 N; Zone 9, NTS 105-O/15

Bryograptus? sp.

Age: Early Ordovician, Tremadoc or Arenig, possibly *C. aureus* Zone or *P. antiquus* Zone

GSC loc. C-84751 (BSN) - lower member, Elmer Creek Formation

411800 E, 7068800 N; Zone 9, NTS 105-O/10

Didymograptus sp. (extensiform)
Isograptus? sp. or *Tetragraptus*? sp.
Pendeograptus cf. *P. fruticosus* (Hall)

Age: Early Ordovician, Arenig, *P. fruticosus* Zone to *D. bifidus* Zone

GSC loc. C-89074 (BSN) - lower member, Elmer Creek Formation

404300 E, 7078300 N; Zone 9, NTS 105-O/15

Bryograptus cf. *B. ramosus* Brøgger
Clonograptus cf. *C.* sp. D of Jackson (1974)
Dictyonema 2 spp.

Age: Early Ordovician, late Tremadoc, *P. antiquus* Zone

GSC loc. C-89086 (BSN) - lower member, Elmer Creek Formation

412850 E, 7065400 N; Zone 9, NTS 105-O/10

Lot A:
Didymograptus 2 spp. (one extensiform)
Tetragraptus approximatus Nicholson
T. cf. *T. quadribrachatus* Hall

Pendeograptus cf. *P. fruticosus* (Hall), 4 stiped forms

Lot B: (a single slab)
Dichograptus sp.
Didymograptus cf. *D. bifidus* Hall
Isograptus sp.

Age A: Early Ordovician, Arenig, *P. fruticosus* Zone
Age B: Early or early Middle Ordovician, probably *D. bifidus* Zone

GSC loc. C-89096 (BSN) - lower member, Elmer Creek Formation, 413 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Cryptograptus sp.
Glyptograptus sp.

Age: Ordovician, Llanvirn to Caradoc

GSC loc. C-89097 (BSN) - lower member, Elmer Creek Formation, 371–374 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Caryocaris sp.
Clonograptus? sp.
Didymograptus sp. (extensiform)
D. cf. *D. vicinus* Harris and Thomas
Phyllograptus anna Hall
Tetragraptus sp. or *Didymograptus* sp.
Pendeograptus fruticosus (Hall) (4-branched)

Age: Early Ordovician, Arenig, *P. fruticosus* Zone

GSC loc. C-89098 (BSN) - lower member, Elmer Creek Formation, 303 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N, Zone 9, NTS 105-O/15

Adelograptus? sp.
Anisograptus richardsoni Bulman

Age: Early Ordovician, Tremadoc, *A. richardsoni* Zone

GSC loc. C-89099 (BSN) - lower member, Elmer Creek Formation, 365–369 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Caryocaris? sp.
Bryograptus cf. *B. ramosus* Brøgger
Clonograptus 2 spp.

Age: Early Ordovician, Tremadoc, *C. aureus* Zone

GSC loc. C-89100 (BSN) - lower member, Elmer Creek Formation, 483 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Caryocaris? sp.
Adelograptus? spp.
Clonograptus sp.

Age: probably Early Ordovician, probably late Tremadoc

GSC loc. C-89251 (BSN) - lower member, Elmer Creek Formation, 608 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Caryocaris? sp.
Adelograptus? sp.
Bryograptus sp.
Clonograptus sp.

Age: Early Ordovician, late Tremadoc

GSC loc. C-89252 (BSN) - lower member, Elmer Creek Formation, 213 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Dictyonema sp.
Staurograptus tenuis Jackson

Age: Early Ordovician, Early Tremadoc, *S. tenuis* Zone

Middle–Upper Ordovician upper member, Elmer Creek Formation

GSC loc. C-84568 (TTU) - upper member, Elmer Creek Formation

404800 E, 7068800 N; Zone 9, NTS 105-O/10

Barren

GSC loc. C-84627 (BSN) - upper member, Elmer Creek Formation

406400 E, 7070700 N; Zone 9, NTS 105-O/15

Dicellograptus sp.
Orthograptus calcaratus Lapworth

Age: Middle to Late Ordovician, Caradoc to Ashgill, *C. bicornis* Zone to *D. ornatus* Zone

GSC loc. C-84628 (BSN) - upper member, Elmer Creek Formation

406000 E, 7072400 N; Zone 9, NTS 105-O/15

Climacograptus? sp.
Cryptograptus? sp.
Glossograptus? sp.
Isograptus sp.
Pterograptus sp.

Age: Middle Ordovician, Llanvirn, *P. tentaculatus* Zone

GSC loc. C-84635 (BSN) - upper member, Elmer Creek Formation

405450 E, 7070500 N; Zone 9, NTS 105-O/15

Climacograptus sp.
Dicellograptus sp.
Orthograptus? sp.

Age: Middle or Late Ordovician, Caradoc or Ashgill

GSC loc. C-85210 (GSN) - upper member, Elmer Creek Formation

405250 E, 7069400 N; Zone 9, NTS 105-O/10

Ansella nevadensis Ethington & Schumacher
Coleodus? sp.
Paroistodus horridus (Barnes & Poplawski)
Drepanoistodus basiovalis (Sergeeva)
Eoplacognathus suecicus Bergström
Histiodella n. sp. 2 Harris et al., 1979
Paroistodus sp.
Periodon aculeatus Hadding
Phragmodus n. sp. cf. *P. inflexus* (Stauffer)
Protopanderodus varicostatus (Sweet & Bergström)
Spinodus spinatus (Hadding)

Age: Middle Ordovician, late Whiterockian (Llanvirn). North Atlantic Province affinity; CAI 4.5–5.0

GSC loc. C-89069 (BSN) upper member, Elmer Creek Formation, at 308 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Arachniograptus? sp.
Climacograptus sp.
Dicellograptus 2 spp.
D. complanatus ornatus Elles and Wood
Leptograptus sp.
Orthograptus sp.
O. calcaratus grandis (Ruedemann)
O. ex gr. *O. calcaratus* (Lapworth)

Age: Late Ordovician, Ashgill, *D. ornatus* Zone

GSC loc. C-89071 (BSN) - upper member, Elmer Creek Formation at 1024 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Climacograptus hastatus Hall
Dicellograptus sp.
D. aff. *D. sextans exilis* Elles and Wood
Glyptograptus sp.
Orthograptus calcaratus grandis (Ruedemann)

Age: late Middle or Late Ordovician, late Caradoc or Ashgill, *O. quadrimucronatus* Zone or *D. ornatus* Zone

GSC loc. C-89072 (BSN) - upper member, Elmer Creek Formation, felsenmeer

402500 E, 7074400 N; Zone 9, NTS 105-O/15 (Ridge near Section 19)

Arachniograptus? sp.
Climacograptus ex gr. *C. bicornis* (Hall)
Glyptograptus? sp.
Orthograptus sp.

Age: late Middle or Late Ordovician, Caradoc or Ashgill

GSC loc. C-89073 (BSN) - upper member, Elmer Creek Formation, felsenmeer

403800 E, 7074500 N; Zone 9, NTS 105-O/15 (Ridge near Section 19)

Dicellograptus sp.
D. complanatus ornatus Elles and Wood
Glyptograptus? sp.
Leptograptus sp.
Orthograptus sp.

Age: Late Ordovician, Ashgill, *D. ornatus* Zone

GSC loc. C-89075 (BSN) - upper member, Elmer Creek Formation, felsenmeer

403150 E, 7077850 N; Zone 9, NTS 105-O/15

Glyptograptus? sp.
Orthograptus? sp.
Reteograptus sp.

Age: late Middle or late Ordovician, Caradoc or Ashgill

GSC loc. C-89078 (BSN) upper member, Elmer Creek Formation, felsenmeer

411300 E, 7061100 N; Zone 9, NTS 105-O/10

inarticulate brachiopod
Climacograptus sp.
Leptograptus sp.
Orthograptus 2 spp.
retiolitid graptolite

Age: late Middle or Late Ordovician, Caradoc or Ashgill

GSC loc. C-89080 (BSN) - upper member, Elmer Creek Formation

412800 E, 7062250 N; Zone 9, NTS 105-O/10

Arachniograptus? sp.
Climacograptus cf. *C. hvalross* Ross and Berry
Dicellograptus 2 spp.
Leptograptus? sp.
Orthograptus cf. *O. calcaratus* Elles and Wood
O. calcaratus grandis (Ruedemann)
O. calcaratus Elles and Wood
O. cf. *O. truncatus abbreviatus* Elles and Wood
Reteograptus? sp.

Age: Late Ordovician, Ashgill, D. ornatus Zone

GSC loc. C-89095 (BSN) - upper member, Elmer Creek Formation, 555 m above the Gull Lake Formation

Measured Traverse - Section 18. Base at 405950 E, 7075750 N; top at 404600 E, 7075100 N; Zone 9, NTS 105-O/15

Dicellograptus sp.
Leptograptus sp.
Orthograptus cf. *O. calcaratus acutus* Elles and Wood
Reteograptus cf. *R. pulcherrimus* Keble and Harris

Age: Late Middle Ordovician, Caradoc

GSC loc. C-89253 (DEJ) - upper member, Elmer Creek Formation at 46 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Climacograptus sp.
Dicellograptus sp.
Orthograptus quadrimucronatus (Hall)

Age: Caradoc, *O. quadrimucronatus* Zone

GSC loc. C-89254 (DEJ) - upper member, Elmer Creek Formation at 120 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Amplexograptus sp.
Dicellograptus sp.
Orthograptus sp.

Age: Caradoc or Ashgill

GSC loc. C-89255 (DEJ) - upper member, Elmer Creek Formation at 170 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Climacograptus hastatus Hall
Dicellograptus sp.
Orthograptus cf. *O. quadrimucronatus* (Hall)
Reteograptus pulcherrimus Keble and Harris

Age: Late Caradoc or Ashgill, *O. quadrimucronatus* Zone to *D. ornatus* Zone

GSC loc. C-89258 (DEJ) - upper member, Elmer Creek Formation at 316 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Dicellograptus cf. *D. morrisi* Hopkinson
Glyptograptus sp.
Orthograptus calcaratus (Lapworth)

Age: Caradoc, probably *D. clingaeni* Zone sensu Jackson et al., 1965

GSC loc. C-89262 (DEJ) - upper member, Elmer Creek Formation at 401 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Climacograptus cf. *C. hastatus* Hall
Dicellograptus sp.

Age: Late Ordovician, Late Caradoc or Ashgill *O. quadrimucronatus* Zone to *D. ornatus* Zone

GSC loc. C-89267 (DEJ) upper member, Elmer Creek Formation at 480 m.

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Dicellograptus complanatus ornatus Elles and Wood
Orthograptus truncatus abbreviatus Elles and Wood

Age: Late Ordovician, Ashgill, *D. ornatus* Zone

GSC loc. C-89268 (DEJ) - upper member, Elmer Creek Formation at 484 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Leptograptus sp.
Orthograptus sp.

Age: Late Ordovician, possibly Ashgill. *Leptograptus* ranges to the top of the Ashgill in Australia

GSC loc. C-89271 (DEJ) - upper member, Elmer Creek Formation at 599 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Dicellograptus complanatus ornatus Elles and Wood
Orthograptus sp.
Orthoretiolites? sp.
Reteograptus pulcherrimus Keble and Harris?

Age: Late Ordovician, Ashgill, *D. ornatus* Zone

GSC loc. C-89273 (DEJ) - upper member, Elmer Creek Formation at 635m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Amplexograptus? sp.
Dicellograptus sp.
Orthograptus truncatus abbreviatus Elles and Wood

Age: Caradoc or Ashgill

GSC loc. C-89275 (DEJ) - upper member, Elmer Creek Formation at 675m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Arachniograptus? sp.
Climacograptus hastatus americanus Ruedemann
C. innotatus pacificus Ruedemann
Dicellograptus sp.
**Orthograptus calcaratus grandis* (Ruedemann)
**Reteograptus pulcherrimus* Keble and Harris

Age: Ashgillian, *D. ornatus* Zone. Asterisked elements are recorded from this level in the United States by Ross and Berry, 1963

Ordovician–Silurian Steel Formation

GSC loc. C-84638 (BSN) Steel Formation

408500 E, 7067600 N; Zone 9, NTS 105-O/10

Monograptus sp. (lobate thecae)
Retiolites sp.
graptolite fragments

Age: Early Silurian, Llandovery to Wenlock, probably late Llandovery to Wenlock

GSC loc. C-89068 (BSN) - Steel Formation at 243m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Linograptus sp.
Monograptus spp.
Bohemograptus bohemicus (Barrande)

Age: Late Silurian, Ludlow

GSC loc. C-89070 (BSN) - Steel Formation at 816 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus cf. *M. yukonensis* Jackson and Lenz

Age: probably Early Devonian, Pragian, probably *M. yukonensis* Zone

GSC loc. C-89077 (BSN) - Steel Formation

411100 E, 7066100 N; Zone 9, NTS 105-O/10

Linograptus sp.
Monograptus spp.

Age: Late Silurian, late Ludlow or early Pridoli

GSC loc. C-89079 (BSN) - Steel Formation

412650 E, 7062200 N; Zone 9, NTS 105-O/10

Monograptus cf. *M. transgrediens praecipus* Přibyl
Pristiograptus cf. *P. chelmiensis* Teller

Age: Late Silurian, Pridoli

GSC loc. C-89082 (BSN) - Steel Formation

407050 E, 7059400 N; Zone 9, NTS 105-O/10

Monograptus spp.
M. ex gr. *M. spiralis* (Geinitz)

Age: Early Silurian, late Llandovery

GSC loc. C-89256 (BSN) - Steel Formation at 152 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Linograptus? sp.
Bohemograptus bohemicus (Barrande)

Age: Late Silurian, Ludlow

GSC loc. C-89257 (BSN) - Steel Formation at 173 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Linograptus sp.
Monograptus sp.
Pristiograptus cf. *P. chelmiensis* Teller

Age: Late Silurian, early Pridoli, probably *P. chelmiensis* Zone

GSC loc. C-89259 (BSN) - Steel Formation at 335–336 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus spp.
M. ex gr. *M. spiralis* (Geinitz)
Retiolites geinitzianus angustidens Elles and Wood.

Age: Early Silurian, late Llandovery, *M. spiralis* Zone.

GSC loc. C-89260 (BSN) - Steel Formation at 336–336.5 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Cyrtograptus? sp.
C. canadensis Jackson and Etherington
Monograptus spp.
M. ex gr. *M. spiralis* (Geinitz)
Retiolites geinitzianus angustidens Elles and Wood

Age: Early Silurian, latest Llandovery, late *C. sakmaricus*–*C. laqueus* Zone

GSC loc. C-89261 (BSN) - Steel Formation at 330-331 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Cucullograptus? *crinitus* Wood
Monograptus sp.
M. aff. *M. angustidens* Přibyl
M. aff. *M. formosus* Bouček

Age: Late Silurian, early Pridoli, *M. formosus* or *C. parultimus*–*C. ultimus* Zone

GSC loc. C-89263 (BSN) - Steel Formation at 422 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus sp.

Age: probably Late Silurian

GSC loc. C-89265 (BSN) - Steel Formation at 416 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Bohemograptus bohemicus (Barrande)
Linograptus? sp.
Monograptus sp.

Age: Late Silurian, Ludlow

GSC loc. C-89266 (BSN) - Basal Steel Formation at 466 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus sp.
M. ex gr. *M. spiralis* (Geinitz)

Age: Early Silurian, Late Llandovery, *M. spiralis* Zone

GSC loc. C-89269 (BSN) - Basal Steel Formation at 491 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus sp.
M. ex gr. *M. spiralis* Geinitz
Retiolites geinitzianus angustidens Elles and Wood

Age: Early Silurian, Late Llandovery, *M. spiralis* Zone

GSC loc. C-89270 (BSN) - Steel Formation at 519

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus 2 spp.

Age: Silurian

GSC loc. C-89272 (BSN) - Steel Formation at 624 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus spp.
M. ex gr. *M. spiralis* (Geinitz)
Retiolites? sp.

Age: Early Silurian, Late Llandovery, *M. spiralis* Zone

GSC loc. C-89274 (BSN) - Steel Formation at 668 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Linograptus posthumus tenuis Jaeger
Pristiograptus cf. *P. bugensius* Teller

Age: Late Silurian, probably early Pridoli, probably *C. parultimus–C. ultimus* Zone

GSC loc. C-89276 (BSN) - Steel Formation at 739 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Monograptus spp.
M. cf *M. turriculatus* (Barrande) or cf. *M.* ex gr. *M. spiralis* Geinitz

Age: Early Silurian, late Llandovery

GSC loc. C-89277 (BSN) - Steel Formation at 866 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

inarticulate brachiopod
Monograptus spp.
Monograptus ex gr. *M. spiralis* Geinitz or *Cyrtograptus* sp.
Retiolites sp.

Age: late Early Silurian or early Middle Silurian

GSC loc. C-89278 (BSN) - Steel Formation at 1036 m

Measured Traverse 19. Base at 403800 E, 7074100 N; top at 401900 E, 7073400 N; Zone 9, NTS 105-O/15

Glyptograptus sp.
Monograptus sp.

Age: Early Silurian

GSC loc. C-84634 (BSN) - Both A and B Steel Formation

405460 E, 7070500 N; Zone 9, NTS 105-O/15

A - 2 slabs:
Bohemograptus cf. *B. bohemicus* (Barrande)
Linograptus sp.

B - 14 slabs:
Monograptus? sp.
M. ex gr. *M. spiralis* Geinitz

Age A: Late Silurian, Ludlow
Age B: Early Silurian, late Llandovery, *M. spiralis* Zone

GSC loc. C-84636 (BSN) - Steel Formation

405900 E, 7070350 N; Zone 9, NTS 105-O/15

Cyrtograptus laqueus Jackson and Etherington
Monograptus ex gr. *M. priodon* (Bronn)

Age: early Wenlock, *C. centrifugus* Zone, or late Llandovery, *C. sakmaricus–C. laqueus* Zone

Siluro–Devonian
Sapper Formation

GSC loc. C-89989 (BSN) - Sapper Formation

450850 E, 7030400 N; Zone 9, NTS 105P/05

Monograptus yukonensis Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone
Collected by: J.G. Abbott[3]

GSC loc. C-237723 (BSN) - Sapper Formation

446300 E, 7033800 N; Zone 9, NTS 105-O/08

Monograptus yukonensis Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

Lower–Middle Devonian
Grizzly Bear Formation

GSC loc. C-84607 (AWN) - Grizzly Bear Formation (at southwest platform edge, 30 m below the top of the formation)

444500 E, 7073800 N; Zone 9, NTS 105-O/16

bulbous stromatoporoid
favositid coral
large rugose coral
undetermined bryozoan
cf. *Moelleritia canadensis* Copeland, 1962

Age: late Early Devonian (Emsian) according to the range for *M. canadensis* of Norris, (1985)

GSC loc. C-84730 (AWN) - Grizzly Bear Formation (at southwest platform edge, 10 m below the top of the formation)

442900 E, 7075500 N; Zone 9, NTS 105-O/16

Favosites sp.
echinoderm ossicle with single axial canal
Gasterocoma? *bicaula* Johnson and Lane, 1969

Age: late Early to early Middle Devonian (upper Emsian to lowermost Eifelian stage) according to the range for *G.*? *bicaula* of Norris, (1985)

Lower–Middle Devonian
Hailstone Formation

GSC loc. C-84611 (AWN) - Hailstone Formation (proximal to platform facies)

439950 E, 7069800 N; Zone 9, NTS 105-O/16

favositid coral
cup coral fragment
Conchidium sp.
Ancillotoechia sp.
Nowakia sp.

Age: Early Devonian

GSC loc. C-84612 (AWN) - Hailstone Formation (proximal to platform facies)

440250 E, 7069600 N; Zone 9, NTS 105-O/16

Gasterocoma? *bicaula* Johnson & Lane, 1969
echinoderm ossicle with single axial canal

Age: late Early Devonian to early Middle Devonian, Zlichovian and Dalejan to earliest Eifelian

GSC loc. C-84613 (AWN) - Hailstone Formation (proximal to platform facies)

436900 E, 7069200 N; Zone 9, NTS 105-O/09

Gasterocoma? *bicaula* Johnson & Lane, 1969
echinoderm ossicle with cross-like axial canal
echinoderm ossicle with single axial canal

Age: late Early Devonian to early Middle Devonian, Zlichovian and Dalejan to earliest Eifelian

GSC loc. C-84618 (BSN) - Hailstone Formation (proximal to platform facies)

433200 E, 7060500 N; Zone 9, NTS 105-O/09

sponge spicules
Monograptus ex gr. *M. yukonensis* Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

GSC loc. C-084621 (BSN) Hailstone Formation, 10 m above C-84622

427700 E, 7071000 N; Zone 9, NTS 105-O/16

Monograptus? sp.

Age: probably Early Silurian to Early Devonian

GSC loc. C-084622 (BSN) - Hailstone Formation, 10 m below C-84621

427700 E, 7071000 N; Zone 9, NTS 105-O/16

Monograptus cf. *M. yukonensis* Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

GSC loc. C-084625 (BSN) - Hailstone Formation

437400 E, 7081600 N; Zone 9, NTS 105-O/16

Monograptus ex gr. *M. yukonensis* Jackson and Lenz

Age: Early Devonian, Lochkovian or Pragian, *M. uniformis* Zone to *M. yukonensis* Zone

GSC loc. C-84626 (AWN) - Hailstone Formation (proximal to platform facies)

437050 E, 7084600 N; Zone 9, NTS 105-O/16

favositid coral fragments
atrypid fragments, coarsely costate
echinoderm ossicle with single axial canal

Age: Not determined, but probably Devonian

GSC loc. C-89051 (AWN) - Hailstone Formation (proximal to platform facies). Outcrop at the same locality as C-89052

446550 E, 7057200 N; Zone 9, NTS 105-O/09

Ogilviella sp. cf. *O. rotunda* Lenz

Age: early Early Devonian, late Lochkovian

GSC loc. C-89052 (BSN) - Hailstone Formation (proximal to platform facies). From felsenmeer at the same outcrop as C-89051

446550 E, 7057200 N; Zone 9, NTS 105-O/09

dacryoconarid
Monograptus cf. *M. yukonensis* Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

GSC loc. C-89056 (AWN) - Top of Hailstone Formation (proximal to platform facies) above Section 11

Section 11. Top at 448350 E, 7055500 N; Zone 9, NTS 105-O/09

Styliolina sp.
Nowakia sp. cf. *N. acuaria* (Richter)

Age: Early Devonian, late Lochkovian to Pragian

GSC loc. C-89093 (BSN) - Hailstone Formation (Basin facies) at approximately 89 m above Undivided Hess River–Duo Lake ($\epsilon S_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

Monograptus yukonensis Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

GSC loc. C-89105 (TTU) - Hailstone Formation (proximal to platform facies) 100 m above the Duo Lake Formation, a submarine breccia-conglomerate facies

427800 E, 7088550 N; Zone 9, NTS 105-O/16

Pelekysgnathus arcticus Uyeno
Ozarkodina confluens (Branson & Mehl) alpha, gamma and delta morphotypes of Klapper and Murphy (1975)
O. excavata excavata (Branson & Mehl)
O. remscheidensis subsp.
Icriodus? sp. or *Pedavis*? (3 small I elements)

Age: Late Silurian, probably early Pridolian

GSC loc. C-89106 (TTU and AWN) - Hailstone Formation (proximal to platform facies - basal submarine limestone clast conglomerate - conodonts from clasts and matrix)

432100 E, 7089450 N; Zone 9, NTS 105-O/16

Conodonts identified by TTU

Ozarkodina remscheidensis remscheidensis (Ziegler)

Age: late Late Silurian to early Early Devonian, late Pridolian to early Lochkovian

Macrofauna identified by AWN
encrusting stromatoporoid
auloporid
Coenites rectilineatus (Simpson)
undet. small cup coral
cf. *Salopina submurifer* Johnson, Boucot and Murphy
cf. *Atrypa nieczlawiensis* Kozlowski
cf. *Ambocoelia* sp.
Howellella sp.
echinoderm ossicle with single axial canal

Age: early Lochkovian or early Early Devonian

GSC loc. C-89112 (TTU) - Upper Hailstone Formation (Basin facies) chip samples across the interval 190–210 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS.106B/1 (immediately adjacent to 105-O/16)

Polygnathus? sp.

Age: probably Devonian to Carboniferous

GSC loc. C-89113 (TTU) - Hailstone Formation (Basin facies) chip samples across the interval 170–190 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

No conodonts recovered

GSC loc. C-89114 (TTU) - Hailstone Formation (Basin facies) chip samples across the interval 150–170 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

No conodonts recovered

GSC loc. C-89115 (TTU) - Hailstone Formation (Basin facies) chip samples across the interval 120–150 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

No conodonts recovered

GSC loc. C-89116 (TTU) - Hailstone Formation (Basin facies) chip samples across the interval 90–120 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

indet. fragment only

Age: indeterminate

GSC loc. C-89117 (TTU) - Hailstone Formation (Basin facies) chip samples across the interval 30–90 m above Undivided Hess River–Duo Lake (ЄS$_{H,D}$ map unit)

Section 217. Centred around 426600 E, 7098500 N; Zone 9, NTS 106B/1 (immediately adjacent to 105-O/16)

Eognathodus sulcatus kindlei Lane & Ormiston

Age: middle Early Devonian, late Pragian to Pragian–Zlichovian boundary, *kindlei* to *dehiscens* zones

Middle?–Upper Devonian Canol Formation

GSC loc. C-237741 (TTU) - Canol Formation

441100 E, 7095250 N; Zone 9, NTS 105-O/16

Palmatolepis sp. (possibly *P. rhomboidea* Sannemann)

Age: Late Devonian

Western Lower–Upper? Devonian Misfortune Formation

GSC loc. C-84565 (TTU) - Misfortune Formation

404700 E, 7070200 N; Zone 9, NTS 105-O/10

Barren. No conodonts

GSC loc. C-84566 (TTU) - Misfortune Formation - Note: associated with occurrences of witherite (Ba-Ca limestone) and norsthetite (Ba-Ca-Mg carbonate - 'dolomite with barium')

405200 E, 7069750 N; Zone 9, NTS 105-O/10

Polygnathus angusticostatus Wittekindt
P. costatus costatus Klapper

P. linguiformis bultyncki Weddige
Icriodus "expansus" Branson & Mehl of Chatterton (1979)

Age: Middle Devonian, early Eifelian, *costatus* Zone

GSC loc. C-84633 (BSN) - Misfortune Formation

405440 E, 7070500 N; Zone 9, NTS 105-O/15

Monograptus yukonensis Jackson and Lenz

Age: Early Devonian, Pragian, *M. yukonensis* Zone

GSC loc. C-237737 (TTU) - Misfortune Formation

409100 E, 7037100 N; Zone 9, NTS 105-O/07

Polygnathus serotinus Telford

Age: late Early to early Middle Devonian (late Emsian to early Eifelian; *serotinus* to *costatus* zones)

Middle?–Upper Devonian
Imperial Formation, lower sandstone unit

GSC loc. C-84604 (AWN) - Imperial Formation, lower sandstone unit

443300 E, 7070850 N; Zone 9, NTS 105-O/16

plant tissue and impressions, some tissue carbonized

Age: not determinable

GSC loc. C-84610 (AWN) - Imperial Formation, lower sandstone unit

446450 E, 7071200 N; Zone 9, NTS 105-O/16

plant tissue impressions

Age: not determinable

Middle?–Upper Devonian
Imperial Formation, lower shale unit

GSC loc. C-89103 (TTU) - Imperial Formation, lower shale

449600 E, 7076950 N; Zone 9, NTS 105-O/16

Palmatolepis glabra cf. *lepta* Ziegler & Huddle
P. subgracilis Bischoff
P. glabra pectinata Ziegler
P. rhomboidea Sannemann

Age: Late Devonian, early Famennian, *rhomboidea* Zone

GSC loc. C-119580 (ACH) - Imperial Formation, lower shale

447500 E, 7076250 N; Zone 9, NTS 105-O/16

Polygnathus sp.
Palmatolepis glabra acuta Helms
Palmatolepis glabra glabra Ulrich and Bassler
Palmatolepis tenuipunctata Sannemann
Palmatolepis perilobata schindewolfi Müller

Age: Late Devonian, middle Famennian, uppermost upper *Crepida* Zone. CAI values 4.0–4.5

GSC loc. C-128331 (AWN) - Imperial Formation, lower shale

437300 E, 7079250 N; Zone 9, NTS 105-O/16

undetermined ammonoid impressions and fragments
cf. *Lamellaptychus* sp.

Age: not determined

GSC loc. C-129324 (AWN) - Imperial Formation, lower shale

437300 E, 7079250 N; Zone 9, NTS 105-O/16

cf. *Platyclymenia* sp.

Age: late Late Devonian, Famennian, *Platyclymenia* 'Stufen'

Middle–Upper Devonian
Thor Hills Formation

GSC loc. C-87561 (MJO) - Middle Thor Hills? Formation, less than 100 below m C-87562

4448250 E, 7057300 N; Zone 9, NTS 105-O/09

Conodont taxa: CAI: 4–4.5
ramiform elements (11)
Palmatolepis sp. (5)
Palmatolepis sp. cf. *P. crepida* Sannemann 1955 (1)
Palmatolepis sp. cf. *P. triangularis* Sannemann 1955 (4)
Palmatolepis minuta Sannemann 1955 (3)
Palmatolepis subperlobata Branson & Mehl 1934 (3)

Palmatolepis tenuipunctata Sannemann 1955 (2)
Pelekysgnathus sp. (1)
Polygnathus sp. (1)

Age: Late Devonian, early Famennian, *crepida* Zone
Remarks: Lower part of section J1 of Gordey et al. (1982); Irwin and Orchard (1991). Section 19 of Gordey and Anderson (1993). Revised as of 1993 by MJO
Collected by: S.P. Gordey[2]

GSC loc. C-87562 (MJO) - Middle Thor Hills Formation, less than 100 m above C-87561

448350 E, 7057400 N; Zone 9, NTS 105-O/09

Fossils: conodonts, sponge spicules
Conodont taxa: CAI: 3–4
coniform elements (1)
ramiform elements (45)
Palmatolepis sp. cf. *P. regularis* Cooper 1931 (1)
Palmatolepis glabra pectinata Ziegler morphotype 1 Sandberg & Ziegler 1973 (10)
Palmatolepis glabra prima Ziegler & Huddle 1969 (6)
Palmatolepis minuta subsp. Branson & Mehl 1934 (10)
Palmatolepis quadrantinodosa subsp. Branson & Mehl 1934 (1)
Palmatolepis quadrantinodosalobata Sannemann 1955 morph. 1 Sandberg and Ziegler 1975 (11)
Palmatolepis subperlobata Branson and Mehl 1934 (7)
Palmatolepis tenuipunctata Sannemann 1955 (2)
Polygnathus ex gr. *nodocostatus* Branson & Mehl 1934 (1)
Polygnathus sp. (3)

Age: Late Devonian, early Famennian, Upper *crepida* Zone
Remarks: Lower part of section J1 of Gordey et al. (1982); Irwin and Orchard (1991); Section 19 of Gordey and Anderson (1993). Revised as of 1993 by MJO
Collected by: S.P. Gordey[2]

Lower Carboniferous
Hawthorne Creek Formation, Tsichu Group

GSC loc. C-84560 (TTU) - Hawthorne Creek Formation, Tsichu Group, limestone bed in the upper shale member, approximately 100 m below the Heritage Trail Formation of the Tsichu Group

443500 E, 7071050 N; Zone 9, NTS 105-O/16

No conodonts recovered

GSC loc. C-84561 (TTU) - Hawthorne Creek Formation, Tsichu Group, limestone bed in upper shale member, approximately 200 m below the Heritage Trail Formation of the Tsichu Group

443500 E, 7071050 N; Zone 9, NTS 105-O/16

No conodonts recovered

GSC loc. C-87564 (MJO) - Hawthorne Creek Formation, Tsichu Group, projected at 18 m above the base of the Hawthorne Creek Formation into Section 9

Section 9. Base at 449100 E, 7057450 N; top at 449400 E, 7057800 N (2093 m peak on map); NTS 105-O/09

Fossils: conodonts, ichytholiths, microgastropods, sphaeromorphs, tubes, ?echinoderm
Conodont taxa: CAI: 3.5–4.5
ramiform elements (70)
Bispathodus sp. cf. *B. bispathodus* Ziegler, Sandberg and Austin (4)
Siphonodella? sp. (1)

Age: Early Carboniferous, early–middle Tournaisian
Remarks: At 413 m of Section J1 of Gordey et al. (1982) but collection was recovered subsequent to the publication. Section 19 of Gordey and Anderson (1993). Revised as of 1993 by MJO
Collected by: S.P. Gordey[2]

GSC loc. C-89107 (TTU) - Hawthorne Creek Formation, Tsichu Group, lower shale member 250 m above the Imperial Formation

Section 9. Base at 449100 E, 7057450 N; top at 449400 E, 7057800 N (2093 m peak on map); NTS105-O/09

Gnathodus sp., probably *G. texanus* Roundy

Age: probably early Mississippian, probably Viséan

Mississippian to early Pennsylvanian
Keele Creek Formation, Tsichu Group

GSC loc. C-087565 (MJO) - Keele Creek Formation, Tsichu Group, Keele Creek Formation approximately 50 m above the Heritage Trail Formation

449050 E, 7060250 N; Zone 9, NTS 105-O/09

Fossils: conodonts, bryozoans, sponge spicules, ?echinoderms
Conodont taxa: CAI: 3.5–4.5
ramiform elements (13)

Gnathodus bilineatus (Roundy 1926) (4)
Gnathodus girtyi collinsoni Rhodes, Austin and Druce 1969 (3)
Idioprioniodus sp. (4)
Lochriea sp. cf. *P. commutatus* (Branson and Mehl) (1)

Age: Late Carboniferous, late Viséan–Serpukhovian
Remarks: At 828 m of composite section J1-J2 of Gordey et al. (1982). Section 19 of Gordey and Anderson (1993). Revised as of 1993 by MJO
Collected by: S.P. Gordey[2]

Mississipian–Early Pennsylvanian Caribou Pass Formation, Tsichu Group

GSC loc. C-87567 (MJO) - Caribou Pass Formation, Tsichu Group

403920 E, 7020250 N; Zone 9, NTS 105-O/07

Conodont taxa: CAI: 4–5.5
ramiform elements (15)
Cavusgnathus sp. (2)
Gnathodus bilineatus (Roundy 1926) (1)
Gnathodus girtyi collinsoni Rhodes, Austin & Druce 1969 (2)
Gnathodus texanus Roundy 1926 (2)
Idioprioniodus? sp. (10)
Palmatolepis? sp. indet. (1)

Age: Early Carboniferous (Mississippian), Late Viséan
Remarks: *Palmatolepis*? is apparently reworked, implying erosion of Late Devonian strata at this time. Revised as of 1993 by MJO from Gordey et al. (1982) and Gordey and Anderson (1993, Section 18)
Collected by: S.P. Gordey[2]

GSC loc. C-87568 (MJO) and GSC loc. C-102273 (MJO) - Caribou Pass Formation, Tsichu Group

403920 E, 7020250 N; Zone 9, NTS 105-O/07

C-87568
Conodont taxa: CAI: 5.5–6
ramiform elements (50)
Gnathodus bilineatus (Roundy 1926) (11)
Gnathodus girtyi subsp. cf. *G. g. collinsoni* Rhodes, Austin & Druce 1969 (12)
Gnathodus girtyi simplex Dunn 1965 (12)
Gnathodus texanus Roundy 1926 (2)
Idioprioniodus sp. (17)
Lochriea sp. cf. *L. commutata* (Branson and Mehl 1941) (10)
Rhachistognathus muricatus (Dunn 1965) (4)
Rhachistognathus prolixus Baesemann & Lane (3)
Siphonodella sp. (2)

Age: Early Carboniferous (latest Mississippian), Serpukhovian, *muricatus* zone
Remarks: Siphonodellids (and possibly some others) are presumably reworked. Revised as of 1993 by MJO from Gordey et al. (1982) and Gordey and Anderson, (1993, Section 18)
Collected by: S.P. Gordey[2]

GSC loc. C-87569 (MJO) - Caribou Pass Formation, Tsichu Group

403920 E, 7020250 N, Zone 9, NTS 105-O/07

Conodont taxa: CAI: 5–5.5
ramiform elements (15)
Gnathodus bilineatus (Roundy 1926) (3)
Gnathodus girtyi Hass 1953 (10)
Idioprioniodus sp. (30)
Rhachistognathus muricatus (Dunn) (5)
Rhachistognathus prolixus Baesemann & Lane (1)

Age: Early Carboniferous (latest Mississippian), Serpukhovian, *muricatus* zone
Remarks: Revised as of 1993 by MJO from Gordey et al. (1982) and Gordey and Anderson (1993), Section 18.
Collected by: S.P. Gordey[2]

Pennsylvanian Fourway Formation, Tsichu Group

GSC loc. C-87570 (MJO) - Near the base of the Fourway Formation, Tsichu Group

450600 E, 7059250 N; Zone 9, NTS 105-O/09

Fossils: conodonts, ichthyoliths, bryozoans
Conodont taxa: CAI: 3–4
?*Rhachistognathodus primus* Dunn 1966 (1)
ramiform elements (33)
Declinognathodus noduliferus (Ellison & Graves 1941) (2)
Gnathodus sp. cf. *G. bilineatus* (Roundy 1926) (2)
Idiognathoides spp. (70)
Idioprioniodus sp. (6)
Lochriea commutata (Branson & Mehl) (1)
Rhachistognathodus muricatus (Dunn) (5)

Age: Late Carboniferous (early Pennsylvanian), Bashkirian
Remarks: At 1134 m of composite section J1-J2 of Gordey et al. (1982). Section 19 of Gordey and Anderson (1993). Revised as of 1993 by MJO
Collected by: S.P. Gordey[2]

GSC loc. C-87571 (MJO) - Basal Fourway Formation, or uppermost Keele Creek Formation, Tsichu Group

45050 E, 7060100 N; Zone 9, NTS 105-O/09

Fossils: conodonts, ichthyoliths
Conodont taxa: CAI: 3–4.5
blade fragment (1)
ramiform elements (1)

Age: ?Carboniferous
Remarks: Ichthyolith is similar to that from the Late Carboniferous Dunira Formation of Prince Rupert map area
Collected by: S.P. Gordey[2]

GSC loc. C-89101 (TTU) - Fourway Formation, Tsichu Group, 40 m above the Keele Creek Formation, Tsichu Group

450900 E, 7059120 N; Zone 9, NTS 105 P/12

Gnathodus girtyi
?*Idiognathoides* sp.
Rachistognaths? sp.
Idioprioniodus sp.

Age: A Namurian fauna showing indication from both sides of the mid-Carboniferous boundary; both latest Early Carboniferous (Serpukhovian) conodonts (*G. Girtyi*) and basal Late Carboniferous (Bashkirian) conodonts (?*Idiognathoides*) are tentatively identified, plus *Rhachistognathus*? and *Idioprionoidus*

GSC loc. C-89104 (TTU) - Fourway Formation, Tsichu Group

450950 E, 7060000 N; Zone 9, NTS 105-O/09

Barren. No microfossils

GSC loc. C-107904 (EWB) - Fourway Formation, Tsichu Group

450600 E, 7060500 N; Zone 9, NTS 105-O/09

gastropods, unidentified
productoid, spiriferid, and other brachiopods - poorly preserved; possibly include fragments of *Yakovlevia*? sp. and *Spiriferella*? sp., but no definite determination possible
echinoderm columnals, indeterminate

Age: Late Carboniferous or Permian, probably Permian
Remarks: See also C-87565, 89101, 89104
Collected by: S.P. Gordey[2]