Stratigraphy, Conodont Taxonomy and Biostratigraphy of Upper Cambrian to Lower Silurian Platform to Basin Facies, Northern British Columbia

by

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We accept this dissertation as conforming to the required standard

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ABSTRACT

This study establishes the stratigraphic framework and conodont biostratigraphy of Lower Paleozoic strata of the Northern Canadian Cordilleran Miogeocline, which document a non-passive tectonic evolution of the rifted margin of Laurentia. Only a few reconnaissance stratigraphic studies have been conducted previously in the study area. Nine key sections span an east-west transect from the Macdonald Platform to the Kechika Trough (platform-miogeocline-basin) and 3 key sections comprise a transect across the parautochthonous Cassiar Terrane. Over 12 000 m of strata from the Kechika and Skoki formations and Road River Group in northeastern British Columbia were measured and described, from which a total of 405 conodont samples (4-5 kg each) were taken. A total of 39 526 conodonts have been used to refine the Upper Cambrian to Lower Silurian conodont biostratigraphy across the transect.

The stratigraphy is revised to divide the Kechika Formation (late Cambrian to early Arenig in age) into 5 formal members: Lloyd George, Quentin, Grey Peak, Haworth and Mount Sheffield members. The Skoki Formation (early to late Arenig in age) comprises 3 new formal members defined as: Sikanni Chief, Keily and Redfern members. The Road River Group is divided into 3 new formations: Ospika (early Arenig to Llanvirn in age), Pesika (Lower Silurian in age) and Kwadacha (formerly the Silurian Siltstone). The Ospika Formation is further subdivided into 5 formal members: Cloudmaker, Finlay Limestone, Chesterfield, Finbow Shale and Ware.

Conodonts of Late Cambrian to Early Silurian age are described taxonomically from the Kechika, Skoki, Ospika and Pesika formations across the transect. A total of 39 526 identifiable conodonts recovered from 142 productive samples indicate high species diversity and abundance in shallow water facies and less diversity and abundance with in deeper water facies. Elements are moderately to well preserved, typically with a colour alteration index (CAI) of 3-5.

A total of 197 species, representing 73 genera are identified and illustrated among which 6 new genera and 39 new species are described. Fifteen of the 39 new species had too little material and were described in open nomenclature. The new genera are *Graciloconus*, *Kallidontus*, *Planusodus* and 3 new genera (A, B, C) treated in open

nomenclature. The new species are *Acodus kechikaensis* n. sp., *Acodus neodeltatus* n. sp., *A. quentinensis* n. sp., *A. warenesis* n. sp., *Cordylodus delicatus* n. sp., *Colaptoconus greypeakensis* n. sp., ?*Diaphorodus* n. sp., *Drepanoistodus minutus* n. sp., *Graciloconus concinnus* n. gen. n. sp., *Kallidontus serratus* n. gen. n. sp., *K. nodosus* n. gen. n. sp., *K. princeps* n. gen. n. sp., *Laurentoscandodus sinuosus* n. sp., *Macerodus cristatus* n. sp., *M. lunatus* n. sp., *Microzarkodina* n. sp., *Oepikodus* n. sp., *Oistodus* n. sp., *Paroistodus* n. sp., *Planusodus gradus* n. gen. n. sp., ?*Prioniodus* n. sp., *Protoprioniodus* n. sp., *Rossodus kwadachaensis* n. sp., *R. muskwaensis* n. sp., *R. sheffieldensis* n. sp., *R. subtilis* n. sp., *Scolopodus amplus* n. sp., *Striatodontus strigatus* n. sp., *Triangulodus akiensis* n. sp., *Tricostatus infundibulum* n. sp., *T. terilinguis* n. sp., 3 unnamed new genera and 3 new species and 5 new species of *Drepanoistodus* (A, B, C, D, E).

The conodont zonation for Upper Cambrian to Lower Silurian strata is refined, using Sections 4, 5, 13 and Grey Peak as reference sections. It allows close dating of stratigraphic boundaries. The oldest zones in the Kechika are cosmopolitan and include the *Eoconodontus* Zone (upper Cambrian), *Cordylodus proavus* and *Cordylodus lindstromi* zones (uppermost Cambrian) and *Iapetognathus* Zone (base of Tremadoc). Ten higher zones are recognized and redefined for shallow water platform facies containing faunas of the Midcontinent Realm. Four of these are new (*Polycostatus falsioneotensis, Rossodus tenuis, Scolopodus subrex* and *Acodus emanualensis* zones) and 10 new subzones are established. Those for the Kechika Formation include, in ascending order, the *Polycostatus falsioneotensis* Zone (lower Tremadoc), *Rossodus tenuis* Zone (lower Tremadoc); *Rossodus manitouensis* Zone with *R. muskwaenesis* and *R. sheffieldensis* subzones (middle Tremadoc), Low diversity interval (upper Tremadoc), *Scolopodus subrex* Zone with *Graciloconus concinnus* and *Colaptoconus bolites* subzones (lower Arenig) and *Acodus kechikaensis* Zone with *Kallidontus serratus*, *Diaphorodus russoi* and *Kallidontus nodosus* subzones (lower Arenig). Those for the Skoki Formation include the *Oepikodus communis* Zone with *Tropodus sweeti*, *Bergstroemognathus extensus* and *Juanognathus variabilis* subzones (middle Arenig). The *O. communis* Zone spans the Kechika-Skoki boundary and the uppermost Kechika lies within the lowermost part of the *O. communis* zone underlying the *T. sweeti* Subzone. The Skoki Formation also contains the *Jumudontus gananda* Zone (middle Arenig) and

Tripodus laevis Zone (upper Arenig). The *Phragmodus undatus* Zone (Upper Ordovician) lies within the Road River Group in the Cassiar Terrane.

Thirteen deep water zones are recognized for basinal facies containing faunas of predominantly the North Atlantic Realm. Five new zones are established (*Drepanoistodus nowlani, Acodus deltatus, Paracordylodus gracilis, Paroistodus horridus* and *Dzikodus tableheadensis* zones) and one new subzone within the *P. gracilis* Zone is proposed. Those within the Kechika Formation include *Cordylodus angulatus* Zone (lower Tremadoc), *Paltodus deltifer* Zone (middle Tremadoc), *Drepanoistodus nowlani* Zone (middle Tremadoc), *Acodus deltatus* Zone, (middle Tremadoc), *Paroistodus proteus* Zone (upper Tremadoc), *Paracordylodus gracilis* Zone with *Oelandodus elongatus* Subzone (upper Tremadoc) and *Prioniodus elegans* Zone (base of Arenig). Those within the Skoki and Ospika formations include *Oepikodus evae* Zone (Skoki Formation, middle Arenig), *Paroistodus originalis* Zone (Skoki and Ospika formations, upper Arenig), *Paroistodus horridus* and *Dzikodus tableheadensis* zones (both within the Ospika Formation, lower Llanvirn). The *Amorphognathus tvaerensis* Zone lies within the Road River of the Cassiar Terrane (Upper Ordovician). The *Distomodus staurognathoides* Zone lies within the Pesika Formation (middle Llandovery).

The conodont faunas therefore provide detailed temporal constraints for the stratigraphic framework. Some evolutionary remarks are made for selected species involved in radiations, especially in the Tremadoc and Arenig, that are useful in further refining the standard Midcontinent Realm zonation. The Midcontinent Realm conodont faunas are used for regional correlations within North America and those of the Atlantic Realm provide calibration on an interregional scale, for example, with Baltica.

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1. INTRODUCTION

1.1. Early Paleozoic World

The early Paleozoic world can be reconstructed using stratigraphic, biological and isotopic data. There are several recent models of global paleogeography that reconstruct the position of major cratons and oceans (e. g. Torsvik et al., 1995 and Scotese, 1997). The position of continents and prevailing climates influenced oceanic circulation patterns. Tectonics, paleoclimatic and paleoceanographic factors in turn influence global environmental change and biological diversification through time.

In the Neoproterozoic, the major cratons of the earth formed a supercontinent called Rodinia. The configuration of Rodinia has varying reconstructions, particularly regarding the issue of what lay against the western margin of the ancestral North American craton called Laurentia. It has been proposed that the eastern margin of Australia-Antarctica was against western Laurentia (e. g., Dalziel, 1991; Hoffman, 1991: Blewett, 1998) and that the timing of the rifting of the interior of Rodinia was the Neoproterozoic (c. 725Ma) (Hoffman, 1991; Torsvik et al., 1996; Unrug, 1997; Handke et al., 1999). Sears and Price (2000) suggest a Siberian connection to western Laurentia which provides better correlation. They suggest the intracontinental rifting event occurred by the latest Neoproterozoic to earliest Cambrian. One enigmatic tectonic issue in Cordilleran tectonics involves the record of and timing of rifting events subsequent to the initial Neoproterozoic event.

The rifted western continental margin of Laurentia was the site of deposition for over 300Ma, into the early Paleozoic. During this period of time, the stratigraphic succession which now outcrops in the Canadian Cordillera was deposited. The succession is thick and continuous along the length of the Cordillera and contains extensive carbonates due to the equatorial position of Laurentia throughout the lower Paleozoic. The stratigraphy has long been referred to as a passive margin succession. However, the lower Paleozoic strata document a history in which several periods of extension followed the main late Neoproterozoic rifting event and cannot be explained by a single continental rifting and separation event (Thompson et al., 1987).

One approach to understanding the evolution of the Laurentian margin is the study of stratigraphy, event and biological data, based on a sound biostratigraphic framework. Large scale continental separation makes the early Paleozoic a dynamic time in terms of complexity and diversity of life.

During the Ordovician and early Silurian, the climate is proposed to have been in greenhouse state (Frakes et al., 1992) with a brief icehouse state at the end of the Ordovician (Barnes et al., 1996). Evidence for warm climates with associated high atmospheric carbon dioxide is in the extensive carbonates. Berner (1994) estimated carbon dioxide in the Paleozoic atmosphere was perhaps 14±6 times greater than today's level. Although atmospheric CO_2 concentrations were high, a glacial period occurred in the late Ordovician (Ashgill) which coincides with a major mass extinction event, second only to the Permo-Triassic mass extinction (Sepkoski, 1995). This period of glaciation has been addressed by a couple model proposed by Poussart et al. (1999) in which the late Ordovician paleogeography played an important role in the occurrence of glaciation during greenhouse state.

Paleoceanographic circulation patterns have been modeled according to postulated paleogeography and paleoclimate. Wilde (1991, figs. 1 to 5) illustrates models of surface current circulation and surface water masses for the late Cambrian to early Silurian, which are patterns shaped by tectonics and climate. For example, trends during the Ordovician include zonal circulation in the polar northern hemisphere in absence of meridonal barriers and a tropical region of land and shallow shelf seas (Wilde, 1991).

The special tectonic, paleoclimate and paleoceanographic conditions in the Ordovician influenced the global biota as discussed by Barnes et al. (1996) who describe five major global bioevents in the Ordovician. One of the major changes in the composition of the global biota is the replacement of the Cambrian Evolutionary Fauna by the Paleozoic Evolutionary Fauna in the early Ordovician. Sepkoski (1981) statistically identified three evolutionary faunas in the marine fossil record which dominated the biota and shared similar patterns of diversification and rates of taxonomic turnover. The Paleozoic Evolutionary Fauna replaced the Cambrian Evolutionary Fauna in the early Ordovician and dominated until the Permian (Sepkoski, 1995, fig. 1). The Paleozoic Evolutionary Fauna has more complex ecological characteristics and high biodiversity and represents a remarkable evolutionary radiation during the Ordovician Period. Several groups of marine organisms diversified at this time including those which are biostratigraphically important such as trilobites, graptolites and conodonts (Sepkoski, 1995, fig. 5).

The Ordovician Radiation was a complex event and includes the appearance of marine groups which dominate for 250Ma (Droser et al., 1996). The radiation occurred over millions of years and the base of the Middle Ordovician is a time when many groups diversify dramatically, culminating in the Caradoc (Droser et al., 1996). Sepkoski (1995, fig. 5) shows that pelagic groups such as graptolites and conodonts began to radiate earlier, in the Tremadoc.

Conodonts undergo an evolutionary radiation across the Cambrian-Ordoviciain boundary (Sweet, 1990, fig. 6.1). Several faunal groups, including graptolites, trilobites and conodonts, exhibit strong faunal provincialism in the Ordovician. By the time of the basal Tremadoc bioevent (of Barnes et al., 1996), strong faunal provincialism among conodonts was established and governed by physical parameters such as climatic and oceanographic factors. The paleobiogeography of Ordovician conodonts, as interpreted by Bergström (1990), is differentiated into two regions, the Midcontinent and Atlantic Faunal Realms. The Midcontinent Realm faunas occupied regions characterized by low-latitude, warm, shallow hypersaline conditions such as the margins of the Laurentian and Siberian cratons which were in an equatorial position (Scotese, 1997). The Atlantic Realm faunas occupied regions of high-latitude, cooler or deeper normal saline, open circulation conditions, respectively (Pohler and Barnes, 1990). Each realm can be further differentiated into provinces such as those outlined by Bergström (1990).

A sound biostratigraphic framework, such as that established by trilobites, graptolites and conodonts for the Ordovician, is required to better understand stratigraphic events. The strong provicialism of these groups necessitates a dual biostratigraphic scheme. The study of widespread Ordovician sequences in Canada allows the compilation of correlation charts which rely on biostratigraphy for international correlation (e.g., Barnes et al., 1981).

One of the main objectives of this thesis is to understand the evolution of the western continental margin of Laurentia, which during the early Paleozoic accumulated widespread carbonate and shale successions. The northern Rocky Mountains of British Columbia preserves well exposed outcrops of continuous marine stratigraphic succession enabling the study of lithostratigraphic and biostratigraphic events in the study area. The platformal and miogeoclinal sequences preserved in the Cordillera are a result of submergence of the North American craton, especially during the late Ordovician when there was almost complete submergence (Barnes, 1984). Eustatic sea level fluctuated throughout the Period (Barnes, 1984; Cecile and Norford, 1993).

An outstanding issue in Cordilleran tectonics is the non-passive nature of the margin during the early Paleozoic. The evolution of the margin can be studied using stratigraphic, event and biological data, based on a refined conodont biostratigraphy. This detailed regional study allows stratigraphic events, such as abrupt lateral facies changes, to be interpreted within a temporal framework based on a large number of conodont samples taken with a platform to basin transect across the western Laurentian margin. The thick and continuous stratigraphy provides for the establishment of a dual biostratigraphy using conodont faunas from both faunal realms, which can then be compared to other regions for local, regional and interregional correlation.

1.2. Location and Regional Setting

The thesis examines stratigraphic data and conodont collections from sections across an east-west, platform-miogeocline-basin transect located within the Ware (94F), Tuchodi Lakes (94K), Kechika (94L) and Cry Lake (104P) map areas in remote, northern British Columbia (Fig. 1). During the Early Paleozoic, a broad miogeoclinal wedge of sediments accumulated along the margin of ancestral North America. Exposed strata in the Northern Rocky Mountains, within the Canadian Cordilleran Foreland Belt, comprise shallow water carbonates of the Macdonald Platform bounded to the west by equivalent deep water slope and basin facies of the Kechika Trough (Fig. 2A). The western boundary of the Foreland Belt and Kechika Trough is the Northern Rocky Mountain Fault/Trench (NRMT). Nine key sections comprise a transect across autochthonous Lower Paleozoic strata and three additional sections provide an east-west transect across the parautochthonous Cassiar Terrane which lies west of the NRMT within the Omineca Belt.

The transect lies within an interpreted upper plate of an asymmetrically rifted margin (Cecile et al., 1997). Regionally, renewed phases of extension of the margin throughout the Lower Paleozoic are recorded in abrupt lateral and vertical facies changes and pulses of volcanism. The tectono-stratigraphic framework was influenced by eustatic sea level changes. The general stratigraphic framework has been established from previous regional mapping projects. This study details and refines the regional stratigraphy in northeastern British Columbia in which the shallow water platform facies of the Skoki Formation (3 new members defined), the shelf to basin facies of the Kechika Formation (5 new members defined) and the slope to basin facies of the Road River Group (3 new formations defined) are described.

Previously in the Northern Canadian Cordillera, Lower Paleozoic conodont biostratigraphy has been based on small collections made during regional mapping projects. The conodont biostratigraphic framework refines east-west temporal and facies relationships based on a collection including over 39,000 conodonts elements from 405 samples. A total of 10 shallow water Zones and 13 deep water Zones are recognized and refined for the Upper Cambrian to Lower Silurian stratigraphic units in the study area.

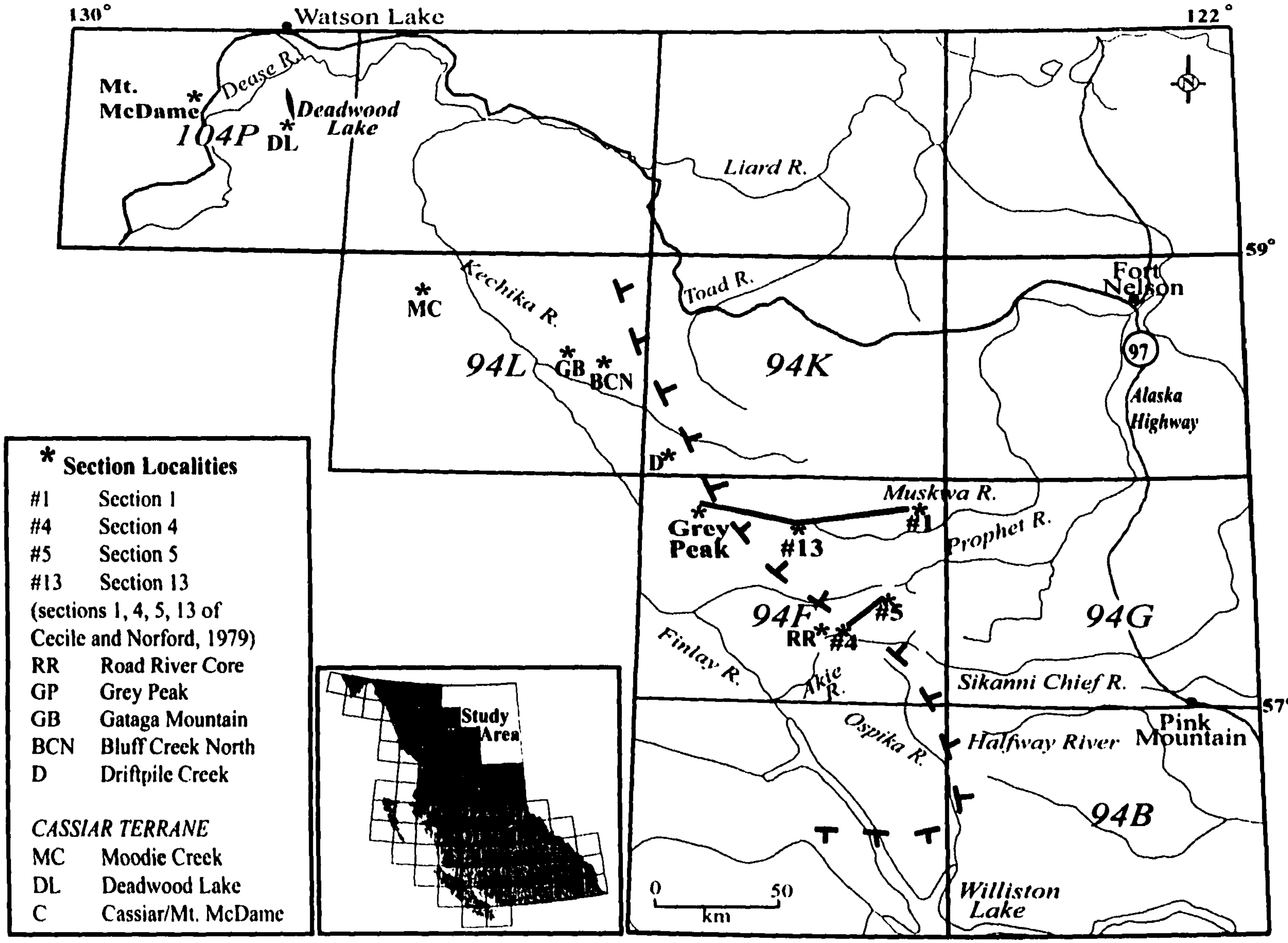


Figure 1. Map showing geographic localities, section localities, position of shelf to off-shelf transition (**T T** teeth point toward shelf, after Cecile and Norford, 1979; Thompson, 1989) and line of cross sections (—) illustrated in Figure 4.

1.3. Previous Studies

1.3.1. Stratigraphic Studies

The stratigraphy in the study area was initially described during reconnaisance style regional mapping (1:250,000) with some later studies at a larger scale (e. g., 1:50,000, Thompson, 1989). Parts of Macdonald Platform and miogeocline were examined during mapping in the Trutch (94G), Ware (94F, east half) (Taylor, 1979; Taylor et al., 1979), Ware (94F, west half) (Gabrielse et al., 1977), the Halfway River (94B) (Thompson, 1978; 1989) and Tuchodi Lakes (94K) (Taylor and Stott, 1973) map areas. Mapping within the Kechika Trough was done within the Kechika (94L), Rabbit River (94M), Ware (94F, west half) and Toodoggone (94E) map areas (Gabrielse, 1962c; 1962b; Gabrielse et al., 1977). The southern extent of the Kechika Trough has been mapped in the Mesilinka River (94C) area by Gabrielse (1975) and in the Halfway River area by Thompson (1989).

Among the earlier Lower Paleozoic stratigraphic descriptions are those by Jackson et al. (1965), Davies (1966), Norford et al. (1966), Fritz (1979; 1980) and Fritz et al. (1991) within the Kechika Trough and those by Cecile and Norford (1979; 1993) and Norford (1979) within the platform to off-shelf facies.

More detailed local mapping (1:50,000) was conducted during mineral exploration by MacIntyre (1980; 1981; 1983) in southern Ware West Half map area, in the Driftpile area by Archer Cathro and Associates (Carne and Cathro, 1982), and McClay and Insley (1986) and by McClay et al. (1987; 1988) in the Driftpile and Gataga areas, which have received attention due to their economic potential. The Driftpile and Gataga areas have also been mapped by the British Columbia Geological Survey (Ferri et al., 1995, 1996, 1997). Recently, detailed local mapping has been carried out in the Trutch (94G) map area in conjunction with the Geological Survey of Canada National Mapping Program (NATMAP) Central Forelands Project (Legun, 1999).

In the Cassiar Mountains, Norford (1962) described the Sandpile Group and its fauna. Gabrielse (1963; 1979; 1998) described the miogeoclinal succession of the Cassiar Platform during regional scale mapping within the McDame (104P) and Cry Lake (104I) map areas. Nelson and Bradford (1989; 1993) mapped part of the geology of the

Cassiar Terrane. Harms (1985) provided structural interpretations for the Sylvester Allochthon and the underlying autochthonous strata.

1.3.2. Biostratigraphic Studies

Few detailed conodont biostratigraphic studies have been initiated for the Lower Paleozoic of the Canadian Cordillera (Barnes et al., 1991). Some small Ordovician conodont collections have been made in the study area during regional mapping projects and are discussed under the heading "Previous Work: Conodont and Graptolite Biostratigraphy".

1.4. Objectives

Due to the remote location of the study area (Fig. 1), few previous detailed stratigraphic studies have been carried out and the conodont biostratigraphy for the Lower Paleozoic has not been established. The main objectives of the thesis are:

1. Measure, describe in detail and establish the Upper Cambrian to Lower Silurian stratigraphic framework (Kechika Formation, Road River Group and Skoki Formation) across a platform to basin transect of the northern Canadian Cordilleran miogeocline. Compare the facies relationships from a transect across the parautochthonous Cassiar Terrane to those of the Cordilleran miogeocline.

2. Sample for conodonts at regular stratigraphic intervals through key sections across the transect. Document the conodont fauna through detailed taxonomic identifications and descriptions of select taxa.

3. Establish, using the taxonomic database from the continuous, thick stratigraphic succession, the Lower Paleozoic conodont biostratigraphy across the platform to basin transect. Refine and adjust the standard Midcontinent and Atlantic Realm zonations for warm, shallow and cooler, deeper water facies, respectively.

4. Temporally constrain sequence boundaries and units in the stratigraphic framework.

5. Refine local, regional and interregional correlations based on the comparison of conodont faunas from the newly established biostratigraphy to that established in other regions. Interpret the early Paleozoic tectonic evolution of the Laurentian margin.

1.5. Methodology

1.5.1. Field Methods

Field work was completed during July and August of 1994, 1995 and 1996. The stratigraphic sections in the study area are accessible only by helicopter with the exception of Mt. McDame near the town of Cassiar (Fig. 1). Fly camps near remote sections were established, either within cols upon ridges or within cirques above the treeline. Logistic and helicopter support from the British Columbia Geologic Survey (BCGS) was received in each field season. In each season a base camp was utilized from which fly camps were established.

In 1994, a base camp established by the BCGS and Teck Exploration Corporation at Driftpile Creek was accessible by small fixed wing aircraft from Fort St. John. In 1995, as the BCGS mapping project expanded northwards, Terminus Mountain Camp served as a base camp and was reached by small aircraft from either Toad River or Liard River on the Alaska Highway. In 1996, a base camp established by Inmet Mining at Finbow, along the Finlay River, served as a base. Finbow is reached by small aircraft from MacKenzie, B. C. Fly camps were then established to study and collect the sections and Inmet Mining Corp. provided some core for study. Also in 1996, a remote section south of Deadwood Lake in the Cassiar Mountains was reached from the Cassiar-Stewart Highway (Centerville) by helicopter.

Twelve sections were measured using a Brunton compass and "pogo" or Jacob's staff. Measurements were compared to thicknesses given in unpublished logs by Brian Norford and Mike Cecile. Conodont samples were collected at an average interval of 20 m, or greater in expanded sections or less than 20 m in condensed sections. Carbonate beds were sampled to give a total of 405 (4-5 kg each) samples from over 12, 000 m of strata.

1.5.2. Laboratory Methods

The technique for processing carbonate rocks to extract phosphatic conodont elements first involves the dissolution of a 3 kg sample in dilute (10%) acetic acid, although with some samples, less weight was processed. The resulting residue is wet sieved into a coarse (16 mesh) fraction and a fine (200 mesh) fraction. The concentration of conodonts from the fine fraction is accomplished by heavy-liquid separation in which the conodont elements with a specific gravity of 2.84-3.10 are separated from the "light" fraction using sodium polytungstate (Stone, 1987). Electromagnetic separation, using a Carpco Inc. magnetic separator, is used on samples with a high proportion of magnetic minerals.

The final extraction of conodonts is accomplished under a binocular microscope using a picking tray, paintbrush and slide. The conodont elements are then sorted by species and fixed on a slide pre-coated with a water soluble glue.

2. Regional Geology

2.1. Tectonic Setting

The early tectonic evolution of the Canadian Cordillera is documented in Lower Paleozoic strata deposited along the northern margin of Laurentia, created by rifting of the interior of the Neoproterozoic (c. 725Ma) supercontinent Rodinia (Hoffman, 1991;Torsvik et al., 1996;Unrug, 1997;Handke et al., 1999). Bond and Kominz (1984; 1988) and Bond et al. (1985) predicted that the transition from rift to post-rift cooling and subsidence occurred in latest Proterozoic or Early Cambrian time. Laurentia was in an equatorial position during the early Paleozoic and from the Neoproterozoic to middle Jurassic and a broad west-facing miogeoclinal wedge of sediments accumulated on Precambrian crystalline basement of the craton (Fritz et al., 1991). Several periods of extension followed the main late Neoproterozoic rifting event as recorded in the Paleozoic stratigraphic sequence, and cannot be explained by a single continental rifting and separation event (Thompson et al., 1987).

Cecile et al. (1997) documented evidence for two or three phases of extension within the northern Cordillera and Lickorish and Simony (1995) have identified evidence of Lower Cambrian rifting in the southern Cordillera. The margin shows variations in deposition along strike which can be accounted for, in part, by divisions of the underlying Precambrian basement geometry into blocks. Another control on depositional variation along the margin has been explained by asymmetric rift interpretations. Cecile et al. (1997) described the tectonic divisions of the Cordilleran Miogeocline, following models of continental margin formation based on division of the crust into blocks formed by asymmetric thinning or attenuation (Lister et al., 1986; Hansen et al., 1993). Asymmetric detachment models suggest there are upper- and lower-plate passive margins comprising the basement of the western margin of the Cordillera. Changes in basement distribution, sedimentation history and thermal and structural evolution along strike are influenced by alternating upper- and lower-plate segments of a rifted margin. The lower plate represents the footwall of a simple shear, that dips away from the craton. The upper plate represents the hanging wall and has a deeper detachment fault dipping toward the craton. Both contain active, gently dipping lithospheric extension faults, separated along strike by transfer faults. The study area lies within the Southern Cordilleran Upper Plate Zone and is characterized by a narrowly preserved miogeocline, dominated by paleogeographic highs (Fig. 2B). The Northern Cordilleran Lower Plate Zone, characterized by a broad margin with a thick sedimentary cover, differs in developments of paleogeographic features, that is facies, rifts and positive areas (Cecile et al., 1997). The recognition of this configuration distinguishes facies trends observed in the study area from the lower plate to the north. The margin of the northern Cordillera is more complex than a simple passive margin, the pattern of extension, subsidence and flexure vary considerably along its length and influence stratigraphy.

2.2. Paleogeography

Widespread carbonate platforms developed in the Ordovician and Silurian (Fig. 2A) and were bordered by basins. troughs and embayments (Cecile and Norford, 1993). The platform carbonates of the northern Blackwater Platform and eastern Macdonald, Kakwa and Bow platforms change abruptly westward to deep water shale and limestone of the Selwyn Basin and its southern extension, the Kechika Trough. The paleogeographic elements discussed herein are part of the Canadian Cordilleran Miogeocline and its tectonic divisions proposed by Cecile et al. (1997).

The study area lies within the Macdonald Block which comprises the Macdonald Platform to the east and Kechika Trough to the west (Fig. 2A). The Kechika Trough records evidence of episodic extension throughout a period of passive margin accumulation (McClay et al., 1989). It is bounded to the east by Lower Paleozoic shallow water carbonates and quartz sandstones of the Macdonald Platform and to the west by the NRMT dextral strike-slip fault system (Gabrielse, 1985; 1998). Its southern extension is the Ospika Embayment (Thompson, 1989, p. 10, fig. 4.). The Peace River Arch, during times of emergence and periodic activation, was a source of clastics deposited along the length of the Cordillera from the latest Middle Cambrian to Middle Devonian (Norford, 1991; Eaton et al., 1999). Detrital zircon provenance studies support the derivation of sediment from the Arch in the Lower Paleozoic (Ross et al., 1993; Gehrels et al., 1995).

Lower Paleozoic stratigraphy of the Cassiar Terrane shows platform or transitional facies in the east which grade into shale and siltstone to the west similar to facies of the Cordilleran Miogeocline (Gabrielse, 1985). The original location of the Cassiar Terrane is uncertain. The terrane may have been displaced at least 450 km from the south representing a segment of the Kakwa Platform (Gabrielse, 1985). A second hypothesis is that it was displaced up to 1700 km and represents a margin segment from Idaho (Pope and Sears, 1997).

Regionally, tectonic influences on the facies trends and sedimentation patterns can be recognized. The Kechika Trough experienced Early Cambrian to Middle Cambrian extension followed by Late Cambrian to Ordovician Kechika Formation deposition during post-rift passive margin thermal subsidence. Turbidite deposition suggests the Kechika Trough was fault-bounded by late Ordovician time (McClay et al., 1989). Thick sedimentary sequences include shale and interbedded limestone (Kechika Formation) and multicoloured shales (Road River Group). Together these features indicate a long phase of periodic extension from the Middle Ordovician to Middle Devonian. After post-rift subsidence, subsidence may have halted and reversed as the second extensional event developed (Middle Ordovician thermal uplift, extension and rifting followed by Late Ordovician to Silurian post-rift subsidence) (Cecile, pers. comm., 1999). Mid to late Devonian extension and rapid subsidence of the Kechika Trough is indicated by abrupt facies changes within the Earn Group. Sedimentary exhalative deposits that accumulate in half-grabens as metalliferous brines, migrate along the listric fault geometry (MacIntyre, 1992). Deposition of the Earn Group occurred within the transpressional Devonian tectonic system (Cecile, pers. comm., 1999).

A similar history of extensional tectonism is recorded to the north in the Misty Creek Embayment of the Selwyn Basin created by latest Early Cambrian and Middle Ordovician rifting (Cecile, 1982; Cecile et al., 1997) (Fig. 3). In the study area, structural evidence of rifting is not as evident, however, abrupt changes in deposition and the occurrence of Middle Ordovician volcanics supports an extensional phase. The difference in preservation of the rift succession may be attributed to the location of the Misty Creek Embayment within the northern lower plate zone (Fig. 2B), which is a broader margin. A third period of rifting along the miogeocline is suggested by upper Silurian and lower Devonian volcanism (Goodfellow et al., 1995).

2.3. Economic Geology

Economically significant sedimentary exhalative (SEDEX) lead-zinc-barite deposits occur within the Kechika Trough and Selwyn Basin (Abbott et al., 1986;Pigage, 1987;MacIntyre, 1992;Ferri et al., 1995;Ferri et al., 1996;Ferri et al., 1997). MacIntyre (1992) summarized the SEDEX deposits of the Gataga district (Kechika map-area) which occur in Ordovician, Silurian and Devonian strata, particularly in the Upper Devonian Earn Group. Significant discoveries in the Kechika Trough include the Cirque (Pigage, 1987) and Driftpile (McClay et al., 1988; 1989) deposits. Stratiform deposits are hosted in both carbonates and shale. The genesis of the deposits is linked to the passage of hot (200-350°C) mineralized fluids along fault systems within submarine rift basins (McClay et al., 1988; MacIntyre, 1992). Interest in such deposits along the ancient continental margin extends to the central and southern Rockies (Nesbitt and Muehlenbachs, 1994;Norford and Cecile, 1994b). South of the study area in the Halfway River map-area (94B), the Robb Lake deposit is hosted in Middle Paleozoic carbonates (Paradis et al., 1999).

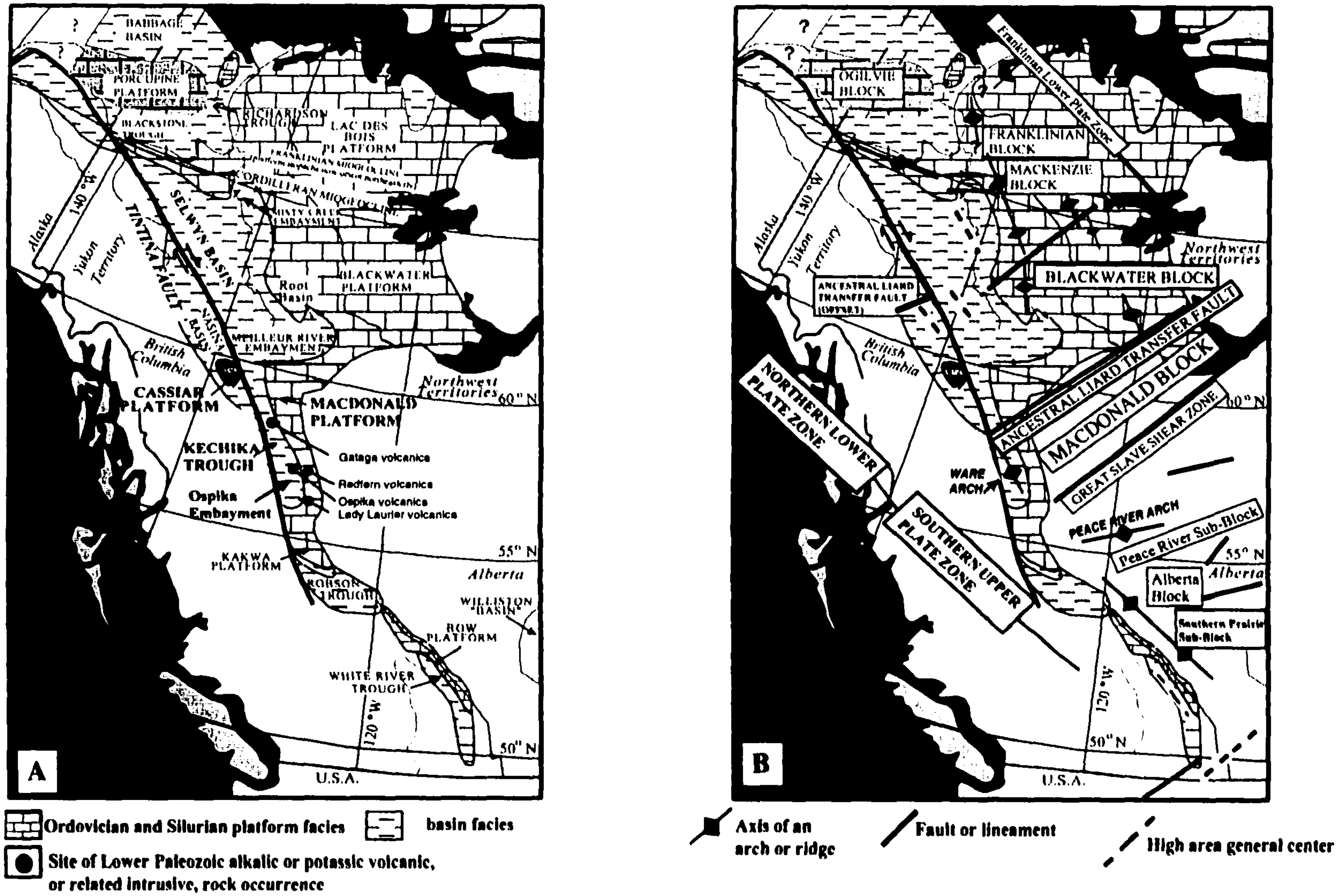


Figure 2. Maps showing Lower Paleozoic paleogeography and occurrences of Lower Paleozoic volcanic rocks (A); map showing paleotectonic features and blocks and upper and lower plate divisions of the Canadian Cordillera (B) modified from Cecile et al., 1997).

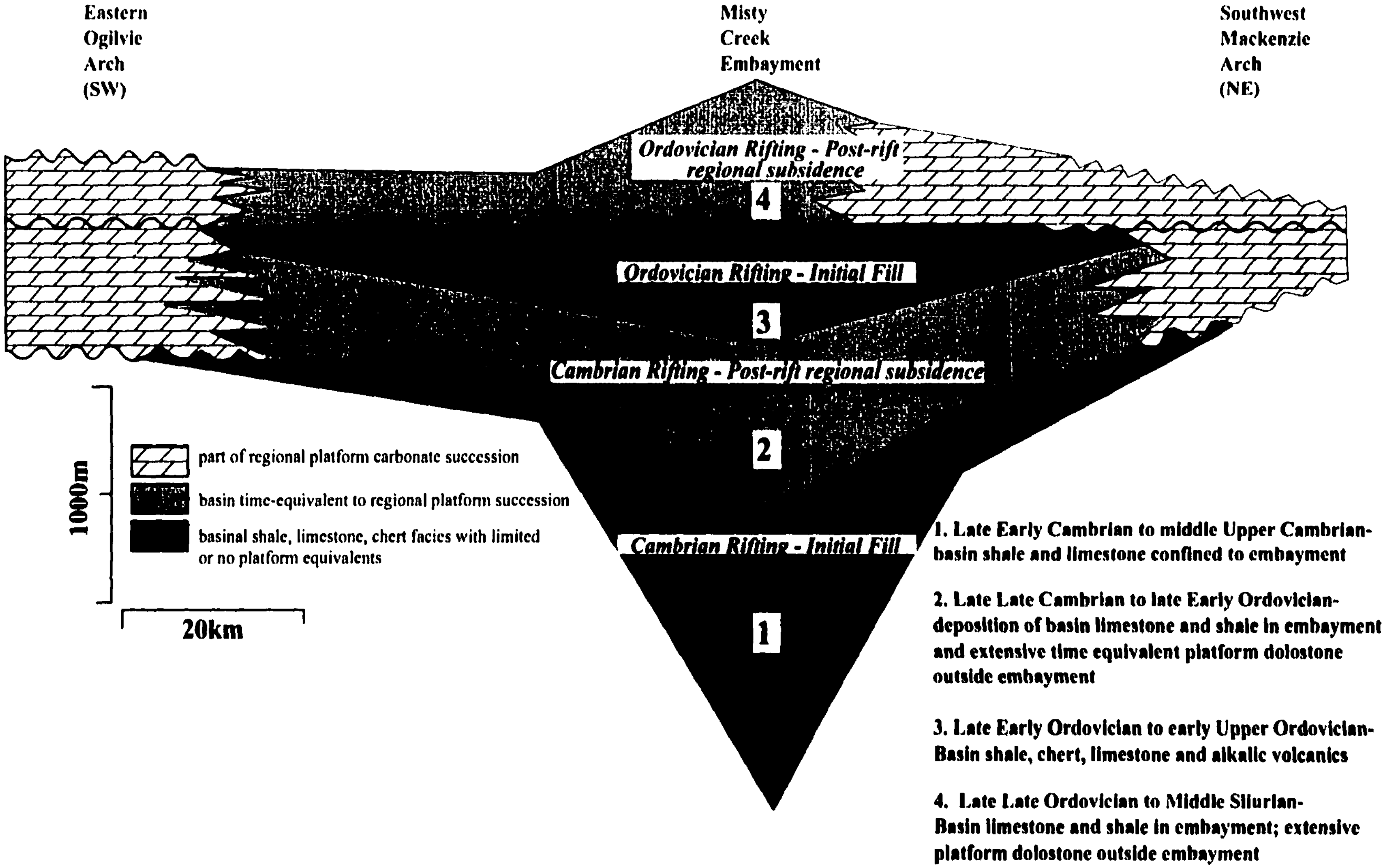


Figure 3. Southwest to northeast cross-section through Misty Creek Embayment (from Cecile, 1982) showing two "steer's head" rift profiles (from Cecile et al., 1997).

3. Stratigraphy

3.1. Lithostratigraphy

3.1.1. Introduction

The stratigraphic units in the study area range from Upper Cambrian (Trempealeauan) to Lower Silurian (Llandovery) and include, in stratigraphic order, the Kechika Formation and Skoki Formation and equivalent Road River Group. Revised stratigraphic terminology proposed herein includes the division of the Kechika Formation into 5 formal members: the Lloyd George, Quentin, Grey Peak, Haworth and Mount Sheffield members. The Skoki Formation comprises three distinct, formal members defined as: the Sikanni Chief, Keily and Redfern members and an informal "Upper Dark" Member (after Cecile and Norford, 1979). The Road River Group is divided into three new formations: The Ospika Formation, the Pesika Formation (formerly the Silurian Limestone) and the Kwadacha Formation (formerly the Silurian Siltstone). The Ospika Formation is further subdivided into five formal members: the Cloudmaker, Finlay Limestone, Chesterfield, Finbow Shale and Ware members (Fig. 4).

Within the study area, the transect spans platform and shelf strata in the east (Sections 1, 5, 13) to slope (Grey Peak) and basin (Section 4, Road River Core A-95-19, Driftpile, Bluff Creek and Gataga Mountain sections). Similarly, across the Cassiar Terrane, the transect spans shallow water facies (Moodie Creek and Deadwood Lake sections) to deeper water facies (Cassiar section). Appendix A contains detailed lithologic descriptions of the units and conodont samples from the 12 measured sections and Figure 1 shows their location within the study area. Appendix B contains the stratigraphic logs, with conodont sample numbers and conodont zones indicated for each section.

3.1.2. Kechika Formation

Gabrielse (1963) was the first to describe the Kechika (as a Group) at its type locality in the McDame map area and applied the name to the Ware map area (Gabrielse et al., 1977). The rank of the Kechika is herein revised from Group to Formation. At the type locality, the Kechika comprises shale, slate, calcareous phyllite, phyllite, limestone and limestone conglomerate and varies in thickness in the type area from 300 m to more than 600 m (Gabrielse, 1963). In the study area, the Kechika typically comprises a succession of grey and light grey, cleaved, phyllitic calcareous shale and thin bedded argillaceous limestone to grainstone. The Kechika is laterally extensive within the study area and ranges in thickness from 200 m in the east, thickening westward up to 1400 m (Fig. 4). It represents a sedimentary package which accumulated on a broad, gentle ramp as indicated by an east to west transition from shallow to deeper water facies (Cecile and Norford, 1979). The unit is thickest on the subsiding shelf, thickening westward from a thin platformal cover which is truncated to the east by the regional sub-Devonian unconformity.

Strata of the Kechika have been reported from the Cry Lake (104I) and McDame (104P) map areas west of the NRMT (Gabrielse, 1962a; 1963). It is laterally extensive in northeastern British Columbia in the Toodoggone, Ware, Trutch and Tuchodi Lakes map areas (94 E, F, G, K) (Jackson et al., 1965; Taylor and Stott, 1973;Gabrielse et al., 1977; Taylor, 1979; Taylor et al., 1979). It also has been reported from the Halfway River (94B) (Thompson, 1989), Mesilinka (94C) (Gabrielse, 1975), Kechika (94L) (Gabrielse, 1962c; MacIntyre, 1992; Ferri et al., 1994; 1995; 1996) and Rabbit River (94M) (Gabrielse, 1962b) map areas. Lateral equivalents are found in the McBride (93H) (Campbell et al., 1973), Pine Pass (93O) (Muller, 1961; Taylor, 1983), Watson Lake (105A) (Gabrielse, 1967a) and Coal River (95D) (Gabrielse and Blusson, 1969).

In the type area, the lower contact of the Kechika with the Atan Group is unconformable and its upper contact with the Road River Group is conformable (Gabrielse, 1998). In the study area, the Kechika unconformably overlies several different Cambrian units. Its upper contact is conformable but abrupt with the Road River in the Kechika Trough and conformable to unconformable with the Skoki in the eastern part of the study area.

The Kechika is correlative in part with the Rabbitkettle Formation and parts of the Road River Group in the Selwyn Basin and with the Broken Skull and Franklin Mountain formations on the Mackenzie Platform. In the southern Cordillera, the Kechika is equivalent to the upper McKay Group and Survey Peak Formation (Norford, 1969; Ji and Barnes, 1996) as illustrated in the correlation charts for the Ordovician of Canada (Barnes et al., 1981) and the Canadian Cordillera (Gabrielse and Yorath, 1991).

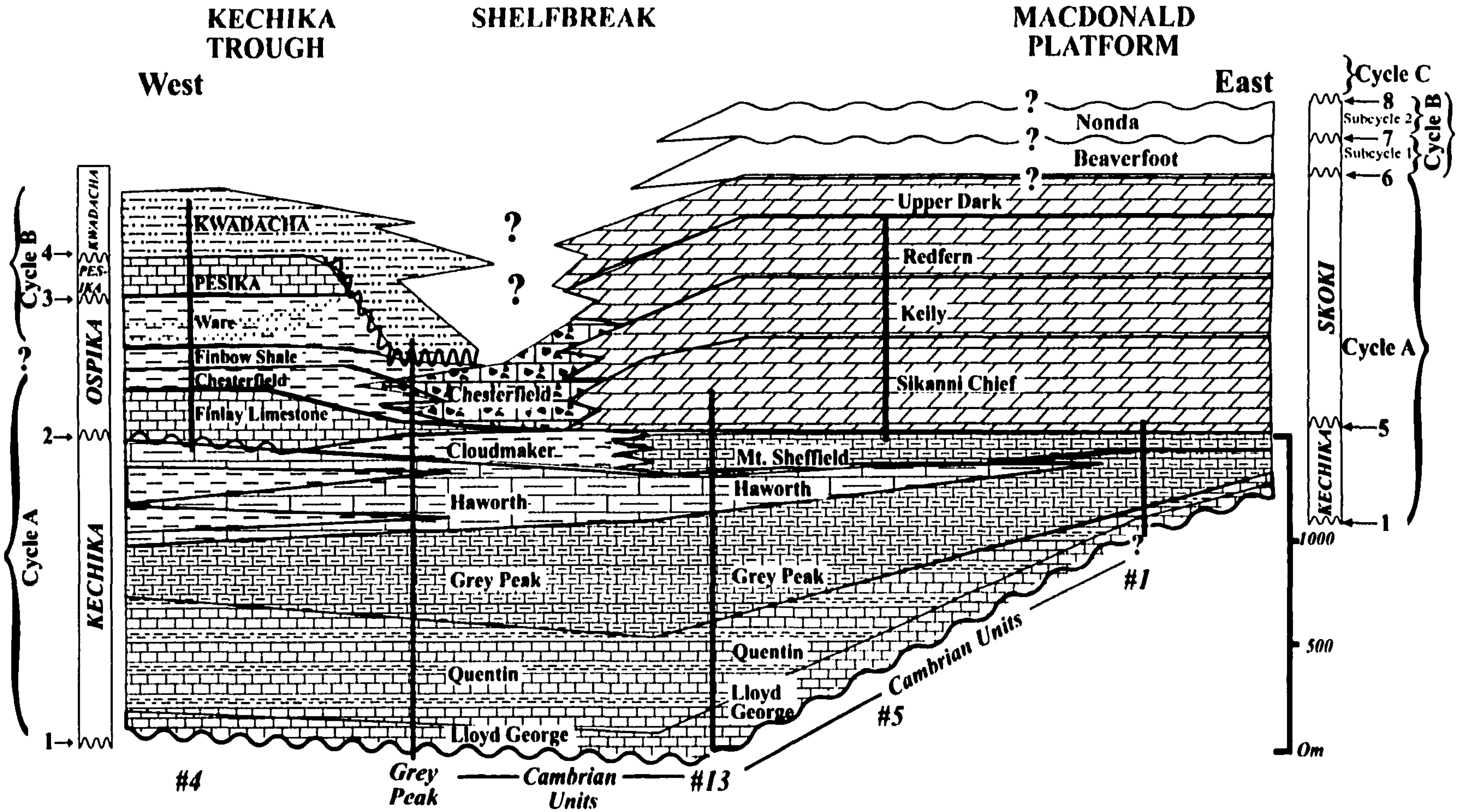


Figure 4. East-west cross-sections from platformal sections 1 and 5 through outer shelf facies of Grey Peak and outer shelf to basin facies of Section 4 showing lateral facies changes and unconformities (modified from (Cecile and Norford, 1979). Table A summarizes bounding surfaces 1 through 8.

In the type area, faunas reported include graptolites, minor trilobites, brachiopods, bryozoans and cephalopods which provide an age from the late Cambrian to early late Ordovician (Gabrielse in Glass, 1990). Pohler and Orchard (1990) reported Ordovician conodonts from the Kechika, Ware and Tuchodi Lakes map areas which spanned the mid-Arenig to mid-Caradoc. Tipnis (unpublished report, 1979) and Nowlan (unpublished report, 1983) identified conodonts from the Kechika from Grey Peak and reported species ranging from late Cambrian to latest Early Ordovician. Jackson (unpublished report, 1980) reported on graptolites from the Grey Peak section, near the top of the Kechika, ranging from late Tremadoc to early Arenig. Our detailed conodont biostratigraphic study substantiates the base of the Kechika as latest Cambrian and its upper limit as early Arenig. The Kechika was divided into five informal members, OK1 through OK5 (Cecile and Norford, 1979) based on subtle lithologic differences. Herein these units are named as formal members. The type section for the Lloyd George, Quentin, Grey Peak and Haworth members is Grey Peak (57° 48'N, 125° 13'W), Ware map-area, where the Kechika is 1394 m thick (App. B-4). The type section for the uppermost Mount Sheffield Member is Section 13, (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area (App. B-1). The five members are most recognizable within the expanded shelf and slope sections and are not recognized within basinal facies nor within sections across the Cassiar Terrane. The contacts of the members are subtle and gradational over a few metres.

The contact of the Kechika with underlying Cambrian units is sharp and probably unconformable on a regional scale. The contact with several different Cambrian units supports this. The contacts with overlying Skoki in the east and Road River equivalents in the west are gradational and conformable with one exception, at Section 1, where the contact with the Skoki is disconformable.

The underlying Cambrian stratigraphy was not studied in detail, but noted at several localities. In the east, it comprises massive bedded (more than 1 m thick), cross-bedded quartzite, sandy dolostone and siltstone of the Upper Cambrian Lynx Formation (Gabrielse and Yorath, 1991) or the Lower Cambrian Atan Group (Long, 1999). At Grey Peak, the Cambrian unit is largely massive conglomerate, oolitic limestone and sandstone containing *Skolithos* traces. Within the basinal sections, units underlying the Kechika contain shale, dolomitic siltstone and minor lime mudstone to thin bedded, orange weathering dolostone, in part encompassing the Gog Group and younger succession mapped by Ferri et al. (1995; 1996). In the Cassiar Terrane, the Kechika unconformably overlies sandstone and carbonates of the Rosella Formation (Gabrielse, 1998).

The Lloyd George Member is the basal member of the Kechika, named after the Lloyd George Icefield located 15 km northeast of the type section. The Member has formerly been referred to as the OK1 or basal platy unit (Cecile and Norford, 1979). It is 68 m thick at Grey Peak and is distinguished by its platy weathering, medium grey intraformational conglomerate, lime mudstone and wackestone which are largely massive bedded with some thin beds of oolitic grainstone containing scattered quartz grains. Its lower contact with Cambrian sandstone and oolite was covered, however Cecile and Norford (1979, fig. 36.2) considered it as unconformable. Its upper contact is conformable and gradational with the Quentin Member. Cecile and Norford (1979) reported the Member to be 60 to 120 m in the Ware map-area and observed oligomictic breccias in its upper part. In Section 13, the Lloyd George is 80 m thick and consists of thin, platy weathering, silty limestone beds interbedded with cleaved calcareous shale and thin bedded dolostone. In Section 1 (Fig. 6A), the member (62 m) comprises orange-grey weathering silty dolostone which appears to overlie gradationally brown weathering Cambrian quartzite and siltstone (Fig. 5A). The Member is late Cambrian in age, from the *Eoconodontus* Zone to the *Cordylodus proavus* Zone. The Member is, in part, equivalent to the Basal Silty Member of the Survey Peak Formation, which at Wilcox Pass, southern Rockies, extends into the *C. lindstromi* Zone (of Ji and Barnes, 1996).

The Quentin Member is named after Quentin Lake, 5 km northwest of Grey Peak. It has formerly been referred to as the Putty Shale (OK2) by Cecile and Norford (1979). It is 560 m thick at its type sections and is defined by strongly cleaved, calcareous shale (70%) with characteristic shiny, phyllitic, putty grey weathering surfaces. The thin, argillaceous to silty, finely laminated lime mudstone to wackestone beds are commonly nodular and have undulatory bedding surfaces. The weathering colour varies little within the member, although some dolomitic shale intervals weather brown and grey-brown. Both its lower and upper contacts with the Lloyd George and Grey Peak members, respectively, are conformable and gradational over a few metres (Fig. 6B). Cecile and

Norford (1979) reported a thickness variation of the Member from 30 to 500 m. In Section 13, the Member is at least 325 m thick and the facies are similar to those at the type section but contain an increased number of limestone interbeds.

The Quentin Member can be traced east into thinner platform facies (Section 1, 50 m thick). It comprises light grey to yellow-grey weathering, thin bedded lime mudstone to trilobitic grainstone and rudstone. Some beds contain intraclasts, sparse macrofaunas (trilobites and brachiopods) and lag surfaces. The unit becomes dolomitic with increased shale upsection. The Member spans the Cambro-Ordovician boundary, its base is within the *Iapetognathus* Zone and ranges into the *C. angulatus* Zone. The base of the Member is diachronous, and is younger at Section 1, lying completely within the *Rossodus manitouensis* Zone (Tremadoc). The Quentin Member is equivalent to the Putty Shale Member defined at Wilcox Pass, the base of which also lies within the *C. lindstromi* Zone (of Ji and Barnes, 1996).

The Grey Peak Member is named for its type section because it is the most resistant member and forms the main peak of Grey Peak (Fig. 5D). It has formerly been called the banded member of OK3 by Cecile and Norford (1979). It is a 230 m thick succession of thin bedded, medium grey-brown lime mudstone to wackestone with grey shale partings, alternating with metre-scale intervals of light grey, calcareous, phyllitic shale. The thin bedded carbonates also comprise platy, grey-brown weathering, dolomitic shale and limestone containing abundant horizontal trace fossils. The lower contact with the Quentin Member is gradational over a few metres and marked by an increase in the number of thin limestone beds (Fig. 6B). The upper contact with the Haworth Member is also conformable. Cecile and Norford reported a thickness of 90 to 500 m. The Member varies laterally in the Ware map area. At Section 13, the banding of the member (625 m) results from the alternation of nodular rich beds with argillaceous partings and nodular-poor intervals which are largely shale. At Section 1 (Fig. 5A) the Grey Peak Member (85m) consists of an alternation of grey, platy weathering calcareous shale and thin bedded lime mudstone to rudstone with orange weathering, silty dolostone containing abundant horizontal traces. The Member spans the *R. manitouensis* Zone to *Scolopodus subrex* Zone and ranges into the upper *Paltodus deltifer* Zone (middle to late Tremadoc) and *Paroistodus proteus* Zone (late Tremadoc).

The Haworth Member is named after Haworth Lake, 3 km southeast of Grey Peak. It has formerly been called the upper recessive unit (OK4) by Cecile and Norford (1979). It is 455m thick at the type section and is distinguished by prominent, widely spaced, nodular, argillaceous lime mudstone and wackestone beds which increase upsection from 20% at the base to 80% at the top of the unit. The shale mainly weathers light grey and brown with intervals of white to pale yellow weathering and decreases upsection. There are rare, medium grey, trilobitic grainstone interbeds. The contact with the underlying Grey Peak Member is conformable and gradational over a few metres. The contact with the overlying Road River Group is abrupt but conformable, marked by a change to brown-black weathering shale over less than one metre (Fig. 5D). Cecile and Norford reported a thickness range of 70 to 500 m. In Section 13, the member (630m) comprises 70% shale with 30% thin argillaceous limestone or nodular limestone to grainstone beds, and overall is massive bedded. The unit appears to be absent at Section 1 (Fig. 4), likely because it thins eastward. The upper part of the unit bears graptolites of the *Tetragraptus approximatus* Zone (Jackson, 1980) and ranges into the upper part of the *P. proteus* Zone and base of the *Paracordylodus gracilis* Zone (late Tremadoc).

The Mount Sheffield Member is named for Mount Sheffield, located in the Ware map area, 4 km north of its type section at Section 13 (57° 42'N, 124° 35'W). The Member has formerly been called the OK5 unit (Cecile and Norford, 1979). It is 453 m thick at its type section (App. B-1) and comprises platy, orange weathering, massive bedded, lenticular limestone, dolomitic limestone and cleaved shale (Fig. 6C). Some shale interbeds weather light grey and buff. The contact with the Haworth Member is conformable and gradational over a few metres, marked by a change in weathering pattern and colour. The member ranges into the *Oepikodus communis* Zone (lower middle Arenig). The contact with the overlying Skoki Formation is also gradational over a few metres, marked by a change to massive bedded, burrow mottled, orange and grey weathering, fossiliferous dolostone. The Member is not observed at Grey Peak because it shales out westward and is laterally equivalent to the Cloudmaker Member of the Ospika Formation.

Cecile and Norford (1979) reported a thickness range of 40 m to 120 m. At Section 1, the Member is 204 m thick and comprises similar platy dolomitic limestone facies and also more grey weathering bedded limestone and bedded chert. The Skoki disconformably overlies the Mount Sheffield Member at Section 1, marked by an abrupt change to thin bedded, light grey weathering, fossiliferous limestone and dolostone. The upper part of the Member extends into the *Prioniodus elegans* and *Oepikodus evae* zones, indicating it upper boundary is Middle Arenig in age.

Within the Kechika Trough, facies of the Kechika comprise typical light grey, cleaved phyllitic shale and thin bedded limestone or lenticular limestone at Section 4 (App. B-5) and Gataga Mountain. The section at Gataga Mountain (App. B-7; Fig. 7D) is possibly tectonically thickened where 720 m of recessive Kechika were measured. Other basinal facies of the Kechika, such as those observed at Driftpile Creek (Fig. 7C), comprise 170m of thin-bedded orange dolostone and buff dolomitic shale and siltstone with thin, isolated, weakly calcareous lime mudstone beds. Typical Kechika lithologies were not recognized at Bluff Creek (App. B-8). The base of the Kechika is drawn where several recessive units (80 m thick) of largely shale with dark grey and brown isolated, platy limestone overlie siltstone, shale and limestone.

Within the Cassiar Terrane, typical upper Kechika strata were recognized at Deadwood Lake (App. B-10; Fig. 8B, C) and comprises 65 m of grey, thin bedded to nodular limestone and cleaved, folded, light grey and buff shale. The contact with the overlying Road River Group is conformable and gradational over less than one metre. At Moodie Creek (App. B-11; Fig. 8A), the base and top of the Kechika were observed, however, the section is tectonically thickened and deformed. The Kechika disconformably overlies the Lower Cambrian Rosella Formation and the contact marks an abrupt change from resistant carbonates and siltstone to recessive shale of the Kechika. The Kechika comprises 1770 m of a variety of lithologies including pink-brown sericitic, cleaved phyllite, orange-brown massive dolostone with prominent quartz veins, green argillaceous, sheared siltstone and grey weathered, thin to massive bedded dolomitic limestone. Alkaline igneous rocks in close proximity to this section are described by Pell (1994). The contact with the overlying Road River Group is conformable and gradational over a few metres.

Figure 5

A - View to the southeast across the valley from Section 1, showing members of the Kechika Formation (430 m thick).

B - Burrow mottled texture of yellow and light grey weathering dolostone, lower part of the Keily Member, Skoki Formation, Section 5 (1 m stick for scale).

C - Sedimentary characteristics of the Sikanni Chief Member, Skoki Formation, Section 5, showing dark grey weathering colour and medium to massive bedding of dolostone and dolomitic limestone (30 cm sample bag for scale).

D - Grey Peak Section showing Grey Peak in the distance, composed of the Kechika Formation, Grey Peak Member which is gradationally overlain by the Haworth Member. The Cloudmaker Member (80 m thick) of the Ospika Formation is in the foreground.

E - Continuation of Grey Peak Section showing the members of the Ospika Formation, unconformably overlain by the Kwadacha Formation. The light coloured beds within the Chesterfield Member are distal carbonate turbidites interbedded with black shale. The upper 60 m of the cliff above the dashed line is composed of platformal carbonate debris.

F - Polymictic conglomerate, dolomitized, top of bed is slumped in a series of flow rolls, within platformal carbonate debris flows of Chesterfield Member.

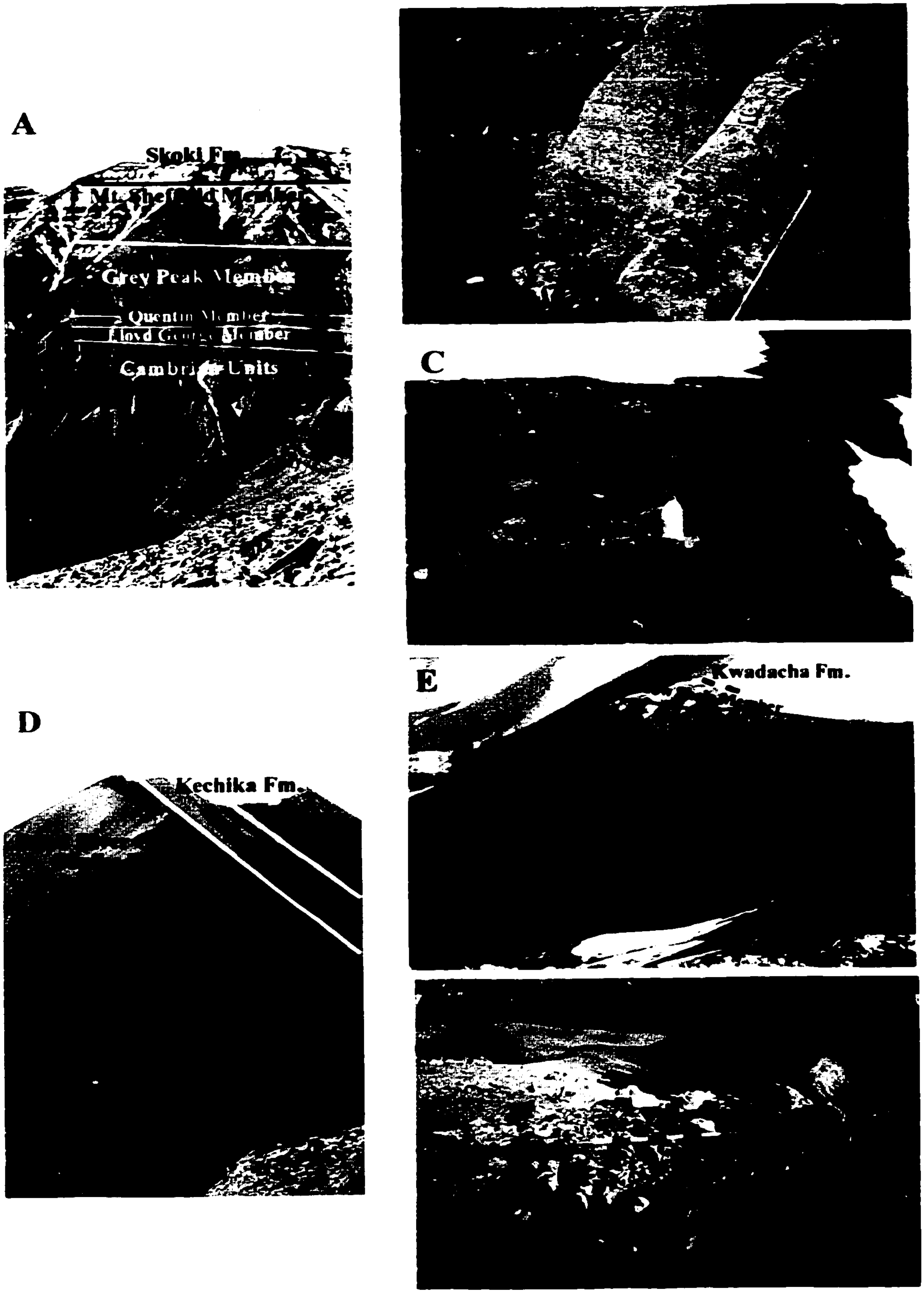

A
Skoki Fm.
Grey Peak Member
Quentin Member
Cambrian Units
C
D
Kechika Fm.
E
Kwadacha Fm.

Figure 6

A - Sedimentary characteristics of the Lloyd George Member, Kechika Formation. Section 13. Unit comprises cleaved shale with medium grey weathering, rare lime mudstone to wackestone interbeds which are boundinaged (at tip of hammer).

B - Gradational contact of the Quentin and Grey Peak members of the Kechika Formation, Section 13.

C - Sedimentary characteristics of the Mt. Sheffield Member, Kechika Formation. Section 13. Cleaved shale weathers orange, interbedded lenticular lime mudstone to packstone weathers medium grey.

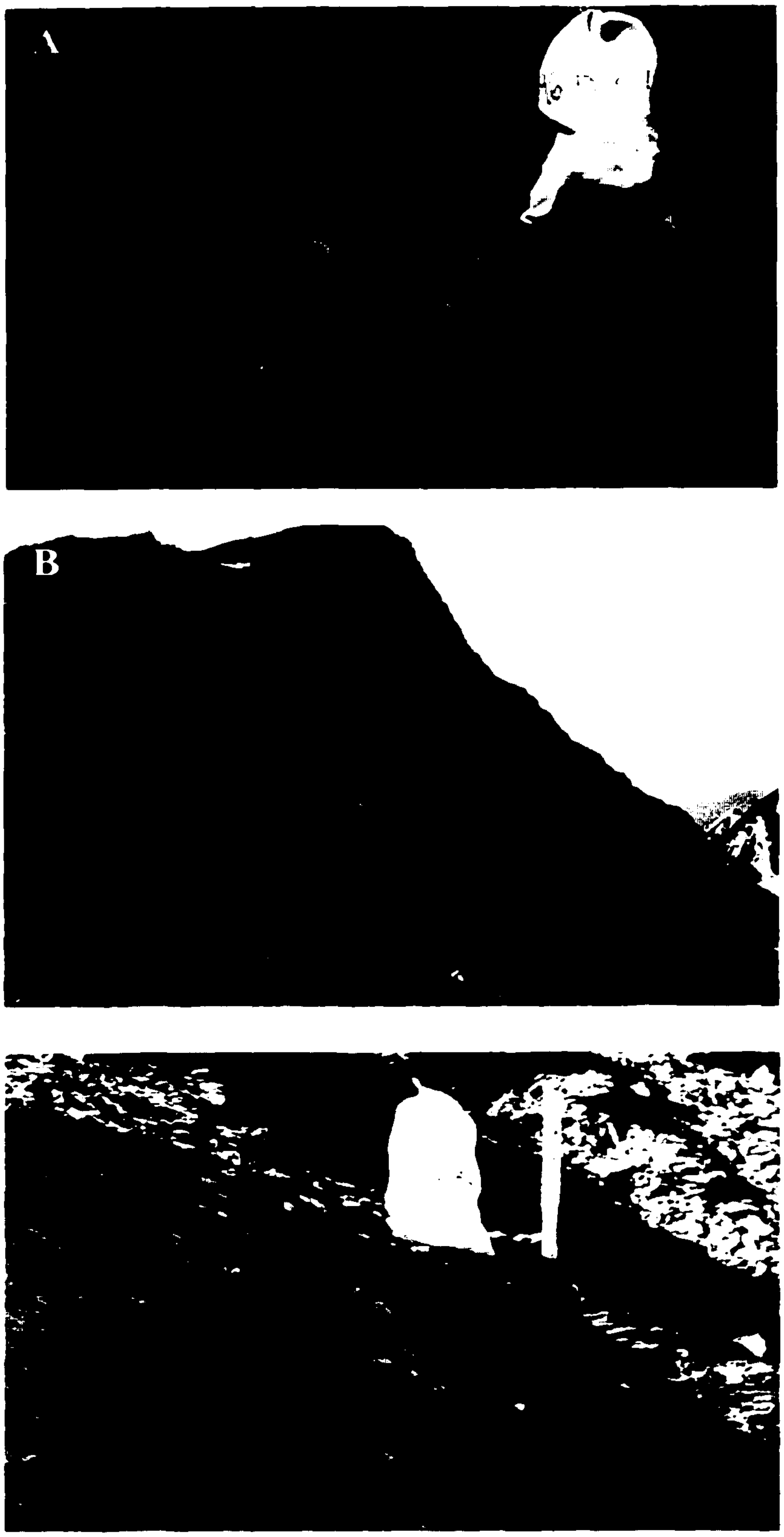

A
B

Figure 7

A - Section 4, showing the members of the Ospika Formation.

B - Sedimentary characteristics of the Kwadacha Formation, Section 4. Dolomitic siltstone weathers orange and platy, bedding planes covered by abundant fan-shaped horizonatal burrows (arrow indicates trace fossil).

C - Driftpile Creek Section showing the inverted sequence of cliff-forming Cambrian units overlying the recessive grey shale and thin bedded dolomitic limestone of the Kechika Formation. The black paper shale and thin bedded lime mudstone of the Road River Group are in the foreground.

D - Gataga Mountain Section showing the fault-repeated sequence of black shale of the Ospika Formation and orange dolomitic siltstone of the Kwadacha Formation. The Kechika Formation in the foreground comprises light grey weathering shale and thin lime mudstone beds.

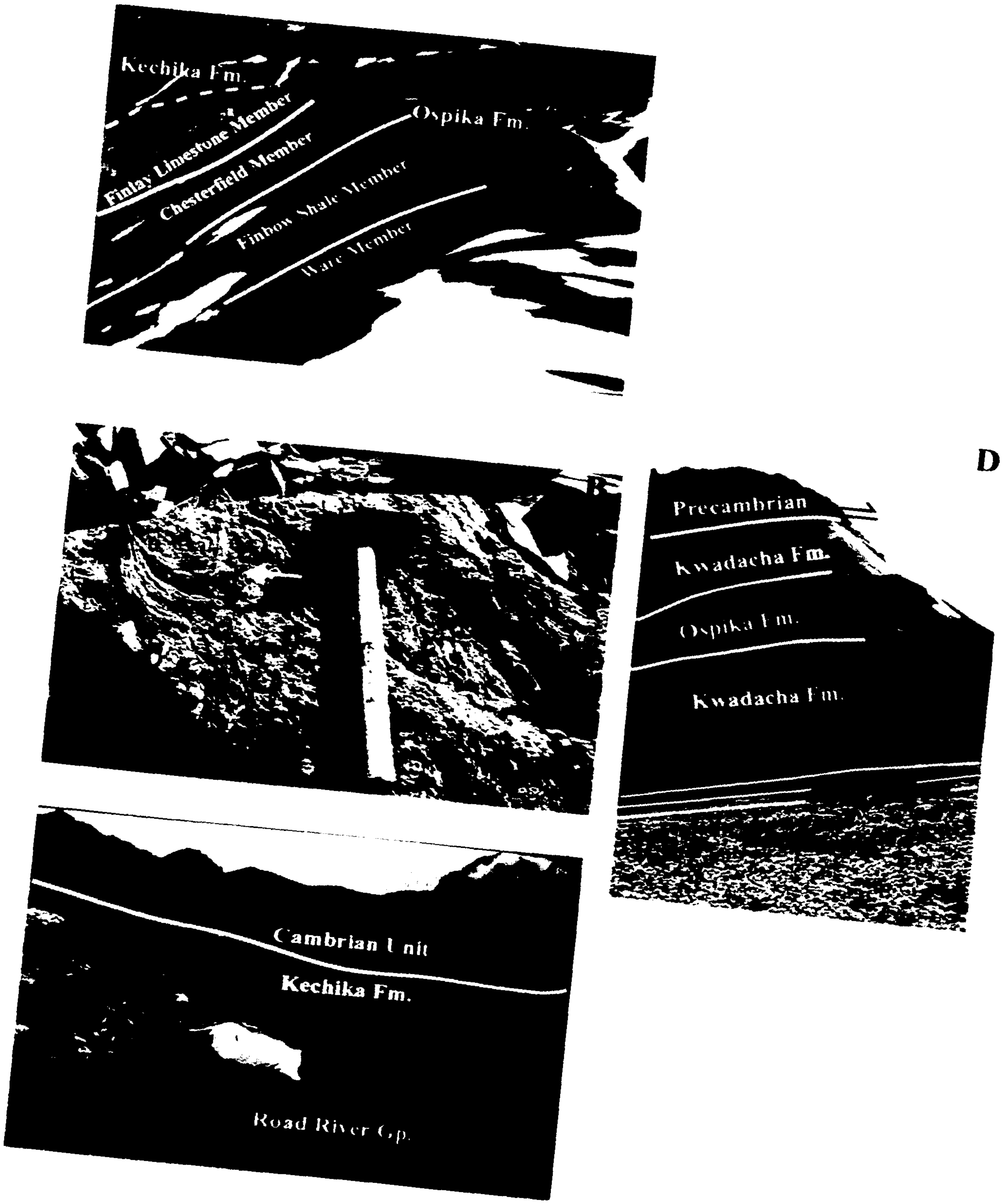

Kechika Fm.
Finlay Limestone Member
Chesterfield Member
Ospika Fm.
Finbow Shale Member
Ware Member
B
D
Precambrian
Kwadacha Fm.
Ospika Fm.
Kwadacha Fm.
Cambrian Unit
Kechika Fm.
Road River Gp.

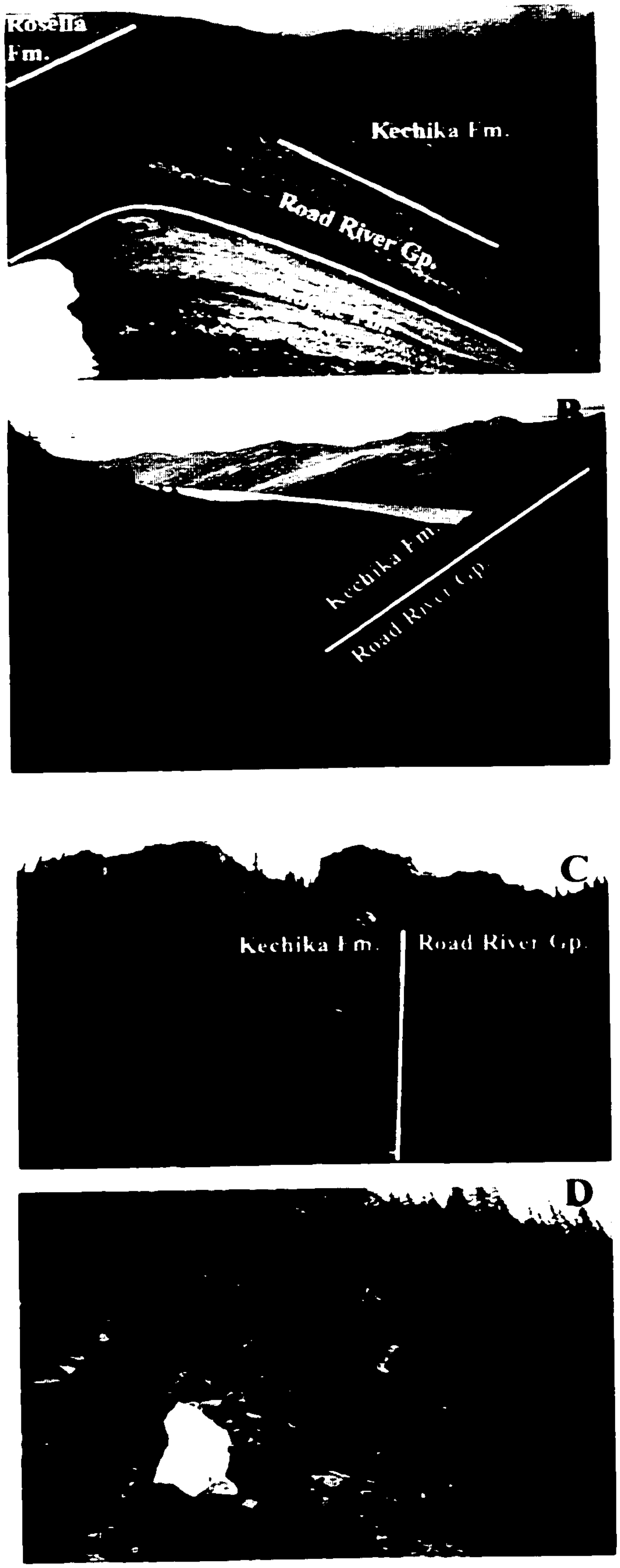
Figure 8

A - Moodie Creek Section within the Cassiar Terrane showing a 6 km long section of Kechika Formation which is gradationally overlain by black shale and thin dolomitic lime mudstone of the Road River Group and orange dolomitic siltstone of the Sandpile Formation.

B - Deadwood Lake Section within the Cassiar Terrane showing the uppermost part of the light grey weathering Kechika Formation overlain by dark shale and limestone of the Road River Group.

C - Kechika-Road River contact, Deadwood Lake Section, is gradational and marked by a change in weathering colour from light grey-brown to dark grey.

D - Upper unit of the Road River Group, Deadwood Lake Section, showing the dark grey to black weathering, well bedded, thin lime mudstone to grainstone.


Rosella Fm.
Kechika Fm.
Road River Gp.
B
Kechika Fm.
Road River Gp.
C
Kechika Fm.
Road River Gp.
D

3.1.3 Skoki Formation

The Skoki Formation has its type section at Skoki Mountain (51° 32'N, 116° 03'W), and reference section at Mount Wilson (52° 00'N, 116° 45'W), southwest Alberta (Norford, 1969). The Skoki Formation was named by Walcott (1928) and is widespread in the southern Rockies, comprising dolostone and rare limestone, commonly with oncolitic facies, beds with quartz silt and sand and argillaceous layers (Norford, 1969). The Skoki ranges from 62 to 186 m thick and is present in several map areas in the southern Rockies (Walcott in Glass, 1990). A much thicker succession, over 1000m, has been measured in the study area. An anomalous thickness of 1260 m has been recorded by Thompson (1989) in the Halfway River map area. The Skoki is reported from the Trutch and Ware map-areas (Cecile and Norford, 1979; Taylor, 1979), the McBride, Monkman Pass and Pine Pass map-areas (Campbell et al., 1973; Taylor and Stott, 1979; Taylor, 1983).

In the study area, the Skoki is a sequence of thick to massive bedded, light grey weathering dolostone, limestone and shale and nodular to thin bedded limestone within massive bedded dolomitic shale. It represents subtidal platformal facies in the east and thickens westward at the platform margin. As Thompson (1989) and Norford (1991) described, the platform margin shifted through time, extending farthest west during early Middle Ordovician, with a narrow shelfbreak facies developed between the platform margin and equivalent basinal facies (see Fig. 1 for position of shale-out).

In the type area, the lower contact of the Skoki is conformable with the Tipperary Quartzite and Outram Formation. Its upper contact with the Owen Creek Formation is paraconformable. In the study area, the Skoki conformably overlies the Kechika except at Section 1 where it appears to be locally disconformable. Its upper contact was not observed.

The Skoki is correlative with the Skoki in the southern Rockies and possibly with the overlying Owen Creek Formation. It is correlative to the Sunblood Formation and possibly the Esbataottine in the Selwyn Basin. Just as the Skoki in the southern Rockies is laterally equivalent to the Glenogle Formation, in the study area, the Skoki passes westwards into the Ospika Formation of the Road River Group.

Based on brachiopod zones in the southern Rockies (Norford, 1969) and conodont identifications in northeastern British Columbia (Tipnis, 1979, unpublished report), the Skoki extends from the latest Ibexian into the Whiterockian. In the Halfway River map area, Thompson (1989) reported an age range of the Skoki from early Whiterock to early Caradoc. Gastropods from this age range have been reported by Rohr et al. (1995). Conodont data from our study indicate the base of the Skoki lies within the *Oepikodus communis* and *O. evae* Zones, late Ibexian (early-middle Arenig) and its middle member, the Keily Member, ranges into the *Jumudontus gananda* Zone (late Arenig).

The Skoki was divided into four informal units by Cecile and Norford (1979), the OSK1 through OSK4. The uppermost unit was not observed in our study area, but three members studied, the Sikanni Chief, the Keily and the Redfern members, are herein named formally using Section 5 (57° 30'N, 124° 26'W) as the type section (App. B-3).

The Sikanni Chief Member is named after the Sikanni Chief River which runs through the Trutch map area and into the Ware map area, 35 km southeast of the type section. It is 440 m thick at the type section and comprises a variety of carbonate lithologies which largely weather medium to dark grey (Fig. 5C). Massive bedded orange weathering, dolomitic shale, containing dark grey weathering dolostone and limestone lenses occurs at the base of the unit. The contact of the Sikanni Chief Member with the Kechika is conformable and gradational over less than a metre. A distinctive subunit (80 m thick) of medium grey weathering, bedded wackestone and packstone is described as a local feature by Cecile and Norford (1979) (Fig. 5). The upper part of the Member comprises massive, medium grey weathering dolostone and limestone. Another distinct subunit of hackly, orange and light grey weathering, more carbonate rich, massive bedded dolostone containing abundant large macluritid gastropods occurs near the top of the Member. Such gastropods are widespread in the Skoki (Rohr et al., 1995). The upper contact with the Keily Member was obscured at Section 5, but Cecile and Norford (1979) reported it is sharp. Cecile and Norford (1979) observed a range in thickness of the Member from 300 to 450 m.

At Section 13 the Sikanni Chief Member overlies the Mount Sheffield Member of the Kechika Formation conformably and gradationally over a few metres. It is characterized by massive bedded, burrow mottled, fossiliferous, dark grey and orange weathering dolostone. At Section 1, the Member disconformably overlies the Mount Sheffield Member and is characterized by gastropod-rich, medium grey weathering, thin bedded limestone.

The Keily Member is named after Keily Creek which is 20 km east of the type section and extends from the Ware map area into the western Trutch map area. The Member is a 340 m thick succession of predominantly light grey and yellow weathering massive dolostone which is extensively burrow mottled (Fig. 5B). Two subunits comprise the top 230 m of the unit: light grey, cross-bedded, platy and orange-grey weathering doloarenite containing abundant gastropods and some oolite beds, and light grey-yellow weathering, laminated dololutite with rip-up clasts. Cecile and Norford reported the Member ranges in thickness from 100 to 130 m and contains rare desiccation features. The lower contact with the Sikanni Chief Member is sharp but the contact with the overlying Redfern Member is gradational over a few metres.

The Redfern Member is named after Redfern Mountain (57° 24'N, 123° 56'W) in the Trutch map-area, 35 km east of the type section. It is at least 300 m thick and contains alternating subunits of massive dolostone (App. B-3). Dark grey to black weathering, laminated and cross-bedded doloarenite alternates with yellow-light grey to buff weathering, laminated dololutite in units up to tens of metres thick. The lower contact of the member is gradational and conformable over several metres and its top contact was not observed. Cecile and Norford (1979) report the upper contact is conformable and gradational with a fourth unit of the Skoki.

The uppermost member of the Skoki was not present at the type section and is not formally named in this report. Cecile and Norford (1979) describe the unit as dark weathering, thick bedded dark and light grey dolostone which ranges from over 100m thick to 190m thick in the Halfway River map area.

The Skoki carbonates represent shallow platform and shelf facies which show subtidal influences such as extensive burrow mottling and oolitic beds within the Keily Member. Features noted within other sections include subaerial exposure and thick oncolitic facies (Cecile and Norford, 1979), but these were not as prominent in the type section. In some localities, it appears that the westernmost edge of Skoki facies develop as a massive undivided succession of dolostone that may represent a marginal reef

(Cecile, pers. comm., 1999), but little of the original fabric is evident. Cecile and Norford (1979, p. 222, location 109) noted that the western edge of the Skoki platform facies was a massive, undivided succession of dolostone and therefore the members of the Skoki established herein are difficult to correlate right to the shelfbreak zone. However, at other sections close to the shelfbreak (Section 5 and Thompson, 1989, section 9, p. 109, Appendix 2-2), members of the Skoki could be correlated with strata in close proximity of the shelfbreak.

3.1.4. Road River Group

The Road River was named as a Formation by Jackson and Lenz (1962) with a type section in the Richardson Mountains (Richardson Trough), northern Yukon. It is a thick succession (over 910 m) of dark graptolitic shale, argillaceous limestone and minor chert, dolostone, siltstone and sandstone. It varies in thickness and has been described from the Yukon, east-central Alaska and northeastern British Columbia (Jackson and Lenz in Hills, 1981). The Road River is exposed extensively in the Northern Cordillera from the Kechika Trough to the Selwyn Basin and Richardson Trough . It is a thick succession of several unnamed basinal equivalents of Lower Ordovician to Devonian shallow water units and contains a variety of facies. In the study area, Cecile and Norford (1979) report a thickness over 1320 m. In the Selwyn Basin and Richardson Trough, the Road River has been mapped during many studies such as those by Blusson (1974), Aitken et al. (1973), Gabrielse et al. (1973), and Cecile (1978; 1982) (see Jackson and Lenz in Hills, 1981 for review). The name Road River was extended to northern British Columbia by Gabrielse (1975) in the Mesilinka (94E) map area and by Gabrielse et al. (1977) and Gabrielse (1981)in the Ware (94F) map area. It has been mapped as a group of undivided, informally named units in the McDame and Cry Lakes (Gabrielse, 1962a; Gabrielse, 1979) and referred to as a Group in the Kechika map area (MacIntyre, 1992; Ferri et al., 1994; 1995; 1996). Similarly, the name Road River Group has since been used as a catch-all for several mappable units of middle Ordovician to middle Devonian basinal strata in the Halfway River map area (Thompson, 1989). The Road River was raised to group level and its base redefined by Fritz (1985) at a level in the

Early Cambrian but in the study area, the oldest Road River strata appear to be early Arenig, based on graptolite collections (Ferri, 1995).

The lower contact of the Road River Group with the Kechika Formation is abrupt but conformable at many of the sections observed in the study area, but is regionally unconformable such as at Section 4 (App. B-5). The upper contact with the Earn Group is unconformable (Ferri et al., 1996).

In the Mackenzie Mountains, the Road River includes Cambrian strata and its lower member is equivalent to the Rabbitkettle and Kechika formations (Hills, 1981). The Road River in northeastern British Columbia is therefore partly equivalent to the Road River in the Selwyn Basin. In the study area, it is equivalent with the Skoki, Beaverfoot and Nonda to the east and in the southern Rockies, to the Glenogle Formation (Fig. 9).

The graptolite biostratigraphy for the type locality has been established (Jackson and Lenz, 1962). Further study in northeastern British Columbia (Jackson et al., 1965; Jackson, 1980) has recognized zones for the Road River ranging from the early Arenig into the Caradoc, and are discussed in more detail for each formation.

The Road River Group comprises several mappable units in the study area. The earlier, informal terminology for the Ordovician units (OR1 through OR5) are herein named as new members of the Ospika Formation. The informal Silurian units are here formally described as new formations called the Pesika Formation (formerly SL or Silurian Limestone) and Kwadacha Formation (formerly SD or Silurian Siltstone). Section 4 (57° 26'N, 124° 35'W) north of the Akie and Ospika rivers (App. B-5; Fig. 7A) is the type section, over 700 m thick, for the three formations of the Road River Group.

3.1.4.1 Ospika River Formation

The Ospika Formation is named for the Ospika River south of the type section, in the southeastern Ware map area. It has formerly been referred to as the Ordovician Road River Group by Ferri et al. (1995; 1996, 1997). The Ospika Formation is 455 m thick at its type section and is defined as a succession of largely black, organic-rich shale and brown to orange weathering shale, minor thin bedded limestone, dolostone and siltstone and quartzite in the upper member. Its lower contact is unconformable with the Kechika at the type section, but abrupt and conformable with the Kechika at other sections within the Kechika Trough and Cassiar Terrane. The upper contact with the Pesika Formation is conformable at the type section, but regionally unconformable (Cecile and Norford, 1979). The Ospika Formation is a recessive package which is widely distributed in the Ware, Halfway River, Kechika and McDame map areas.

Five formal members are recognized (formerly OR1 through OR5 respectively): the Cloudmaker, Finlay Limestone, Chesterfield, Finbow Shale and Ware members. All are defined at the type section except the Cloudmaker Member, observed only at Grey Peak (57° 48'N, 125° 13'W), which is designated as the type section for the basal Member.

The Cloudmaker Member is named for Cloudmaker Mountain, 7.5 km southeast of Grey Peak. It is 80 m thick and comprises recessive, cleaved, dark grey and black pencil shale and minor, thin bedded brown weathering siltstone, thin bedded, dark grey and brown weathering lime mudstone or nodular lime mudstone and calcareous siltstone. It conformably but abruptly overlies the Haworth Member of the Kechika Formation at Grey Peak (Fig. 5D). Its lower contact is gradational over less than one metre. It is the lateral equivalent to the Mount Sheffield Member of the Kechika, which shales-out westward. Its upper contact with the Finlay Limestone Member is conformable. The Cloudmaker Member is not present at Section 4 because it is cut out by an unconformity near the top of the Kechika. Cecile and Norford (1979) reported a thickness variation of 120 to 200 m. Graptolites of Early Arenig age (*approximatus* Zone) have been reported from the Kechika-Ospika contact (Jackson et al., 1965; Jackson, 1980).

The Finlay Limestone Member is named after the Finlay River which runs through the western Ware map area. The member is 175 m thick at its type section (Section 4) and is a more resistant unit than the underlying Cloudmaker Member and overlying Finbow Shale Member. It is distinguished by its platy, yellow-grey weathering (Fig. 7A). At its type section, it comprises thin bedded argillaceous lime mudstone and wackestone and medium grey weathering shale and dolomitic limestone. It unconformably overlies the Kechika Formation where the Cloudmaker Member is removed by an unconformity. Its upper contact is conformable with the Chesterfield Member. At Grey Peak, the unit is 60 m thick and contains thin bedded, laminated lime mudstone which alternately weathers light yellow-grey and dark grey and is interbedded with light brown weathering shale. Its contact with the Cloudmaker Member at Grey Peak is conformable but abrupt, marked by a change to bedded limestone. Cecile and Norford (1979) report a range in thickness of the member from 20 to 130 m. Graptolites indicate an early Arenig age, *T. approximatus* to *T. fruticosus* Zones. Conodonts are within the *Lenodus variabilis* Zone, and appear to lie within its subzone, the *Paroistodus horridus* Zone at the base of the Llanvirn.

The Chesterfield Member is named after Chesterfield Lake, 7 km southeast of Grey Peak. The Member is 55 m thick at its type section, where it comprises a distinct recessive sequence of dolomitic, dark grey to green weathering shale and minor pale weathering dolostone interbeds (Fig. 7A). Its lower contact with the Finlay Limestone Member and upper contact with the Finbow Shale Member are both conformable and gradational over less than one metre.

At Grey Peak the Chesterfield Member is 180 m thick, comprising dark grey shale and siltstone and thin bedded, platy weathering limestone. It also contains a subunit of polymictic conglomerate containing clasts of dolostone and chert within a matrix of dolostone and an upper subunit of yellow-grey weathering, oligomictic, debris flow breccia and conglomerate of the Skoki-Road River transition (Fig. 5E). The breccia and conglomerate represent a series of flows that are wavy bedded and interbedded with laminated lime mudstone. The clasts of dolostone weather dark grey and the matrix of lime mudstone weathers light grey. Debris flow breccias were transported downslope and interbedded with basinal facies. Cecile and Norford (1979) have observed 200 to 300 m of the Chesterfield Member in the study area and report an age range of Llanvirn to early Caradoc based on graptolites (Davies, 1966). Jackson (1980) reported a range from the *T. fruticosus* to *Paraglossograptus tentaculatus* Zone (late Arenig) and conodonts range into the base of the Llanvirn.

The Finbow Shale Member is named after the Finbow airstrip (57° 16'N, 125° 22'W) on the Finlay River, 53 km east of the type section. It is 25m thick at its type section and comprises cleaved, dark grey shale which weathers distinctly rusty orange and dark grey-orange, with minor thin, veined buff and dark grey weathering dolostone beds (Fig. 7A). The contact with the Chesterfield Member is conformable but abrupt, marked by a change in weathering colour of the shale. Its upper contact with the black shale of the Ware Member is also conformable but abrupt. Thicknesses ranging from 30 to 40 m and the occurrence of calcite nodules and calcareous shale were observed by Cecile and Norford (1979, section 10). Graptolites of Caradoc age were identified from this unit, and *Climacograptus bicornis* Zone was identified just above (Davies, 1966), so that the unit likely ranges from Llanvirn to middle Caradoc.

The Ware Member is named after the Ware settlement (57° 25'N, 125° 37'W) on the Finlay River, 63 km east of the type section. It is 184m thick at its type section and comprises black shale at its base and thick bedded dolostone and rare blue-grey weathering quartzite, which becomes thick to massive bedded upsection (Fig. 7A). The quartzite is composed of mature quartz sand (>90%) and minor lithics (<5%). The grains are of fine to coarse sand size, rounded, moderately sorted and grain supported with 5% dolomitic cement. The lower contact is conformable and abrupt, marked by a change in weathering colour over less than one metre from the Finbow Shale Member. The upper contact with the Pesika Formation was covered when studied by the authors but was observed to be conformable by Cecile and Norford (1979, fig. 36.2). The unit extends into the *Dicellograptus complanatus* Zone (Davies, 1966) and therefore into the Ashgill.

3.1.4.2. Pesika Formation

The Pesika Formation is named after Pesika Creek, located 30 km south of the type section (Section 4; 57° 26'N, 124° 35'W) in the southern Ware map area. The formation has been called informally the Silurian Limestone (SL unit of Cecile and Norford, 1979). It is 230m thick at its type section and comprises mostly thin bedded, grey, dolomitic limestone and dark grey, graptolitic shale with some thin beds of medium grey calcareous lime mudstone to grainstone (App. B-5). It ranges from 20-100m thick and also comprises slope breccia, thin bedded limestone, minor shale and dolostone as observed by Cecile and Norford (1979) . Its lower contact with the Ware Member of the Ospika Formation and upper contact with the Kwadacha Formation were snow covered when studied by the authors but were observed to be conformable by Cecile and Norford (1979, fig. 36.2). However, at other localities (loc. 109 and Section 10, Cecile and Norford, 1979) the Pesika is removed by the sub-Kwadacha unconformity.

The formation is present in the Ware east-half map area, only in the southern Kechika Trough. A correlative, unnamed unit of dolostone and shale is a time equivalent unit in the Ware west-half map area (Jackson et al., 1965), and the Nonda is possibly a time equivalent platformal unit in the east. Graptolites from the type section indicate a Middle Llandovery to perhaps Wenlock age (Davies, 1966; Cecile and Norford, 1979). Conodonts from the upper part of the unit are from the *Distomodus staurognathoides* Zone of the Middle Llandovery.

3.1.4.3 Kwadacha Formation

The Kwadacha Formation is extensive in the study area and is named after the Kwadacha River in the central, western Ware map area, 30 km northwest of the type section (Section 4; 57° 26'N, 124° 35'W). The formation has previously been referred to informally as the SD unit (Cecile and Norford, 1979) and the Silurian Siltstone of the upper Road River Group (Ferri et al., 1995; 1996; 1997; McIntyre, 1992). The unit is exposed in the Ware and Kechika map areas where thicknesses vary considerably from 75 m to 200 m (Gabrielse, 1981; McClay et al., 1988), 250 m to more than 500 m thick (Cecile and Norford, 1979; Gabrielse, 1981) and up to 1000 m in the northern Kechika map area (Ferri et al., 1996). The Kwadacha Formation has been mapped in several thrust panels in the Gataga map area where it thins westward (Ferri et al., 1995; 1996).

At its type section, the Kwadacha Formation is estimated to be 300 m thick. It is a uniform, resistant, cliff-forming succession which weathers orange to brown. It is predominantly thin bedded, well laminated, medium to coarse grained, medium grey, argillaceous siltstone and light grey dolomitic siltstone. The platy talus contains abundant, large horizontal feeding traces in the basal part of the formation. At Grey Peak, the unit comprises orange weathering siltstone and brown, grey and orange weathering shale (Fig. 5E). Elsewhere in the study area, the unit contains variable amounts of interbedded shale and quartz sandstone (Cecile and Norford, 1979) and massive bedded, bioturbated siltstone with minor recessive beds of argillite, limestone, chert and quartz sandstone (Ferri et al., 1997). Insley (1990) observed proximal clastic facies of quartz sandstone and siltstone and sedimentary structures of proximal turbidites in the western Kechika Trough.

The contact with the underlying Pesika Formation was obscured by talus in 1996, but was observed to be conformable by Cecile and Norford (1979, p. 220, fig. 36.2) at the type section. Elsewhere in the Ware map area, the lower contact was observed to be unconformable (Cecile and Norford, 1979). At Grey Peak, the Kwadacha overlies the Finbow Shale Member of the Ospika Formation. The upper boundary of the unit was not observed, but Ferri et al. (1996) described the top as containing a limestone and chert succession which is overlain by siltstone and slate of the Earn Group and is abrupt at most localities.

The unit may be time-correlative to part of the Nonda Formation to the east and in part correlative to the Sandpile Formation of the Cassiar Terrane. Graptolite collections from the Kwadacha Formation indicate a latest Llandovery or Wenlock age (Norford, 1980), and conodonts from the limestone in the upper part of the formation are Early to Middle Devonian (Ferri et al., 1996). Macrofossils are sparse, however, Rigby et al. (1998) described Silurian sponges from the southern Kechika Trough.

3.1.4.4. Road River Group, Kechika Trough

Sections of Road River Group were studied within the Kechika Trough (Fig. 2), where differentiation into recognizable units was not possible. Core supplied by Inmet Mining Corp. from a locality north of the Akie River (57° 23'N, 124° 52'W) comprised mainly black shale and slate, grey siltstone, calcareous siltstone and lime mudstone (App. B-6). The upper siltstone unit of the core is possibly the Kwadacha Formation.

At Bluff Creek, 200 m of Road River Group was measured (App. B-8). The base of the Road River is drawn at the change from the orange and grey weathering shale and minor limestone of the underlying Kechika Formation to bedded limestone, platy calcareous siltstone and interbedded chert and black shale of the Road River Group. Subsequent units were distinguished based on weathering colour of shale from blue-black to orange and brown. The uppermost unit comprises phyllite, weathering green to white and compact siltstone beds weathering silver. Ferri et al. (1995; 1996) agreed that the stratigraphy is more difficult to interpret within basinal sequences as units show facies variations. They recognized an Ordovician sequence of black shale and chert, which is difficult to differentiate from shaly Kechika, and a Lower Silurian to Lower Devonian siltstone and slate sequence as the upper Road River.

At Gataga Mountain (App. B-9, Fig. 7D), a fault repeated section comprises finely laminated, dolomitic, orange weathering siltstone of the Kwadacha Formation, alternating with cleaved, black pencil shale of the Ospika Formation which contains rare concretions of recrystallized carbonate. Between the Kechika and Ospika formations is a 20m interval of basic volcanics referred to as the Ospika Volcanics (Goodfellow et al., 1995, fig. 1; table 1). At Driftpile Creek, 20 m of the Road River gradationally overlies the Kechika with a colour change to dark paper shale with thin lime mudstone beds over less than one metre (App. B-6).

3.1.4.5. Road River Group, Cassiar Terrane

Within the Cassiar Terrane, the Ordovician Road River was observed in all sections in the transect and its facies are varied. The overlying Sandpile Formation (late Llandovery to early Wenlock) comprises dolomitic sandstone and cherty dolostone. The Ramhorn Formation is more widespread, comprises dolomitic sandstone and dolostone and may be Silurian and Devonian in age (Gabrielse, 1998). At Moodie Creek, 90 m of Road River conformably overlies the Kechika with the contact gradational over a few metres. The Road River comprises cleaved grey and brown shale and recrystallized silty limestone and dolostone. Dolostone veins are common in the upper part of this unit of shale and silty dolostone. The overlying dolomitic siltstone and sandstone are assigned to the Sandpile Formation and the contact appears to be conformable and gradational over a few metres (Fig. 8A).

A section of calcareous Road River is at Deadwood Lake (Fig. 8C, D) where it conformably and gradationally overlies the light grey weathering Kechika (Gabrielse, 1963). Its basal unit comprises lenticular limestone and shale in metre-scale packages which weathers orange-grey. The lenses increase in number and lateral continuity upsection. The basal unit (155 m) is overlain by a series of grey quartzite beds, quartz veins, interbedded dolostone and black slate (117 m). A third unit (52 m), comprises largely grey, dolomitic siltstone, black shale and phyllite and minor lime mudstone beds. The uppermost unit (144 m) comprises bedded limestone interbedded with black shale which decreases from 30-50% at the base to less than 5% at the top of the unit. The limestone is medium to dark grey, thin to medium bedded and ranges from lime mudstone to grainstone with some intraclast breccia. Some beds are undulatory and contain chert nodules. Grainstone becomes abundant near the top of the unit represented in part by phosphatic lags. The unit is disconformably overlain by massive bedded, light grey dolostone which Gabrielse (1963) called the Sandpile Group, now referred to as the Sandpile Formation (Gabrielse, 1998).

A collection of macrofossils from the top of the Road River Group at Deadwood Lake was interpreted by G. W. Sinclair (in Gabrielse, 1963, p. 38-39) as Middle or Late Ordovician (Trenton or Edenian) age. Conodonts from the base of the Road River at Moodie Creek and Deadwood Lake indicate it is much older than the Road River east of the NRMT, lying within the *R. manitouensis* Zone. The top of the Road River at Deadwood Lake lies within the *Phragmodus undatus* Zone, middle Caradoc.

The Road River examined at Mt. McDame (Fig. 15) comprises 120 m to 200 m of nodular lime mudstone interbedded with blue-black shale and slate. The thin, rare limestone beds were typically veined and pyritic. Volcanics were observed near the top of the black shale units and the Road River is conformably overlain by sandstone bodies of the Sandpile Formation.

3.2. Stratigraphic Interpretations

The stratigraphy records abrupt changes in deposition, phases of volcanism, flooding surfaces and prominent regional unconformities. The underlying late Cambrian units are shallow water carbonates and clastics. The initiation of Kechika Formation sedimentation during the latest Cambrian is marked by a flooding surface within the study area and is regionally unconformable. The Kechika shows a westward change in depositional environment from platform to shelf and deep shelf which is part of the post-rift subsidence phase and differentiation of platform and basin strata during the Late Cambrian and Early Ordovician (MacIntyre, 1992). The Kechika is a westward thickening succession which shows gradual lateral and vertical facies changes during its depositional history on a broad, gentle ramp. The basinal equivalents are typical Kechika lithologies which could not be differentiated into units, and in other sections, the unit was largely thin bedded clastic basinal facies (Ferri et al., 1995; 1996).

Volcanics are localized along reactivated faults within basins along the miogeocline (Goodfellow et al., 1995). Extensional tectonism is widespread during the Cambrian, Early to Middle Ordovician and Middle to Late Devonian. Volcanics within the Kechika include the Redfern volcanics (Taylor and Stott, 1973) and Looncry volcanics, which also occur in the Sandpile Formation in the Cassiar Terrane (Gabrielse, 1963). The Ospika volcanics, which lie at the Kechika-Road River boundary (Gabrielse, 1975; Cecile and Norford, 1979; Gabrielse, 1981; MacIntyre, 1992), are probably related to the Gataga volcanics (Ferri, 1995). The Skoki also contains the Lady Laurier volcanics as noted in the Halfway River map area by Thompson (1989). The basins receiving the submarine volcanic flows were undergoing episodic reactivation and subsidence which is also supported by the lateral facies changes, changes in thicknesses and possibly by the thermal subsidence history of the margin modelled by Bond and Kominz (1988).

The depositional changes in the late Early Ordovician are more abrupt as reflected in the well defined Skoki-Road River transition (Fig. 4). The steepening of the shelf-break margin is recorded in transitional facies in the Grey Peak Section in which the Chesterfield Member of the Road River Group contains thick debris flow breccia, conglomerate and distal turbidites interbedded with black Road River shale. The steepening of the margin coincides with a period of renewed extension, however, Cecile et al. (1997) caution that non-tectonic controls could be an influence. The transgressive phase during the Middle to Late Ordovician deposition of the Chesterfield Member and quartzites of the Ware Member of the Road River Group was ended by a period of erosion in the Lower Silurian over much of the study area.

Silurian units unconformably and conformably overlie Ordovician Road River. The Pesika Formation unit represents continued deposition of transitional facies and is present mainly in the eastern part of the Kechika Trough. The prominent Kwadacha Formation unconformably overlies Ordovician Road River Group at some localities and represents an influx of quartz silt and sand. It is a peculiar unit in that it is present only within northeastern British Columbia above a sub-Llandovery unconformity which is also a locally distinct event (Cecile and Norford, 1993).

3.3. Regional Correlations

The Lower Paleozoic stratigraphic framework illustrated in the Decade of North America Geology correlation chart shows the extensive nature of the units discussed above (Gabrielse and Yorath, 1991, fig. 1). Figure 9 summarizes the regional correlation of units and shows regionally significant bounding surfaces. The similarities of facies along the length of the Cordillera is evident. The regional influence of paleogeography within the interpreted upper-lower plate model controls thicknesses and lateral facies variations.

The Kechika Formation is laterally extensive within the northern Cordillera. The platformal Kechika is equivalent to the Survey Peak Formation and possibly the Outram Formation in the southern Rocky Mountains and the basinal facies of the Kechika are equivalent to the upper McKay Group. The Survey Peak comprises a succession of platformal carbonates of the Bow Platform which passes laterally into a thick package of thinly bedded shale and bedded and nodular limestone of the McKay Group within the White River Trough (Fig. 2A). Within the Mackenzie Platform, equivalent strata of the Franklin Mountain and its southern equivalent, the Broken Skull Formation have an interfingering relationship with deeper water equivalents to the west, the Rabbitkettle Formation. The Rabbitkettle is similar to the western facies of the Kechika in that it comprises slope and basinal dark grey platy limestone and shale of the Selwyn Basin and Misty Creek Embayment and has been called Rabbitkettle-Kechika in the southern Selwyn Basin (Fritz, 1985).

The Kechika is overlain by platformal carbonates of the Skoki in the east. A similar relationship exists in the southern Cordillera in which the Skoki and Owen Creek overlie the Outram. In the study area, the Keily Member of the Skoki is possibly equivalent to the Owen Creek. In the south, the Tipperary underlies the Skoki and a similar sandstone unit, the Monkman, is present in limited lateral extent south of the

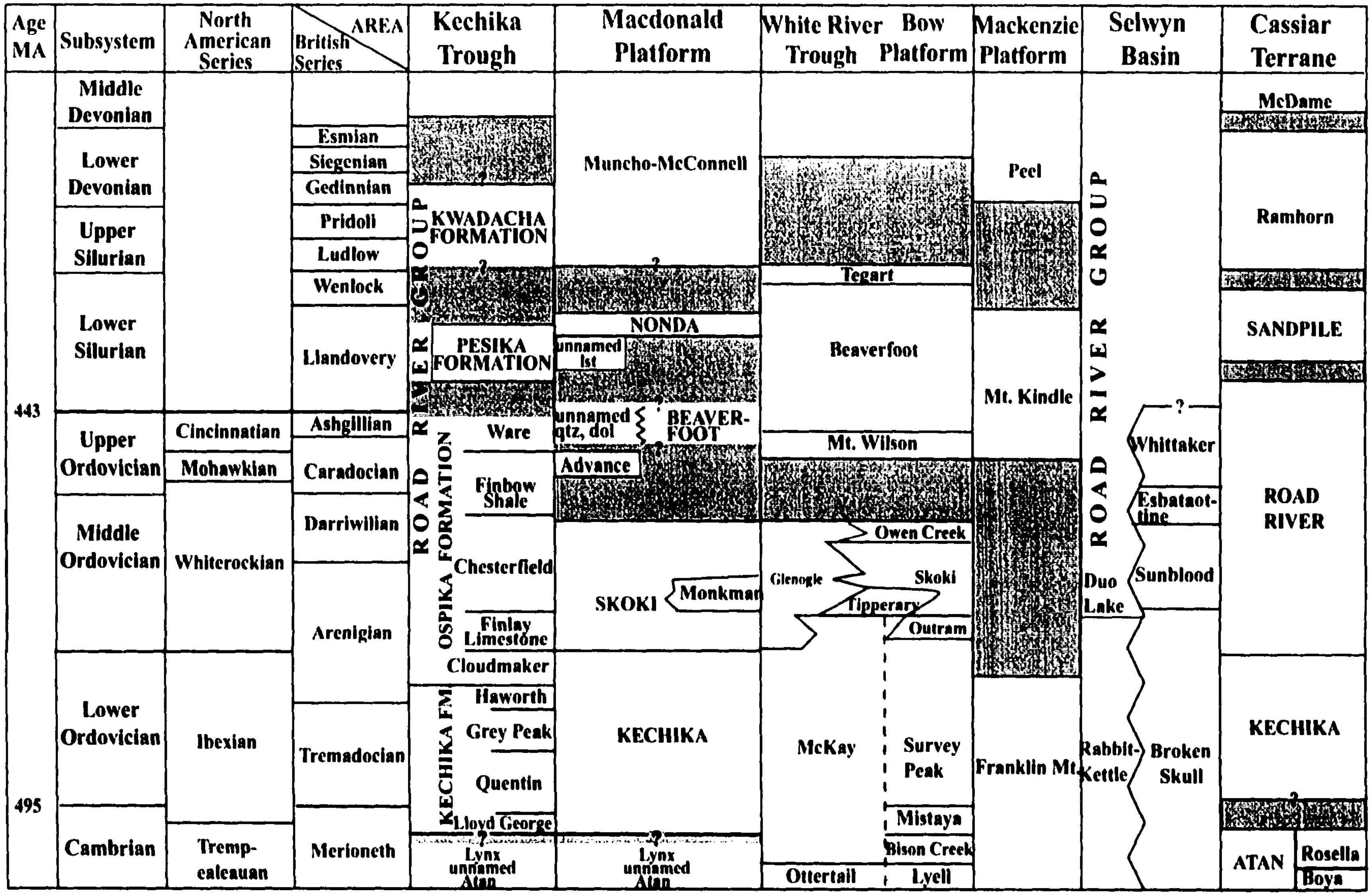


Figure 9. Correlation of lithostratigraphic units. Time scale after Webby (1998) and Cooper and Nowlan (1999), regional correlations for the Kechika Trough and Macdonald Platform modied from Norford (1990), for the White River Trough, Bow Platform, Mackenzie Platform and Selwyn Basin from Gabrielse and Yorath (1991), and for the Cassiar Terrane, from Gabrielse (1998).

study area. The Middle Ordovician platformal strata equivalents in the Mackenzie Platform are carbonates of the Sunblood Formation.

The lateral facies change from Skoki to Road River in the study area is also observed in the south. Just as the Road River overlies the Kechika in the study area, a similar relationship is observed with the McKay and the overlying Glenogle. The lower Glenogle is a time equivalent of the Outram, Tipperary and Skoki (Slind et al., 1994). In the north, the Road River is extensive in the Selwyn Basin although its base has included Cambrian strata within the northeast Selwyn Basin and Richardson Trough and stratigraphic relations are complicated by erosion (Fritz, 1985, Fig. 25.7).

The similarity of Cassiar Platform strata to those east of the NRMT was first discussed by Gabrielse (1967b). The Kechika and Road River both east and west of the NRMT are generally similar, although the overlying Silurian carbonates of the Sandpile and Ramhorn formations differ from the Kwadacha Formation within the study area. Gabrielse (1998) suggested that the Sandpile is correlative with the Nonda and the Ramhorn possibly with the Early Devonian Wokkpash Formation. The Cassiar Terrane has been regarded as displaced northward along the dextral strike-slip fault (Tintina-Northern Rocky Mountain Fault) a minimum of 450 km to 750 km (Gabrielse, 1985) from the Kakwa Platform, or up to 1700 km (Pope and Sears, 1997) as a margin segment from Idaho.

3.4. Sequence Stratigraphy

Superimposed on the record of non-passive margin sedimentation are oscillatory eustatic sea level changes represented by interregional unconformities subdividing the Paleozoic stratigraphic record into three cratonic transgressive-regressive cycles: the Sauk, the Tippecanoe and the lower Kaskaskia Sequences (Sloss, 1963). In the Canadian Cordillera, eustatic platformal cycles have been recognized by Cecile and Norford (1993) as subdivisions of the cratonic Sloss sequences. Cycle A represents the upper third of the Sauk Sequence and resulted from widespread transgression during the Late Cambrian to Early Ordovician. Cycle B approximates the Tippecanoe Sequence and is divided into two subcycles which are separated by an unconformity representing a regression of the latest Ordovician. Cycle C approximates the Lower Kaskaskia Sequence and represents an Upper Silurian transgression.

Much of the succession is cut out by the sub-Devonian unconformity and much of the Lower Paleozoic succession is truncated eastward in the subsurface. The sequence boundaries are well defined and abrupt on the craton and platform but become less distinct in the thicker miogeoclinal successions within the study area where sedimentation was more continuous. The surfaces and units discussed below have regional significance and biostratigraphic control is fundamental in constraining the duration of sequence boundaries. Distinguishing between eustatic and tectonic controls on sea level changes is difficult, however, those surfaces which correspond to cratonic sequence boundaries are attributed to eustatic changes (Fig. 4 and Table A).

In the southern Rockies, Cycle A comprises depositional Grand Cycles from the late Cambrian Bison Creek and Mistaya formations through the Survey Peak, Outram, Skoki and Owen Creek Formations (Cecile and Norford, 1993). In the study area, the Grand Cycle pattern ends with the Kechika (Norford, 1991) and is not as well expressed as in the south, even within the thick sequences of Kechika. The base of the Kechika marks a flooding surface of late Cambrian age. The onset of Cycle A within the Kechika could also be attributed to post-rift thermal subsidence, which is an example of the difficulty in distinguishing the cause of the transgressive phase. The top of Cycle A is within the Skoki and ends with regression and erosion in the late Middle Ordovician (Cecile and Norford, 1993).

The base of Cycle B (Subcycle 1) is drawn at the top of the Skoki (?Caradoc) and perhaps at the base of the Ware Member of the Ospika Formation (Fig. 4). It begins with an upper Ordovician transgression and the cycle is equivalent to the Mount Wilson quartzite in the southern Rockies. Subcycle 2 of Cycle B encompasses lower Silurian deposition of the Nonda, which has an erosional contact at its base and top (Norford, 1991). Within the Kechika Trough, Subcycle 2 is possibly represented by the Pesika Formation, which conformably overlies the Ware Member at Section 4, but has unconformable boundaries elsewhere in the study area.

In addition to sequence bounding unconformities, there are a number of local unconformities within the study area which are attributed to regional tectonic events. At

Section 1, the Kechika is disconformably overlain by the Skoki and marked by a mineralized horizon rich in pyrite. Within the Road River, there are unconformable relationships in which Lower Silurian surfaces cut out units, such as at Grey Peak (sub-Kwadacha) and on the platform (sub-Nonda). However, within Section 4, sedimentation is continuous from the Kechika through to the Kwadacha Formation, except for the Cloudmaker Member of the Ospika Formation. With the exception of this section in the central study area, Silurian erosion is widespread, likely from a period of localized uplift (Cecile and Norford, 1993).

Within the Cassiar Terrane, at the Deadwood Lake Section, the upper unit of thin bedded limestone of the Road River Group is disconformably overlain by massive bedded sandstone and dolostone of the Sandpile Formation.

Unconformable Surface	Age	Cycle	Event / Cause
8. Sub-Devonian	Late Silurian	Base of Cycle C	Eustatic
7. Sub-Nonda	Early Silurian	Base of Subcycle 2, Cycle B	Eustatic
6. Sub-Beaverfoot	Late Ordovician	Base of Subcycle 1, Cycle B	Eustatic
5. Sub-Skoki	Early Arenig	Upper Cycle A	Regional
4. Sub-Kwadacha	?Late Lower Silurian	?Cycle C	Regional
3. Sub-Pesika	Late Ord.-Llandovery	?Base of Subcycle 2, Cycle B	Eustatic or ?Regional
2. Sub-Ospika	Early Arenig	Upper Cycle A	Regional
1. Sub-Kechika	Late Cambrian	Base of Cycle A	Eustatic

Table A. Summary of bounding surfaces shown in Figure 4.

3.5. Regional Tectonic Interpretations

The thickness and abrupt lateral and vertical facies changes within the Lower Paleozoic succession of the northern Cordilleran Miogeocline suggest a history which is more complex than that of a classic passive margin. The detailed stratigraphy and conodont biostratigraphy from an east-west, platform to basin transect provides constraints on the timing of the deposition of the Kechika and Skoki formations and Road River Group.

The Kechika Formation is a westward thickening, platform to outer shelf and basin facies deposited on a broad ramp with gradual lateral facies changes. The Ospika Formation represents a pronounced platform to off-shelf transition with abrupt lateral facies changes from platformal dolostones of the Skoki Formation to the east. The thick sedimentary sequence of the Kechika Formation and Road River Group suggest that both the onset of Kechika and of the Ospika Formation of the Road River Group are possibly attributed to renewed periods of extension of the margin followed by thermal subsidence. The timing of these extensional events is constrained by conodont biostratigraphy as Late Cambrian (base of Kechika) and Early Arenig (base of Road River). Local alkaline volcanics occur within the succession such as those observed near the Kechika-Road River boundary and which also may indicate a phase of extension.

Sequence stratigraphic relationships within the succession include those which correspond to cratonic sequence boundaries, probably with the base of the Kechika as the base of Cycle A and the top of the Skoki and coeval Road River as the base of Cycle B (of Cecile and Norford, 1993). The regressive phase of a post-Skoki unconformity is followed by a late Ordovician transgression represented by the Ware Member. The latter may represent a phase of reactivation and uplift of the Peace River Arch during the late Ordovician. Continuous sedimentation from the Ware Member to the Pesika and Kwadacha formations is localized. More commonly, the Kwadacha Formation unconformably overlies the Ospika Formation indicating Early Silurian erosion.

The Lower Paleozoic stratigraphy of the parautochthonous Cassiar Terrane is generally similar to the successions studied east of the NRMT. However, the conodont fauna from the Kechika and Road River Group of the Cassiar Terrane establishes that the boundary of the Kechika and Road River lies within the *Rossodus manitouensis* Zone (middle Tremadoc), which is older than that observed east of the NRMT (base of the Road River Group within the *Prioniodus elegans* Zone, lower Arenig). The conodont fauna also indicates that the Road River ranges into the Caradoc (*Phragmodus undatus* and *Amorphognathus tvaernesis* zones) at the Deadwood Lake Section.

4. CONODONT PALEONTOLOGY

4.1. Introduction

Conodonts are phosphatic, toothlike microfossils found in marine sedimentary rocks ranging from Middle Cambrian to Late Triassic. They are discrete elements of a feeding apparatus located in the oral region of a soft-bodied chordate described by Briggs et al. (1983). They were discovered and first described by Christian H. Pander (1856). As the biological affinity of the enigmatic microfossils was unknown, Pander and other conodont researchers after him took a taxonomic approach called form taxonomy in which the shape of individual conodont elements was used for generic classification. This approach, which lacked a biological basis, proved useful in recognizing their utility to biostratigraphy as noted by Ulrich and Bassler (1926).

Sweet (1988) provides a detailed historical account of the study of conodonts. A phase critical to biostratigraphy was the advent of multielement taxonomy. Recurrent association of element morphotypes were used to group different elements into one taxon. In principle, this was recognized as early as 1879 by G. J. Hinde who described a variety of elements but assigned them to one taxon. Natural assemblages of conodont elements further advanced the concept of multielement taxonomy since the first description by Schmidt (1934). Recurring discrete elements have been reconstructed into apparatuses by using empirical methods such as by Huckriede (1958) and Walliser (1964). Symmetry transitions of elements, first proposed by Lindström (1964), are the basis of multielement taxonomy.

Multielement taxonomy is used in this study and many recent advancements have been made for simple coniform-coniform apparatuses. The recognition of natural assemblages and the conodont animal have led to proposed suprageneric classification, such as that by Aldridge and Smith (1993) which is followed in this study.

Various schemes for naming homologous positions of elements have been proposed. The most readily used is that of Sweet and Schönlaub (1975) who introduced a notation for element position within an apparatus for the genus *Oulodus*. They proposed using the letters S, M and P: P stands for pectiniform, usually of two types in two pairs, Pa and Pb. The M is the pick-shaped makelliform element comprising a single pair. The S elements for a symmetry transition series, typically filled by four element positions: Sa which is symmetrical, an alate coniform or ramiform; the Sb element which is asymmetrical with unequal lateral processes; the Sc element which is bipennate with anterior and posterior processes or dolabrate with a posterior process. There can be intermediates in this scheme or sometimes an Sd position filled by a quadriramate element.

The application of the S, M, P notation to coniform apparatuses is problematic because of the difficulty in recognizing homologous element positions without known bedding plane assemblages. Purnell et al. (2000) have proposed a new notation scheme using numeric subscripts in the P-S scheme, however, this notation is not followed as few of the taxa in this present study are known from natural assemblages. The notation proposed by Barnes et al. (1979) and modified by Ji and Barnes (1994) which uses a, b, c, e, f, g terminology is more useful for describing apparatus architecture of coniform apparatuses.

4.2 Conodont Paleobiology

The biostratigraphic usefulness of conodonts was noted long before any understanding of the biological affinity of the animal. As this study is devoted to stratigraphic applications of conodonts, the affinities and function of the conodonts and their apparatus are discussed briefly below.

The conodont animal was a soft-bodied chordate with a feeding apparatus of conodont elements, the only mineralized skeletal component, located in the oral region. The soft tissue morphology of the conodont animal is known from specimens from three localities: the Lower Carboniferous Granton Shrimp Bed of Scotland (Briggs et al., 1983; Aldridge et al., 1986; Aldridge et al., 1993), the Lower Silurian Brandon Bridge Dolomite of Wisconsin (Smith et al., 1987) and the Upper Ordovician Soom Shale of South Africa (Aldridge and Theron, 1993; Gabbott et al., 1995). The specimens preserve body musculature, a notochord, a caudal fin, eye capsules with associated musculature and possibly the otic capsules and branchial structures in addition to the complete feeding apparatus in the head region.

The biological affinities of the conodont animal were not understood until the evidence of the whole animal's anatomy emerged, and this, coupled with work on element histology (Sansom et al., 1992) and ongoing studies of apparatus architecture, suggest the conodonts are an extinct group of chordates. Recent cladistic investigations place the conodonts among the agnathans as the earliest vertebrates (Aldridge and Donoghue, 1998; Donoghue et al., 1998).

The paleobiology of conodonts is also studied through evidence of their apparatus architecture known from bedding plane assemblages. Architectural models for ozarkodinids (Purnell and Donoghue, 1997; Purnell and Donoghue, 1998) and prioniodontids (Stone and Geraghty, 1994; Aldridge et al., 1995) provide glimpses of the arrangement and function of elements within some taxa. Further studies on growth, function and feeding mechanisms include those by Purnell, (1994; 1995) and Donoghue and Purnell (1999).

4.3. Previous Work: Conodont and Graptolite Biostratigraphy

The utility of conodonts as biostratigraphic tools stems from their rapid evolution and abundance in marine rocks of Middle Cambrian to Late Triassic age. Their biostratigraphic usefulness was noted long before an understanding of the conodont animal developed, and first described by Bassler (1925) and Ulrich and Bassler (1926). Sweet (1988) provided an account of the evolution of conodont research.

In the northern Canadian Cordillera, previous work on Lower Paleozoic conodont biostratigraphy has been based on some small Cambrian to Devonian collections made in the study area during regional mapping projects. Pohler and Orchard (1990) reported on 59 Ordovician conodonts assigned to 17 species from the Kechika Trough and on 3 species identified from the Cassiar Terrane. Reports on conodont collections from Road River strata in the Yukon and Northwest Territories, the northern equivalents of the Kechika Formation, are reported by McCracken and Lenz (1987) and McCracken (McCracken and Lenz, 1987; McCracken, 1989a; McCracken, 1989b; McCracken, 1991) and Pohler and Orchard (1990).

Unpublished paleontological reports of the Geological Survey of Canada contain information on conodont and graptolite collections from Grey Peak and the Kechika Formation adjacent to the study area in the northern Cordillera. Nowlan (unpublished reports, 1983; 1995) lists conodonts identified from one Road River sample from Grey

Peak and from three samples from the Kechika from Mount Sheffield. Tipnis (unpublished report, 1979) reported ages of Grey Peak conodonts to range from Cambrian to Early Ordovician, however, these collections have been misplaced. Orchard (unpublished report, 1995) reported on sparse faunas from 11 samples from the Kechika River (94L) map area, four of which were from Ordovician Kechika and Road River.

Jackson (unpublished report, 1980) reported on graptolites from the Grey Peak section, near the top of the Kechika, ranging from late Tremadoc to early Arenig. Data from these reports are included in the discussion of each lithostratigraphic unit. Information from the existing graptolite zonation for the region are integrated with the conodont data where possible based on Jackson's (1980) report, the unpublished thesis by Davies (1966) and Lower to Middle Ordovician graptolite zonation by Lenz and Jackson (1986).

5. BIOSTRATIGRAPHY

5.1. Conodont Biostratigraphy and Provinciality

The correlation of shallow and deep water facies is complicated by the provincialism of conodonts in the Ordovician as first noted by Sweet et al. (1959) and Sweet and Bergström (1962). In the Tremadoc, two faunal realms, the Atlantic and North American Midcontinent realms, are distinguished and a biozonation is proposed for each (Fig. 10). Provincialism is controlled by ecologic factors in which conodont faunas are adapted to warmer, more saline waters (Midcontinent) or cooler waters of normal salinity (Atlantic) (Pohler and Barnes, 1990).

The zonation for the Atlantic Realm has been well established from the Baltic area of Europe (Bergström, 1971; Lindström, 1971; van Wamel, 1974; Löfgren, 1978; Löfgren, 1985; Löfgren, 1994; Löfgren, 1995; Löfgren, 1996) and from Newfoundland (Bagnoli et al., 1987; Pohler et al., 1987; Barnes, 1988; Stouge and Bagnoli, 1988; Johnston and Barnes, 1999). The zonation for the Lower Ordovican Midcontinent Realm was informally established by Ethington and Clark (1971; 1981) and Repetski (1982) and for the Cambro-Ordovican boundary by Miller (1980; 1984; 1988) in the southwestern United States. A significant contribution was made by Ji and Barnes (1994) who established eight shallow water Assemblage Zones and six deeper-water Lineage Zones for the St. George Group, western Newfoundland. Correlation of the ten lineage and assemblage zones for the Survey Peak Formation established by Ji and Barnes (1996) is possible with the Lower Ordovician zones proposed herein. Ross et al. (1997) proposed a revised conodont zonation for the Ibexian strata of Utah which is used as the standard in Figure 10.

5.2. Preservation of Conodont Fauna

The majority of the conodonts recovered are well preserved. Those from the Kechika Formation are the most well preserved and numerous, especially within the Mt. Sheffield Section (Section #13). Those from the Skoki Formation and Road River Group, particularly from dolomitic facies, are less pristine, bearing crystal overgrowths and commonly broken, but identifiable. The conodont faunas are most diverse and abundant within the platform and shelf facies of the Kechika and Skoki formations and less diverse and abundant within basinal Road River Group equivalents. Samples from basinal facies of the Kechika and Road River from three localities in the Kechika Trough were sparse to barren. Of the 405 samples collected, 142 were productive, yielding 39 526 conodont elements (Appendix C). Yields from productive samples ranged from less than 10 to over 2000 per sample.

The colour alteration index (CAI) of conodonts was quantified by Epstein et al. (1977) by experimental calibration and a scale was proposed ranging from values for pale yellow elements (CAI 1) through light and dark brown to black (CAI 5). Rejebian et al. (1987) extended the calibration to CAI 6-8 for black to grey (CAI 6), white (CAI 7) and clear (8). The CAI of an element is time and temperature dependent and occurs due to loss of organic matter and degradation of crystalline structure as temperatures increase (Epstein et al., 1977). The CAI values of the specimens in the study area range from 3 to 5 indicating burial temperatures of 110°-200° to over 300°. The highest values are those in the Moodie Creek Section, which is in close proximity to the NRMT and a carbonatite occurrence (Pell, 1994).

5.3. Conodont Zonation

Based on the conodont data from the most productive sections, that is, Sections 1, 4, 5, 13 and Grey Peak, the stratigraphic ranges of conodonts have been plotted to determine the proposed zonation (Appendix B).

In this study, 10 zones, some with subzones, are defined based on the Midcontinent Realm faunas and 13 zones are defined based on the Atlantic Realm faunas. Two sets of zones, those for shallow, warm water Midcontinenent and those for colder water Atlantic Realm faunas are proposed for precise correlation of strata where mixing of the two realms occurs. New zones are named in accordance with the North American Stratigraphic Code (Hedberg, 1976). The zones for the Cambrian-Ordovician boundary, that is the *Cordylodus* zones and *Iapetognathus* Zone, are useful in both realms and are discussed first. Some zones do not have a defined base because of breaks in some sections and their base is therefore indicated by a dashed line in Figs. 10 and 11. The use of subzones is proposed to further refine zones based on the expanded stratigraphic sequences preserved in the study area. The zones are described in ascending stratigraphic order and shown in Figures 10 and 11. Those zones and subzones which are new are indicated and those which correspond to the standards are defined based on reference sections from the study area. In the following section, a comparison of the zones recognized and proposed in this study to that of the standard is discussed.

5.3.1. Cosmopolitan Zones

The following zones are based on taxa which are cosmopolitan in their distribution.

Eoconodontus Zone

Definition.—The base of the zone is defined as the the first appearance of *Eoconodontus notchpeakensis* (Miller) and was originally proposed as a subzone by Miller (1980) and as a zone by Miller (1988).

Reference section.—Section 13, (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone is taken at 10.5 m above the point where measurement of the Lloyd George Member began (sample 96-13-C2). However, the contact with underlying Cambrian strata was not observed, and as data comes from one sample only, the top of the zone and therefore thickness of the zone has not been determined.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *E. notchpeakensis* and level of appearance of *Cordylodus proavus* Müller.

Discussion.—Miller (1988) proposed the *Eoconodontus* Zone in Utah as comprising a lower *E. notchpeakensis* Subzone and *Cambrooistodus minutus* Subzone. The latter of these subzones is not recognized, and as conodont data come from one sample, the occurrence within the Lloyd George Member of the Kechika Formation is assigned to the *Eoconodontus* Zone rather than to a subzone.

Cordylodus proavus Zone

Definition.—The base of the zone is defined as the first appearance of *Cordylodus proavus* and was emended to include subzones by Miller (1988).

Reference section.—Grey Peak (57° 48'N, 125° 13'W), Ware map-area. The zone includes strata 112 m above the base of the measured section and 66 m above the base of the Lloyd George Member of the Kechika Formation (sample GP-94-6-6). As data comes from one sample only, the base and top of the zone and therefore thickness of the zone has not been determined.

Discussion.—The zone marks the appearance of *C. proavus* and has been divided into subzones for strata in the type area of the Ibex (Miller, 1988; Ross et al., 1997). Although the total thickness of the zone has not been determined in this study, a number of important species occur with *C. proavus* at its first occurrence in the Kechika Formation. These include the continuation of *E. notchpeakensis* and *Protoconodontus muelleri* Miller from strata below, *Cordylodus primitivus* Bagnoli Barnes and Stevens, *C. hastatus* Barnes, *C. deflexus* s. f. Bagnoli, Barnes and Stevens and *Teridontus nakamurai* (Nogami).

IAPETOGNATHUS ZONE

Definition.—The base of the zone is defined as the first appearance of *Iapetognathus aengensis* (Lindström) and *I. fluctivagus* Nicoll et al. and was proposed by Nicoll et al. (1999).

Reference section.—Section 13, (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone is not constrained but taken at 0 m within limestone of the Quentin Member of the Kechika Formation (sample 96-13-A1) after a section break where measurement for the Kechika begins. The zone is at least 154.5 m thick and occurs in the lower part of the Quentin Member. The top of the zone is not constrained because an interval of 110 m within the Quentin Member comprises a covered interval and a sampled interval which yields long ranging species from the *Iapetognathus* Zone, but no species of *Iapetognathus*.

Type of zone.—The zone is an interval zone based on the first appearance of *I. fluctivagus*.

Discussion.— Nicoll et al. (1999) discuss the importance of the *Iapetognathus* Zone in defining the base of the Ordovician and the utility of this cosmopolitan genus for global correlation. The zone is characterized by species of *I. aengensis* and *I. fluctivagus* and *I. sprakersi* Landing appears in younger strata, as observed in the Ibex area, Utah. *Cordylodus lindstromi* Druce and Jones appears at the same level as *I. fluctivagus* so there is no evidence for a sequential nature of these zones. Nicoll et al. (1999) indicate the two species are likely coincident but maintained a *C. lindstromi sensu lato* zone due to the different interpretations of *C. lindstromi*.

Other important taxa occur in the zone such as *Cordylodus caboti* Bagnoli, Barnes and Stevens, *C. caseyi* Druce and Jones and *C. delicatus* n. sp., *Utahconus utahensis* Miller and *Semiacontiodus nogamii* (Miller).

5.3.2. Midcontinent Realm Zones

Ten Midcontinent Realm Zones are recognized in the Kechika and Skoki formations of which five are new.

POLYCOSTATUS FALSIONEOTENSIS ZONE, NEW

Definition.—The base of the zone is defined as the the first appearance of *Polycostatus falsioneotensis* Ji and Barnes and is a new zone.

Reference section.—Section 13 (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs within the upper part of the Quentin Member at 264.5 m above the base of the section (sample 96-13-A10). The top of the zone coincides with a covered interval below the base of the Grey Peak Member, at 325 m, so that the zone is 60.5 m thick.

Type of zone.—The zone is an interval zone, ranging between the level of first occurrence of *P. falsioneotensis* and the first occurrence of *Rossodus tenuis* (Miller).

Discussion.—*P. falsioneotensis* has been reported mainly from the Midcontinent Realm of North America (Landing and Barnes, 1981; Nowlan, 1985; Ji and Barnes, 1994) and also from China (Zhang in An et al., 1983). Ji and Barnes (1994) defined a *P. falsioneotensis-R. tenuis* Zone, however, *R. tenuis* occurs in younger strata at the reference section and its first occurrence marks the level of the overlying *R. tenuis* Zone.

There is lower species diversity through the *P. falsioneotensis* Zone and no new species appear. Of the species ranging from strata below, *Teridontus nakamurai* (Nogamii) and *T. gracillimus* Nowlan occur at the level of first appearance of *P. falsioneotensis*. *Utahconus utahensis* and several long ranging species of *Cordylodus* range through the zone. The zone is partly coeval with the *C. angulatus* Zone.

ROSSODUS TENUIS ZONE, NEW

Definition.—The base of the zone is defined as the first appearance of *Rossodus tenuis* and is a new zone.

Reference section.—Section 13 (57° 42'N, 124° 35'W). The base of the zone coincides with the base of the Grey Peak Member, 430 m above the base of the section (sample 96-13-A14). The zone is a 21 m thick interval.

Type of zone.—The zone is an interval zone extending from the first appearance of *R. tenuis*, to the level of the appearance of its descendant, *R. manitouensis*.

Discussion.—*R. tenuis* is a Midcontinent Realm species reported from western Newfoundland (Ji and Barnes, 1994), Western United States (Miller, 1980 and Taylor and Landing, 1982) and from China (Wang, 1984). The zone is characterized by the appearance of its nominate species and the first appearance of *Variabiloconus spurius* Ethington and Clark. Characteristic species include *Variabiloconus bassleri* (Furnish) and *Utahconus longipinnatus* Ji and Barnes. It is coeval with the middle part of the *C. angulatus* Zone. The zone contains long ranging species such as *C. caseyi, C. lindstromi, C. delicatus, C. intermedius* and *Drepanoistodus pervetus*. *R. tenuis* is considered an immediate predecessor of *R. manitouensis* and is therefore useful to distinguish strata underlying the first appearance of *R. manitouensis*.

ROSSODUS MANITOUENSIS ZONE
ROSSODUS MUSKWAENSIS SUBZONE, NEW
ROSSODUS SHEFFIELDENSIS SUBZONE, NEW

Definition.—The base of the zone is defined as the first appearance of *Rossodus manitouensis* which was designated by Landing et al. (1986). The base of the *Rossodus muskwaensis* Subzone is defined by the first appearance of *R. muskwaensis* n. sp. in association with *R. manitouensis* and is a new subzone. The base of the *R. sheffieldensis* Subzone is defined by the first appearance of the nominate species in association with *R. manitouensis* and is a new subzone.

Reference section.—Section 13 (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area). The base of the zone is at 451 m above the base of the section (sample 96-13-A15). The zone can be divided into subzones after a covered interval with the base of the *R. muskwaensis* Subzone at 679 m (sample 96-13-B1), which is 57 m thick. The *R. sheffieldensis* Subzone occurs at a level 736 m above the base of the section (sample 96-13-B3) and is 97 m thick. The total thickness of the *R. manitouensis* Zone is 382 m.

Type of zone.—The zone is an interval zone extending from the first appearance of *R. manitouensis* to that of the level of the Low Diversity Interval, which is marked by the diappearance of *R. manitouensis*. The *R. muskwaensis* Subzone is an interval zone extending from the first appearance of *R. muskwaensis* to the level of the first appearance of *R. sheffieldensis* which marks the next subzone.

Discussion.—The *R. manitouensis* Zone was established by Landing et al. (1986) as a North American biostratigraphic unit for marginal and open shelf sequences. It is equivalent to Fauna C of Ethington and Clark (1971) and has mainly been reported from North America, however Lofgren et al. (1998) reported *R. manitouensis* in low abundance from the P. deltifer Zone in Baltoscandia.

The division of the *R. manitouensis* Zone into two subzones provides refinement of the upper part of the Zone. The lower part of the Zone is characterized by the appearance of *R. manitouensis* which occurs with *R. tenuis* and *V. spurius, V. bassleri* and *U. longipinnatus*. Species of *Cordylodus* also range through the Zone, including *C. angulatus, C. intermedius, C. lindstromi, C. caseyi* and also *Drepanoistodus pervetus* and *Utahconus utahensis*. The top of the Zone is characterized by the disappearance of all of these species but the latter two and *Acanthodus lineatus*, which range into the overlying Low Diversity Interval.

The termination of several lineages at the top its Zone has been noted by Ethington and Clark (1982) and Ji and Barnes (1994) and is not only evident among the long ranging species, but among new species which are introduced in both of the upper subzones. The *R. muskwaensis* Subzone is characterized by the first appearance of *Laurentoscandodus* cf. *L. triangularis* (Furnish), *Tricostatus terilinguis* n. sp. and *Striatodontus strigatus* n. sp.

New appearances within the *R. sheffieldensis* Subzone include *Striatodontus prolificus, Polycostatus* cf. *P. sulcatus*, *Macerodus lunatus* n. sp., *Macerodus cristatus* n. sp., *Rossodus subtilis* n. sp. and *Paltodus deltifer*. The Subzone is coeval with the *Paltodus deltifer* Zone.

Low Diversity Interval

Definition.—The interval is an informal zone designated by Ethington and Clark (1982) for an interval of less diverse and abundant conodonts.

Reference section.—Section 13 (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone is at 833 m above the base of the section (sample 96-13-B7). The zone is 30 m thick.

Type of zone.—The zone is an informal interval zone which coincides with the disappearance of *Rossodus manitouensis* at its base and ranges to the first appearance of *Scolopodus subrex*.

Discussion.—The interval is characterized by the low number and diversity of taxa in which only a few long ranging species such as *Utahconus utahensis* and *Rossodus tenuis* from the underlying *R. manitouensis* Zone range. *Paroistodus numarcuatus* (Lindström) occurs within this zone and the first appearance of *Drepanoistodus nowlani* Ji and Barnes at the base of the zone is useful for correlation with the deeper water *D. nowlani* Zone. In Utah, Ethington and Clark (1982) did not define a zone for this interval due to the appearance of long ranging taxa only, and Ross et al. (1997) followed this designation, suggesting the zone is equivalent to the lower part of Fauna D (Ethington and Clark, 1971).

Scolopodus subrex Zone, new
Graciloconus concinnus Subzone, new
Colaptoconus bolites Subzone, new

Definition.—The base of the zone is defined as the level of the first appearance of *Scolopodus subrex*. The base of the *Graciloconus concinnus* Subzone is defined as the level of the first appearance of *Graciloconus concinnus* n. gen. n. sp. and the overlying *Colaptoconus bolites* Subzone is marked by the first appearance of *Colaptoconus bolites* (Repetski).

Reference section.—Section 13 (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone is at 863 m above the base of the section (sample 96-13-B8). The base of the *G. concinnus* Subzone is at 923 m above the base of the section (sample 96-13-B10) and is 367 m thick. It spans the upper part of the Grey Peak

Member and into the Haworth Member. The base of the *C. bolites* Subzone is at 1230 m above the base of the section (sample 96-13-B16) within the uppermost Haworth Member. The upper boundary of the subzone is not determined because of an overlying covered interval and an interval of shale, both at the base of the Mt. Sheffield Member.

Type of zone.—The zone is an interval zone extending from the first appearance of *Scolopodus subrex* to the first appearance of *Acodus kechikaensis* n. sp. The *G. concinnus* Subzone is an interval zone extending from the first appearance of *G. concinnus* to the first appearance of *C. bolites*. The *C. bolites* Subzone is an interval zone extending from the first appearance of *C. bolites*.

Discussion.—As discussed by Ji and Barnes (1994), *S. subrex* is the Midcontinent Realm form which differs from the younger Atlantic realm *S. rex* (see Systematics). *S. subrex* occurs in North America (e. g. Ji and Barnes, 1994, 1996) and also has been reported from Korea (Lee 1970, 1975). As a new genus and species, *G. concinnus* is reported as a Midcontinent Realm species which occurs in platformal and marginal shelf facies. *C. bolites* has been reported by Ji and Barnes (1994) and Repetski (1982).

The zone is characterized by an assemblage including abundant *S. subrex*, ?*Paltodus jemtlandicus* Löfgren, and *Paroistodus proteus* throughout the zone. The *S. subrex-G. concinnus* Subzone is characterized by the appearance of *Kallidontus princeps* n. gen. n. sp., *Colaptoconus greypeakensis* n. sp. and *C. quadraplicatus* (Branson and Mehl) and *Semiacontiodus* cf. *S. cornuformis* (Sergeeva). The *S. subrex-C. bolites* Subzone is coeval with the *Paracordylodus gracilis* Zone and is characterized by the appearance of *C. floweri* (Repetski), and long ranging taxa such as *Parapanderodus striatus* (Graves and Ellison), *Cornuodus longibasis* (Lindström), and *Eucharodus parallelus* (Branson and Mehl). The *Scolopodus subrex* Zone is equivalent to the deeper water *Acodus deltatus* and *Paroistodus proteus* zones.

ACODUS KECHIKAENSIS ZONE, NEW
KALLIDONTUS SERRATUS SUBZONE, NEW; *DIAPHOROUS RUSSOI* SUBZONE, NEW
KALLIDONTUS NODOSUS SUBZONE, NEW

Definition.—The base of the zone is defined as the level of the first appearance of *Acodus kechikaensis* n. sp.. The base of the *Kallidontus serratus* Subzone is the level of the first appearance of *Kallidontus serratus* n. gen. n. sp. The base of the *Diaphorodus russoi* Subzone is the level of the first appearance of the nominate species. The base of the *Kallidontus nodosus* Subzone is the level of the first appearance of the nominate species.

Reference section.—Section 13 (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone is at 1444.5 m above the base of the section (sample 96-13-B21). It is 262 m thick. The base of the *Kallidontus serratus* Subzone is at 1518 m above the base of the section. It is 75 m thick. The base of the *Diaphorodus russoi* Subzone is at 1593 m above the base of the section. It is 30 m thick. The base of the *Kallidontus nodosus* Subzone is at 1623 m above the base of the section. It is 83.5 m thick.

Type of zone.—The zone is an interval zone extending from the first appearance of *A. kechikaensis* n. sp. to the first appearance of *O. communis*. Each subzone is an interval zone based on the first appearance of the nominate species.

Discussion.—As discussed within the Systematics, *A. kechikaensis* n. sp. is broadly similar to Australian forms reported by McTavish (1973) but is here considered to be a new North American form, reported also by Ethington and Clark (1982). It extends into deeper water facies but is dominant in shallow water facies. The species which designate the subzones are from a new genus, *Kallidontus*, which is most abundant in shelf facies but also extends into platformal and off-shelf facies. *D. russoi* has been reported from North America by Repetski (1982), from the Argentine Precordillera by Serpagli (1974) and Albanesi (1998) and from Greenland by Smith (1991).

The zone is characterized by an assemblage including the first appearances of *Tropodus australis, Paroistodus parallelus* and *Fahraeusodus marathonensis* and *Kallidontus serratus* n. gen. n. sp. The first appearances of *D. russoi* coincides with that of *A. longibasis* and with *Oelandodus elongatus* and *Stolodus stola*. The *D. russoi* Subzone is coeval with *Oelandodus elongatus* Subzone of the *P. gracilis* Zone. The *K. nododus* Subzone includes the first appearances of *Acodus neodeltatus, Oistodus lanceolatus, Drepanoistodus amoenus* and *Prioniodus elegans* and is coeval with the lower *Prioniodus elegans* Zone. Long ranging taxa within the zone include *Cornuodus longibasis, Scolopodus krummi* and *Paracordylodus striatus.*

OEPIKODUS COMMUNIS ZONE
TROPODUS SWEETI SUBZONE, NEW
BERGSTROEMOGNATHUS EXTENSUS SUBZONE, NEW
JUANOGNATHUS VARIABILIS SUBZONE, NEW

Definition.—The base of the zone is defined as the level of the first appearance of *Oepikodus communis*, established by Repetski and Ethington (1983). Each of the subzones are new and based on the first appearance of the nominate species.

Reference section.—Section 5 (57° 30'N, 124° 26'W), Ware map area. The base of the zone is not observed but sample 96-5-K1 (0 m) is within the zone, which is at least 339 m thick. At Section 13 (57° 42'N, 124° 35'W) the base of the zone is at 1706.5 m above the base of the section (sample 96-13-B28) and lies within the platy limestone of the upper Mt. Sheffield Member of the Kechika Formation and ranges into the Skoki Formation. It at least 264 m thick at Section 13, but the top of the zone is not observed.

At Section 5, the base of the *Tropodus sweeti* Subzone occurs at 44 m above the base of the Skoki Formation (sample 96-5-3). It is 70 m thick. The base of the *Bergstroemognathus extensus* Subzone occurs at 114 m above the base of the Skoki Formation (sample 96-5-6). It is 80 m thick. The base of the *Juanognathus variabilis* Subzone occurs at 194 m above the base of the Skoki Formation (sample 96-5-8). It is 145 m thick. All of these subzones lie within the Sikanni Chief Member of the Skoki Formation.

Type of zone.— The zone is an interval zone extending from the level of the first appearance of *Oepikodus communis* to the level of the first occurrence of *Jumudontus gananda*. Each of the subzones is base on the first appearances of *Tropodus sweeti* (Serpagli), *Bergstroemognathus extensus* Serpagli and *Juanognathus variabilis* Serpagli, respectively.

Discussion.—The *O. communis* Zone is widely recognized in North America (Ross et al., 1997), established by Repetski and Ethington (1983), which is equivalent to the lower part of Fauna E of Ethington and Clark (1971).

The zone includes characteristic species in each subzone as well as some long ranging species from the *A. kechikaensis* Zone below. The *T. sweeti* Subzone includes species which range from below such as *Fahraeusodus marathonensis* (Bradshaw), *Tropodus australis* (Serpagli) and *Oepikodus intermedius* (Serpagli). The *B. extensus* Subzone includes species which range from below and the first appearance of *Prioniodus adami* Stouge and Bagnoli. Species characteristic of the *J. variabilis* Subzone include *Periodon selenopsis* (Serpagli), *P. flabellum* (Lindström), *P. aculeatus* Hadding, *Oistodus multicorrugatus* Harris, *Protoprioniodus nyinti* Cooper, *P. cowheadensis* Stouge and Bagnoli, *Juanognathus jaanussoni* Serpagli and *Planusodus gradus* n. gen. n. sp.

JUMUDONTUS GANANDA ZONE, NEW

Definition.—The base of the zone is defined as the level of the first appearance of *Jumudontus gananda* Cooper and is new.

Reference section.— Section 5 (57° 30'N, 124° 26'W), Ware map area. The lower boundary of the zone occurs at 339 m above the base of the Skoki Formation (sample 96-5-15) and the top is at 343.5 m (sample 96-5-15A). The zone is 4.5 m thick and lies within the uppermost Sikanni Chief Member.

Type of zone.— The zone is an interval zone extending from the level of the first appearance of *Jumudontus gananda* to the level of the first appearance of *Tripodus laevis* Bradshaw.

Discussion.—This zone is used instead of the *Reutterodus andinus* Zone proposed by Ross et al., (1997) as *J. gananda* is an associated species in that zone. They have based the *R. andinus* zone on the occurrence of coniform elements assigned to that species, which have herein been assigned to *T. sweeti*. *J. gananda* is not usually an abundant species, but is a common taxon in the early Arenig in several areas of the world. In Australia, it has been reported from the Horn Valley Siltstone, Amadeus Basin (Cooper, 1981) and Canning Basin (Nicoll, 1992). Other occurrences include those within the Precordilleran Argentina (e. g., Serpagli, 1974, Albanesi, 1998), Scotland (Ethington and Austin, 1991), Baltocandia (Bergström, 1988), and southwest United States (Ethington and Clark, 1982; Repetski, 1982).

Characteristic species within the zone include the first appearances of *Protoprioniodus* n. sp., *Microzarkodina* n. sp. and *Drepanoistodus forceps* (Lindström) as well as long ranging species from the underlying *O. communis* Zone.

TRIPODUS LAEVIS ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Tripodus laevis* and was defined by Ross et al. (1997).

Reference section.— Section 5 (57° 30'N, 124° 26'W), Ware map area. The lower boundary of the zone occurs at 353 m above the base of the Skoki Formation (sample 96-5-16A) and is at least 249.5 m thick, however, the top of the zone has not been defined in this study. The zone ranges from the upper part of the Sikanni Chief Member and into the Keily Member.

Type of zone.—The zone is an interval zone extending from the level of the first appearance of *Tripodus laevis.*

Discussion.—The base of this zone has been used to define the base of the Whiterockian and Middle Ordovician Series in the Ibex area (Webby, 1998). Characteristic species in the zone include *Protoprioniodus aranda* Cooper, *Pteracontiodus cryptodens* (Mound) and *Ansella jemtlandica* (Löfgren).

PHRAGMODUS UNDATUS ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Phragmodus undatus* Branson and Mehl as proposed by Sweet (1984).

Reference section.—Deadwood Lake Section, (59° 01' N, 128° 23'W), SW end of Deadwood Lake, Cry Lake map-area. The base of the zone is 478.5 m above the base of the measured section and 413 m above the base of the Road River Group (sample DL-96-27). The top of the zone is not constrained as it is cut by a disconformity, but is at least 15.5 m thick.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Phragmodus undatus.*

Discussion.—The zone is well known and widespread throughout the Midcontinent Realm (Sweet, 1984). Characteristic species which appear with the nominate species include *Panderodus sulcatus* (Fåhræus), *Protopanderodus liripipus* Kennedy, Barnes and Uyeno, *Plectodina tenuis* (Hinde) and *Pseudooneotodus mitratus* (Moskalenko).

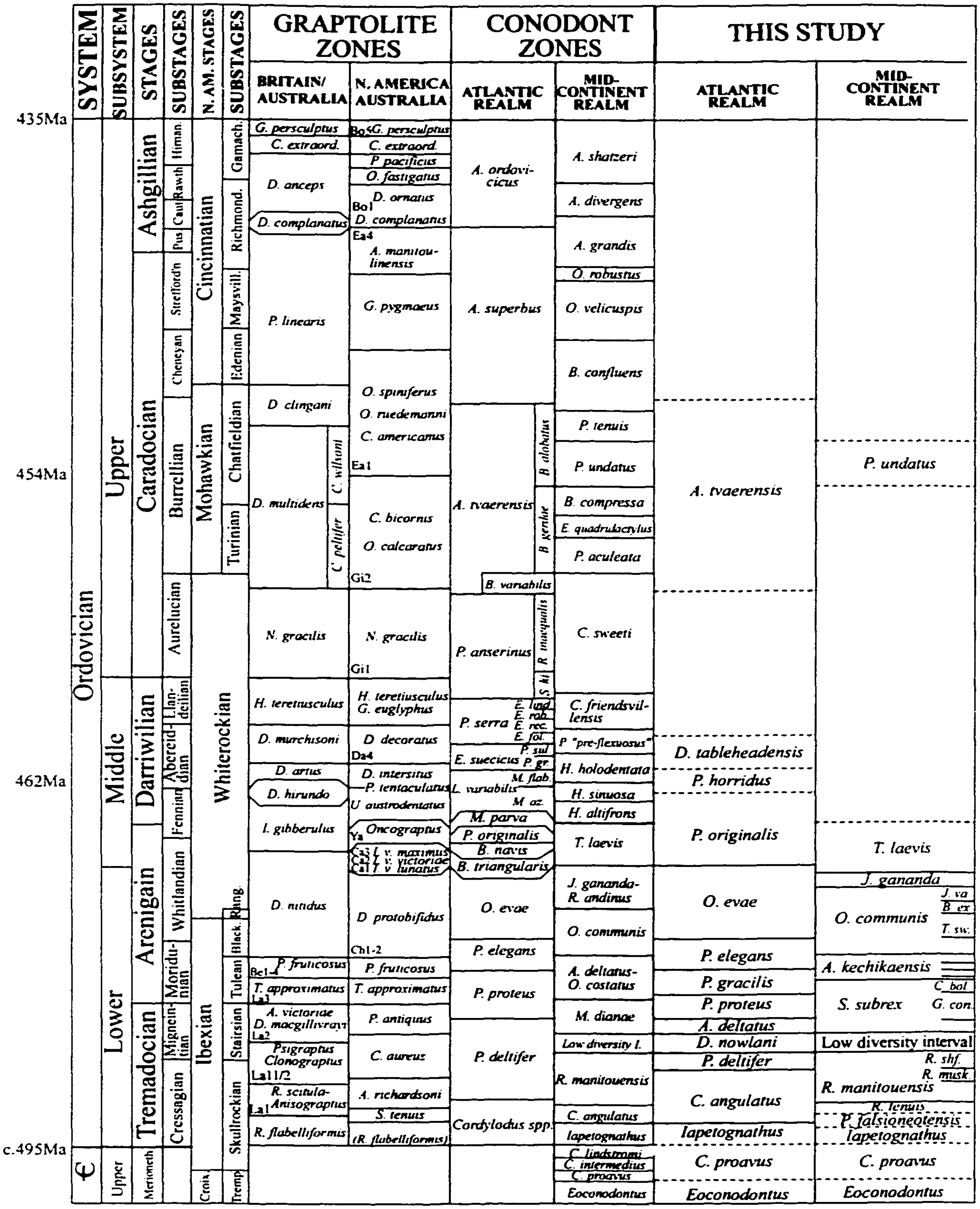


Figure 10. Biostratigraphic correlation chart for the Ordovician System. Conodont and graptolite zones after Fortey et al. (1995), Harris et al. (1995), Webby et al. (1995) and time scale after Webby (1998) and Cooper and Nowlan (1999). See figure 11 for full names of abbreviations used for subzones from this study. (Tremp.=Trempealeauan).

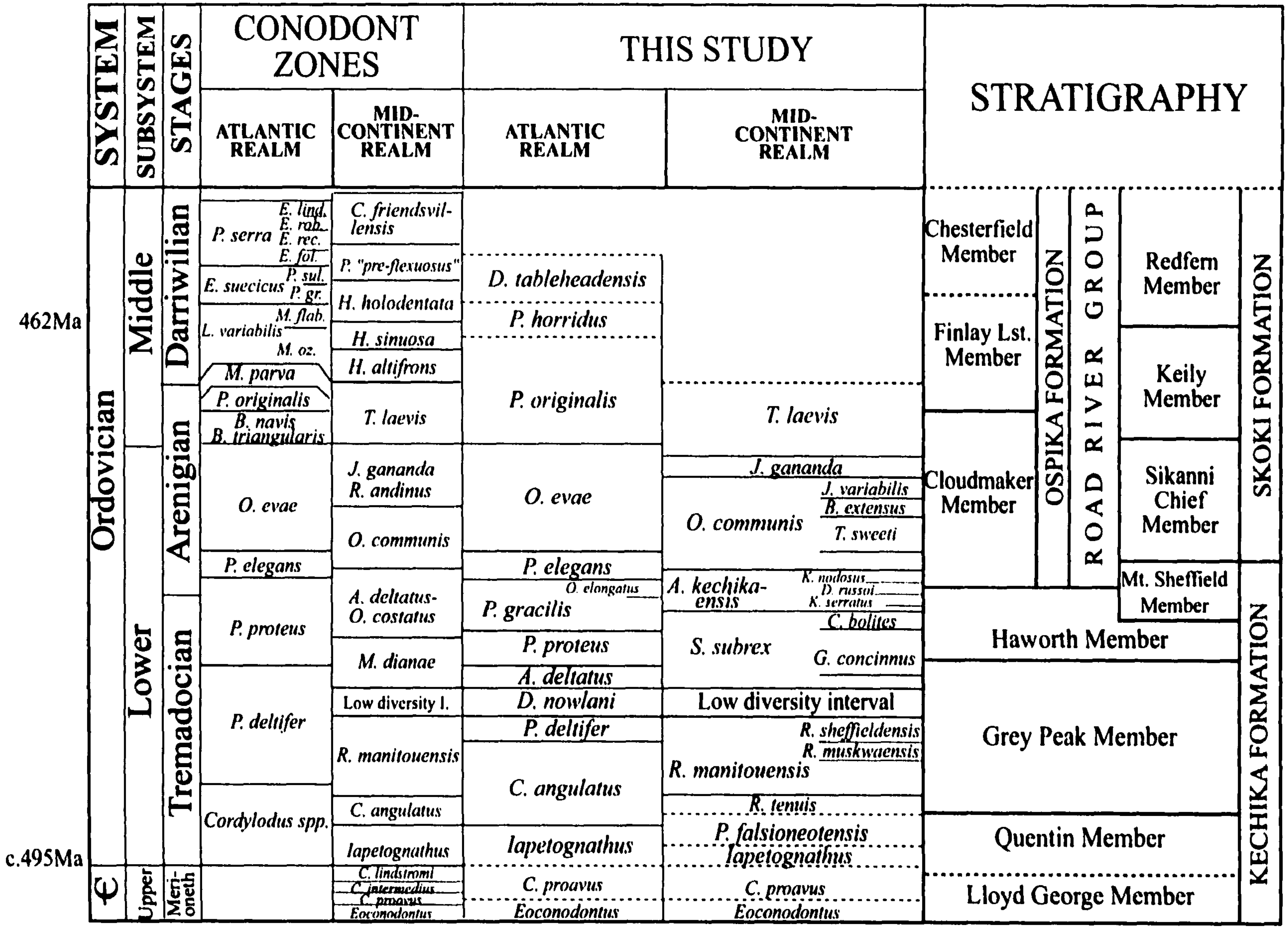


Figure 11. Conodont biostratigraphy of the Kechika, Skoki and Ospika formations compared to the standard Atlantic and Micontinent Realm Conodont Zones from Figure 10.

5.3.3. Atlantic Realm Zones

Thirteen cooler water Atlantic Realm zones are recognized and some redefined for the Kechika Formation and Road River Group.

Cordylodus angulatus Zone

Definition.—The base of the zone is defined as the the first appearance of *Cordylodus angulatus* as proposed by Miller (1988).

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 305.5 m above the base of the section (sample 96-13-A12). It is 430.5 m thick and ranges through the upper part of the Quentin Member into the Grey Peak Member.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *C.angulatus* to the level of the first occurrence of *P. deltifer* (Lindström).

Discussion.—This zone was proposed as a Midcontinent Realm zone which underlies the *R. manitouensis* Zone and equivalent to the upper part of Fauna B (of Ethington and Clark, 1971) by Ross et al. (1997). In this study, it is defined as a deeper water zone which is equivalent to the upper part of the *P. falsioneotensis* Zone, *R. tenuis* Zone, and all but the upper part of the *R. manitouensis* Zone. *C. angulatus* is a cosmopolitan species which occurs in abundance in both platformal and off-shelf facies, but is proposed to define a deeper water zone and provide tie-points to the Midcontinent Realm zones. The species which range in those zones occur with *C. angulatus* and are not listed again here.

Paltodus deltifer Zone

Definition.—The base of the zone is defined as the first appearance of *Paltodus deltifer* as proposed by Lindström (1971).

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 736 m above the base of the section (sample 96-13-B3). It is 97 m thick and lies within the middle of the Grey Peak Member of the Kechika Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *Paltodus deltifer* to the level of the first occurrence of *Drepanoistodus nowlani.*

Discussion.— Although *P. deltifer* occurs in low abundance, it provides correlation to the upper part of the Midcontinent *R. manitouensis* Zone. The *P. deltifer* Zone is well established in Sweden (e. g., Lindström, 1955; Löfgren, 1985; Bagnoli et al., 1988) and occurs in low abundance from the Argentine Precordillera as reported by Albanesi (1998). The *Paltodus deltifer* Zone is coeval with the *R. sheffieldensis* Subzone of the *R. manitouensis* Zone.

DREPANOISTODUS NOWLANI ZONE, NEW

Definition.—The base of the zone is defined as the first appearance of *Drepanoistodus nowlani* and is a new zone.

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area). The base of the zone occurs at 833 m above the base of the section (sample 96-13-B7). It is 30 m thick and occurs within the middle of the Grey Peak Member of the Kechika Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *Drepanoistodus nowlani* to the level of the first appearance of *Acodus deltatus.*

Discussion.— Ji and Barnes (1994) recognized a *D. nowlani-M. dianae* Assemblage Zone which overlies their deeper water *C. angulatus* Zone in the Boat Harbour Formation. *D. nowlani* has also been reported by Repetski (1982). Although the species is low in abundance in this study, the recognition of this zone is significant because it is coeval with the Low Diversity Interval, where there are too few diagnostic species of the shallow water realm to define a zone.

ACODUS DELTATUS ZONE, EMENDED

Definition.—The base of the zone is defined as the level of the first appearance of *Acodus deltatus* and is a emended as an Atlantic Realm Zone.

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 863 m above the base of the section (sample 96-13-B8). It is 108 m thick and occurs within the upper part of the Grey Peak Member of the Kechika Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *Acodus deltatus* to the level of the first occurrence of *Paroistodus proteus*.

Discussion.—Ross et al. (1997) proposed an *Acodus deltatus/Oneotodus costatus* Zone which is equivalent to the upper part of Fauna D and overlies the *Macerodus dianae* Zone and Lower Diversity Interval. *A. deltatus* is a widely reported species which Ross et al. (1997) note is not widely distributed in the continental interior in the western United States. Therefore, in this study, the *A. deltatus* Zone is used as a cooler water zone to improve the correlation of strata as this zone is coeval with the lower part of the *Scolopodus subrex* Zone.

PAROISTODUS PROTEUS ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Paroistodus proteus* as was originally proposed by Lindström (1971).

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area). The base of the zone occurs at 923 m above the base of the section (sample 96-13-B10). It is 307 m thick and ranges from the upper part of the Grey Peak Member to the upper part of the Haworth Member of the Kechika Formation.

Type of zone.—In this study, the zone is an interval zone which ranges from the level of the first occurrence of *Paroistodus proteus* to the level of the first occurrence of *Paracordylodus gracils.*

Discussion.—The *P. proteus* Zone is widely recognized in Sweden and Löfgren (1994) divided the *P. proteus* Zone into four subzones. Characteristic species used by Löfgren to subdivide the lower part of the zone are not observed in this study, however, two species used for her upper two subzones, *Paracordylodus gracilis* and *Oelanodus elongatus* are here proposed to comprise a separate zone and subzone, respectively. The species which occur within the *P. proteus* Zone in this study include *Scolopodus subrex,* *Acodus deltatus, Graciloconus concinnus* n. gen. n. sp., ?*Paltodus jemtlandicus, Kallidontus princeps* n. gen. n. sp. and the first appearances of *Colaptoconus greypeakensis* n. sp., *C. quadriplicatus, Semiacontiodus* cf. *S. cornuformis* and *Drepanoistodus concavus*. In this study, the zone is coeval with the *S. subrex* Zone.

PARACORDYLODUS GRACILIS ZONE

OELANDODUS ELONGATUS SUBZONE, NEW

Definition.—The base of the zone is defined as the level of the first appearance of *Paracordylodus gracilis* as proposed by Johnston and Barnes (1999). The base of the - *Oelandodus elongatus* Subzone is defined by the first appearance of *Oelandodus elongatus* (Lindström) and is a new subzone.

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 1230 m above the base of the section (sample 96-13-B16). It is 393 m thick and ranges from the uppermost Haworth Member to the upper Mt. Sheffield Member of the Kechika Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first occurrence of *Paracordylodus gracilis* to the level of the first occurrence of *Prioniodus elegans* Pander. The *Oelandodus elongatus* Subzone is an interval zone which ranges from the level of the first occurrence of *O.elongatus* to the first occurrence of *P. elegans*.

Discussion.—The zone contains characteristic species including those which first appear within the *C. bolites* Subzone of the *Scolopodus subrex* Zone and within the *Acodus kechikaensis* Zone. The *Oelandodus elongatus* Subzone marks the first appearance of *Stolodus stola* (Lindström), *Paroistodus parallelus* and *Fahraeusodus marathonensis*. The *Paracordylodus gracilis* Zone has also been proposed by Johnston and Barnes (1999) as underlying the *P. elegans* Zone in the Cow Head Group, western Newfoundland.

PRIONIODUS ELEGANS ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Prioniodus elegans* and was originally proposed by Lindström (1971).

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 1623 m above the base of the section (sample 96-13-B26). It is 151 m thick. It ranges through the upper part of the platy limestone of the Mt. Sheffield Member of the Kechika Formation and into the lower part of the Skoki Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Prioniodus elegans* and ranges to the level of the first appearance of *Oepikodus evae* (Lindström).

Discussion.—The occurrence of *P. elegans*, although in low abundance, provides for correlation to the zone recognized in Sweden, where it is often 0.1 m thick (Lindström, 1971; Löfgren, 1993). It has been reported from North America by Stouge and Bagnoli (1988) and Pohler and Orchard (1990) and from the Argentine Precordillera by Lehnert (1995) and Albanesi (1998).

Species which first occur in this zone include the nominate species of that subzone and *Oistodus lanceolatus* and *Drepanoistodus amoenus*. Species that range from the underlying zone include *Paroistodus proteus* which is replaced by increasing abundance of *P. parallelus* (Pander). *Paracordylodus gracilis* and *Oelandodus elongatus* also occur in this zone. The lower half of the zone is coeval with the *K. nodosus* Subzone of the *A. kechikaensis* Zone. The upper half of the zone is coeval with the lowermost part of the *Oepikodus communis* Zone.

OEPIKODUS EVAE ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Oepikodus evae* as proposed by Lindström (1971).

Reference section.—Section 13, near Mt. Sheffield (57° 42'N, 124° 35'W), 4 km south of Mount Sheffield, Ware map-area. The base of the zone occurs at 1774 m above the base of the section (sample 96-13-B30). The base occurs at 33 m above the base of the Skoki Formation. It is at least 196.5 m thick at Section 13. At Section 5 (57° 30'N, 124° 26'W), Ware map area, the base of the zone occurs at 144 m above the base of the Skoki (sample 96-5-7). However, this section is dominated by Midcontinent Realm species.

The upper boundary of the zone was observed at 590.5 m above the base of the Skoki Formation.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Oepikodus evae* and ranges to the level of the first appearance of *Paroistodus originalis* (Sergeeva).

Discussion.—The zone is well established in Baltoscandia (e. g., Lindström, 1955, 1971; Löfgren, 1978, 1993) and the species has been reported in North America by Pohler and Orchard (1990), Stouge and Bagnoli (1988) and iin the Argentine Precordillera by Serpagli (1974), Lehnert (1995) and Albanesi (1998). The zone is largely coeval with the *O. communis* Zone, although its base is younger than that of *O. communis* Zone. It is also coeval with at least the lower half of the *Tripodus laevis* Zone.

PAROISTODUS ORIGINALIS ZONE

Definition.—The base of the zone is defined as the level of the first appearance of *Paroistodus originalis* as defined by Lindström (1971).

Reference section.— Section 5 (57° 30'N, 124° 26'W), Ware map area. The base of the zone occurs at 590.5 m above the base of the Skoki, within the Keily Member (sample 96-5-17). The top of the zone is not observed at Section 5. At the Grey Peak Section (57° 48'N, 125° 13'W), Ware map-area, the base of the zone is taken at 184.5 m above the base of the Ospika Formation, Road River Group, within the Chesterfield Member.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Paroistodus originalis.*

Discussion.— Löfgren (1994) commented that the base of the *P. originalis* Zone should be drawn at the boundary of increasing frequencies of *P. originalis* and *D. basiovalis* over *P. parallelus* and *D. forceps*, rather than at the first appearances of these taxa. In this study, as data from underlying strata at Section 5 and Grey Peak is sparse, the boundary of the zone is tentatively suggested to be at the first occurrence of *P. originalis* as comparision of abundances is not available.

The zone is partially coeval with the *Tripodus laevis* Zone. At Section 5, species which first occur in the zone include *Ansella longicuspica* Zhang and *Ansella jemtlandica* (Löfgren), *Pteracontiodus cryptodens* (Mound) and *Multioistodus ?compressus* Cullison.

At the Grey Peak Section, long ranging taxa from underlying zones occur such as *Paroistodus parallelus*, *Periodon flabellum* and *P. aculeatus*, *Protopanderodus leonardi* Serpagli and *P. gradatus* Serpagli. New taxa which appear include *Protopanderodus robustus* (Hadding) and *P. varicostatus* (Sweet and Bergström), *Drepanoistodus basiovalis* (Sergeeva) and *D. bellburnensis* Stouge, *Spinodus spinatus* (Hadding) and *Erraticodon balticus* Dzik.

Paroistodus horridus Zone, new

Definition.—The base of the zone is defined as the level of the first appearance of *Paroistodus horridus* (Barnes and Poplawski) and is a new zone.

Reference section.—Section 4 (57° 26'N, 124° 35'W) north of the Akie and Ospika rivers. The base of the zone occurs at 135 m above the base of the Ospika Formation, Road River Group, within the upper part of the Finlay Limestone Member (sample 96-4-2). The zone is 14.5 m thick.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Paroistodus horridus* and ranges to the level of the first appearance of *Dzikodus tableheadensis* (Stouge).

Discussion.—The zone has been used as a subzone by Albanesi (1998) within the *Lenodus variabilis* Zone which overlies the *Paroistodus originalis* and *Microzarkodina parva* Zone proposed for the Atlantic Realm. The absence of the nominate species of the *Lenodus variabilis* Zone may be attributed to endemism of this taxa within the Baltic region, however it does occur in Argentina (Albanesi, 1998). The *P. horridus* Zone is therefore proposed as a deep water zone which lies above the *P. originalis* Zone.

Characteristic species which occur within this zone at Section 4 include *Paroistodus originalis* and *Periodon aculeatus* from underlying strata, *Spinodus spinatus* and *Pteracontiodus cryptodens* and the appearance of *Walliserodus ethingtoni* (Fåhræus).

Dzikodus tableheadensis Zone, emended

Definition.—The base of the zone is defined as the level of the first appearance of *Dzikodus tableheadensis* as proposed by Zhang (1998).

Reference section.—Section 4 (57° 26'N, 124° 35'W) north of the Akie and Ospika rivers. The base of the zone occurs at 148.5 m above the base of the Ospika Formation, Road River Group, within the upper part of the Finlay Limestone Member (sample 96-4-3). The zone is at least 13.5 m thick. Its upper boundary is tentatively drawn at the base of the Chesterfield Member which is a shale and dolostone unit at Section 4 and contains graptolites of the *Paraglossograptus tentaculatus* Zone.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Dzikodus tableheadensis*.

Discussion.—Zhang (1998) proposed the *Dzikodus tableheadensis* Zone as overlying the *Lenodus variabilis* and *Yangtzeplacognathus crassus* zones. The taxon is distinct and useful for zonation of deeper water strata. Characteristic species which appear with *D. tableheadensis* at Section 4 include *Walliserodus costatus* Dzik, *Protopanderodus cooperi* (Sweet and Bergström) and *P. calceatus* Bagnoli and Stouge and *Triangulodus akiensis* n. sp.

Amorphognathus tvaerensis Zone

Definition.—The base of the zone is defined as the level of the first appearance of *Amorphognathus tvaerensis* Bergström and was originally defined by Bergström (1971).

Reference section.—Deadwood Lake Section, (59° 01' N, 128° 23'W), SW end of Deadwood Lake, Cry Lake map-area. The base of the zone is 417.5 m above the base of the measured section and 352 m above the base of the Road River Group (sample DL-96-21). The top and thickness of the zone is not constrained.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Amorphognathus tvaerensis*.

Discussion.—The zone was originally defined by Bergström (1971) in Baltoscandia, who divided it into subzones and discussed its widespread occurrence in Europe and in North America for intercontinental correlation. Characteristic species which occur in the zone from this study include *Drepanoistodus basiovalis*, *Ansella jemtlandica*, *Panderodus sulcatus* (Fåhræus), *Phragmodus undatus*, *Protopanderodus liripippus* Kennedy, Barnes and Uyeno and *Plectodina furcata* (Hinde). The zone is coeval with the *Phragmodus undatus* Zone.

Distomodus staurognathoides Zone

Definition.—The base of the zone is defined as the level of the first appearance of *Distomodus staurognathoides* (Walliser) and was originally proposed by Walliser (1964).

Reference section.—Section 4 (57° 26'N, 124° 35'W) north of the Akie and Ospika rivers. The base of the zone occurs at 620 m above the base of the Ospika Formation, Road River Group, and 192 m above the base of the Pesika Formation, Road River Group (sample 96-4-6). The top of the zone is not constrained.

Type of zone.—The zone is an interval zone which ranges from the level of the first appearance of *Distomodus staurognathoides*.

Discussion.—The *Distomodus staurognathoides* Zone has been recognized as a global zone for the middle Llandovery (Aldridge and Schönlaub, 1989) and has been reported in Europe (Viira and Mannik, 1997) and Australia (Simpson, 1995) and Anticosti Island (Uyeno and Barnes, 1983). Associated taxa observed in this study include *Panderodus unicostatus* (Branson and Mehl), *Oulodus* sp. A, and *Pseudooneotodus beckmanni* (Bischoff and Sannemann).

5.4. Comparison with Standard Zonations

The following discussion compares the conodont biozonation established by this study to those established as standards from well-studied regions elsewhere in the world. Adjustments are made to the standard by the inclusion of new zones and by introduction of new subzones. Rather than include a list of correlations with sections studied in Ordovician successions around the world, the discussion focuses on those correlations to which key tie points of zonal levels can be made.

5.4.1. Comparison with Zonation across the Cambro-Ordovician Boundary

In the Kechika, only the *Eoconodontus*, *C. proavus*, and *Iapetognathus* zones established for both realms are recognized. The *C. intermedius* Zone, established by Miller (1988) between the *C. proavus* and *Iapetognathus* zones is not recognized due to a section break below the *Iapetognathus* Zone. The Cambrian-Ordovician boundary has been defined at the base of the *Iapetognathus fluctivagus* Zone (Nicoll et al., 1999). The base of the Tremadoc therefore lies within the Quentin Member of the Kechika

Formation, where measurement began above the section break, so the first appearance of *Iapetognathus* may not have been observed.

The *C. angulatus* Zone was established as a shallow water zone by Ross et al. (1997) as underlying the *R. manitouensis* Zone. In this study, *C. angulatus* is used as a deep water zone which, in agreement with the standard, occurs in older strata than *R. manitouensis* in which it correlates with the upper one-third of the *P. falsioneotensis* Zone, all of the *R. tenuis* Zone, but also with the lower two-thirds of the *R. manitouensis*. The range of the zone has therefore been adjusted to extend into younger strata, thus shortening the overlying *P. deltifer* zone of the standard Atlantic Zonation.

5.4.2. Comparison with Standard Atlantic Realm Zonation

Conodont faunas provide critical tie points with the standard Atlantic Realm zonation. In the Kechika Formation, the *P. deltifer*, *P. proteus* and *P. elegans* zones established within the Atlantic Realm (Lindström, 1971; Löfgren 1978, 1985, 1993, 1994, 1995, 1996) are recognized. This indicates that the Kechika spans the Tremadoc-Arenig boundary.

Adjustments to this standard include a younger first appearance of *P. deltifer* and expansion of the *C. angulatus* Zone which occupies the lower half of the standard *P. deltifer* zone. *C. angulatus* is a much more abundant and distinct species than *P. deltifer* within the middle Tremadoc. The *P. deltifer* Zone used in this study is also much shorter compared to the standard because two new zones are proposed which are equivalent to the upper half of the standard *P. deltifer* Zone. These are the *D. nowlani* and *A. deltatus* zones. The *D. nowlani* Zone correlates to the Low Diversity Interval of the standard Midcontinent Realm and is thus an important tie point.

The *P. proteus* Zone has also been adjusted compared to the standard because a new overlying zone, the *Paracordylodus gracilis* Zone has been proposed. Löfgren (1994) proposed the *P. gracilis* and *O. elongatus-A. deltatus* subzones within the upper *P. proteus* Zone. The *P. gracilis* Zone established in this study contains *O. elongatus* as an uppermost subzone. *A. deltatus* has a lower first appearance in the study area than in Balto-Scandia. Johnston and Barnes (1999) regard the *P. gracilis* Zone as uppermost

Tremadoc and suggest that *P. gracilis* has a lower first appearance in the Cow Head Group than in Balto-Scandia and the material from the Kechika supports this.

The base of the Arenig is taken at the base of the *Tetragraptus approximatus* Zone, and although the global stratotype has yet to be formally decided (Williams et al., 1999), the base is just below the base of the *P. elegans* Zone recognized in Cow Head strata (Johnston and Barnes, 1999). The recognition of the *P. elegans* Zone within the Kechika allows correlation to that in the Cow Head Group and in Balto-Scandia.

The *O. evae* Zone is recognized in the Skoki Formation and can be correlated to that recognized within the Cow Head Group. The zones overlying this interval are different from those proposed in Balto-Scandia. The *Baltoniodus triangularis, B. navis* and *Microzarkodina parva* zones are not recognized (Löfgren 1978, 1993, 1994, 1995, 1996; Stouge and Bagnoli, 1990). Instead, the *Paroistodus originalis* Zone is proposed as overlying the *O. evae* Zone. The absence of *Baltoniodus* may be due to the endemic nature of the genus in Balto-Scandia, however it has been recognized elsewhere in Laurentia such as in Argentina (Albanesi, 1998). The *P. originalis* Zone is therefore much thicker than that proposed in Balto-Scandia.

The *P. horridus* Zone is proposed and was used as a subzone of the *Lenodus variabilis* Zone by Albanesi (1998). In this study, *Lenodus variabilis* was not present. The other new zone proposed is the *Dzikodus tableheadensis* Zone, which was proposed by Zhang (1998) from Sweden. Again, as some species that are used in the standard Atlantic Realm Zonation are likely endemic, the use of these latter two zones can provide tie-points within the early Darriwilian.

5.4.3. Comparison with Standard Midcontinent Realm Zonation

The main comparison of the Midcontinent Realm zonation proposed in this study will be made to that of the composite stratotype (836m) described by Ross et al. (1997) in the type Ibex area, Utah.

The long, continuous section of Section 13 as a reference section for all of the new zones of the Kechika Formation and that of Section 5, which is a reference section for the zones of the Skoki Formation exceed 2500 metres. There are several adjustments made to the Midcontinent Realm zonation proposed in this study compared to the standard.

The first is the addition of two new zones between the *Iapetognathus Zone* and the *R. manitouensis* zone. These are the *Polycostatus falsioneotensis* and *R. tenuis* zones. The *R. manitouensis* Zone is refined by the definition of two new subzones, the *R. muskwaensis* and *R. sheffieldensis* subzones. The overlying Low Diversity Interval could not be revised and as noted by Ethington and Clark (1982) and Ross et al., (1997) will remain as an informal zone due to sparse fauna in the interval. However, the equivalency of this interval to the new *D. nowlani* Zone proposed for the Atlantic Realm provides a tie-point for this interval.

The *S. subrex* Zone is new and replaces the *Macerodus dianae* Zone of the standard Midcontinent Realm zonation as proposed by Ross et al. (1997). *M. dianae* was first described from slope deposits (Fåhræus and Nowlan, 1978) and may be restricted to deeper waters and was not recognized in this study. *S. subrex*, however is an abundant and distinct species and its zone has been subdivided into the *Graciloconus concinnus* and *Colaptoconus bolites* subzones. The *S. subrex* Zone extends into the lower half of the *A. deltatus-O. costatus* Zone of the standard Midcontinent Realm zonation. The upper half of the *A. deltatus-O. costatus* Zone is replaced by the new *A. kechikaensis* Zone which is subdivided into three new subzones.

The *O. communis* Zone is recognized at the same level as in the standard, but is further refined by division into three subzones.

The *J. gananda-R. andinus* Zone is revised as the *J. gananda* Zone and has a slightly higher occurrence based on the first appearance of the nominate species. As discussed within the Systematic Paleontology, the coniform element of *R. andinus* which was used as a basis for the lowest occurrence of the standard zone by Ross et al. (1997), has been reassigned to the *J. variabilis* apparatus so that the base of the *J. variabilis* Subzone of the *O. communis* Zone correlates to the base of *R.andinus* Zone of Ross et al. (1997).

The *T. laevis* Zone is the same as that proposed for the standard.

Based on the zonation proposed in this study, a number of local and regional correlations can be drawn.

5.5. Correlations

5.5.1. Local Correlations

Biostratigraphic correlation is possible between the sections which have yielded conodont data. The *Rossodus manitouensis* and *Cordylodus angulatus* zones can be correlated from their reference section, Section 13 to Section 1 within the Quentin and Grey Peak members. Both also correlate to the Cassiar Terrane at Moodie Creek and Deadwood Lake sections and at both sections appear at the base of the Road River Group, indicating a much older age of the base of the Group compared to that noted within the Kechika Trough.

The *Scolopodus subrex* Zone correlates from Section 13, Grey Peak Member to Grey Peak Section, Haworth Member. The *Graciloconus concinnus* Subzone correlates from Section 13 to Grey Peak and occurs in strata younger than the first appearance of *S. subrex* at Grey Peak Section. The Subzone also correlates to Section 1, where it occurs with the first appearance of *S. subrex*, within the Mt. Sheffield Member. The *C. bolites* Subzone also correlates from Section 13 to Grey Peak and to Section 1. Similarly, the *Paroistodus proteus* Zone correlates from the Grey Peak and Haworth Members at Section 13 to the Haworth Member at Grey Peak and coincides closely to the base of the Haworth Member at both localities, but is occurs lower in the stratigraphy at Section 13. The zone also correlates to Section 1, where it appears in the Mt. Sheffield Member at that locality. The zone also correlates to the Deadwood Lake Section in the Cassiar Terrane where it occurs in the upper part of Unit 1 of the Road River Group.

The *Acodus kechikaensis* Zone correlates from the Mt. Sheffield Member at Section 13 to the upper Haworth Member at Grey Peak based on the occurrence of *Stolodus stola* at the latter locality. It also correlates from Section 13 to Section 4, specifically, the *Diaphorodus russoi* Subzone, which occurs near the top of the Mt. Sheffield Member and top of the Kechika Formation at both localities. The correlation from Section 13 to Section 4 of the top of the Kechika is also indicated by the occurrence of *Oelandodus elongatus*, within the upper *P.gracilis* Zone.

The *Oepikodus communis* Zone correlates from Section 13, where it spans the Kechika-Skoki boundary to Section 5, where it occurs in the base of the Skoki. It is also recognized in the base of the Ospika Formation at Section 4 and has been reported from Ospika Formation strata at Grey Peak Section by Tipnis (unpublished report, 1978). Each of the three subzones defined at Section 5 correlate to those identified at Section 13.

The *Prioniodus elegans* Zone correlates from the upper part of the Mt. Sheffield Member of the Kechika Formation to the Cloudmaker Member of the Ospika Formation, which are lithologically equivalent units. The zone also correlates to the upper part of the Kechika Formation at Section 4.

The *Paroistodus originalis* Zone correlates from the Keily Member of the Skoki Formation at Section 5 to the Chesterfield Member of the Ospika Formation at Grey Peak. The overlying *Paroistodus horridus* and *Dzikodus tableheadensis* zones were observed only within the upper Finlay Limestone Member of the Ospika Formation at Section 4, indicating that the strata ranges into the base of the Darriwilian.

The *Amorphognatus tvaerensis* Zone indicates a Caradoc age for the upper part of the Road River Group within the Cassiar Terrane. It is coeval with the *Phagmodus undatus* Zone which also occurs within the Road River Group of the Kechika Trough, at the Gataga Mountain Section.

The *Distomodus staurognathoides* Zone provides an age constraint within the Pesika Formation of the Road River Group as Middle Llandovery in age. As this was the only section where the formation was observed, correlation will be possible in future studies of the younger stratigraphic succession.

5.5.2. Regional Correlations

Correlation with other North American sequences including the Southern Cordillera, Northern Cordillera, Arctic Canada, Great Basin, Western Newfoundland, Greenland and the Argentine Precordillera shown in Figure 12 and are here discussed.

The Kechika is the northern equivalent of the Survey Peak Formation and the correlation of the members of the Kechika to informal members of the Survey Peak of Ji and Barnes (1996) is possible. The Lloyd George Member correlates to the Basal Silty Member based on the occurrence of *C. proavus*. The Quentin Member correlates to the Putty Shale Member based on the occurrence of *C. lindstromi*. The Grey Peak Member is equivalent to upper part of the Putty Shale and lower half of the Middle Carbonate members based on the occurrence of *C. angulatus* and *R. manitouensis*. The Haworth Member is equivalent to the upper part of the Middle Carbonate and Upper Carbonate based on the occurrence of *S. subrex*. The Mt. Sheffield Member correlates to the lower Outram Formation based on the occurrence of *O. communis* and the lowermost Skoki correlates to the upper Outram Formation in the Southern Rockies (Ji and Barnes, unpublished data).

In the Mackenzie Mountains, correlation of the Kechika Formation to the Rabbitkettle Formation is based on the occurrence of *C. proavus* and taxa from Fauna B of Ethington and Clark (1971) (Tipnis et al., 1978; Landing et al., 1980). The Kechika also correlates to the Road River Formation of the Mackenzie Mountains, which Tipnis et al. (1978) report contains conodonts of Fauna D and those which range into the Llanvirn. The Kechika and Skoki also correlate to the parts of the Broken Skull Formation which contains Faunas D and E of Ethington and Clark (1971) (Pohler and Orchard, 1990).

In the Richardson Mountains, correlation of the Ospika Formation to part of the Road River Group is possible based on the occurrence of *P. horridus* and associated species from the Road River (McCracken, 1991).

In the Canadian Arctic Islands, the Lower Kechika is correlated to the Cape Clay Formation based on the occurrence of *C. angulatus* (Landing and Barnes, 1981; Nowlan, 1985).

In the Great Basin, type Ibex area, Utah, Ross et al. (1997) proposed the composite stratotype which comprises the Notch Peak Formation, House Limestone, Fillmore Formation and Wah Wah Limestone. These stratigraphic units range through Conodont Faunas A through E of Ethington and Clark (1971). The Kechika correlates to the Notch Peak Formation, House Limestone and lower half of the Fillmore Formation. The Skoki correlates to the upper half of the Fillmore Formation and Wah Wah Formation. Based on these correlations, other sections within the United States with well documented conodont faunas such as the El Paso Group of western Texas (Repetski, 1982) can be correlated to the northern Cordillera.

Another region which has well established conodont biostratigraphy for the Lower and Middle Ordovician is western Newfoundland. The Kechika Formation correlates to the Berry Head Formation of the Port au Port Group, and to the Watts Bight, Boat Harbour and lower Catoche formations of the St. George Group (Stouge, 1982; Pohler et al., 1987; Barnes, 1988; Ji and Barnes, 1994). The Skoki correlates to the upper Catoche and Aguathuna formations (Stait and Barnes, 1991; Ji and Barnes, 1994). The Kechika Formation also correlates to the deeper water strata of part of the Cow Head Group (Beds 6-11) (Fåhræus and Nowlan, 1978; Bagnoli et al., 1987; Pohler, 1994; Johnston and Barnes, 1999).

Two other regions to which correlation can be made based largely on the Midcontinent Realm zonation are Greenland and the Argentine Precordillera. In Greenland, the upper Kechika correlates to the Cape Weber Formation based on the occurrence of Fauna D of Ethington and Clark (1971) and the upper Kechika and lower Skoki correlate to the Wandel Valley Formation based on the occurrence of *O. communis* (Smith, 1991). Finally, correlations can be made from the Kechika, Skoki and Road River to the strata of Argentina based on the faunas documented from the San Juan Formation, for example, by Serpagli (1974) and Lehnert (1995) and the succession of La Silla, San Juan, Gualcamayo and Las Plantas formations by Albanesi (1998).

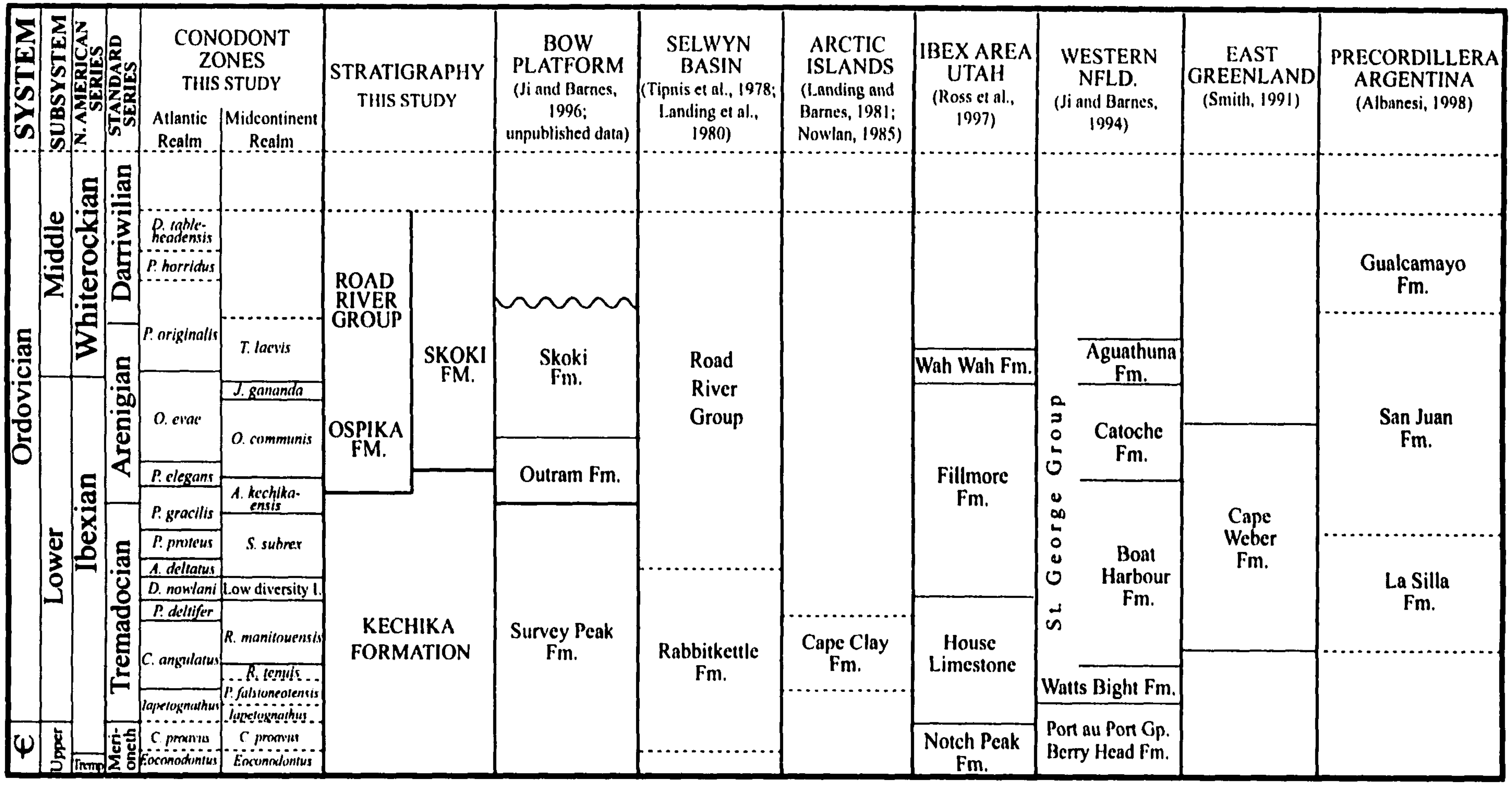


Figure 12. Correlation chart showing conodont-based correlations of the Kechika and Skoki formations and Road River Group in northern British Columbia with stratigraphic units of other selected regions referred to in the text. The source of each is given at the top of each column. Details of subzones and stratigraphic members for the study area are shown in Figure 11. (Tremp. = Trempealeauan).

5.5.3. Discussion

This study is significant due to the long, continuous stratigraphic sections examined which have yielded excellent conodont faunas, especially because few other comparable sections in the world for the Early Ordovician have been studied intensively. The Midcontinent Realm faunas allow correlation with other sequences in North America. However, studies such as that by Löfgren et al. (1998) of trans-Iapetus connections of Lower Ordovician conodont faunas improve the potential for more precise interregional correlation.

In addition to refining the conodont biostratigraphy, especially for the Lower and Middle Ordovician, this study also shows the potential to refine the ties with graptolite biostratigraphy, particularly within the Road River Group, similar to the integrated studies which have been accomplished in western Newfoundland.

6. Discussion of Key Evolutionary Lineages

The species diversity of conodonts was highest in the early Ordovician and the diversification of several lineages is observed in this study. The lineages discussed in this section are those that are important to the biostratigraphic zonation. The faunas from this study can be compared to the interpretations by Sweet (1988) who suggested phylogenetic relationships among the major conodont groups and to those of Ji and Barnes (1994) who more specifically depicted several phylogenies of Early Ordovician conodont taxa. The following discussion provides an overview of some of the major lineages and further details are discussed within the Systematic Paleontology section.

The most dramatic diversification within an early Tremadoc lineage is that within *Cordylodus*. The transition from *Proconodontus muelleri* to *Eoconodontus notchpeakensis* to *Cordylodus primitivus* in the late Cambrian is evident (Systematic Paleontology). By the early Tremadoc, 7 species of *Cordylodus* occur and the last descendant, *C. angulatus,* appears in the middle Tremadoc. Another early denticulate genus, *Iapetognathus*, also diversifies in the earliest Tremadoc into 3 species recognized in this study. Its origins are discussed by Nicoll et al. (1999). Neither *Cordylodus* nor *Iapetognathus* are ancestral to later conodonts, but are key in the zonation of the Cambrian-Ordovician boundary.

Sweet (1988) interpreted that the *Proconodontus* stock also gave rise to the Family Fryxellodontidae and an important genus for the zonation of lower Arenig strata is the new genus *Kallidontus*. The first representative of the *Kallidontus* lineage is *K. princeps* n. sp. which appears in the *S. subrex* Zone and speciates first into *K. serratus* n. sp. which gives rise to *K. nodosus* n. sp. (Plate 11). The latter two species are used to refine the *A. kechikaensis* Zone. The lineage may represent a separate line within the Fryxellodontidae, rather than an ancestor to later forms such as *Pygodus*.

Ji and Barnes (1994) described the *Teridontus* complex which includes the *Teridontus, Semiacontiodus, Polycostatus, Variabiloconus, Striatodontus* and *Colaptoconus* lineages. The material from this study supports the proposal of *Teridontus nakamurai* as an ancestor for *T. gracillimus* and *T. obesus* and *Semiacontiodus nogamii*, the latter of which gave rise to the costate species of members of the Family Protopanderodontidae such as *Polycostatus, Variabiloconus* and *Striatodontus*. The *Colaptoconus* lineage appears in younger strata, within a second diversification event of the middle Tremadoc. Ji and Barnes (1994) suggested a close evolutionary relationship of *Colaptoconus* lineage to the *Striatodontus* lineage due to a close similarity in morphology and stratigraphic range. The apparatus structure of the two genera is close, but the stratigraphic ranges are not as close as those observed in western Newfoundland by Ji and Barnes (1994), which suggests that *Striatodontus* may have an earlier appearance along the Cordilleran margin in comparison to the eastern Laurentian margin.

The Family Drepanoistodontidae also has its origins among oneotodontid ancestors such as *Teridontus*, but the origins of *Drepanoistodus* and *Acanthodus* are not as clear. *Drepanoistodus pervetus* is the earliest representative of that lineage and within the Midcontinent Realm gave rise to two new species, *D. minutus* n. sp. and *D. rotolimbus* n.sp. and to *D. nowlani* before the Tremadoc-Arenig boundary. Sweet (1988) suggested *Paltodus* as the rootstock of the Drepanoistodontidae, however, from this study, species of *Drepanoistodus* appear earlier than the first occurrence of *Paltodus*. It is interesting to note that late forms of *Acanthodus lineatus*, which range through the boundary, are similar to early forms of *Scolopodus subrex* but with the addition of costae to the cusp.

The next major group of importance for biostratigraphy is the Prioniodontida. Sweet (1988) suggested the oldest genus within the order is *Rossodus*. The fauna from this study suggest that the origin of the prioniodinids during the first diversity peak (Sweet, 1988, fig. 6.1) is one which extends back to the appearance of *Utahconus utahensis*, *Acodus quentinensis* and *A. oneotensis*, which may have been derived from a *Teridontus* lineage ancestor. *Acodus* is, therefore, a much more common genus in the earliest Tremadoc and is considered within a separate family, the Acodontidae (Dzik, 1994) rather than among the Oistodontidae which contains *Rossodus* and is not a *nomina dubia* as suggested by Sweet (1988).

Utahconus utahensis clearly gave rise to *Rossodus tenuis*, the direct ancestor of *Rossodus manitouensis*. In the late Tremadoc, the *Rossodus* lineage underwent a speciation event to produce four new species, two of which have been used to define subzones (*R. muskwaenesis* and *R. sheffieldensis*) within the *R. manitouensis* Zone in this study. *Tricostatus*, which is likely another descendent of *U. utahensis*, also diversified during this interval into three species. Ji and Barnes (1994) suggested that *T. glyptus* is closely related to *R. tenuis*, and the similarity of the apparatus of *Tricostatus* to *Rossodus* suggests that the two genera may have had a common ancestor, *U. utahensis*.

A second peak in diversity (Sweet, 1988, fig. 6.1) occurs within the *Acodus kechikaensis* Zone. There is a rapid diversification of the Acodontindae and Prioniodontidae. The *Acodus* lineage diversifies from *Acodus deltatus* which likely decended from *A. quentinensis* n. sp., into *A. kechikaensis* n. sp., *A. longibasis*, *A. warensis* n. sp. and *A. neodeltatus* n. sp. *Tropodus australis* and *Diaphorodus russoi* are also abundant in this interval. Although there has been much confusion in the past about the assignment of the genera *Acodus*, *Tropodus* and *Diaphorodus*, the faunas from this study support the apparatus reconstructions proposed by Albanesi (1998) and favour the assignment of the genera to the Acodontidae rather than to the Oistodontidae as proposed by Sweet (1988). Thus, the early forms of *Acodus* are better candidates as the root stock of the Acodontidae, rather than *Rossodus* as proposed by Sweet (1988, fig. 5.11). However, the Oistodontidae (including *Rossodus*) are an important root stock for a number of other lineages.

The early Arenig is also a time of high diversity which peaks with the initiation of the *Oepikodus* lineage. The abundant and diverse conodont fauna of the early Arenig indicates that *Acodus neodeltatus* n. sp. is the direct ancestor of *Oepikodus communis*. *Protopanderodus* also radiates in this interval, the ancestral species is *P. leonardi*. This diversity diminishes at the base of the *Tripodus laevis* Zone, or base of the Whiterockian. The faunas within the Skoki are high in diversity but not as abundant as compared to those of the Kechika, however, future studies may provide more material for the study of several lineages of the early and middle Arenig.

In summary, this overview illustrates the significance of the northern Cordilleran faunas in modifying the understanding of early conodont evolutionary lineages. There is clearly high potential for studying lineages preserved within the thick stratigraphic successions of the northern Cordilleran miogeocline. Speciation events are well documented, such as those within the *Rossodus* and *Acodus* lineages, and provide refinement of the conodont biostratigraphy. The diversification of Lower Ordovician conodonts is a critical event in the 300 million year history of the group, yet is one to which few studies have been devoted.

7. CONCLUSIONS

The early Paleozoic represents an exceptional time in earth history when continental separation was high and a greenhouse state prevailed throughout most of the Ordovician. The paleogeography influenced paleoceanographic factors and hence global marine environments and the diversity of the world's biota. The thick and well exposed stratigraphy of the lower Paleozoic Canadian Cordilleran Miogeocline documents the evolution of the rifted western margin of Laurentia. Study of a platform to basin transect across the margin provides stratigraphic and biological information. The lower Paleozoic stratigraphy contains abrupt lateral facies changes which are interpreted as evidence that the margin is more complex than a simple passive margin and experienced phases of extension and thermal subsidence which cannot be explained by a single rifting event in the Neoproterozoic.

The biological data compiled from this study is one which provides the biostratigraphic precision necessary to understand both stratigraphic and biological events. The high diversity of marine faunas which existed in the Ordovician and peaked in the Middle Ordovician included an evolutionary radiation of conodonts. The paleogeography influenced the strong provincialism of conodonts such that a dual biostratigraphy for both the Midcontinent and Atlantic Realm faunas is necessary. As no detailed studies had been carried out in the study area, the project demonstrates the potential for biostratigraphic correlation and to interpret the stratigraphy, including tectono-stratigraphic and eustatic events, based on a conodont biostratigraphic framework.. The biodiversity which is unique to the Ordovician can also be better interpreted based on a sound biostratigraphic framework established for the Northern Cordillera.

The non-passive nature of the rifted margin of Laurentia is documented by abrupt lateral and vertical facies changes with the Lower Paleozoic succession of the Northern Cordilleran Miogeocline. Over 12 000 m of strata were measured and described in detail in 12 key sections from an east-west, platform to basin transect. The stratigraphic framework has been substantially revised. The Kechika Formation is divided into the Lloyd George, Quentin, Grey Peak, Haworth and Mount Sheffield members. The Skoki Formation is divided into the Sikanni Chief, Keily and Redfern members. The Road River Group is divided into three new formations: the Ospika Formation, the Pesika Formation and the Kwadacha Formation. The Ospika Formation is further subdivided into the Cloudmaker, Finlay Limestone, Chesterfield, Finbow Shale and Ware members. The Lower Paleozoic stratigraphy of the parautochthonous Cassiar Terrane is generally similar to the successions studied east of the Northern Rocky Mountain Trench (NRMT).

A total of 405 conodont samples were taken across the transect, which yielded 39 526 conodont elements. Detailed taxonomic study resulted in the identification, illustration and description of 197 species representing 73 genera, of which there are 6 new genera (*Graciloconus, Kallidontus, Planusodus* and 3 new genera in open nomenclature) and 24 new species (*Acodus kechikaensis* n. sp., *Acodus neodeltatus* n. sp., *A. quentinensis* n. sp., *A. warenesis* n. sp., *Colaptoconus greypeakensis* n. sp., *Cordylodus delicatus* n. sp., *Drepanoistodus minutus* n. sp., *Graciloconus concinnus* n.

gen. n. sp., *Kallidontus serratus* n. gen. n. sp., *K. nodosus* n. gen. n. sp., *K. princeps* n. gen. n. sp., *Laurentoscandodus sinuosus* n. sp., *Macerodus cristatus* n. sp., *M. lunatus* n. sp., *Paroistodus* n. sp., *Planusodus gradus* n. gen. n. sp., *Rossodus kwadachaensis* n. sp., *R. muskwaensis* n. sp., *R. sheffieldensis* n. sp., *R. subtilis* n. sp., *Scolopodus amplus* n. sp., *Striatodontus strigatus* n. sp., *Triangulodus akiensis* n. sp., *Tricostatus infundibulum* n. sp., *T. terilinguis* n. sp.) are recognized. Fifteen additional new species are described in open nomenclature but not formally named as too few elements were recovered.

The taxonomic database allows the refinement of the standard Upper Cambrian to Middle Ordovician conodont biostratigraphy across a platform-miogeocline-basin transect in the northern Canadian Cordillera. Although the fauna is dominated by conodonts typical of the shallow water Midcontinent Realm assemblage common to North American successions, cosmopolitan and deeper water species also occur so that a parallel zonation of shallow water Midcontinent Realm and cooler water Atlantic Realm faunas has been established. The greatest refinement is made for the Lower Ordovician (Tremadoc and Arenig) and further data from beds within the Upper Ordovician and Lower Silurian provide ages for units within the Road River Group which have not been previously determined.

The conodont faunas are referred to a total of 10 shallow water zones containing faunas of the Midcontinent Realm. Four of these are new (*Polycostatus falsioneotensis, Rossodus tenuis, Scolopodus subrex* and *Acodus kechikaensis* zones), and 10 new subzones are established. Cosmopolitan zones in the Kechika Formation include the *Eoconodontus* Zone (upper Cambrian), *Cordylodus proavus* (uppermost Cambrian), and *Iapetognathus* Zone (base of Tremadoc). The shallow water zones include *Polycostatus falsioneotensis* Zone (lower Tremadoc), *Rossodus tenuis* Zone (lower Tremadoc); *Rossodus manitouensis* Zone with *R. muskwaenesis* and *R. sheffieldensis* subzones (middle Tremadoc), Low diversity interval (upper Tremadoc), *Scolopodus subrex* Zone with *Graciloconus concinnus* and *Colaptoconus bolites* subzones (lower Arenig) and *Acodus kechikaensis* Zone with *Kallidontus serratus*, *Diaphorodus russoi* and *Kallidontus nodosus* subzones (lower Arenig). Those for the Skoki Formation include the *Oepikodus communis* Zone with *Tropodus sweeti*, *Bergstroemognathus extensus* and *Juanognathus variabilis* subzones (middle Arenig). The *O. communis* Zone spans the

Kechika-Skoki boundary and the uppermost Kechika lies within the lowermost part of the zone underlying the *T. sweeti* Subzone. The Skoki Formation also contains the *Jumudontus gananda* Zone (middle Arenig) and *Tripodus laevis* Zone (upper Arenig). The *Phragmodus undatus* Zone (Upper Ordovician) lies within the Road River Group in the Cassiar Terrane.

A total of 13 deep water zones are recognized for basinal facies containing faunas of predominantly the Atlantic Realm. Five new zones are proposed including *Drepanoistodus nowlani, Acodus deltatus, Paracordylodus gracilis, Paroistodus horridus* and *Dzikodus tableheadensis* zones, and one new subzone within the *P. gracilis* Zone is proposed. Those within the Kechika Formation include *Cordylodus angulatus* Zone (lower Tremadoc), *Paltodus deltifer* Zone (middle Tremadoc), *Drepanoistodus nowlani* Zone (middle Tremadoc), *Acodus deltatus* Zone, (middle Tremadoc), *Paroistodus proteus* Zone (upper Tremadoc), *Paracordylodus gracilis* Zone with *Oelandodus elongatus* Subzone (upper Tremadoc) and the *Prioniodus elegans* Zone (base Arenig). Those within the Skoki and Ospika formations include *Oepikodus evae* Zone (Skoki Formation, middle Arenig), *Paroistodus originalis* Zone (Skoki and Ospika formations, upper Arenig), *Paroistodus horridus* Zone and *Dzikodus tableheadensis* Zone (both within the Ospika Formation, lower Llanvirn). The *Amorphognathus tvaerensis* Zone lies within the Road River of the Cassiar Terrane (Upper Ordovician). The *Distomodus staurognathoides* Zone lies within the Pesika Formation (middle Llandovery).

The diverse conodont faunas from the thick, continuous stratigraphic succession represent several important evolutionary lineages, particularly those developing during the Tremadoc, when conodonts reach their highest diversity. The abundant and well preserved faunas indicate the rapid speciation events of some taxa (e. g. *Rossodus*, *Acodus* and *Kallidontus* n. gen.) which provide refinement of parts of the zonation into subzones.

The Kechika Formation contains gradual lateral facies changes from the platform to outer shelf and basin and thickens westward. The base of the formation is uppermost Cambrian in age, lying within the *Eoconodontus* Zone. Although the Kechika is a laterally continuous unit, its members are diachronous. The diachronous nature of these facies is understood from the time lines established using conodont biostratigraphy. For example, the base of the Quentin Member lies within the *Iapetognathus* Zone at Section 13 and within the *Rossodus manitouensis* Zone at Section 1.

The Ospika Formation of the Road River Group represents a pronounced platform to off-shelf transition of abrupt lateral facies changes from platformal dolostones of the Skoki Formation to the east. The conodont biostratigraphy indicates the time equivalency of the Sikanni Chief Member of the Skoki Formation to the Cloudmaker Member of the Ospika Formation.

The onset of Kechika and Ospika formations is possibly attributed to renewed periods of extension of the margin followed by thermal subsidence as evidenced by the thick sedimentary succession and abrupt lateral facies changes from the Skoki to the Ospika Formation. Local alkaline volcanics occur within the succession, and those observed in the study area lie near the Kechika-Road River boundary, below the *P. undatus* Zone and are likely early Middle Ordovician in age.

Sequence stratigraphic relationships within the succession include those which correspond to cratonic sequence boundaries, possibly the base of the Kechika as the base of Cycle A and the top of the Skoki and coeval Road River as the base of Cycle B (of Cecile and Norford, 1993).

The stratigraphy of the Cassiar Terrane is similar to that of east of the NRMT. This study established the conodont biostratigraphy of the Kechika Formation and Road River Group and indicates that the boundary of the two units lies within the *R. manitouensis* Zone, older than that observed east of the NRMT (base of the Road River within the *P. elegans* Zone). The Road River of the Cassiar Terrane ranges into the Caradoc as observed east of the NRMT.

In addition to regional stratigraphic interpretations and local correlations, the established biostratigraphy provides correlation within ancient North America (Southern Cordillera, Great Basin, Western Newfoundland, Greenland and the Argentine Precordillera). The calibration of the Atlantic Realm faunas with those of the Midcontinent Realm improves interregional correlation.

8. Taxonomic Remarks and Systematic Paleontology

8.1 Introduction

The classification of conodonts was largely based on form genera prior to 1970. Lindström (1971) and authors in the Treatise on Invertebrate Paleontology, (Robison (ed.), 1981) proposed a suprageneric classification based on multielement taxonomy which provided a means of evaluating the phylogenetic relationships of taxa. The suprageneric classification of conodonts proposed in Sweet (1988) and modified by Aldridge and Smith (1993) is followed herein.

Species for which there are few comments and which require no revision are treated in the section "Taxonomic Remarks". Within the "Systematic Paleontology", taxa are listed in alphabetical order and assigned to the appropriate family and order. The synonymy lists are kept to a minimum by referring the reader to the most complete synonymy in a recent publication for which all the references listed are in agreement with the taxonomic assignment.

In most identifications, a multielement apparatus has been determined. However, in some situations, the suffix s.f. *(sensu formo)* (Barnes and Poplawski, 1973) designates a form taxon which has not yet been synonymized in a multielement scheme (e. g. *Cordylodus deflexus* s. f.). In situations where full identification is not possible, genera are reported in open nomenclature. The uncertainty of assignments is indicated by a question mark placed either behind the genus or species name, depending on which category is uncertain. A provisional identification is indicated by cf. (e. g. *Agenus* cf. *aspecies*). A new, undescribed taxon is related to a known taxon using aff. (e. g., *Agenus* aff. *aspecies*). When specific identification is not attempted or not possible, the abbreviation sp. is used. Recognition of a new genus is indicated by n. gen. and new species by n. sp. (Bengtson, 1988).

The terminology used for multielement taxonomy follows the letter designations after Sweet and Schönlaub (1975) for the location of elements within well-known septimembrate apparatuses (S, M, P notation). For coniform apparatuses, the letter designations proposed by Ji and Barnes (1994) are followed (a, b, c, e, f). The study favours nomenclaturally neutral terms and the naming of element types after form genera or species which they resemble (e. g. oistodiform) is avoided as much as possible.

All conodonts illustrated were photographed by a Hitachi S-3500N Scanning Electron Microscope. All figured specimens are deposited in the National Type Collections of the Geological Survey of Canada (GSC).

8.2. Taxonomic Remarks

The following taxa are those which require no further taxonomic description or require only brief taxonomic remarks.

Phylum CHORDATA Bateson, 1886

Class CONODONTA Pander, 1856

Order PROCONODONTIDA Sweet, 1988

Family FRYXELLODONTIDAE Miller, 1980

Genus DZIKODUS Zhang, 1998

DZIKODUS TABLEHEADENSIS (Stouge, 1984)

Plate 15, figs. 1-7

Remarks.—Zhang (1998) erected the genus *Dzikodus* to encompass those specimens of *Polonodus* which have paired stelliplanate and unpaired pastiniplanate elements. *Polonodus* Dzik includes platforms which are stelliscaphate and pastiniscaphate. A series of ramiform elements and an oistodontiform element have been identified by Löfgren (1990).

Occurrence.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—11 S elements, 12 P elements.

Repository.—GSC 119438 to GSC 119444.

Order BELODELLIDA Sweet, 1988

Family ANSELLIDAE Fåhræus and Hunter, 1985

Genus ANSELLA Fåhræus and Hunter, 1985

ANSELLA JEMTLANDICA (Löfgren, 1978)

Plate 15, figs. 16-17

Remarks.—*Ansella jemtlandica* has been described in detail by Löfgren (1978) and additional elements by Zhang (1998). The M elements were not recognized in the sparse material in this collection.

Occurrence.—*Paroistodus originalis* Zone to *Amorphognathus tvaerensis* Zone, Skoki Formation and Road River Group.

Material.—0 M elements, 8 S elements, 1 P element.

Material.—0 M elements, 8 S elements, 1 P element.

Repository.—GSC 119453 and 119454.

ANSELLA LONGICUSPICA Zhang, 1998

Plate 21, figs. 1-3

Remarks.—The elements of *A. longicuspica* differ from those of *A. jemtlandica* in having a shallower basal cavity which extends to about half of the length of the cusp rather than to the point of curvature of the cusp as in *A. jemtlandica.*

Occurrence.—*Paroistodus originalis* Zone, Skoki Formation.

Material.—3 M elements, 2 S elements, 1 P element.

Repository.—GSC 119613, 119614, 119615.

Family BELODELLIDAE Khodalevich and Tschernich, 1973

Genus STOLODUS (Lindström, 1955)

STOLODUS STOLA (Lindström, 1955)

Plate 7, figs. 28-31

Remarks.—Elements are long, narrow, delicate conodonts which have a deeply excavated cusp ornamented by strong costae connecting a thin basal sheath. The cusp tip is small and erect to recurved. The apparatus plan for *S. stola* is as illustrated for the Bellodellids in Sweet (1988) and Dzik (1994). However a quinquimembrate plan as described by Albanesi (1998) includes a bicostate (a), tricostate (b), quadricostate (c), compressed (e) and possibly an f element. Of these morphotypes, a, b and c elements have been identified among this collection.

Occurrence.—*Paracordylodus gracilis* Zone, Kechika Formation

Material.—48 elements.

Repository.—GSC 119246, 119247, 119248, 119249.

Genus WALLISERODUS Serpagli, 1967

WALLISERODUS COSTATUS Dzik, 1976

Plate 15, fig. 27

Occurrence.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—4 elements.

Repository.—GSC 119464.

WALLISERODUS ETHINGTONI (Fåhræus, 1966)

Plate 15, figs. 23-26

Occurrence.—*Paroistodus horridus* Zone, Ospika Formation.

Material.—35 elements.

Repository.—GSC 119460, 119461, 119462, 119463.

?WALLISERODUS NAKHOLMENSIS (Hamar, 1966)

Plate 15, fig. 22

Remarks.—A few elements are tentatively assigned to *W. nakholmensis* based on the morphology of the P element.

Occurrence.—*Paroistodus originalis* Zone, Ospika Formation.

Material.—10 elements.

Repository.—GSC 119459.

Order PROTOPANDERODONTIDA Sweet, 1988

Family ACANTHODONTIDAE Lindström, 1970

Genus ACANTHODUS Furnish, 1938

ACANTHODUS LINEATUS (Furnish, 1938)

Plate 22, figs. 8-9

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—4772 a elements, 1177 e elements.

Repository.—GSC 119647 and 119648.

ACANTHODUS UNCINATUS Furnish, 1938

Plate 9, figs. 1-2

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—59 a elements, 6 c elements, 48 e elements.

Repository.—GSC 119279 and 119280.

Family DREPANOISTODONTIDAE Fåhræus and Nowlan, 1978

Genus DREPANOISTODUS Lindström 1971

DREPANOISTODUS BASIOVALIS (Sergeeva, 1963)

Plate 19, figs. 20-21

Remarks.—The a elements of *D. basiovalis* and *D. forceps* are similar, but the c element of each vary slightly in the flare of the basal cavity and extension of the antero-basal corner (more flared and extended in *D. forceps*). *Occurrence.*—*Oepikodus communis* Zone, Skoki Formation to *Phragmodus undatus* Zone, Road River Group.

Material.—17 a elements, 1 c element.

Repository.—GSC 119571 and 119572.

DREPANOISTODUS BELLBURNENSIS Stouge, 1984

Plate 14, figs. 7-9

Remarks.—Stouge (1984) described the species as having a compressed element which has a short base that is extended posteriorly. The compressed elements observed in this collection have a flexed posterior extension and rounded antero-basal margin. The c element is distinguished from other species by the posterior extension of the base.

Occurrence.—*Paroistodus originalis* Zone, Ospika Formation.

Material.—3 a elements, 1 c element and 1 e element.

Repository.—GSC 119417, 119418, 119419.

DREPANOISTODUS CONCAVUS (Branson and Mehl, 1933)

Plate 13, figs. 14-17

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—334 a elements, 38 c elements, 86 e elements.

Repository.—GSC 119391, 119392, 119393, 119394.

DREPANOISTODUS NOWLANI Ji and Barnes, 1994

Plate 13, figs. 8-10

Occurrence.—*Drepanoistodus nowlani* Zone, Kechika Formation.

Material.—71 a elements, 2 c elements, 9 e elements.

Repository.—GSC 119385, 119386, 119387.

DREPANOISTODUS FORCEPS (Lindström, 1955)

Plate 14, figs. 1-3

Occurrence.—*Oepikodus communis* Zone, Kechika and Skoki formations to *Paroistodus originalis* Zone, Ospika Formation.

Material.—28 a elements, 9 c elements, 10 e elements.

Repository.—GSC 119411, 119412, 119413.

DREPANOISTODUS PERVETUS Nowlan, 1985

Plate 13, figs. 1-3; Plate 22, fig. 11

Occurrence.—*Iapetognathus* Zone to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—1311 a elements, 90 c elements, 890 e elements.

Repository.—GSC 119378, 119379, 119380 and 119650.

DREPANOISTODUS cf. D. PITJANTI Cooper, 1981

Plate 14, figs. 10-13

Remarks.—Cooper (1981) described the elements as robust and hyaline with one to five lateral costae near the posterior cusp margin. The elements in this collection are similar but exhibit a much more compressed antero-basal corner The compressed e element bears the most pronounced posterior keeled cusp margin and a longitudinal postero-lateral groove.

Occurrence.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—10 a elements, 1 c elements, 2 e elements.

Repository.—GSC 119420, 119421, 119422, 119423.

DREPANOISTODUS SUBERECTUS (Branson and Mehl, 1933)

Plate 14, figs. 4-6

Occurrence.—*Paroistodus originalis* Zone, Ospika Formation.

Material.—3 a elements, 1 c elements, 8 e elements.

Repository.—GSC 119414, 119415, 119416.

Genus PAROISTODUS Lindström, 1971

PAROISTODUS ORIGINALIS (Sergeeva, 1963)

Plate 16, figs. 4-6

Occurrence.—Paroistodus originalis Zone, Skoki and Ospika formations.

Material.—33 M elements, 102 S elements, 9 P elements.

Repository.—GSC 119465, 119466, 119467.

PAROISTODUS PARALLELUS (Pander, 1856)

Plate 16, figs. 1-3

Occurrence.—Acodus kechikaensis Zone, Kechika Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—33 M elements, 102 S elements, 9 P elements.

Repository.—GSC 119414, 119415, 119416.

PAROISTODUS PROTEUS (Lindström 1955)

Plate 13, figs. 24-26; Plate 23, fig. 1

Occurrence.—Paroistodus proteus Zone to *Oepikodus communis* Zone, Kechika Formation.

Material.—92 M elements, 523 S elements, 79 P elements.

Repository.—GSC 119401, 119402, 119403 and 119666.

Family ONEOTODONTIDAE Miller, 1980

Genus SEMIACONTIODUS Miller, 1969

SEMIACONTIODUS NOGAMII (Miller, 1969)

Plate 6, figs. 18-20

Occurrence.—Iapetognathus Zone to *Polycostatus falsioneotensis* Zone, Kechika Formation.

Material.—35 a elements, 18 b elements, 4 c elements, 19 e elements.

Repository.—GSC 119208, 119209, 119210.

SEMIACONTIODUS cf. S. CORNUFORMIS (Sergeeva, 1963)

Plate 7; figs. 6-7

Remarks.—Specimens occur in the upper Kechika which have long slender cusps that bear conspicuous fine striae on all cusp faces. Base flares to anterior and posterior, but most prominently on inner lateral side which distinguishes this species from *S. cornuformis.*

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—43 elements.

Repository.—GSC 119226 and 119227.

Genus TERIDONTUS Miller, 1980

TERIDONTUS GRACILLIMUS Nowlan, 1985

Plate 6, figs. 11-13

Remarks.—The specimens observed are in agreement with the description by Ji and Barnes (1994), however, a suberect symmetrical element was observed in this collection which also has a small base and weak posterior carina.

Occurrence.— *Iapetognathus* Zone to *Polycostatus falsioneotensis* Zone, Kechika Formation.

Material.—5 a elements, 7 b elements, 1 c element, 4 e elements.

Repository.—GSC 119201, 119202, 119203.

TERIDONTUS NAKAMURAI (Nogami, 1967)

Plate 6, figs. 8-10

Occurrence.—*Cordylodus proavus* Zone to *Polycostatus falsioneotensis* Zone, Kechika Formation.

Material.—195 a elements, 65 b elements, 12 c element, 36 e elements.

Repository.—GSC 119198, 119199, 119200.

TERIDONTUS OBESUS Ji and Barnes, 1994

Plate 6, figs. 15-17

Occurrence.— *Iapetognathus* Zone, Kechika Formation.

Material.—21 a elements, 13 b elements, 10 c elements, 8 e elements.

Repository.—GSC 119204, 119205, 119206.

Family PROTOPANDERODONTIDAE Lindström, 1970

Genus ANODONTUS Stouge and Bagnoli, 1988

ANODONTUS LONGUS Stouge and Bagnoli 1988

Plate 17, fig. 18

Remarks.—Stouge and Bagnoli (1988) described the apparatus of *Anodontus* as forming a symmetry transition series of subrounded antero-posteriorly compressed elements, asymmetrical elements and laterally compressed elements. In this collection, a few subround (a) elements and compressed (e) elements were observed. *Occurrence.*—*Jumudontus gananda* Zone to *Tripodus laevis* Zone, Skoki Formation.

Material.—6 a elements, 5 e elements.

Repository.—GSC 119511.

Genus COLAPTOCONUS Kennedy, 1994

COLAPTOCONUS BOLITES (Repetski, 1982)

Plate 9, figs. 21-24

Occurrence.— *Scolopodus subrex* Zone, Kechika Formation.

Material.—75 a elements, 3 c elements, 2 e elements.

Repository.—GSC 119299, 119300, 119301, 119302.

COLAPTOCONUS FLOWERI (Repetski, 1982)

Plate 9, figs. 17-20

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—127 a elements, 10 b elements, 8 c elements, 2 e elements.

Repository.—GSC 119295, 119296, 119297, 119298.

Genus EUCHARODUS Kennedy, 1980

EUCHARODUS PARALLELUS (Branson and Mehl, 1933)

Plate 17, fig. 17

Occurrence.—*Scolopodus subrex* Zone to *Oepikodus communis* Zone, Kechika and Skoki formations.

Material.—130 elements.

Repository.—GSC 119510.

Genus POLYCOSTATUS Ji and Barnes, 1994

POLYCOSTATUS FALSIONEOTENSIS Ji and Barnes, 1994

Plate 6, figs. 1-3

Remarks.—As defined by Ji and Barnes (1994), the apparatus comprises robust, multicostate elements with a deep basal cavity. The genus is distinguished from *Variabiloconus* by being multicostate, and the c elements are much more compressed antero-posteriorly.

Occurrence.—*Polycostatus falsioneotensis* Zone, Kechika Formation.

Material.—12 a elements, 4 c elements, 2 e elements.

Repository.—GSC 119191, 119192, 119193.

GENUS PROTOPANDERODUS Lindström, 1971

PROTOPANDERODUS CALCEATUS Bagnoli and Stouge, 1996

Plate 16, figs. 17-19

Remarks.—Although not all of the elemental morphotypes are present in this collection, those that are unicostate to bicostate with a small, hyaline base are assigned to *P. calceatus*. The species differs from *P. varicostatus* by having fewer costae and by having a well-developed antero-lateral groove.

Occurrence.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—38 a/b elements, 5 c elements, 2 e elements, 1 f element.

Repository.—GSC 119481, 119482, 119483.

PROTOPANDERODUS COOPERI (Sweet and Bergström, 1962)

Plate 16, figs. 15-16

Remarks.—*P. cooperi* is characterized by having one strong costa on one or two lateral sides and by its basal profile. The aboral margin of the base bears a notch near the antero-basal corner, which is compressed.

Occurrence.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—21 a/b elements, 14 c elements, 3 e elements, 1 f element.

Repository.—GSC 119479 and 119480.

PROTOPANDERODUS GRADATUS Serpagli, 1974

Plate 16, figs. 11-13

Occurrence.—***Oepikodus communis*** Zone to ***Paroistodus originalis*** Zone, Skoki and Ospika formations.

Material.—79 a/b elements, 21 c elements, 17 e elements.

Repository.—GSC 119475, 119476, 119477.

PROTOPANDERODUS LEONARDII Serpagli, 1974

Plate 21, figs. 12-14

Remarks.—*P. leonardii* has an apparatus containing simple cones with a short base and less deflection of the anterior edge of the element compared to other species of *Protopanderodus*. The elements have rounded to sharp costae which do not reach the basal margin. *Occurrence.*—***Oepikodus communis*** Zone to ***Paroistodus originalis*** Zone, Skoki and Ospika formations.

Material.—87 a/b elements, 29 c elements, 17 e elements, 2 f elements.

Repository.—GSC 119624, 119625, 119626.

PROTOPANDERODUS LIRIPIPUS Kennedy, Barnes and Uyeno, 1979

Plate 23, figs. 6-7

Occurrence.—***Amorphognathus tvaerensis*** Zone, Road River Group.

Material.—5 elements.

Repository.—GSC 119671 and 119672.

PROTOPANDERODUS RECTUS (Lindström, 1955)

Plate 21, fig. 15

Occurrence.—***Oepikodus communis*** Zone, Skoki Formation.

Material.—8 a elements, 2 c elements, 3 e elements.

Repository.—GSC 119627.

PROTOPANDERODUS ROBUSTUS (Hadding, 1913)

Plate 16, figs. 7-10

Occurrence.—***Paroistodus originalis*** Zone, Ospika Formation.

Material.—26 a/b elements, 2 c elements, 3 e elements.

Repository.—GSC 119471, 119472, 119473., 119474.

PROTOPANDERODUS VARICOSTATUS (Sweet and Bergström, 1962)

Plate 16, fig. 14

Remarks.—*P. varicostatus* has been synonymized with *P. gradatus* by Albanesi (1998) but as illustrated in Dzik (1994), the former has a wider base with more alate external margins and a more sinuous basal profile. Not all of the elements of the apparatus are present in this collection, but the a-b elements are distinctive.

Occurrence.—*Paroistodus originalis* Zone to *Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—8 elements.

Repository.—GSC 119478.

GENUS STRIATODONTUS Ji and Barnes, 1994

STRIATODONTUS PROLIFICUS Ji and Barnes

Plate 5, figs. 8-11; Plate 22, fig. 26

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation and Road River Group of Cassiar Terrane.

Material.—79 a elements, 21 c element, 17 e elements.

Repository.—GSC 119171, 119172, 119173, 119174 and 119665.

Genus STULTODONTUS Ji and Barnes, 1994

STULTODONTUS COSTATUS (Ethington and Brand, 1981)

Plate 5, figs. 26-27

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—9 elements.

Repository.—GSC 119189 and 119190.

Order PANDERODONTIDA Sweet, 1988

Family PANDERODONTIDAE Lindström, 1970

Genus PANDERODUS Ethington, 1959

PANDERODUS UNICOSTATUS (Branson and Mehl, 1933)

Plate 16, figs. 24-25

Occurrence.—***Distomodus staurognathoides*** Zone, Pesika Formation.

Material.—30 elements.

Repository.—GSC 119488 and 119489.

PANDERODUS SULCATUS (Fåhræus, 1966)

Plate 23, fig. 21

Occurrence.—***Phragmodus undatus*** Zone, Road River Group, Cassiar Terrane.

Material.—9 elements.

Repository.—GSC 119686.

Order PRIONIODONTIDA Dzik, 1976

Family ACODONTIDAE Dzik, 1994

Genus PTERACONTIODUS Harris and Harris, 1965

PTERACONTIODUS CRYPTODENS (Mound, 1965)

Plate 20, figs. 2-3

Occurrence.—***Paroistodus originalis*** Zone to ***P. horridus*** Zone, Skoki and Ospika formations.

Material.—3 elements.

Repository.—GSC 119584 and 119585.

Genus TRIPODUS Bradshaw, 1969

TRIPODUS LAEVIS Bradshaw, 1969

Plate 20, fig. 1

Occurrence.—*Tripodus laevis* Zone, Skoki Formation.

Material.—4 elements.

Repository.—GSC 119583.

Genus TROPODUS Kennedy, 1980

TROPODUS COMPTUS (Branson and Mehl, 1933)

Plate 6, figs. 25-27 *Occurrence.*—*Scolopodus subrex* Zone, Kechika Formation.

Material.—4 elements.

Repository.—GSC 119215, 119216, 119217.

Family BALOGNATHIDAE Hass, 1959

Genus AMORPHOGNATHUS Branson and Mehl, 1933

AMORPHOGNATHUS TVAERENSIS Bergström, 1962

Plate 23, figs. 13-15 *Occurrence.—Amorphognathus tvaerensis* Zone, Road River Group, Cassiar Terrane.

Material.—64 elements.

Repository.—GSC 119678, 119679, 119680.

Family CYRTONIODONTIDAE Hass, 1959

Genus PHRAGMODUS Branson and Mehl, 1933

PHRAGMODUS UNDATUS Branson and Mehl, 1933

Plate 23, figs. 16-20

Occurrence.—Phragmodus undatus Zone, Road River Group, Cassiar Terrane.

Material.—3 M elements, 71 S elements, 16 P elements.

Repository.—GSC 119686.

Family DISTOMODONTIDAE Klapper, 1981

Genus DISTOMODUS Branson and Branson, 1947

DISTOMODUS STAUROGNATHOIDES (Walliser, 1964)

Plate 16, figs. 20-23

Occurrence.—Distomodus staurognathoides Zone, Pesika Formation.

Material.—3 M elements, 3 S elements, 3 P elements.

Repository.—GSC 119484, 119485, 119486, 119487.

Family OISTODONTIDAE Lindström, 1970

Genus JUMUDONTUS Cooper, 1981

JUMUDONTUS GANANDA Cooper, 1981

Plate 21, figs. 10-11

Occurrence.—Jumudontus gananda Zone, Skoki Formation.

Material.—3 P elements.

Repository.—GSC 119622 and 119623.

Genus OISTODUS Pander 1856

OISTODUS BRANSONI Ethington and Clark, 1982

Plate 18, fig. 6

Remarks.—*O. bransoni* was described by Ethington and Clark (1982) as having a short and stubby posterior extension of the base which is a feature displayed by the few elements in this collection which do not have characteristics of *O. lanceolatus* nor *O. multicorrugatus.*

Occurrence.—*Oepikodus communis* Zone, Skoki Formation.

Material.—3 elements.

Repository.—GSC 119529.

OISTODUS LANCEOLATUS Pander, 1856

Plate 18, figs. 7-10

Remarks.—The apparatus is quinquimembrate and comprises hyaline elements with a symmetry transition of elements which lack a strong lateral costa (Sc), have one or two strong lateral outer costa(e) (Sb) or are symmetrical (Sa). The P element has been described by Bagnoli et al., (1988).

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation to *Paroistodus originalis* Zone, Skoki and Ospika formations.

Material.—20 M elements, 34 S elements, 5 P elements.

Repository.—GSC 119530, 119531, 119532, 119533.

OISTODUS MULTICORRUGATUS Harris, 1962

Plate 18, figs. 1-5

Remarks.—The apparatus has been adequately described by Stouge and Bagnoli (1988) as comprising S, M and P elements which have one or more costae on the base. The elements have a variable number of costae. The elements originally illustrated by Harris (1962) have many costae, but those illustrated by Stouge and Bagnoli (1988) include acostate M elements with one strong lateral carina, and costate to multicostate S and P elements, as well as a range in the development of the costae. *Occurrence.*—*Oepikodus communis* Zone to *Paroistodus originalis* Zone, Skoki Formation.

Material.—12 M elements, 51 S elements, 6 P elements.

Repository.—GSC 119524, 119525, 119526, 119527, 119528.

Genus YAOXIANOGNATHUS AN in AN ET AL., 1985

YAOXIANOGNATHUS SP.

Plate 23, figs. 10-11

Remarks.—Only fragmentary specimens have been recovered from the Road River Group, Cassiar Terrane. They are P elements which are extremely thin and are most similar to Y. ani (Zhen et al.) in being unarched with a straight lower margin. However, as elements are broken, it is difficult to determine the prominence of the cusp, number of denticles and length of anterior process which are diagnostic characters.

Occurrence.—*Amorphognathus tvaerensis* Zone, Road River Group, Cassiar Terrane.

Material.—3 elements.

Repository.—GSC 119675 and 119676.

Family PARACORDYLODONTIDAE Bergström, 1981

Genus FAHRAEUSODUS Stouge and Bagnoli, 1990

FAHRAEUSODUS MARATHONENSIS (Bradshaw, 1969)

Plate 20, figs. 15-18

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation to *Oepikodus communis* Zone, Skoki Formation.

Material.—7 M elements, 47 S elements, 16 P elements.

Repository.—GSC 119597, 119598, 119599, 119600.

Genus OELANDODUS van Wamel 1974

OELANDODUS ELONGATUS van Wamel 1974

Plate 10, figs. 14-17

Occurrence.—*Paracordylodus gracilis* Zone, Kechika Formation.

Material.—14 M elements, 97 S elements, 19 P elements.

Repository.—GSC 119320, 119321, 119322, 119323.

Genus PARACORDYLODUS Lindström, 1971

PARACORDYLODUS GRACILIS Lindström, 1955

Plate 8, figs. 19-22

Occurrence.— *Paracordylodus gracilis* Zone, Kechika Formation.

Material.—34 M elements 54 S elements, 34 P elements.

Repository.—GSC 119268, 119269, 119270, 119271.

Family PERIODONTIDAE Lindström, 1970

Genus PERIODON Hadding, 1913

PERIODON ACULEATUS Hadding, 1913

Plate 14, figs. 23-25

Occurrence.—*Oepikodus communis* Zone, Skoki Formation to *Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—216 M elements 562 S elements, 167 P elements.

Repository.—GSC 119433, 119434, 119435.

PERIODON FLABELLUM (Lindström, 1955)

Plate 21, figs. 6-9

Occurrence.—*Oepikodus communis* Zone, Skoki Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—69 M elements 98 S elements, 18 P elements.

Repository.—GSC 119618, 119619, 119620, 119621.

PERIODON SELENOPSIS (Serpagli, 1974)

Plate 21, figs. 4-5

Occurrence.—*Oepikodus communis* Zone to *Jumudontus gananda* Zone, Skoki Formation.

Material.—8 M elements, 7 P elements.

Repository.—GSC 119116 and 119617.

?PERIODON sp.

Plate 23, fig. 8

Occurrence.—29 m below *Amorphognathus tvaerensis* Zone, Road River Group, Cassiar Terrane.

Material.—3 elements.

Repository.—GSC 119673.

Family PLECTODINIDAE Sweet, 1988

Genus PLECTODINA Stauffer, 1935

PLECTODINA TENUIS (Hinde, 1879)

Plate 23, figs. 22-25

Occurrence.—***Phragmodus undatus*** Zone, Road River Group, Cassiar Terrane.

Material.—1 M element, 7 S elements, 5 P elements.

Repository.—GSC 119687, 119688, 119689, 119690.

Family PRIONIODONTIDAE Bassler, 1925

Genus OEPIKODUS Lindström, 1955

OEPIKODUS COMMUNIS (Ethington and Clark, 1964)

Plate 17, figs. 1-4

Occurrence.—***Oepikodus communis*** Zone, Kechika and Skoki formations.

Material.—110 M elements, 752 S elements, 273 P elements.

Repository.—GSC 119494, 1194495, 119496, 119497.

OEPIKODUS EVAE (Lindström, 1955)

Plate 17, figs. 10-12

Occurrence.—***Oepikodus evae*** Zone, Skoki Formation.

Material.—13 M elements, 67 S elements, 27 P elements.

Repository.—GSC 119503, 119504, 119505.

OEPIKODUS INTERMEDIUS (Serpagli, 1974)

Plate 17, figs. 7-9

Occurrence.—***Oepikodus communis*** Zone to ***Jumudontus gananda*** Zone, Kechika and Skoki formations.

Material.—27 M elements, 142 S elements, 61 P elements.

Repository.—GSC 119500, 119501, 119502.

Genus PRIONIODUS Pander, 1856

PRIONIODUS ADAMI Stouge and Bagnoli, 1988

Plate 19, figs. 13-15

Occurrence.—***Oepikodus communis*** Zone, Skoki Formation.

Material.—7 S elements, 2 P elements.

Repository.—GSC 119564, 119565, 119566.

PRIONIODUS ELEGANS Pander, 1856

Plate 10, figs. 3-6

Occurrence.—***Prioniodus elegans*** Zone, Kechika and Ospika formations.

Material.—2 M elements, 11 S elements, 1 P element.

Repository.—GSC 119309, 119310, 119311, 119312.

Family RHIPIDOGNATHIDAE Lindström, 1970

Genus BERGSTROEMOGNATHUS Serpagli, 1974

BERGSTROEMOGNATHUS EXTENSUS (Graves and Ellison, 1941)

Plate 17, figs. 13-15

Remarks.—The apparatus of *B. extensus* was described as multielement by Serpagli (1974) and Albanesi (1998) illustrates a quinquimembrate apparatus plan containing Sa, Sb, Sc, M and P elements. As Stouge and Bagnoli (1988) noted, the nature of the denticulation of the anterior process of the M element can vary between early and late members of the species which is observed in early and late forms in this present collection.

Occurrence.—*Oepikodus communis* Zone, Skoki Formation.

Material.—19 M elements, 10 S elements.

Repository.—GSC 119506, 119507, 119508.

Order PRIONIODINIDA Sweet, 1988

Family CHIROGNATHIDAE Branson and Mehl, 1944

Genus ERRATICODON Dzik, 1978

ERRATICODON BALTICUS Dzik, 1978

Plate 14, figs.26-27

Occurrence.—*Paroistodus originalis* Zone, Ospika Formation.

Material.—1 S element, 1 P element.

Repository.—GSC 119436 and 119437.

Genus SPINODUS Dzik, 1976

SPINODUS SPINATUS (Hadding, 1913)

Plate 14, figs. 14-15

Occurrence.—*Paroistodus originalis* to *P. horridus* Zone, Ospika Formation.

Material.—4 S elements.

Repository.—GSC 119424 and 119425.

Family PRIONIODINIDAE Bassler, 1925

Genus OULODUS Branson and Mehl, 1933

OULODUS sp. A

Plate 16, figs. 26-27

Remarks.—The specimens are treated in open nomenclature because too few specimens are available for a determination. An Sa, Sb and Sc element can be recognized.

Occurrence.—*Distomodus staurognathoides* Zone, Pesika Formation.

Material.—9 S elements.

Repository.—GSC 119490 and 119491.

OULODUS sp. B

Plate 16, fig. 28

Remarks.—Specimens from the Kwadacha Formation are assigned to *Oulodus*, but too few specimens were recovered to make a determination of species.

Occurrence.—Kwadacha Formation.

Material.—5 S elements.

Repository.—GSC 119492.

FAMILY NOV. 5 Aldridge and Smith, 1993

GENUS PSEUDOONEOTODUS Drygant, 1974

PSEUDOONEOTODUS BECKMANNI (Bischoff and Sannemann, 1958)

Plate 16, fig. 29

Remarks.—P. beckmanni shows variation in its basal outline from round to oval and bears a single apex which is reclined posteriorly (Cooper, 1977). The specimens in this collection are laterally compressed and have an oval basal outline.

Occurrence.—*Distomodus staurognathoides* Zone, Pesika Formation.

Material.—2 elements.

Repository.—GSC 119493.

PSEUDOONEOTODUS MITRATUS (Moskalenko, 1973)

Plate 23, fig. 12

Remarks.—Nowlan and Barnes (1981) describe the simple conical elements as having a deep basal cavity and folded lateral faces. They also showed symmetry differences among elements. The few elements recovered from the Road River Group conform to their description.

Occurrence.—*Phragmodus undatus* Zone, Road River Group, Cassiar Terrane.

Material.—4 elements.

Repository.—GSC 119671 and 119672.

8.3. SYSTEMATIC PALEONTOLOGY

Phylum CHORDATA Bateson, 1886

Class CONODONTA Pander, 1856

Order PROCONODONTIDA Sweet, 1988

Family CORDYLODONTIDAE Lindström, 1970

Genus CORDYLODUS Pander 1856

Type species.—Cordylodus angulatus Pander 1856

Discussion.—Cordylodus Pander is a common and important faunal component in uppermost Cambrian and Lower Tremadoc strata. Its apparatus was described by Miller (1980) and Bagnoli et al. (1987) as bimembrate. Nicoll (1990) has interpreted the apparatus as septimembrate, however, the M elements he illustrated are not recognized in this collection and the P elements he illustrated are here interpreted to be compressed e elements. Therefore, the apparatus of all species is described as having three morphotypes as defined by Ji and Barnes (1994) and Andres (1988). These are a (subrounded) with two variants and c (suberect) elements within the first transition series and e (compressed) with two variants having slight to strong compression, making up the second transition series. However, in early forms, not all of these morphotypes are well defined. Among species which occur together, the compressed element formerly named *C. prion* under form taxonomy is synonymized with *C. caboti*. Similar shaped compressed elements within the apparatus of *C. intermedius* are close to those of *C. caboti* but have an "*intermedius*" shaped basal cavity.

CORDYLODUS ANGULATUS Pander, 1856

Plate 2, figs. 11-13; Plate 22, figs. 3-4

a element

Cordylodus angulatus PANDER, 1856, p. 33, pl. 2, fig. 31, pl. 3, fig. 10; NICOLL, 1990, pp. 536-543, fig. 3, 4b (S element), fig. 6, 7, 11.4 (S elements) only; JI AND BARNES, 1994, pp. 31-32, pl. 5, fig. 1-4 (contains synonymy through 1994); HARRIS ET AL., 1995, p. 24, pl. I, fig. AB.

c element

Cordylodus angulatus PANDER, 1856, p. 33, pl. 2, fig. 30; NICOLL, 1990, pp. 536-543, fig. 5.3, 5.4, fig. 10.3, 10.4 (Sa element) only; JI AND BARNES, 1994, pp. 31-32, pl. 5, fig. 5; LÖFGREN, 1997, p. 260, fig. 4E.

e element

Cordylodus angulatus PANDER, 1856, p. 33, pl. 2, figs. 27-29; NICOLL, 1990, pp. 536-543, fig. 3 (4c), fig. 8 (Pb element), fig. 9 (Pa element), fig. 12 (Pa and Pb elements); JI AND BARNES, 1994, pp. 31-32, pl. 5, fig. 6-9 (contains synonymy to 1994); LÖFGREN, 1997, p. 260, fig. 4D.

not *Cordylodus angulatus* Pander. NICOLL, 1990, fig. 3 (4a), fig. 5.1, 5.2, fig. 10.1, 10.2.

Discussion.—The apparatus of *C. angulatus* contains three morphotypes as discussed in Ji and Barnes (1994): a (subround, with symmetry variants), c (suberect) and e (compressed, with two variants). The distinguishing characteristic of *C. angulatus* is the shape of the shallow basal cavity in lateral view in which the anterior margin of the cavity is deeply concave and the posterior margin originates under the posterior process and runs parallel to the process, turning down to form the cavity tip below or on line with the process. In robust elements, where the cavity cannot be observed, the a elements vary in the degree of lateral compression and have a notch or wide angle between the cusp and first denticle. They have an extremely high base, the margin of which is straight. The c elements are characterized by a suberect element morphology and often have an arched basal margin and process. The e elements are characterized by one variant in which a prominent basal flare is developed on the inner lateral margin or the basal margin (previously described as *C. rotundatus*). The other variant of the e element is compressed along the cusp and basal margin and does not develop the basal flare. Both, however, are characterized by the notch between the cusp and first denticle. The septimembrate apparatus plan proposed by Nicoll (1990) has been partially synonymized here, however, the P elements he figures are the variants of the compressed e elements and the M element is not observed in this material.

Occurrence.—*Cordylodus angulatus* Zone, Kechika Formation.

Material.—1000 a elements, 76 S elements, 303 P elements.

Repository.—GSC 119078, 119079, 119080 and GSC 119642, 119643.

CORDYLODUS CABOTI Bagnoli, Barnes and Stevens, 1987

Plate 2, figs. 1-4

a element

Cordylodus caboti BAGNOLI, BARNES AND STEVENS, 1987, p. 152, pl. 1, figs.10-14 (contains synonymy to 1987).

e element

Cordylodus prion LINDSTRÖM 1955, pp. 552-553, pl. 5, figs. 14-16; DRUCE AND JONES, 1971, p. 70, pl. 2, figs. 1-7, text-fig. 23 (I, k-o); MÜLLER, 1973, p.33, pl. 10, fig. 4a, b, text-fig. 2E, 8; LANDING AND BARNES, 1981, pp. 1617-1621, pl. 2, fig. 16, text-fig. 3 (6); FORTEY ET AL., 1982, p. 119, text-fig. 6W, Y, 8I, L; LANDING, 1983, p. 1161, text-figs. 7I, J, 8B, D. *Cordylodus oklahomensis* Müller. LANDING, 1983, p. 1161, text-fig. 7f; FORTEY ET AL., 1982, p. 119, text-figs. 6v, x, 8g, o.

C. intermedius? Furnish. MILLER, 1980, p. 17-18, pl. fig. 17, text-fig. 4M.

not *Cordylodus caboti* BAGNOLI ET AL., 1987, p. 152, pl. 1, figs.10.

Discussion.—As described by Bagnoli et al. (1987), the apparatus comprises rounded elements (p) which are the a and c elements and compressed (q) elements which are the e elements, often referred to the species *C. prion*. The specimens of *C. prion* and *C. oklahomensis* listed in the synonymy are those which have straight edged basal cavities. However, the compressed elements, referred to as *C. prion* and *C. oklahomensis*, are very similar and possibly represent the compressed elements of other species, differentiated only by the shape of the basal cavity. The basal cavity of the elements is a characteristic feature in that it is not as deep as in *C. proavus*, extending to a point slightly higher than the posterior process. The basal cavity has straight margins to convex near the tip and its apex is centrally located. Both features distinguish it from *C. intermedius*.

Occurrence.—*Iapetognathus* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—52 a elements, 9 c elements, 353 e elements.

Repository.—GSC 119068, 119069, 119070, 119701.

CORDYLODUS CASEYI Druce and Jones, 1971

Plate 2, figs. 7-10; Plate 22, fig. 6

Cordylodus caseyi DRUCE AND JONES, 1971, pp. 67-68, pl. 2, figs. 9-12, text-figs 23d, e; NICOLL, 1990, pp. 543-545, fig. 13 (4, 5), 14 (1, 2) only; JI AND BARNES, 1996, p. 881, fig. 12.17-12.23.

Description.—Apparatus of three morphotypes characterized by robust elements with lateral costae. Basal cavity is similar shape to that of *C. intermedius* because anterior basal cavity margin is concave and tip of cavity is located anteriorly. Basal cavity is broad, extending under posterior process. Basal margin is drawn out anteriorly to form anticusp.

The a elements are subsymmetrical, subround and comprise two variants within symmetry transition series. Cusp is long and slender, cusp margins are rounded, cusp cross-section is circular. Cusp has inner postero-lateral keel and inner lateral compression. Cusp is twisted laterally, and denticulated posterior process is twisted toward inner side, denticles are slightly compressed. Basal margin is arched and drawn out antero-laterally into anticusp. Other variant has antero-lateral buttress drawn out onto anticusp and is more stout. Outer surface of cusp is smooth and inner lateral surface is compressed postero-laterally. Base is compressed.

The symmetrical c element has keel which originates basally parallel to anterior cusp margin and turns posterior and downward. Posterior process is arched. Element is slightly laterally compressed; cusp cross-section is oval with rounded margins.

The compressed e elements are of two variants in which degree of arching of the basal margin differs. In both variants, anticusp is developed, more strongly in more arched specimens. Denticles are discrete to slightly confluent along their bases.

Discussion.—*C. caseyi* is characterized by rounded, robust elements with long slender cusps and lateral or antero-lateral buttresses. The basal cavity shape is similar to that of *C. intermedius* and the two species are likely closely related. The original description by Druce and Jones (1971) was only of the a elements. In this study, compressed e elements and symmetrical c elements are included in the apparatus reconstruction. The e elements are similar to those of coeval *Cordylodus* species and are distinguished by the presence of the anticusp.

Occurrence.—*Iapetognathus* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—71 a elements, 7 c elements, 19 e elements.

Repository.—GSC 119074, 119075, 119076, 119077; GSC 119645.

CORDYLODUS DEFLEXUS s.f. Bagnoli, Barnes and Stevens, 1987

Plate 1, fig. 4

Cordylodus deflexus BAGNOLI, BARNES AND STEVENS, 1987, p. 153, figs. 1-4 (contains synonymy to 1987).

? *Cordylodus tortus* BARNES, 1988, p.412, figs. 13p-r, 14b.

Discussion.—As noted in the synonymy within Bagnoli et al. (1987), it is difficult to distinguish rounded and compressed elements from previous studies. They describe p elements which are rounded with an anticusp. The q elements are compressed and the process is laterally deflected. In both element types, the cusp is twisted laterally and the process is twisted. The specimens in this study are in agreement with their observations, and are likely part of another *Cordylodus* apparatus, but sufficient material is lacking in this collection to confirm this.

Occurrence.—*Cordylodus proavus* Zone, Kechika Formation.

Material.—2 elements.

Repository.—GSC 119043.

CORDYLODUS DELICATUS n. sp.

Plate 1, figs. 11-13; Plate 22, fig. 5

Cordylodus andresi BARNES, 1988, pp. 410-411, fig. 13 e, 14a only (c element).

Cordylodus proavus Müller. MILLER, 1969, p. 432, pl. 65, fig. 38, 39 only; DRUCE AND JONES, 1971, p. 120, pl. 1, figs. 2 a, b only; MÜLLER, 1973, p. 35, pl. 9, fig. 8 only; MILLER, 1980, pp. 19-20, pl. 1, fig. 14, 15 only; LANDING, 1983, p. 1168, fig. 9C only; CHEN AND GONG, 1986, pp. 130-133, pl. 35, fig. 8, pl. 36, fig. 2, 11, 12, 15, text-fig. 40 (1, 2) only. *C.* sp. cf. *C. proavus* Müller. NOWLAN, 1985, p. 111, fig. 4 (4) only.

Diagnosis.—A small, delicate species of *Cordylodus* with extremely wide angle between slender, elongate cusp and first denticle of posterior denticulated process.

Description.—Apparatus of three elemental morphotypes, all with long, slender cusp and denticulated posterior process. Characteristic feature of elements is broad, sweeping angle between first discrete denticle of posterior process and slender cusp.

The subrounded a elements are laterally compressed, some slightly and others strongly, and comprise first symmetry transition series. Cusp is slender, reclined to recurved, cusp margins are rounded. Basal cavity is deep and broadly based, extending under long posterior cusp margin but not into discrete denticles. Basal cavity narrows at the point of curvature of cusp, but extends deep into cusp. Cusp tip and denticles are filled with white matter. Anterior margin of basal cavity is concave from antero-basal margin and is close to anterior cusp margin. Posterior basal cavity margin is directly under posterior cusp margin and curves anteriorly to join anterior basal margin, forming central apex at or above at point of curvature and flexure of cusp. Shape of basal margin and degree of lateral compression of cusp is variable. Most have horizontal basal margin and posterior process and oval basal cross-section. Anterobasal corner is smoothly rounded and laterally compressed. Denticles are laterally compressed, reclined posteriorly and oval in cross-section.

The c element shares similar characteristics with a elements but is symmetrical and not as compressed as a element. Cusp is erect. Basal margin is slightly arched and anterobasal corner is sharp, not rounded.

The compressed e elements are not as abundant. They have strongly compressed cusp and basal flare, usually between first denticle and cusp. Degree of compression along inner anterior lateral margin varies from slight to strong. Some elements have basal margin with inner flare and downwardly directed posterior cusp margin.

Etymology.—Named for its delicate nature.

Discussion.— *C delicatus* is similar to *C. primitivus* in its primitive characters such as a deep basal cavity, and simple morphology within an undifferentiated apparatus. As Barnes (1988) described, variation in the flexure of the posterior process is a distinguishing feature, however, in this study the elements vary in the degree of compression and curvature of the cusp. The p2 and p3 elements of Barnes (1988) have wider basal cavities and narrow angle between the cusp and process and are not observed in this collection. Possibly they are other morphotypes in the apparatus.

C. andresi was originally proposed for elements with large, deep basal cavities, extending nearly to the tip (Viira et al., 1987). The elements of *C. andresi* are variable but are denticulated at a point high on the posterior margin of the cusp. As suggested by

Müller and Hinz (1991), *C. andresi* as described by Barnes (1988) is neither *C. primitivus* nor *C. andresi* sensu Viira and Sergeyeva (1987). Hence, this new species, *C. delicatus*, is erected. *Occurrence.—Iapetognathus* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—28 a elements, 6 c elements, 13 e elements.

Repository.—GSC 119050, 119051, 119052 and GSC 119644.

CORDYLODUS HASTATUS Barnes, 1988

Plate 1, figs. 14-16

Cordylodus hastatus BARNES, 1988, pp. 411-412, Fig. 13 s-x, Fig. 14d (contains synonymy to 1988); FÅHRAEUS AND ROY, 1993, p. 18, pl. 1, figs. 15, 17 only.

Description.—Basal cavity extends beneath denticulated posterior process in all elements. White matter is present in tip of cusp and within denticles. The a elements comprise subround, subsymmetrical elements. Cusp suberect to reclined. Cusp margins are rounded to keeled and vary in degree of lateral compression. Posterior process and anterior margin are slightly downwardly directed. In some, angle between first denticle and posterior margin is wide, in others more acute. Denticles are laterally compressed and confluent.

The c element is suberect and symmetrical. Cusp is broad and keeled, process and anterior margin are downwardly directed. Element retains symmetry as process is not deflected nor cusp curved laterally. Denticles are inclined posteriorly. Inner cusp margin bears faint carina.

The e element is distinctive, broad and robust with laterally compressed cusp with strongly keeled margins and well developed inner carina on some and slight lateral curvature of cusp. Posterior process contains laterally compressed, broad denticles, confluent and inclined posteriorly. Process slightly upwardly deflected in some specimens. Angle between first denticle and posterior margin of cusp is sharp and acute. Base is nearly flat in only one specimen, in all others anterior margin is directed downward.

Discussion.—C. hastatus contains three morphotypes which Barnes (1988) distinguished as p1, p2, p3 and q. The p1 and p2 are the two variants of the a element, the p3 is equivalent to e elements and c elements are equivalent to q elements. The specimens are similar to those described by Barnes (1988). If the a elements are broken, they can resemble rounded *C. primitivus*, or if the basal cavity is not observed, elements can resemble *C. proavus*. The basal cavity differs from that of *C. proavus* in having a straight, not curved, anterior margin. The a elements of *C. hastatus* are distinct from *C. proavus* in having confluent bases of the denticles. *Occurrence.—Cordylodus proavus* Zone, Kechika Formation.

Material.—2 a elements, 2 c elements, 9 e elements.

Repository.—GSC 119053, 119054, 119055.

CORDYLODUS INTERMEDIUS Furnish, 1938

Plate 1, figs. 24-26

a element

Cordylodus intermedius FURNISH, 1938, p. 338, pl. 42, fig. 31, text-fig. 2c; JI AND BARNES, 1994, p. 32, pl. 5, fig. 10-13 (contains synonymy to 1994); HARRIS ET AL., 1995, p. 27, pl. II, fig. G.

c element

Cordylodus lenzi MÜLLER, 1973, p. 31, text-fig. 2F, pl. 10, fig. 7 (only); JI AND BARNES. 1996, pl. 5, fig. 14, 16. e element

Cordylodus oklahomensis DRUCE AND JONES, 1971, p. 69, pl. 5, fig. 7b, 7c only, text-fig. 23j.

Cordylodus intermedius Furnish. JI AND BARNES, 1996, pl. 5 (17, 18).

Discussion.—As described by Barnes (1988), *C. intermedius* is an evolutionary intermediate between *C. proavus* and *C. angulatus*. Of the three morphotypes described by Ji and Barnes (1994), the a elements are most distinct in having a shallow basal cavity extending to the level of the process, its anterior margin is concave and the basal cavity tip is located anteriorly. The compressed elements are more difficult to distinguish among coeval species, but can be identified by the anterior concavity of the basal cavity margin in *C. intermedius*.

Occurrence.—Iapetognathus to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—86 a elements, 3 c elements, 15 e elements.

Repository.—GSC 119063, 119064, 119065.

CORDYLODUS LINDSTROMI Druce and Jones, 1971

Plate 1, figs. 20-23; Plate 22, fig. 7

a element

Cordylodus lindstromi DRUCE AND JONES, 1971, pp. 68-69, pl. 1, figs. 7a-8b (only), pl. 2, figs. 8a-c; JONES, 1971, p. 47, pl. 2, figs. 4a-c; MÜLLER, 1973, p. 32, pl. 9, fig. 10 only, text-figs. 2D, 6A-B; MILLER, 1980, pp. 18-19, pl. 1, fig. 18 only; VIIRA ET AL., 1987, pl. 2, fig. 7, pl. 4, figs. 7, 8 only; ANDRES, 1988, pp. 134-136, Abb. 36 (middle fig.), Abb. 37 (in part); BARNES, 1988, pp. 408-409, figs. 13 k, l only (p element); JI AND BARNES, 1996, p. 881, fig. 12.6- 12.8, 12.11-12.12; HARRIS ET AL., 1995, p. 27, pl. II, fig. H.

not JI AND BARNES, 1994, p. 32, pl. 5, figs. 19, 20 (e element variant)c element

Cordylodus lindstromi Druce and Jones. MÜLLER, 1973, p. 32, pl. 9, fig. 11; ANDRES, 1988, pp. 134-136, Abb. 36 (top fig.), Abb. 37 (in part); JI AND BARNES, 1996, p. 881, fig. 12.9, 12.10.

e element

Cordylodus lindstromi DRUCE AND JONES, 1971, pp. 68-69, pl. 1, figs. 9a-b only, text-fig. 23h; MILLER, 1980, pp. 18-19, pl. 1, fig. 19 only; ANDRES, 1988, pp. 134-136, Abb. 36 (lower fig.), Abb. 37 (in part); BARNES, 1988, pp. 408-409, fig. 13j; JI AND BARNES, 1994, p. 32, pl. 5, figs. 19-22; JI AND BARNES, 1996, p. 881, fig. 12.13.

Discussion.—The apparatus was initially illustrated by Druce and Jones (1971) and described by Miller (1980) as having two elemental morphotypes. Andres (1988) figured three morphotypes which are recognized in this study. The characteristic feature of *C. lindstromi* is the biapical basal cavity, however, this character must be used with caution as it may be exhibited by other species. The shape of the basal cavity is a distinguishing feature in that it is narrow and its anterior margin follows the margin of the cusp and its apex is situated anteriorly. Another characterisitic is the proximity to the cusp of the first denticle of the posterior process. The elements of *C. lindstromi* can be distinguished from *C. proavus* because the cavity of *C. proavus* is much broader and deeper and the majority of the elements observed in this material are robust compared to the slender, more delicate cusps of *C. lindstromi*. As Ji and Barnes (1994) described. the a elements are much more common than the e elements and both the a and e elements show variations in curvature. The c elements are distinguished by being symmetrical, the cusp is suberect and basal margin is arched.

Occurrence.—*Iapetognathus* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—1221 a elements, 27 c elements, 615 e elements.

Repository.—GSC 119059, 119060, 119061 and GSC 119646.

CORDYLODUS PRIMITIVUS Bagnoli, Barnes and Stevens, 1987

Plate 1, figs. 8-10

Cordylodus primitivus BAGNOLI, BARNES AND STEVENS, 1987, p.154, pl.1, figs. 1-6 (contains synonymy to 1987); LEHNERT, 1995, p. 80, pl. 14, fig. 2; MENS ET AL., 1996, pl. 1, figs. 7, 8. not *Cordylodus primitivus* Bagnoli, Barnes and Stevens sensu MÜLLER AND HINZ, 1991, p. 54, pl. 43, figs. 4,5, 8-15, 21A-F (*C. andresi* sensu Viira and Sergeyeva, 1987).

Description.—Three elemental morphotypes are recognized. Subrounded (a) elements have symmetry variants of nearly symmetrical and rounded, asymmetrical and compressed on one side, and fully laterally compressed. Cusps are slender to broader based. Basal cavity is broad and deep, with its margins close to anterior and posterior margins of cusp, expands under posterior margin below denticles. Cusp is long, reclined to recurved, smooth in rounded forms and keeled anteriorly and/or posteriorly in variants. Basal margin is flat to extended anteriorly and posteriorly. Denticulated extension of posterior margin bears laterally compressed denticles with variation in point of origin along margin; some arise just below point of curvature of the cusp, others are along flat basal margin. No distinct process developed. Denticles are discrete, vary in number from one to four along margin, at right angles to posterior margin or reclined posteriorly.

Symmetrical (c) element is rare and has suberect cusp which is smoothly rounded and contains white matter in cusp tip. The basal margin is slightly arched. Denticles are reclined, process is directed downward.

Compressed asymmetrical (e) elements have compression along inner postero-lateral margin, some have minor inner carina and basal flare, others are smooth along basal margin. Cusp is twisted laterally and bent inward. White matter is present in cusp tip, above basal cavity, and within denticles.

Discussion.—*C. primitivus* is a transitional species from *E. notchpeakensis* to *C. proavus* and although it lacks a well developed posterior process, its posterior margin is denticulate, and when broken, elements are indisguishable from *E. notchpeakensis*. The apparatus contains elements of variable morphology which Bagnoli et al. (1987) did not differentiate into three morphotypes but described as approximate to Miller's (1980) rounded and compressed elements. I agree with Mens et al. (1996) that *C. primitivus* is a separate species from *C. andresi* Viira and Sergeyeva, based on the distribution of white matter, however, Szaniawski and Bengston (1998) caution using white matter as a diagnostic feature especially depending on the state of preservation. *C. primitivus* is different from *C. andresi* Viira and Sergeyeva in the overall shape of the cusp and the nature of denticulation in which the denticles arise much higher on the cusp margin in *C. andresi* than in *C. primitivus*. Szaniawski and Bengston (1998) suggest *C. andresi* is derived from *Proconodontus* stock. *C. primitivus* is clearly a descendant of *E. notchpeakensis*.

Occurrence.—*Cordylodus proavus* to *Iapetognathus* Zone, Kechika Formation.

Material.—47 a elements, 6 c elements, 9 e elements.

Repository.—GSC 119047, 119048, 119049.

CORDYLODUS PROAVUS Müller, 1959

Plate 1, figs. 17-19

a element

Cordylodus proavus MÜLLER, 1959, pp. 448-449, pl. 15, figs. 11, 12, 18, text-fig. 3B; MILLER, 1980, pp. 19-20, pl. 1, fig. 14, text-fig. 4G; BAGNOLI ET AL., 1987, p. 154, pl. 1, fig. 8 (see synonymy within); BARNES, 1988, fig. 13A, B; JI AND BARNES, 1996, p. 881, fig. 12 (1, 2, 4, 5); NICOLL, 1990, p. 550, fig. 20, 21 only; HARRIS ET AL., 1995, p. 25, pl. I, fig. AE; PARSONS AND CLARK, 1999, p. 6, fig. 5.24, 5.25.

c element

Cordylodus proavus Müller. NOWLAN, 1985, p. 111, fig. 5 (12, 13, 18, 19); NICOLL, 1990, p. 550, Fig. 19 (3, 4) only; JI AND BARNES, 1996, fig. 12 (3).

e element

Cordylodus oklahomensis MÜLLER, 1959, p. 447, pl. 15, figs. 15-16, text-fig. 3A

Cordylodus proavus Müller. MILLER, 1980, pp. 19-20, pl. 1, fig. 15, text-fig. 4H; BAGNOLI ET AL., 1987, p. 154, Pl. 1, fig. 9 only (see synonymy within); BUGGISCH AND REPETSKI, 1987, p. 154, pl. 4, figs. 1, 2, 5, 6, pl. 5., fig.1, pl. 8, fig. 7; BARNES, 1988, fig. 13C; NICOLL, 1990, p. 550, Fig. 22 (2, 4, 5) only.

Description.—Apparatus of three morphotypes in which elements have distinct posterior denticulated process and rounded to keeled cusp. Basal cavity is deep and its margins are parallel to the cusp margins, extending into cusp tip beyond point of curvature of cusp and under process. Cusp tip and denticles are filled with white matter. Basal cavity is biapical in some elements.

The a elements are subround and comprise variants with a symmetry transition series. Asymmetry is attributed to lateral flexure of the posterior process. Basal outline is flat to slightly arched. Denticles are discrete and rounded.

The c element is characterized by symmetry and arching of basal margin. Cusp margins are rounded and anterior cusp margin is extended in some specimens. Posterior denticulated process contains up to five laterally compressed, discrete denticles.

The e elements are strongly laterally compressed. Posterior cusp margin is keeled more strongly than anterior and cusp is laterally compressed along length of inner lateral posterior margin and extends along basal margin. Denticles are compressed and confluent along their bases. Inner basal margin is flared.

Discussion.—Bagnoli et al. (1987) describe *C. proavus* as having a more differentiated apparatus in which elements develop a distinct posterior process than the denticulated posterior margin of *C. primitivus*. The basal cavity is a distinguishing characteristic in *C. proavus* elements because it is deep, extends parallel to the cusp margins and its anterior outline curves convexly. The e elements are distinguished from *C. hastatus* by the development of a faint carina along the inner compressed lateral margin and flare to the basal margin, whereas the cusp of *C. hastatus* is smooth and evenly compressed along the length of the cusp. Elements within a septimembrate plan by Nicoll (1990) have been partially synonymized. No M elements are observed as he illustrated, and the P elements are synonymized as laterally compressed e elements, the Sa element is symmetrical and arched and synonymized as the c element, and the Sc, Sb, and Sd elements described by Nicoll (1990) are variants of the a element.

Occurrence.—*Cordylodus proavus* to *Iapetognathus* Zone, Kechika Formation.

Material.—52 a elements, 3 c elements, 6 e elements.

Repository.—GSC 119056, 119057, 119058.

Genus EOCONODONTUS Miller, 1980

Type species.—*Proconodontus notchpeakensis* Miller, 1969

EOCONODONTUS NOTCHPEAKENSIS (Miller, 1980)

Plate 1, figs. 1-3

Proconodontus notchpeakensis MILLER, 1969, p. 438, pl. 66, figs. 21-29, text-fig. 5G

Eoconodontus notchpeakensis (Miller). MILLER, 1980, pp. 22-23, pl.1, figs. 10-12; text-figs. 3D-E (includes synonymy to 1980); BAGNOLI, BARNES AND STEVENS, 1987, pp.155-156, pl.2, figs.5-7 (includes synonymy to 1987); BUGGISCH AND REPETSKI, 1987, p. 155, pl.6, figs. 8a, pl. 8 fig. 12 only; VIIRA ET AL., 1987, p. 148, pl.1, figs. 9-11; MENS ET AL., 1996, pl. 2, figs. 4, 5; HARRIS ET AL., 1995, p. 24, pl. I, fig. X, Y; LEHNERT, 1995, p. 85, pl. 1, figs. 1, 2; HEIN AND NOWLAN, 1998, p. 181, pl. 3, figs. 17-19.

Description.—Elements have two morphotypes (a and e) with variants within two symmetry transition series. The a elements are subround to round, subsymmetrical to symmetrical, slender and wider based; varying degree of lateral compression, slight to strong, transitional forms compressed on one side. Oval to round in cross-section, erect to reclined long cusp, deep basal cavity extends to point of curvature of cusp, cusp tip filled with white matter. Smooth surfaces, with or lacking keeled anterior and/or posterior margin, basal margin drawn out slightly into anterior and posterior extensions, other specimens have relatively flat basal margin.

Asymmetrical, compressed (e) elements, cusp long and laterally bent, inner or concave side is carinate, giving slight lateral flare to inner side of base. Degree of compression along inner postero-lateral margin varies through a symmetry transition.

Discussion.—The genus, as established by Miller (1980), is described as a bimembrate apparatus of nongeniculate, smooth elements, comprising a rounded, drepanodiform and a compressed asymmetrical, scandodiform element referred to by Bagnoli et al. (1987) as a p and q element, respectively. Some elements in which the tip of the cusp was broken have not been included because they could be *Proconodontus* sp. if white matter is lacking. Nicoll (1992) indicated that *Eoconodontus* could have a septimembrate apparatus but did not describe it. *Eoconodontus* is ancestral to lineages of *Cordylodus* and broken specimens of *C. primitivus* and *C. proavus* can easily be mistaken for *Eoconodontus*.

Occurrence.—*Eoconodontus* to *Iapetognathus* Zone, Kechika Formation.

Material.—104 a elements, 22 e elements.

Repository.—GSC 119040, 119041, 119042.

Genus IAPETOGNATHUS Landing, 1982

Type species.—*Pravognathus aengensis* Lindström 1955

Discussion.—The genus Iapetognathus was first established by Landing (in Fortey and others, 1982). Nicoll et al. (1999) define *Iapetognathus* as comprising ramiform elements with one or sometimes two lateral, denticulated processes. The cusp is compressed laterally or antero-posteriorly and may have anterior or lateral keels or carinae. The cusp becomes posteriorly recurved above the point of origin of the process. They describe *Iapetognathus* as a multielement taxa containing S and P elements and discuss its importance in defining the Cambrian-Ordovician boundary. *Iapetognathus* can be distinguished from *Cordylodus* by its denticulated processes which are in a lateral position rather than posterior.

IAPETOGNATHUS AENGENSIS Lindström 1955

Plate 1, fig. 28; Plate 2, fig. 17

Pravognathus aengensis LINDSTRÖM, 1955, p. 585, pl. 5, figs. 10-13.

Iapetognathus aengensis (Lindström). NICOLL ET AL., 1999, pp. 44-46, pl. 1.1-1.5, 2.1-2.4, 3.1-3.4 only (contains synonymy through 1999).

Discussion.—The specimens in this study are similar to those described by Nicoll et al. (1999). The Sb element is asymmetrical, its cusp recurved posteriorly. The posterior margin of the cusp is characterized by a prominent keel extending from the apex of the basal cavity to the edge of the basal margin. The deep basal cavity extends along the denticulated anterior inner-lateral process, and posterior shelf. The narrowing of the process anterior to the cusp and the keeled posterior margin are characteristics of the Sb elements. The Sc element has a wide cavity which does not narrow and the keeled posterior margin extends to the basal margin with only a slight development of a posterior shelf. The Sd element has a prominent posterior keel and shelf, such that a posterior extension is created and it has a larger proximal denticle than in other elements. As in the Sc element, the process does not narrow anteriorly. White matter is located in the cusp tip and within the denticles.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—13 Sb elements, 3 Sc elements, 3 Sd elements.

Repository.—GSC 119067, 119084.

IAPETOGNATHUS FLUCTIVAGUS Nicoll et al., 1999

Plate 2, figs. 14-16

Iapetognathus fluctivagus NICOLL ET AL., 1999, pp. 46-48, pl. 6. 1-6.5, pl. 7.1-7.4 (Sb and Sc elements).

Discussion.—Only two elemental morphotypes were recognized in this collections. The Sb element has an anterior outer lateral process that differentiates it from *I. aengensis*, which has an inner lateral process. The process is also strongly attached to the cusp as its base does not constrict under the anteriormost denticle. The cusp has a keel extending to the basal margin and is laterally compressed. The keel twists outward and extends to the posterior edge of the base which distinguished it from the Sc element. The Sc element has a reduced posterior keel. The elements lack a prominent keel and node on the anterior margin as described by Nicoll et al. (1999). The cusp tip and denticles contain white matter.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—3 Sb elements, 2 Sc elements.

Repository.—GSC 119081, 119082, 119083.

IAPETOGNATHUS SPRAKERSI Landing et al., 1996

Plate 2, figs. 18-19

Iapetognathus sprakersi LANDING, WESTROP AND KNOX, 1996, p. 672, figs. 5.1-5.3; NICOLL ET AL., 1999, pp. 50-51, pl. 21.1-21.4 (Sb and Sc elements).

Discussion.—I. sprakersi is characterized by a thin and weak attachment of the outer lateral process to the cusp and shallow basal cavity. The cusp is longer than in other elements in the collection and has an outer-lateral carina which is developed differently in the S elements. Only two morphotypes were observed, the Sb elements, which have a short outer-lateral carina and the Sc elements, which lack the carina.

Occurrence.—Iapetognathus Zone, Kechika Formation.

Material.—2 Sb elements, 11 Sc elements.

Repository.—GSC 119085, 119086.

IAPETOGNATHUS SP.

Plate 1, fig. 27

Description.—Cusp is strongly antero-posteriorly compressed and inclined posteriorly. It is broader than in other species described and lacks a keeled posterior margin, but has slight keel on anterior margin and strongly keeled lateral margins. Denticulated lateral process arises from outer anterior margin, and denticles are compressed in plane of process and are directed antero-laterally. Basal cavity is broad and deep, extending to point of recurvature of cusp, its tip is filled with white matter. Basal cavity narrows slightly under process and under a postero-lateral extension of basal margin.

Discussion.—The element is more robust than species and cannot be ascribed to an existing species.

Occurrence.—Iapetognathus Zone, Kechika Formation.

Material.—1 element.

Repository.—GSC 119066.

Family FRYXELLODONTIDAE, Miller 1981

Genus KALLIDONTUS new genus

*Type species.—**Kallidontus serratus*** new genus and species

Diagnosis.—Conodonts with apparatus of conical S elements and platform P elements. Elements have deeply excavated cusps which have thin walls and cusp tip filled with white matter. Coniform elements range from simple costate forms to forms with blunt, rounded denticle along the posterio process. Sa elements have denticulate lateral cusp margins.

Platform elements have a variety of morphologies in which the nature of denticulation and ridge development varies. All P elements are broad with thin walls which bear faint to strongly developed transverse ridges. They are deeply excavated with white matter in cusp tip and denticle tips. Large Pb elements share characteristics of being large and cap-like in which the base length is two times the element height. Elements are antero-posteriorly compressed and bear weak to strongly developed, equally spaced transverse ridges parallel to base, extending from base to tip, extending across anterior and posterior cusp faces. Pa elements are of two forms: one has broadly laterally expanded cusp wall which bear transverse ridges and nodose lateral ridges. Anterior cusp face convex; posterior cusp face convex. Nodose lateral processes curve in opposite directions giving the basal margin an S-shape in oral view. In some forms these lateral processes bifurcate distally. Cusp tip short and blunt. The second form is laterally compressed and has rounded anterior element face witih nodose lateral margins. Posterior cusp face concave with transverse ridges. Cusp tip is one-third height of total element height and recurved posteriorly.

Etymology.—Kalli means beautiful; dont means tooth.

Occurrence.—*Scolopodus subrex* Zone to *Oepikodus communis* Zone, Kechika and Skoki formations.

KALLIDONTUS NODOSUS n. gen. n. sp.

Plate 11, figs. 18-22; Plate 12 figs. 12-20

Diagnosis.—A new species of *Kallidontus* in which the Pb element has strongly developed transverse ridges terminating laterally as strong nodes on one lateral process and as transverse nodes on the other lateral process. Coniform S elements have strongly developed nodose posterior and lateral processes.

Description.—Apparatus of conical S elements and large, nodose, ridged P elements.

S elements are conical and deeply excavated. Cusp tip filled with white matter and recurves posteriorly. Anterior cusp face rounded. Lateral cusp faces smooth and crossed by transverse ridges. Posterior process extended and denticulated from base to cusp tip. Base is wide and basal cavity deep. Basal margin slightly arched. Symmetrical Sa element (Pl. 11, fig. 19) is symmetrical and bear nodose posterior process and denticulated lateral processes which curve posteriorly and are joined by transverse ridges. One morphotype observed which may be an S element is conical and bears costae on the anterior cusp face (Pl. 12, fig. 19). Element is stout with small cusp tip, recurved posteriorly and filled with white matter. Lateral cusp faces bear costae and element has concentric ridges from base to tip.

Pb elements deeply excavated with thin, ridged, element walls Cusp tip is recurved posteriorly. Anterior cusp face convex; posterior cusp face concave. Lateral processes strongly nodose and joined by strong transverse ridges from base to cusp tip. Ridges terminate laterally as strong nodes on one lateral process and as transverse nodes on the other lateral process (Pl. 11, fig. 20). In smaller Pb elements (?juvenile), the transverse ridges terminate along lateral processes which are equally developed and do not have strong transverse nodes.

Pa elements are stout and broad based. Element expands in anterior and posterior direction and constricts laterally under lateral processes. Strong transverse ridges are concentric about element and arise as nodose ridges along lateral process (Pl. 11, fig. 22). Second morphotype is one in which the element is compressed laterally and expands anteriorly and posteriorly. Anterior process is ridged, with ridges extending concentrically around elements. Posterior process bifurcates distally as two lateral processes which are ornamented by nodose denticles (Pl. 12, fig. 15).

Etymology.—Named after the nodular appearance of ridges

Discussion.—*K. nodosus* differs from *K. serratus* in the development of strong nodes rather than blunt denticles along the lateral margins of the Pb elements and posterior process of S elements. The distinct feature of all elements of *K. nodosus* the presence of well developed transverse ridges which are weak in *K. serratus* and barely visible in *K. princeps*.

Occurrence.—*Acodus kechikaensis* Zone, Skoki Formation.

Material.—8 S elements, 10 P elements.

Repository.—GSC 119352 to 119356 and GSC 119366 to 119374.

KALLIDONTUS cf. K. NODOSUS n. gen. n. sp.

Plate 10, figs. 26-28; Plate 12, figs. 21-23; Plate 17, fig. 16

Discussion.—A few elements from the upper Kechika and lower Skoki Formation are similar to S and P elements of *K. nodosus*. The P elements are elongate in which element height is equal to base length. Lateral cusp margins bear small denticles which are highly fused and extend from base to cusp tip. Denticle are much smaller than those of *K. serratus* and differ from the ridges developed along the lateral margins of *K. nodosus*. Cusp tip is bulbous. The P elements are more similar to *K. nodosus* than to *K. serratus* in the development of two nodose ridges on the posterior element face. Postero-lateral cusp margin is also ridged (Pl. 10, fig. 28).

The S elements are conical with elongate, recurved cusp tip and deeply excavated basal cavity. Posterior and lateral cusp margins are sharp. These are similar to those of early forms of *K. serratus*. An Sa element (Pl. 12, fig. 22) has base expanded laterally with nodose lateral cusp margins and posterior cusp margin. Posterior cusp face is concave.

This species occurs stratigraphically higher than *K. nodosus* and as it has some differences, mainly in the finer nodes and denticles of the P element, it is referred to as *K.* cf. *K. nodosus*.

Occurrence.—*Acodus kechikaensis* Zone, Skoki Formation.

Material.—20 S elements, 4 P element.

Repository—GSC 119332, 119333, 119334 and GSC 119375, 119376, 119377 and GSC 119509.

KALLIDONTUS PRINCEPS n. gen. n. sp.

Plate 11, figs. 1-5

Diagnosis.—A new species of *Kallidontus* with an apparatus of coniforms and platforms with thin walls joined to sharp processes. Coniforms are triangular in lateral view with three processes. Platform is broad with smooth walls which bear faint transverse ridges.

Description.—Apparatus of deeply excavated coniforms (S elements) and platforms (P elements) which have thin walls. S elements are triangular in lateral view and have deep basal cavities which extend almost to cusp tip. Asymmetrical elements have one strong lateral costa extending from base to cusp tip. Anterior and posterior cusp margins sharp. Base extends posteriorly in some elements. Cusp is stout in some forms, as long as base is wide, and cusp margins extend below basal margin (Pl. 11, fig. 5).

Symmetrical (?Sa) element has strong posterior costa and two lateral costae. Cusp is slender and lateral margins project slightly below basal margin.

Platform element expands laterally and is cap-like. Height of element is one-half length of base. Anterior cusp face convex; posterior cusp face unevenly concave and asymmetrical. One lateral process is longer than the other. Cusp walls bear faint transverse ridges. Base is wide and basal cavity is deep.

Etymology.—Princeps means first.

Discussion.—K. princeps appears to be the first species in this lineage as it has the simplest morphology without the development of elaborate architecture of cusp walls and processes. The P elements bear weak transverse ridges which become more visible in *K. serratus* and strongly developed in *K. nodosus*. The S elements in *K. princeps* have straight cusp margins, which in *K. serratus* become ornamented with nodose serrations and in *K. nodosus* are developed into nodose denticles.

Occurrence.—Scolopodus subrex to *Acodus kechikaensis* Zone, Skoki Formation.

Material.—113 S elements, 4 P element.

Repository GSC 119335 to 119339.

KALLIDONTUS SERRATUS n. gen. n. sp.

Plate 11, figs. 6-17; Plate 12, figs. 1-11

Diagnosis.—A new species of *Kallidontus* in which coniforms have thin walls and three processes which have transverse ridges and nodes along one to three lateral processes. Platforms have one to three serrated to nodose processes and broad bases.

Description.—Apparatus of conical S elements and platform P elements.

S elements are conical with three processes (2 lateral, one posterior) connected by thin, element walls. Elements are stout to elongate, with sharp lateral cusp margins that extend below basal margin. Elements are erect to proclined with weak curvature of distal portion of albid cusp tip. Lateral margins are straight edged in some elements and weakly serrated in others (Pl. 11, fig. 6). Anterior cusp face is flat to gently convex. Posterior process bears four to six rounded denticles or nodes which are short and blunt. Posterior process extends below basal margin in some elements and projects as a sharp process, directed downward. In others, the posterior process is denticulate right to end of process and expands posteriorly but does not project below basal margin (Pl. 11, figs. 7 and 12). All elements observed are asymmetrical due to unequal development of lateral processes (Pl. 11, fig. 11, posterior view).

Platform elements are broad-based and comprise elements with a main cusp and lateral and posterior processes which extend as denticulated sheathes.

Pb element is diagnostic. It is an almost symmetrical, large platform element with two lateral denticulate processes. Element antero-posteriorly compressed. Cusp tip is slightly curved posteriorly and filled with white matter. Anterior face is convex; posterior face is broadly concave. Element has equally spaced transverse ridges parallel to the base, extending from the base to the cusp on posterior and anterior cusp faces. Lateral cusp margins bear at least seven large, blunt denticles, along each margin, which arise where transverse ridge meets lateral edge. Denticles give serrated appearance to cusp margins in posterior view (Pl. 11, fig. 9). Denticles filled with white matter. Basal cavity is deep and extends under lateral processes. Basal outline is straight.

In late Pb elements (Pl. 11, fig. 15), a posterior denticulate process is added. Element broadly expanded and anterior and posterior cusp faces bear transverse ridges. Anterior cusp face convex; posterior cusp face convex in region between posterior process and lateral processes. Lateral processes and posterior process bear at least five broad denticles.

Pa elements are broad based, stout elements. Cusp tip recurved posteriorly and filled with white matter. Anterior of element bears two costae which diverge from cusp tip to base and are connected by transeverse ridges (Pl. 11, fig. 10). In lateral view, anterior element margin appears rounded (Pl. 11, fig. 8). Posterior process extends as denticulate process which in some elements bifurcates distally (Pl. 11, fig. 10). Lateral element faces ornamented by transverse ridges. Element bulges laterally in anterior portion of element, but narrows posteriorly giving basal outline an S-shape (Pl. 11, fig. 10). A second form of Pa element is one in which element bulges to anterior and posterior rather than laterally. Cusp tip recurves posteriorly. Lateral processes curve in opposite directions giving the basal margin an S-shape (Pl. 11, fig. 14). Lateral cusp margins bear a ridge extending from cusp to base. Transverse ridges cross anterior and posterior cusp face to join lateral ridges.

Etymology.—Named for the serrated edges of the P elements.

Discussion.—*K. serratus* appears to have arisen from *K. princeps* by the elaboration of a denticulated sheath in coniform and platform elements. Late forms of the large, broad Pb element develop a posterior process in addition to the lateral processes. There are two Pa elements which differ in the nature of expansion of the element (lateral versus antero-posteriorly) and in the bifurcation of the posterior process.

Occurrence.—*Acodus kechikaensis* Zone, Skoki Formation.

Material.—126 S elements, 32 P element.

Repository.—GSC 119340 to 119351 and GSC 119357 to 119365.

NEW GENUS C, NEW SPECIES

Plate 20, figs. 4-7

Description.—Two morphotypes (S and P) recognized which are similar to those of *Kallidontus* n. gen. S elements are simple cones with laterally compressed cusp. Anterior cusp margin rounded to sharply rounded and posterior cusp margin sharp. Inner lateral cusp face flat to concave, outer lateral face convex. Cusp erect and unornamented. Anterobasal corner sharply rounded. Base posteriorly extended. Basal margin straight; basal outline oval and expanded to outer lateral side. Basal cavity deep; cusp walls thin.

P element is diagnostic and a cap-like platform. Element expands laterally and is wider than cusp height. Anterior side of element rounded with irregular surface and one prominent keel extending from base to lateral cusp margin. Posterior side of element concave. Element surface is irregular. Basal margin is irregular.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation.

Material.—3 S elements, 1 P element.

Repository.—GSC 119586, 119587, 119588, 119589.

Family PROCONODONTIDAE Lindström 1970

Genus PROCONODONTUS Miller, 1969

emend. Szaniawski and Bengtson, 1998

Type species.—*Proconodontus muelleri* Miller, 1969

PROCONODONTUS MUELLERI Miller, 1969

Plate 1, figs. 5-6

Proconodontus muelleri MILLER, 1980, pp. 29-30, pl. 1, fig. 7, text-fig. 4C (contains synonymy to 1980); LANDING, 1983, fig. 11G, H, p. 1180; MÜLLER AND HINZ, 1991, p. 56, pl.42, figs. 1, 3-9 (includes synonymy to 1991); HEIN AND NOWLAN, 1998, p. 180, pl. 3, fig. 9; SZANIAWSKI AND BENGSTON, 1998, pp. 17-18, pl.2, fig. 4-13 only, text fig. 4g, h, i only (includes synonymy to 1998).

Discussion.—As described by Miller (1980), the elements of P. *muelleri* are similar to *E. notchpeakensis* but the basal cavity extends to the tip and elements have prominent posterior and anterior keels. Szaniawski and Bengston (1998) described a multielement apparatus of simple cones with deep basal cavities, thin crowns, oval to round cross-sections and keeled anterior and posterior margins. They describe an apparatus of three morphotypes, "comparatively slender and rounded in cross section, slightly wider and compressed from one side, and nearly geniculate", the latter of which are rare (Szaniawski and Bengston, 1998, p. 17). The compressed and nearly geniculate elements are within a transition series. The elements in this study include only specimens with intact distal cusps. The nearly geniculate elements were not observed. The rounded specimens studied are laterally compressed, asymmetrical elements are compressed along the posterior inner margin and have a slight lateral curvature of the cusp. All elements have keeled anterior and posterior margins.

Unlike *E. notchpeakensis*, the asymmetrical elements do not have an inner carina. The *Proconodontus* lineage could be the ancestral stock for the Drepanodontidae as discussed by Szaniawski and Bengston (1998), and appears to have given rise to one species of *Cordylodus*, *C. andresi*. From the material in this study, *C. hastatus* may also have arisen from *Proconodontus* due to strong similarity of its cusp morphology.

Occurrence.—*Eoconodontus* Zone, Kechika Formation.

Material.—3 a elements, 4 e elements.

Repository.—GSC 119044 and 119045.

Order PROTOPANDERODONTIDA Sweet, 1988

Family CLAVOHAMULIDAE Lindström, 1970

Genus GRANATODONTUS Wang, 1986

Type species.—Hirsutodontus? ani WANG IN CHEN ET AL., 1986.

Discussion.—The genus was erected for small simple cones which are similar to *Hirsutodontus* but covered with a surface sculpture of fine warts, rather than sculpture of larger nodes confined to the basal region of the element.

GRANATODONTUS cf. G. ANI (Wang, 1986)

Plate 1, fig. 7

cf. *Hirsutodontus? ani* WANG IN CHEN ET AL., 1986, pp. 92-93, pl. 26, figs. 4-6.

cf. *Granatodontus ani* (Wang) CHEN, 1986, pp. 148-149, pl. 26, fig. 8, pl. 27, figs. 1-5, 13, pl. 31, fig. 10, text-fig. 53 only (contains synonymy to 1986).

cf. *Hirsutodontus ani* (Wang) MEI, 1993, p. 18, pl. 1, fig. 7.

Discussion.—A few specimens of small, simple cones with a deep basal cavity and surface sculpture of fine warts are reported. There appears to be two morphotypes. A symmetrical cap-shaped coniform element has a wide base and deep basal cavity. The asymmetrical form has a posterior carina and some compression along the posterior cusp face, but is similarly cap-shaped and covered in fine, warty sculpture.

Occurrence.—Iapetognathus Zone to *Scolopodus subrex* Zone, Kechika Formation.

Material.—8 elements.

Repository.—GSC 119046.

Family CORNUODONTIDAE Stouge, 1984

Genus MACERODUS Fåhræus and Nowlan, 1978

emend. Ji and Barnes, 1994

Type species.—Macerodus dianae Fåhræus and Nowlan, 1978

Discussion.—Ji and Barnes (1994) defined the genus as comprising a (subrounded curved) and e (compressed) elements characterized by an extremely long base and deep basal cavity.

MACERODUS CRISTATUS n. sp.

Plate 4, figs. 26-28

Diagnosis.—A new species of *Macerodus* with apparatus of two morphotypes (a and e) in which elements bear one high, prominent costa on one lateral cusp face in medial or antero-lateral position.

Description.—Apparatus of two morphotypes: a is subround and e is compressed. The a element is stout with broad, long base. Cusp is recurved, antero-posteriorly compressed and flexed posteriorly. Anterior cusp margin rounded; posterior cusp margin sharp. Cusp bears costa which arises from basal margin at antero-lateral position and remains strong along length of cusp but fades near cusp tip. Costa has its highest point at basal margin, giving basal outline quadrate shape. Cusp is compressed along postero-lateral and antero-lateral flanks of costa.

The e element is laterally compressed. Cusp is broad and recurved. Cusp bears strong lateral costae which arises basally and joins anterior cusp margin distally. Posterior and anterior cusp margins sharp. Base is long and wide and has oval outline with flare posterior to costae.

Etymology.—Named for the high crest-like costa on all elements (cristatus = crested).

Discussion.—This new species shares similarities with and is likely derived from *M. lunatus* n. sp. *M. cristatus* n. sp. shows stronger development of the carina or costae in the a and e elements.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—3 a elements, 2 e elements.

Repository.—GSC 119161, 119162, 119163.

?MACERODUS DIANAE Fåhræus and Nowlan, 1978

Plate 22, fig. 25

Macerodus dianae FÅHRÆUS AND NOWLAN, 1978, p. 461, pl. 1, fig. 27; JI AND BARNES, 1994, p. 47, pl. 13, figs. 9-18, text-fig. 30B (contains synonymy to 1994)

Discussion.—A specimen is questionably assigned to *M. dianae* based on the long, compressed cusp with quadrate cross-section. However, the compression is not even but is strongest at the antero-basal corner. *Occurrence.—Paroistodus proteus* Zone, Road River Group, Cassiar Terrane.

Material.—2 elements.

Repository.—GSC 119664.

MACERODUS LUNATUS n. sp.

Plate 4, figs. 24-25

Diagnosis.—A new species of *Macerodus* with apparatus of two morphotypes (a and e) which have crescent-shaped outline of element with stout, broad, curved cusp.

Description.—Apparatus of two morphotypes: a is subround and e is compressed. The a element is stout with broad, long base. Cusp is recurved posteriorly giving element crescent shape. Anterior and posterior cusp margins are sharply rounded. Raised, rounded carina arises at base in medial-lateral position and fades at point of curvature of cusp. Base has triangular outline and is flared under carina.

The e element is laterally compressed with sharp cusp margins. Strong antero-lateral costa arises at base and merges with posterior cusp margin at point of curvature of cusp. Basal outline is oval.

Etymology.—Named for the crescent or lunate shape of elements.

Discussion.—The specimens observed are close to *M. crassatus* but differ in the degree of asymmetry due to twisting of the cusp. The base is also not as wide as those illustrated by Ji and Barnes (1994).

Occurrence.—Rossodus manitouensis Zone, Kechika Formation.

Material.—2 a elements, 1 e element.

Repository.—GSC 119159 and 119160.

?MACERODUS sp.

Plate 22, figs. 17-21

Description.—Elements of two morphotypes (a and e) include conodonts with elongate, compressed cusps and long, broad, posteriorly extended bases. The a elements have laterally compressed, recurved cusps with sharply rounded anterior and posterior cusp margins. Cusp is slender, about two-thirds width of base. Cusp is unornamented. Base is expanded posteriorly. Antero-basal corner is straight in some elements (Pl. 22, fig. 19) as anterior cusp margin meets base at right angle. In other elements, the antero-basal corner is rounded. Basal margin is flat; basal outline is oval.

The e element is compressed with long, recurved cusp. Cusp margins are sharp and cusp is unornamented. Base is short and antero-basal corner is rounded and compressed. Base flares open posteriorly and has rounded basal outline.

Discussion.—The specimens are tentatively assigned to *Macerodus* but more material is need to ascertain the relationship. The e element is unlike that in other species of *Macerodus*, but the a elements bear some similarity to *M. lunatus* n. sp.

Occurrence.—*Rossodus manitouensis* Zone, Road River Group, Cassiar Terrane.

Material.—11 a elements, 2 e elements.

Repository.—GSC 119656 to 119660.

Family DREPANOISTODONTIDAE Fåhræus and Nowlan, 1978

Genus DREPANOISTODUS Lindström 1971

Emend. Ji and Barnes, 1994

Discussion.—The apparatus of *Drepanoistodus* was defined by Ji and Barnes (1994) as having three elemental morphotypes: a (subround, drepanodiform), c (suberect symmetrical) and e (compressed oistodontiform) forming two symmetry transition series.

DREPANOISTODUS AMOENUS (Lindström, 1955)

Plate 13, figs. 18-20

Drepanodus amoenus LINDSTRÖM, 1955, p. 588, pl. 2, fig. 25 only.

Paroistodus amoenus (Lindström). VAN WAMEL, 1974, pp. 78-79, pl. 7, figs. 8-11

Drepanodus aff. *D. amoenus* (Lindström). REPETSKI, 1982, p. 19, pl. 5, fig. 8

Discussion.—*D. amoenus* has been synonymized with *P. numarcuatus* by some authors, but shows several differences. The base of the elements is much wider than in *Paroistodus* and the basal edges are roumded. The elements in this collection are exactly as illustrated by van Wamel (1974), in which the a element bears a keeled posterior edge. There is no recessive basal margin as in *Paroistodus*, and the basal cavity is much deeper. The e element is geniculate and the apparatus plan is like that of *Drepanoistodus* rather than *Drepanodus*.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation to *Oepikodus communis* Zone, Skoki Formation.

Material.—60 a elements, 6 e element.

Repository.—GSC 119395, 119396, 119397.

DREPANOISTODUS MINUTUS n. sp.

Plate 13, figs. 11-13; Plate 22, fig. 10

Diagnosis.—A species of *Drepanoistodus* in which elements are characterized by small size and small base with slender, extremely elongate cusp.

Description.—Apparatus of three morphotypes (a, c, e) of simple, unornamented coniforms characterized by small size and small base with slender, extremely elongate cusp.

The a element is subsymmetrical to symmetrical with elongate, erect to reclined cusp. Cusp margins sharply rounded. Base is short and expands weakly to posterior. Basal outline round; basal margin straight. Antero-basal corner is straight as cusp meets base at right angle. Basal cavity is shallow with apex located centrally.

The c element is diagnostic. Cusp is erect, long and laterally compressed with sharply rounded anterior and posterior cusp margins. Base is small and flared equally both posteriorly and anteriorly. Antero-basal corner concave just above basal margin. Basal margin is sinuous, arching under antero-basal corner.

The e element is compressed with sharp posterior margin and sharply rounded anterior cusp margin. Asymmetrical element with compression along posterior margin. Antero-basal corner is straight; basal margin is straight. Base expands weakly to posterior.

Etymology.—Named after its small size (minute=small).

Discussion.—This small, delicate apparatus is distinguished from other species of *Drepanoistodus* by the c element and the slender nature of the a and e elements, all of which have a poorly defined base.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation and Road River Group, Cassiar Terrane.

Material.—34 a elements, 14 c elements, 15 e elements.

Repository.—GSC 119388, 119389, 119390 and 119649.

DREPANOISTODUS EXPANSUS (CHEN AND GONG, 1986)

Plate 13, figs. 4-7

Drepanodus expansus CHEN AND GONG, 1986, pp. 136-137, pl. 48, figs. 2, 6, 9, pl. 50, figs. 1, 7, 8, 12, 13; pl. 52, fig. 13, text-fig. 44 (contains synonymy to 1986).

Discussion.—Chen and Gong (1986) illustrate asymmetrical and subsymmetrical elements with a characteristic strongly flared base. Elements from this collection are assigned to this species, but have an apparatus plan of *Drepanoistodus*. The c element is diagnostic (Pl. 13, fig. 5) and are exactly as Chen and Gong (1986) illustrate and describe. The subsymmetrical elements they describe as having a base which bulges on the inner lateral side are the a elements.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—32 a elements, 16 c elements, 33 e elements.

Repository.—GSC 119381, 119382, 119383, 119384.

DREPANOISTODUS n. sp. A

Plate 13, figs. 21-23

Description.—A species of *Drepanoistodus* which is characterized by gaping base which opens widely to both inner and outer lateral sides of element. Apparatus of three morphotypes (a, c, e).

The a element is compressed with broad, erect cusp. Posterior and anterior cusp margins sharp. Lateral cusp faces smooth. Postero-basal margin sharp; antero-basal margin rounded. Basal margin has inner lateral flare and flares anteriorly.

The c element is suberect and symmetrical with compressed cusp (broken, so curvature not determined). Base opens widely laterally.

The e element is geniculate and compressed. Antero-basal margin rounded; postero-basal margin sharp. Base opens widely laterally and has prominent inner lateral flare.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—7 a elements, 3 c elements, 7 e elements.

Repository.—GSC 119398, 119399, 119400.

DREPANOISTODUS cf. n. sp. A

Plate 23, figs. 2-5

Description.—Elements which are similar to those of *Drepanoistodus* n. sp. A occur within Deadwood Lake Section. The a elements are similar to those described above, however, distinct, sharp anterior margin is more developed into keel which deflects from posterior cusp margin to join base in antero-lateral position. Shape of base, however, is identical to that described above. Other a elements do not have such strong development of antero-lateral keel and base has two carinae, near each basal corner. Base on these elements opens anteriorly. The e element is different from *D.* n. sp. A in being non-geniculate with recurved cusp. Base has inner lateral flare and is not as expanded posteriorly.

Occurrence.—*Paroistodus proteus* Zone, Road River Group, Cassiar Terrane.

Material.—6 a elements, 2 e elements.

Repository.—GSC 119667, 119668, 119669, 119670.

DREPANOISTODUS n. sp. B

Plate 19, fig. 22

Drepanodus sp. 3 SERPAGLI, 1974, p. 45, pl. 10, figs. 7a, b, pl. 21, fig. 15.

Discussion.—Serpagli (1974) described the suberect symmetrical element which has been observed in the present collection. The cusp is stout and bears an anticusp which is posterior to a characteristic notch in the short base.

Occurrence.—*Oepikodus communis* Zone, Skoki Formation.

Material.—1 c element.

Repository.—GSC 119573.

DREPANOISTODUS n. sp. C

Plate 19, figs. 23-25

Description.—A new species of *Drepanoistodus* which is characterized by its compressed e element which has short base, extended posteriorly and anteriorly, with narrow basal opening and inner lateral flare. Apparatus of three elemental morphotypes (a, c, e). The a element is laterally compressed and geniculate. Cusp bears weak lateral carina which extends from cusp tip onto base. Antero-basal corner rounded; postero-basal edge sharp. The c element is symmetrical and has slender cusp and concavity in anterior cusp margin just above base. Base has inner lateral flare and extends posteriorly and anteriorly. The e element is diagnostic. It is laterally compressed and has narrow basal opening with inner lateral flare to basal margin. Antero- and postero-basal corners extend as flanges. Anterior cusp margin straight.

Occurrence.—*Oepikodus communis* Zone, Skoki Formation.

Material.—4 c element, 2 e elements

Repository.—GSC 119574, 119575, 119576.

DREPANOISTODUS n. sp. D

Plate 19, figs. 26-28

Description.—A new species of *Drepanoistodus* which is close to *Drepanoistodus* n. sp. C, but has more open and flared base. The e element is diagnostic and has sinuous, flared base. Cusp is erect. Base expands anteriorly and opens anteriorly. Base has inner lateral flare. The a elements have open bases, round in profile which also open anteriorly under anterior extension. Cusp is erect and laterally compressed. Cusp margins are sharply rounded. Anterior cusp margin concave above antero-basal corner.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation.

Material.—3 a elements.

Repository.—GSC 119577, 119578, 119579.

DREPANOISTODUS n. sp. E

Plate 19, figs. 29-31

Description.—A new species of *Drepanoistodus* with two morphotypes recognized (a and e). The e element is diagnostic and has a large, circular base which opens posteriorly and tapers anteriorly. Base has a thickened rim. Cusp is slender and erect. Cusp bears fine striae on lateral cusp faces and is laterally compressed. The a element is laterally compressed. Cusp ornamented by fine striae on medial part of lateral faces and one stronger costae which extends up cusp. Cusp is concave posterior to costae. Cusp margins sharp. Base is large and unornamented with notch in anterior basal corner.

Occurrence.—Jumudontus gananda Zone, Skoki Formation.

Material.—8 a elements, 3 e elements.

Repository.—GSC 119580, 119581, 119582.

GENUS LAURENTOSCANDODUS Landing, Westrop and Knox, 1996

Type species.—Oistodus? triangularis Furnish, 1938

Discussion.—Landing et al. (1996) established the genus to include elongate, microstriated, albid coniforms. They described subsymmetrical to symmetrical drepanodiforms (a elements), acodiforms (b elements) and suberectiforms (c elements). Compressed oistodiform (e) elements were also recognized. The morphotypes described are similar to those of *Drepanoistodus* but there are four, not three, element morphotypes (a, b, c and e) that are similar to early forms of *Drepanoistodus*; the e element is non-geniculate. The most distinct morphotype is the b element and all elements have a base that is triangular in lateral view and some have longitudinal microstriae on the cusp which distinguish them from *Drepanoistodus*.

LAURENTOSCANDODUS cf. L. TRIANGULARIS (Furnish, 1938)

Plate 2, figs. 20-23

cf. *Oistodus? triangularis* FURNISH, 1938, p. 330, pl 42, fig. 22, text-fig. 1P.

cf. *Laurentoscandodus triangularis* (Furnish). LANDING, WESTROP AND KNOX, 1996, pp. 672-674, fig. 8.12-8.29, 9.14, 9.18-9.21 (contains synonymy to 1996).

cf. *Drepanoistodus? pervetus* NOWLAN, 1985, pp. 112-113, figs. 5.54-5.55, 6.2, 6.3 (only).

Discussion.—An apparatus of four morphotypes in which all elements have a large, triangular base and weak lateral rounded costae is similar to that described by Landing et al. (1996). However, their type of oistodiform (e) element is not observed in the present collection, but rather it has a much more flared and expanded base and tapered cusp. The suberect c element bears a faint longitudinal lateral carina and has an elongate antero-basal margin which is flattened. The a and b elements differ in having a posterior keel on the b element, and also a faint longitudinal carina and postero-lateral groove.

Occurrence.—Rossodus manitouensis Zone, Kechika Formation.

Material.—37 a elements, 34 b elements, 9 c elements, 7 e elements.

Repository.—GSC 119087, 119088, 119089, 119090.

LAURENTOSCANDODUS SINUOSUS n. sp.

Plate 2, figs. 24-27

Diagnosis.—A new species of *Laurentoscandodus* characterized by the a element which has a sinuous, flared base which expands laterally, anteriorly and posteriorly.

Description.—Apparatus of four morphotypes (a, b, c, e) in which elements are robust with elongate, longitudinally striated cusps and broad, expanded bases with shallow basal cavities and sinuous basal outline.

The a element is subround subsymmetrical to symmetrical. Cusp is erect and laterally compressed. Anterior and posterior cusp margins are sharp. Inner and outer lateral faces bear carina on base, giving lateral flare to base. Element is concave on either side of carinae. Subsymmetrical variants have basal flare on inner side only. Basal outline is sinuous. Basal cavity is large and gaping. Postero-basal margin straight; antero-basal margin convex.

The b element is laterally compressed. Anterior and posterior cusp margins are sharp. Postero-lateral margin bears a longitudinal groove and is compressed along length of posterior cusp margin, which is keeled and laterally deflected. Base flares laterally on inner and outer sides. Antero-lateral basal margin rounded; postero-basal margin straight.

The c element is suberect and symmetrical. Cusp is evenly laterally compressed along its length. Base expands slightly laterally and extends further posteriorly than anteriorly. Antero-basal corner is slightly concave.

The e element is non-geniculate and laterally compressed. Cusp is reclined and laterally flexed. Outer lateral surface is smoothly rounded with faint compression on postero-basal edge of cusp. Inner lateral surface bears even compression along cusp but base is compressed on either side of inner lateral basal flare. Basal cavity cross section is oval.

Etymology.—Named for sinuous nature of basal outline

Discussion.—This species is similar to *L.* cf. *L. triangularis* but is characterized by the flared base and more pronounced lateral deflection of the posterior keel on the b and e elements. The symmetrical element is close to that of *D. pervetus*, but can be distinguished by the longitudinal striae on the elongate cusp and the triangular profile of the base.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—106 a elements, 50 b elements, 13 c elements, 14 e elements.

Repository.—GSC 119100, 119101, 119102, 119103.

GENUS PALTODUS Pander, 1856

Type species.—*Paltodus subaequalis* Pander, 1856

?PALTODUS JEMTLANDICUS Löfgren, 1978

Plate 9, figs. 12-16

aff. *Paltodus? jemtlandicus* LÖFGREN, 1978, p. 65, pl. 4, fig. 1-3, 6 only; ETHINGTON AND CLARK, 1982, p. 75, pl. 8, fig. 10, fig. 19

Diagnosis.—A species which is tentatively assigned to *Paltodus* characterized by the compressed M element which has short base with a sharp postero-basal corner and broad cusp. Apparatus of three morphotypes (S, M, P) of simple cones with triangular bases and cusps which bear lateral costae.

Description.—M element is oistodiform and has broad cusp. Base is short with round antero-basal outline and sharp, straight postero-basal margin. Base flared on inner lateral face and opens laterally.

P element is compressed antero-posteriorly and bears a faint rounded carina on the posterior face. Anterior face rounded. Lateral cusp margins sharp. Base is short and has posterior flare.

S elements are erect with small triangular base. Strongly to weakly costae on outer lateral face. Costae arise above the base and fade distally. Inner lateral face smooth. Base poorly defined with rounded antero-basal margin and sharp to sharply rounded postero-basal margin.

Discussion.—Elements similar to the M element have been illustrated but the full apparatus has not been reconstructed. The assignment to *Paltodus* is questioned, but seems appropriated based on the triangular shape of the base of all elements.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—161 M elements, 781 S elements, 88 P elements.

Repository.—GSC 119290, 119291, 119292, 119293.

GENUS PAROISTODUS Lindström, 1971

Type species.—*Oistodus parallelus* Pander, 1856

Discussion.—The apparatus of *Paroistodus* was reconstructed by Löfgren (1997) as containing seven elemental morphotypes. The genus is characterized by its geniculate M element and nongeniculate S and P elements which are all extremely laterally compressed and have a recessive antero-basal margin in all but the earliest species, *P. numarcuatus*. Löfgren (1997) makes subtle distinctions between S elements based on a large and well preserved collection. Albanesi (1998) illustrated an apparatus of five morphotypes and discusses the evolution of *P. horridus* in which the dolabrate S and P elements are more easily distinguished. Albanesi and Barnes (2000) document the evolutionary transitions of *P. originalis* to *P. horridus*.

PAROISTODUS HORRIDUS (Barnes and Poplawski, 1973)

Plate 15, figs. 18-21

Cordylodus horridus BARNES AND POPLAWSKI, 1973, pp. 771-772, pl. 2, figs. 16-18.

Paroistodus horridus (Barnes and Poplawski). ALBANESI, 1998, pp. 140-141, pl. 8, figs. 1-6, pl. 15, figs. 14-15, text-figs. 17-18 (contains synonymy to 1998); ALBANESI AND BARNES, 2000, p. 496, figs. 3, 4.

Discussion.—Albanesi (1998) recognized two subspecies and illustrated five morphotypes in the apparatus. The material in the present collection is assigned to *P. horridus* sensu stricto. Five morphtypes are recognized and have been adequately described previously. The elements show elongate processes in the S and P elements and the P elements are characterized by an alternating lateral deflection of the denticles.

Occurrence.—*Paroistodus horridus* Zone, Ospika Formation.

Material.—19 M elements, 27 S elements, 26 P elements.

Repository.—GSC 119455, 119456, 119457, 119458.

PAROISTODUS n. sp.

Plate 19, figs. 9-10

Description.—Apparatus consists of some elements which are similar to *Paroistodus* in having inverted basal cavity and resemble S and P elements of genus. Antero-basal margin is recessive and posterior margin and oral margin of base is thinly keeled. Base is expanded laterally and cusp bears fine striae which do not extend on base. There are varying degrees of curvature of cusp and in lateral compression of elements.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation.

Material.—4 elements.

Repository.—GSC 119560 and 119561.

NEW GENUS A, NEW SPECIES

Plate 13, figs. 27-31

Diagnosis.—Apparatus of S, M and P elements in which the robust, albid elements have compression along the postero-lateral cusp margin and P elements are diagnostic in having a keeled anterior cusp margin and inner lateral flare on the base.

Description.—S elements are coniforms with erect cusps. Cusp is laterally compressed along the posterior. Posterior cusp margin is sharp. Anterior cusp margin is rounded. Base is short, about one-tenth the length of the cusp. Antero-basal corner is round; postero-basal corner is sharp. Base flared on inner lateral side.

M element is geniculate with a rounded antero-basal margin and sharp postero-basal margin. Angle between base and cusp is 30 degrees. Cusp laterally compressed along its length. Basal cavity open downward.

P element is laterally compressed with raised and keeled anterior cusp margin. Posterior cusp margin sharp. Base flares on both lateral cusp faces. Another morphotype has less flared basal margin and less developed anterior keel.

Discussion.—Elements of this new genus bear some resemblance to coniforms such as *Paltodus* and *Drepanoistodus* so the genus is tentatively placed within the

Protopanderodontidae. However, no elements resembling a symmetrical c element of the *Drepanoistodus* apparatus were observed and the P elements are different from those of *Paltodus* in the strong development of the anterior keel on the cusp.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—7 M elements, 9 S elements, 19 P elements.

Repository.—GSC 119404, 119405, 119406, 119407, 119408.

FAMILY ONEOTODONTIDAE Miller, 1980

Genus UTAHCONUS Miller, 1980

Type species.— *Paltodus utahensis* Miller, 1969

Emended diagnosis.—The apparatus of *Utahconus* contains three to four elemental morphotypes characterized by compression along the cusp and round to triangular basal outline. The a elements are rounded and subsymmetrical simple cones with compression along the posterior cusp margin and a rounded basal outline in lateral view. The symmetrical c elements are antero-posteriorly compressed with sharp lateral cusp margins and a rounded basal cavity. The e elements are variable (three morphotypes in *U. utahensis*) among the two species recognized but have an evenly compressed cusp along its length. The b elements are present in *U. utahensis* but not in *U. longipinnatus* and are laterally compressed morphotypes.

Discussion.—Ji and Barnes (1994) described the apparatus of *U. longipinnatus* as having three morphotypes in which the a elements are unicostate, asymmetrical subround with lateral and/or posterior costae and the e elements are bicostae and postero-laterally compressed. A bimembrate apparatus plan containing a and e elements occurs in early species as originally described by Miller (1980). Suberect symmetrical c elements which have two lateral costa and one faint posterior carina are recognized by Ji and Barnes (1994).

UTAHCONUS LONGIPINNATUS Ji and Barnes, 1994

Plate 5, figs. 1-3

Utahconus longipinnatus JI AND BARNES, 1994, pp. 66-67, pl. 25, figs. 1-4, 7, 8 only text-fig. 38A (see synonymy within).

Scalpellodus longipinnatus (Ji and Barnes). LANDING, 1996, pp. 675-676, fig. 7.9, 7.10, 7.12-7.19, 7.24, 9.22, 9.23 only.

Discussion.—The elements in this study are in agreement with Ji and Barnes' (1994) description, except for the c (suberect symmetrical) element in which the basal cavity is oval. The c element of *U. longipinnatus* is rare, and has a rounded base and smooth anterior cusp face. Specimens of *U. longipinnatus* which occur with *Variabiloconus* are distinguished from it by lacking grooves and a prominent posterior carina and wide base. *U. longipinnatus* has a triangular to round basal cross-section and is characterized by strong antero-posterior compression in bicostate forms and antero- or postero-lateral compression in unicostate forms. The apparatus lacks the compressed e elements in the *U. utahensis* apparatus but shares the characteristics of the genera such as the compression of the cusp and the rounded base. The elements of *U. longipinnatus* are recognized by their robust elements with elongate cusps.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—450 a elements, 42 c elements, 266 e elements.

Repository.—GSC 119164, 119165, 119166.

UTAHCONUS UTAHENSIS (Miller 1980)

Plate 3, figs. 1-7; Plate 22, fig. 22

Paltodus utahensis MILLER, 1969, p. 436, text-fig. 5F, pl. 63, figs. 33-40.

Utahconus utahensis (Miller). MILLER, 1980, pp. 35-36, fig. 3B, C, F, G, pl. 2, figs. 1, 2 (contains synonymy to 1980); WANG, 1986, p. 242, pl. 2, figs. 1, 2, pl. 6, fig. 6, pl. 8, fig. 19, pl. 11, figs. 1, 8, pl. 13, figs. 19, 20; WANG IN CHEN ET AL., 1986, pp. 195-197, pl. 44, figs 2-6, 10-17, pl. 51, fig. 2, 10, 13-14, only, text-fig. 82 (in part). ORNDORFF, 1988, p. A16, pl. 2, figs. 22, 23, LANDING, 1993, p. 6, fig. 4.11-4.15.

Utahconus aff. *U. utahensis* (Miller). NOWLAN, 1985, pp. 117-118, figs. 5.45-5.52; 9.1, 9.3.

Description.—Apparatus of four elemental morphotypes of small, simple cones with shallow, rounded basal cavities and compressed cusps. The a, b and c elements form the first symmetry transition series and three compressed e elements form the second series.

The a elements are subsymmetrical forms which vary in degree of postero-lateral compression. Unicostate forms have rounded anterior cusp margin and sharply keeled posterior cusp margin. Cusp is compressed along inner lateral face; outer lateral face is rounded. Basal cavity is right triangle in lateral view, apex anterior. Postero-basal margin is rounded. Basal cross-section round to oval. Bicostate forms bear sharp anterior and posterior cusp margins and develop inner lateral carina.

The b element is laterally compressed with sharply rounded antero-lateral and postero-lateral cusp margins. Basal cross-section is oval; basal cavity is right triangle in lateral view. Posterior basal corner is drawn out slightly.

The c element is symmetrical and erect with long, slender cusp. Cusp curves posteriorly. Anterior cusp face is rounded and smooth. Posterior cusp face is concave and bears faint costae from cusp tip to base. Lateral cusp margins are sharp. Basal cavity is shallow, apex is centrally located. Basal cross-section is round. Base is expanded slightly posteriorly to produce posterior carina.

Three compressed, non-geniculate e elements vary from erect to proclined. All have laterally compressed cusps with sharp posterior cusp margins. The most common are those with even compression above the basal portion (Pl. 3, fig. 2). Anterior and posterior cusp margins are sharp. Basal cavity is extremely narrow, oval and shallow and is right triangle in lateral view. Another variant (Pl. 3, fig. 1) has postero-lateral compression and bears inner lateral carina. Anterior cusp margin rounded. Posterior cusp margin is sharp. Base is more rounded and extremely shallow.

The third e element (Pl. 3, fig. 7) is non-geniculate with shallow basal cavity. Cusp is compressed postero-laterally and is flexed laterally. Posterior cusp margin is sharp, anterior margin is sharply rounded. Anterior and posterior basal margin sharp; basal cavity is oval; inner lateral cusp face flared basally. Basal cavity shallow and narrow and close to anterior cusp margin.

Discussion.—The apparatus of *U. utahensis* has previously been described as bimembrate by Miller (1980) who illustrates unicostate (a) and bicostate (e) elements. This collection has allowed the multielement reconstruction of an apparatus which contains the ancestors to *Rossodus*. There is an abundance of compressed elements in the apparatus which perhaps suggests there were more pairs of the three e elements. Two pairs were subsequently lost in *U. longipinnatus*.

Occurrence.—*Iapetognathus* Zone to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—334 a elements, 141 b elements, 90 c elements, 843 e elements.

Repository.—GSC 119105, 119106, 119107, 119108, 119109, 119110, 119111 and 119661.

Family PROTOPANDERODONTIDAE Lindström, 1970

Genus COLAPTOCONUS Kennedy, 1994

Emend. Ji and Barnes, 1994

Type species.—*Scolopodus quadraplicatus* Branson and Mehl, 1933

Discussion.—The genus contains up to five morphotypes of simple cones which have coarse carinae and deep grooves as described by Ji and Barnes (1994). Kennedy (1980) originally assigned symmetrical and asymmetrical cones to *Glyptoconus*, but provided the replacement name, *Colaptoconus* because *Glyptoconus* was a junior homonym of a gastopod taxon (Kennedy, 1994).

COLAPTOCONUS GREYPEAKENSIS n. sp.

Plate 9, figs. 25-29

Diagnosis.—A new species of *Colaptoconus* in which apparatus consists of four morphotypes (a, b, c and e) of strongly costate and grooved simple cones with wide and expanded bases.

Description.—The a element bears strong costae on lateral cusp faces and grooved posterior cusp face. Anterior cusp face rounded. Cusp is erect and twice as long as base is wide. Lateral cusp faces may bear smaller costae in grooves flanking major costae and arise basally and fade distally at point of curvature of cusp. Elements are symmetrical to asymmetrical, resulting from twisting and compression of cusp. Base is wide and round to oval in outline. Base expands under lateral costae which extend to base.

The b element is transitional and postero-laterally compressed. Antero-lateral and posterior cusp margins are sharp. Inner lateral cusp face bears strong central costae flanked by two grooves. Basal profile sinuous as costae project below basal margin as sharply rounded flanges.

The c element is suberect and symmetrical. Lateral cusp margins sharp. Anterior cusp face rounded; posterior cusp face concave with two major costae flanked by two deep grooves. Central costae are separated by groove which contains smaller costae that arise basally and fade distally at point of curvature of cusp. Base is wide and expands laterally. Basal margin flares under posterior costae.

The e element is laterally compressed and non-geniculate. Antero-lateral and posterior cusp margins are sharp. Inner lateral cusp face bears one major costae flanked by a secondary postero-lateral costa which fades distally. Base is oval in outline and expanded laterally.

Etymology.—Named after Grey Peak, the section locality where this new species is most abundant.

Discussion.—The apparatus plan is similar to that of *C. floweri*, but the elements are more robust with stronger costae and an expanded base.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—114 a elements, 31 b elements, 3 c elements, 18 e elements.

Repository.—GSC 119303, 119304, 119305, 119306, 119307.

COLAPTOCONUS sp.

Plate 5; figs. 20-21; Plate 22; figs. 15-16

Discussion.—Limited material is assigned to *Colaptoconus* based on the extreme rounded lateral costae and concave posterior cusp face that bears strong, rounded posterior carina. The symmetrical c elements have a very shallow cavity and are rounded with expand antero-posteriorly basally. Anterior cusp face is rounded with a weak carina from tip to base. Elements are spear-head shaped.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—74 elements.

Repository.—GSC 119183, 119184; GSC 119654, 119655

Genus JUANOGNATHUS Serpagli, 1974

Type species.—Juanognathus variabilis Serpagli, 1974

Discussion.—Serpagli (1974) originally defined the genus as having an apparatus of elements within a transition series, in which elements bear two lateral keel-like costae on a twisted cusp, in which one costa projects beyond the base. Albanesi (1998) defined the apparatus as quinquimembrate, containing a, b, c, e and f elements, however f elements were not observed in this collection.

JUANOGNATHUS JAANUSSONI Serpagli, 1974

Plate 19, figs. 5-8

Juanognathus jaanussoni SERPAGLI, 1974, p. 50-51, pl. 11, fig. 8a-12c. pl. 23, fig. 1a-5b (contains synonymy to 1974); LEHNERT, 1995, pp. 92-93, pl. 3, fig. 2, 3 (contains synonymy to 1995); ALBANESI, 1998, p. 125, pl. 5, fig. 4-7, 9, text-fig. 13 (only).

Discussion.—Albanesi (1998) proposed a quinquimembrate apparatus, however, the f element is not observed in this collection. The other elements are similar to those previously described and some have a basal body attached. *J. jaanussoni* differs from *J. variabilis* in that only the antero-lateral costa projects beyond the base as a process. The elements are also more slender than those of *J. variabilis.* The compressed element may be similar to the f element illustrated by Albanesi (1998) and has a similar morphology to the e element of *J. variabilis* but lacks the prominent postero-lateral costa.

Occurrence.—Oepikodus communis to *Jumudontus gananda* Zone, Skoki Formation.

Material.—61 a/b elements, 4 c elements, 4 e elements.

Repository.—GSC 119556, 119557, 119558, 119559.

JUANOGNATHUS VARIABILIS Serpagli, 1974

Plate 19, figs. 1-4

Juanognathus variabilis SERPAGLI, 1974, pp. 49-50, pl. 11, figs. 1a-7c, pl. 22, figs. 6-17, text-fig. 8; ALBANESI, 1998, p. 126, pl. 5, figs. 10-14 (contains synonymy to 1998).

Reutterodus andinus SERPAGLI, 1974, pp. 78-81, pl. 17, fig. 7a, b, 9a-d; pl. 28, fig. 4, 8, 9a, b, text-fig. 19 (left) only; STOUGE AND BAGNOLI, 1988, p. 138, pl. 10, fig. 8; RAO, 1998, p. 150, pl. 3, fig. 9 (coniform element).

?Reutterodus andinus Serpagli. ETHINGTON AND CLARK, 1982, p. 91, pl. 10, fig. 18.

Reutterodus andinus? Serpagli. REPETSKI, 1982, pl. 18, fig. 7, pl. 19, figs. 1-3.

Discussion.—The apparatus is close to that illustrated by Albanesi (1998) but has some differences, in that an f element is not included in the apparatus. The most important aspect of this apparatus reconstruction is the inclusion of the cone-like element of *Reutterodus andinus* as the compressed e element of *J. variabilis.* Serpagli (1974) reported that the cone-like element of *R. andinus* occurred alone, without the denticulated elements of the apparatus. The other reported occurrences listed in the synonymy are also isolated, but do occur in beds with *J. variabilis.* This element is very similar in shape and preservation to those of *J. variabilis* and seems more likely to fit in its apparatus than with the denticulated elements of *R. andinus.* As Ross et al. (1997) defined a zone based on the occurrence of this distinctive element, the proposal that it is part of the *J. variabilis* apparatus has implications to the zonation of the Middle Arenig.

Occurrence.—*Oepikodus communis* to *Jumudontus gananda* Zone, Skoki Formation.

Material.—227 a/b elements, 39 c elements, 119 e elements.

Repository.—GSC 119552, 119553, 119554, 119555.

Genus PARAPANDERODUS Stouge, 1984

Type species.—*Protopanderodus asymmetricus* Barnes and Poplawski, 1973

Discussion.—The apparatus plan of *Parapanderodus* was established by Stouge (1984) as comprising slender, simple cones which have a posterior groove, are finely striated. Ji and Barnes (1994) described the apparatus plan as having two to four morphotypes (a, b, c and e), and Albanesi (1998) described f elements in the apparatus of *P. paracornuformis.*

PARAPANDERODUS STRIATUS (Graves and Ellison, 1941)

Plate 17, figs. 19-24

Drepanodus striatus GRAVES AND ELLISON, 1941, p. 11, pl. 1, figs. 3, 12.

Parapanderodus striatus (Graves and Ellison). SMITH, 1991, pp. 49-52, figs. 28a-f, 29a-d, 30 (contains synonymy to 1991); JI AND BARNES, 1994, pp. 49-50, pl. 21, figs. 1-10, text-fig. 31A; LEHNERT, 1995, pp. 106-107, pl. 1., fig. 15, pl. 2, figs. 7-10, pl. 8, fig. 12, 13, pl. 9, fig. 8, pl. 12, fig. 12, pl. 20B, fig. 10, 11); ALBANESI, 1998, p. 117, pl. 7, fig. 27.

Semiacontiodus potrerillensis ALBANESI, 1998, pp. 134-135, pl. 12, figs. 1-7, 34, text-fig. 1 (contains synonymy to 1998).

Discussion.— The elements of *P. striatus* bear fine longitudinal striae which extend from the cusp tip to the basal margin. The cusp is elongate and elements vary through a symmetry transition. The a and b elements show a range of morphologies in which some bear longitudinal grooves on the lateral cusp faces in addition to the posterior sulcus. The apparatus reconstruction by Smith (1991) who observed fused clusters of the elements is followed. The compressed elements are like those illustrated as t elements by Smith (1991) rather than those illustrated as e elements by Ji and Barnes (1991).

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation to *Tripodus laevis* Zone, Skoki Formation.

Material.—84 a elements, 14 b elements, 2 c elements, 7 e elements.

Repository.—GSC 119512, 119513, 119514, 119515, 119516.

Genus PLANUSODUS new genus

Type species.—*Planusodus gradus* n. gen. n. sp.

Diagnosis.—Coniform elements which are laterally compressed with broad cusp that bears lateral costa on each lateral cusp face. Elements have thin, keeled posterior and anterior cusp margins. Basal cavity, in lateral view, has concave anterior margin and apex which lies close to anterior cusp margin at point of curvature of cusp. Cusp tip filled with white matter. Apparatus of four morphotypes (a, b, c and e elements) with a plan similar to that of *Protopanderodus*.

Etymology.—Plano means flat.

PLANUSODUS GRADUS n. gen. n. sp.

Plate 20, figs. 8-14

Diagnosis.— Elements are broad, flat, costate cones with sharp anterior and posterior cusp margins. Basal cavity is shallow and in lateral view has concave anterior margin and apex which lies close to anterior cusp margin at point of curvature of cusp.

Description.—Apparatus of four morphotypes (a, b, c and e elements) comprising simple cones which bear a lateral costa on each cusp face. All morphotypes have a basal cavity with diagnostic shape described above.

The a element is subsymmetrical and laterally compressed. Lateral cusp faces bear a lateral costa near medial position, flanked by antero-lateral groove from base to tip. Anterior cusp margin sharply keeled comprising two keels: one arises on outer lateral cusp face near antero-basal corner, the other on inner lateral face arises at antero-basal corner. Anterior keels are closely spaced along anterior cusp margin basally and merge near cusp tip. Posterior cusp margin is an extremely thin keel. Base is short with straight basal margin and oval basal outline. Anterior basal corner is rounded. Base expands weakly to posterior. In late form (Pl. 20, fig. 12), costae are sharper and cusp margins more strongly developed and thinly keeled. Cusp also is recurved rather than erect and the base extends more posteriorly compared to early forms.

The b element shares all characteristics described for the a element above but is asymmetrical because the lateral costae are in postero-lateral postion rather than medial.

The c element shares all characteristics of the a elements but is symmetrical with both lateral costae in a medial position on the lateral cusp faces.

The e element is more compressed than other morphotypes. Cusp is recurved. Anterior and posterior cusp margins are sharply keeled. Lateral cusp faces each bear weakly developed carinae which extend from base to cusp tip. Basal margin is straight and antero-basal corner is rounded. In late form (Pl. 20, fig. 14), cusp margins are more strongly keeled. Lateral carinae are more prominent and flanked by compression on antero- and postero-lateral cusp face. Base bears inner lateral flare under carina.

Etymology.—Gradus means step, referring to step-like appearance of sharp posterior keel meeting the lateral costae.

Discussion.—This new genus has a protopanderodontid apparatus plan and has therefore been placed in the Family Protopanderodontidae. The early and late forms may represent separate species, but more material is needed to ascertain this. The elements are different from those of ***Protopanderodus*** in the shape of the basal cavity and nature of the thinly keeled cusp margins. ***Planusodus*** also does not have the characteristic notch in the base found in most species of ***Protopanderodus***.

Occurrence.—***Oepikodus communis*** to ***Jumudontus ganada*** Zone, Skoki Formation.

Material.—36 a/b elements, 23 c elements, 16 e elements.

Repository.—GSC 119590, 119591, 119592, 119593, 119594, 119595, 119596.

Genus POLYCOSTATUS Ji and Barnes, 1994

Type species.—*Acodus oneotensis* Furnish, 1938

Discussion.—The apparatus of *Polycostatus* consists of 3 morphotypes characterized by multicostate cusps. The a (subround) elements have two lateral and one posterior costa, the c (suberect symmetrical) elements have a characteristic posterior carina with a median groove and the e elements (postero-laterally compressed) vary in having or lacking a posterior costa.

POLYCOSTATUS cf. P. SULCATUS (Furnish, 1938)

Plate 6; figs. 4-7

cf. *Scolopodus sulcatus* FURNISH, 1938, p. 334, pl. 41, figs. 14, 15.

cf. *Polycostatus sulcatus* (Furnish). JI AND BARNES, 1994, pp. 52-53, pl. 15, figs. 20-29, text-fig. 32A (contains synonymy to 1994).

Discussion.—*P. sulcatus*, as defined by Ji and Barnes (1994) contains three morphotypes, a (subround), c (suberect, symmetrical), and e (compressed) of robust, multicostate coniform elements. The elements are distinguished by having more than four major costae and the c element is distinct in having an anterior costae. Elements in this material are close to those described by Ji and Barnes (1994) but the c element lacks a broad posterior carina and rather has a groove flanked by two sharp longitudinal carina and two strong lateral keels. The posterior face is concave and the posterior part of the base has a rounded, lip-like expansion. The e element has a more defined base than those illustrated by Ji and Barnes (1994) and bears fainter costae. The a elements do not have as an expanded base but are sharply costae. The apparatus may have a symmetrical b element with two strong costae on the anterior lateral margin. The anteriormost costa on the inner and outer lateral cusp face are sharp basally but smoothly curve into the anterior cusp margin.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—11 a elements, 5 b elements, 2 c elements, 4 e elements.

Repository.—GSC 119194, 119195, 119196, 119197.

Genus SCOLOPODUS Pander, 1856

Emend. Ji and Barnes, 1994

Type species.—*Scolopodus sublaevis* Pander, 1856

Discussion.—Pander's (1856) form species *Scolopodus* was redescribed by Fåhræus (1982) and Balto-Scandian forms are mainly from the *Oepikodus evae* zone and higher. Lindström (1955, 1971) and van Wamel (1974) also emended the genus but the species they figured occur much higher than the first occurrence in this collection. Herein, the emended diagnosis of Ji and Barnes (1994) is followed in which costate, simple cones comprise an apparatus consisting of a, b and e elements associated with rarer c and f elements. The elements may have an anterior or posterior keel such as in the compressed morphotypes, but have a rounded cross-section and bear fine to coarse striae.

SCOLOPODUS AMPLUS n. sp.

Plate 17, figs. 25-30

Diagnosis.—A new species of *Scolopodus* in which multicostate, robust, hyaline elements have extremely large, expanded bases.

Description.—An apparatus of four morphotypes (a, b, c, e) in which the multicostate, robust, hyaline elements have an extremely large, expanded base. Basal margin is well defined by smooth, thickening around margin producing a rim. Costae are strongly developed and directed posteriorly.

The a element is rounded and symmetrical. Cusp is recurved and bears coarse costae that extend from cusp tip but do not reach basal margin. Postero-lateral cusp face is smooth. Antero-basal corner rounded. Base is expanded posteriorly and basal cavity is wide.

The b element is similar to a element but is asymmetrical due to twisting of cusp Rounded base is not as extended posteriorly but is circular and opens widely to posterior.

The c element is suberect and symmetrical. Posterior cusp face bears three coarse costae separated by deep grooves. Anterior cusp face is smooth. Wide base is expanded laterally and has oval cross section.

The e element is laterally compressed and non-geniculate. Cusp bears three coarse costae on inner lateral face and multiple costae on outer antero-lateral face. Base is expanded posteriorly and has oval cross section.

The ?f element is suberect and asymmetrical due to twisting of cusp. It is multicostate and has a narrow, oval base which is slightly expanded posteriorly.

Etymology.—Named for its large size (amplus=large).

Discussion.—This new species of *Scolopodus* differs from *S. subrex* and *S. krummi* in having additional morphotypes (c and ?f) in its apparatus. S. amplus has coarser costae and expanded base in contrast to finer costae and smaller base in *S. subrex* and *S. krummi*.

Occurrence.—*Oepikodus communis* Zone, Kechika and Skoki formations.

Material.—12 a/b elements, 2 c elements, 4 e elements, 1 f element.

Repository.—GSC 119518, 119519, 119520, 119521, 119522, 119523.

SCOLOPODUS KRUMMI (Lehnert, 1995)

Plate 10, figs. 11-13

Scolopodus cornutiformis Branson and Mehl. ETHINGTON AND CLARK, 1965, p. 200, pl. 1, fig. 12.

Scolopodus aff. *cornutiformis* Branson and Mehl. BARNES AND POPLAWSKI, 1973, p. 786, pl. 1, fig. 9-10.

Scolopodus cf. *S. cornutiformis* Branson and Mehl. TIPNIS ET AL., 1978, pl. 2, figs. 14, 16. *Scolopodus rex* Lindström. SERPAGLI, 1974, pp. 70-71, pl. 17, figs 1a-3b, pl. 28, fig. 10; REPETSKI, 1982, pp. 50-51, pl. 23, fig. 6.

Tropodus? krummi LEHNERT, 1995, pp. 130-131, pl. 5, fig. 7, 9, 13-19.

Scolopodus krummi (Lehnert), ALBANESI, 1998, pp. 131-132, pl. 12, figs. 18-26, text-fig. 15.

?Walliserodus ethingtoni (Fåhræus). ETHINGTON AND CLARK, 1982, pp. 116-117, pl. 13, fig. 16 only (e element).

Scolopodus rex paltodiformis Lindström. REPETSKI, 1982, p. 51, pl. 23, figs. 8, 10, 11 (e element).

Discussion.—*Scolopodus krummi* contains costate elements in which the costae arise above the basal margin and are finer than in *S. subrex*. The base is less pronounced than in *S. subrex* and the cusp is more tapered. As in *S. subrex*, three morphotypes were observed, a, b and e.

Occurrence.—*Acodus kechikaensis* Zone to *Oepikodus communis* Zone, Kechika and Skoki formations.

Material.—126 a elements, 110 b elements, 37 e elements.

Repository.—GSC 119317, 119318, 119319.

SCOLOPODUS SUBREX Ji and Barnes, 1994

Plate 9, figs. 6-11

Scolopodus rex Lindström. LEE, 1970, p. 334, pl. 8, figs 8, 9; LEE, 1975, p. 89, pl. 2, fig. 13, text-fig. 4I. *Scolopodus* cf. S. *rex* Lindström. JI AND BARNES, 1996, p. 883, fig. 14.9-14.18.

Scolopodus subrex JI AND BARNES, 1994, pp. 58-59, pl. 19, figs. 1-15, text-fig. 35A.

Discussion.—*Scolopodus subrex* has been defined by Ji and Barnes (1994) as containing up to 5 elemental morphotypes and is the name for the Midcontinent Realm form of *Scolopodus* which occurs much earlier than *S. rex* in Balto-Scandia. The main differences are the more robust nature compared to *S. rex* reported by Lindström (1955, 1971), van Wamel (1974) and Löfgren (1994) which occur in the *Prioniodus elegans* to *Paroistodus originalis* zones. The elements in this collection are distinctive and characterized by their strong, coarse costae which extend from the basal margin to the cusp tip, small but defined base and slender cusp. However, of the 5 morphotypes illustrated by Ji and Barnes (1994) only the a and b elements are observed and a non-geniculate e element with a compressed and twisted cusp is present. There appear to be early and late forms of the species in which the early forms have less numerous and distinct costae.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—454 a elements, 137 b elements, 41 e elements.

Repository.—GSC 119284, 119285, 119286, 119287, 119288, 119289.

Genus STRIATODONTUS Ji and Barnes, 1994

Type species.—***Striatodontus prolificus*** Ji and Barnes, 1994

Discussion.—Ji and Barnes (1994) defined the genus as having up to five morphotypes of simple cones which bear longitudinal striae and well-developed posterior grooves.

STRIATODONTUS STRIGATUS n. sp.

Plate 5; figs. 4-7; Plate 22, fig. 14

Diagnosis.—A new species of *Striatodontus* in which robust simple cones are covered by fine striae and bear two prominent longitudinal grooves. Apparatus of at least three morphotypes, a, b, and c elements.

Description.—Apparatus of at least three morphotypes, a, b, and c elements, of slender cones with slightly expanded bases and cusps which are covered by fine striae and bear two prominent longitudinal grooves on inner lateral or posterior cusp face.

The a element is subsymmetrical and rounded with proclined cusp. Anterior cusp face is rounded and covered in fine longitudinal striae. Posterior cusp face is covered in striae and bears two longitudinal grooves on either side of posterior costa which is striated basally. Basal outline is round and basal cavity is deep.

The b element is erect and laterally compressed with fine striae covering whole element. Two faint longitudinal grooves are located antero- and postero-laterally.

The symmetrical c element has erect, gently tapered cusp. Anterior cusp face is smoothly rounded finely striated. Posterior cusp face bears two longitudinal grooves and posterior costa which is striated basally. Basal outline is round.

The e element is laterally compressed and has proclined cusp. Cusp is finely striated on both lateral faces. Outer lateral cusp face bears one stronger medial striae. Anterior and posterior margins of cusp are sharp. Base has oval outline and is expanded posteriorly.

Etymology.—Strigatus means furrowed or grooved

Discussion.— The elements observed are similar in the overall morphology to *S. prolificus* but are more robust and have more prominent striae covering the elements and deeper longitudinal grooves.

Occurrence.—***Rossodus manitouensis*** Zone, Kechika Formation and Road River Group, Cassiar Terrane.

Material.—122 a elements, 14 b elements, 28 c elements, 15 e elements.

Repository.—GSC 119167, 119168, 119169, 119170 and GSC 119653.

Genus STULTODONTUS Ji and Barnes, 1994

?STULTODONTUS sp.

Plate 13, figs. 32-33

Description.—Stout coniform elements which have longitudinal costae are questionably assigned to *Stultodontus*. Two morphotypes (a and e) have short cusps which are slightly longer than base is wide. Anterior cusp margin round; posterior cusp margin sharply rounded. Base is short but extends posteriorly as flattened flange. The e element is similar to the a element but lacks strong longitudinal costae and is more laterally compressed.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—17 a elements, 5 e elements.

Repository.—GSC 119409 and 119410.

Genus VARIABILOCONUS Landing et al., 1986

Emend. Ji and Barnes, 1994

Type species.—*Paltodus bassleri* Furnish, 1938

Discussion.—Four morphotypes are recognized as described by Ji and Barnes (1994). The distinguishing characteristics of this genus are the posterior carina, wide base, sharp costae and grooves. The a elements are subround with a wide posterior carina bounded by grooves. The transitional b elements have an offset carina and unequal grooves due to lateral twisting of the cusp. The symmetrical c elements have a wide base and two posterior grooves. The e elements are laterally compressed and have an antero-lateral groove.

VARIABILOCONUS BASSLERI (Furnish, 1938)

Plate 5, figs. 16-19; figs. 22-25; Plate 22, figs. 23-24

Paltodus bassleri FURNISH, 1938, p. 331, pl. 42, fig. 1; ETHINGTON AND CLARK, 1971, p. 72, pl. 2, figs. 2, 4, 6; REPETSKI, 1982, p. 37, pl. 14, fig. 12.

Variabiloconus bassleri (Furnish). JI AND BARNES, 1994, pp. 67-68, pl. 25, figs. 14-26, text-fig. 38B (contains multielement synonymy to 1994); LANDING ET AL., 1996, p. 678, fig. 7.25-7.33 only; SMITH AND CLARK, 1996, p. 370, pl. 1, figs. 9-11; PARSONS AND CLARK, 1999, p. 7, fig. 5.10, 5.11

Variabiloconus neobassleri JI AND BARNES, 1994, pp. 68-69, pl. 25, figs. 9-13, text-fig. 38C.

Discussion.—Landing et al. (1996) revised the genus to include forms such as *Teridontus gracillimus*, which is rejected from the definition of the multielement apparatus in which the elements are costate and grooved and much more robust than *Teridontus*. In early forms of *V. bassleri*, the costae, grooves and posterior carinae are not as pronounced as in later forms, such as *V. neobassleri* Ji and Barnes which is herein synonymized because it is considered to show morphologic variation within the same species. Specimens co-occur with *Utahconus longipinnatus* and are somewhat similar, but are characterized by the development of postero- and antero-lateral grooves, wide posterior carina and wide base. The two species are likely derived from the same ancestor.

A later form is recognized in the material and has an apparatus containing four morphotypes, but the elements have a more defined base and deeper grooves on the cusp. The a elements are symmetrically to subsymmetrically rounded coniforms with a more deeply grooved posterior to postero-lateral cusp face which has a sharply rounded to sharp posterior carina and one or two rounded lateral costae. The anterior cusp face is smoothly rounded. The b elements are more compressed along the posterior cusp margin and have displaced lateral costae. The symmetrical c element is similar to that of earlier forms but has a more defined rounded posterior costa which expands onto the base as a carina. The compressed e elements bear faint lateral costae and are compressed along the length of the element in most specimens, although some have a base which expands slightly postero-laterally.

Occurrence.—*Rossodus tenuis* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—550 a elements, 416 b elements 83 c elements, 324 e elements.

Repository.—GSC 119179, 119180, 119181, 119182, 119185, 119186, 119187, 119188 and GSC 119662, 119663.

VARIABILOCONUS SPURIUS (Ethington and Clark, 1964)

Plate 5, figs. 12-15

Paltodus spurius ETHINGTON AND CLARK, 1964, p. 695, pl. 114, figs. 3, 10, text-fig. 2B; ETHINGTON AND CLARK, 1971, p. 72, pl. 1, fig. 12; GREGGS AND BOND, 1971, p. 1468, pl. II, figs. 1, 2, 2a; ETHINGTON AND CLARK, 1982, p. 76, pl. 8, figs. 9, 13; REPETSKI, 1982, pp. 37-38, pl. 15, figs. 2, 4, 6; TAYLOR AND LANDING, 1982, p. 189, text-fig. 5H; An et al., 1983, p. 113, pl. 9, figs. 25-27; MILLER AND DOCKUM, 1983, p. 411, fig. 2A, B. *Paltodus* aff. *P. spurius* Ethington and Clark. ORNDORFF, 1988, p. 23, pl. 2, fig. 4.

Paltodus sp. cf. *P. spurius* Ethington and Clark. MOUND, 1968, p. 415, pl. 4, figs. 14-17.

"*Paltodus*" *spurius* Ethington and Clark. HARRIS ET AL., 1995, p. 24, pl. 1, fig. T.

Emended Diagnosis.—A species of *Variabiloconus* in which the apparatus comprises four mophotypes (a, b, c, e) characterized by simple coniforms with sharply recurved, elongate cusps which are bulbous midway along their length, constrict basally and bear longitudinal grooves.

Description.— An apparatus of four morphotypes. The a element is symmetrical with reclined to recurved cusp. Lateral cusp faces each bear longitudinal groove which arises above base. Cusp commonly expands distally and is constricted basally. Posterior cusp margin is sharp. Anterior cusp margin sharply rounded and sharpens distally. Base is expanded anteriorly and posteriorly. Basal cross-section is rounded; basal cavity shallow.

The b element is an asymmetrical morphotype in which there is unequal development of longitudinal groove on lateral cusp faces. Element is more compressed on inner lateral side.

Rare, symmetrical c element bears bulbous cusp. Cusp bulges distally and is constricted basally. Posterior cusp margin is sharp; anterior cusp margin is round. Cusp lacks longitudinal grooves. Basal cross-section is round; base is expanded.

The e element is geniculate with strongly recurved, laterally compressed cusp that is constricted basally. Anterior and posterior cusp margins are sharp. Cusp has maximum width basally and tapers distally. Angle between base and cusp is about 30°. Base is flared posteriorly and has rounded antero-basal margin.

Discussion.—Ethington and Clark (1964, 1981) have described the a elements but the multielement apparatus has not been reconstructed previously. The c and e elements are rare but have the characteristic constriction of the cusp near the base. This taxon is reassigned to *Variabiloconus* because it is one of the many taxa that were grouped into *Paltodus* by early workers. The *Paltodus* apparatus is different and characterized by triangular based elements.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—208 a elements, 166 b elements 5 c elements, 1 e elements.

Repository.—GSC 119175, 119176, 119177, 119178.

Order PRIONIODONTIDA Dzik, 1976

Family ACODONTIDAE Dzik, 1994

Genus ACODUS Pander, 1856

Type species.—Acodus erectus Pander, 1856

Discussion.—The apparatus of *Acodus* is sexi- to septimembrate and has a geniculate M and P element in late forms. Early species of *Acodus* lack a strongly geniculate M and P element but are characterized by S elements with well developed costae. The S elements among some species such as *A. kechikaensis* n. sp., *A. deltatus* and *A. longibasis* are similar, but the P elements are diagnostic.

ACODUS DELTATUS Lindström, 1955

Plate 7; figs. 13-20

Acodus deltatus LINDSTRÖM, 1955, p. 544, pl. 3, fig. 30; ALBANESI, 1998, p. 146, pl. 1, figs. 1-5 (contains synonymy to 1998).

Discussion.—The apparatus is seximembrate and contains a transition series of S elements with variable positions of the costae. The M element is non-geniculate in early forms and is laterally compressed with a flexed cusp. The P element is non-geniculate and bears strong outer lateral costae. A symmetrical Sa element appears to be lacking in early forms and other S elements show a great deal of variability in number of lateral costae.

Occurrence.—Acodus deltatus to *Acodus kechikaensis* Zone, Kechika Formation.

Material.—278 M elements, 1318 S elements, 288 P elements.

Repository.—GSC 119232, 119233, 119234, 119235, 119236, 119237, 119238, 119239.

ACODUS KECHIKAENSIS n. sp.

Plate 8; figs. 1-6

Acodus? aff. *A. emanuelensis* McTavish. ETHINGTON AND CLARK, 1982, p. 19-20, pl. 1, fig. 11-13 (Sb, Sa, P) only, text-fig. 5 (in part).

Diagnosis.—Apparatus of six element morphotypes characterized by robust elements with elongate cusps and ramiform complex in which adentate processes are basally adjoined by sheath which is concave in inter-process region of element.

Description.—Sa is symmetrical with posterior process and two lateral processes. Processes are joined by sheath which extends between all three and is concave in between. Anterior cusp face is flat but basal sheath region is concave. Posterior cusp face concave except for prominent posterior process. Basal cavity triangular, apex located under posterior process. Basal margin is flat.

Sb element is asymmetrical and bears three processes; posterior process is most prominent and extends below basal margin. Processes join cusp in smooth curve just above the point of curvature of cusp. Cusp is reclined. Anterior cusp face is rounded.

Sc element is laterally compressed and broad-based. Anterior and posterior processes taper distally and extend below the basal margin. Cusp is erect. Inner postero- and antero-lateral cusp margins are slightly concave longitudinally. Antero-basal corner sharply rounded. Base extends posteriorly and basal margin is slightly arched under anterior and posterior processes.

Sd element is asymmetrical, its cusp is erect and bear four processes. Processes taper distally, posterior process is most prominent.

M element is geniculate with posterior process joining the cusp at 30 degrees angle. Posterior process is rounded along top margin. Cusp bears broad carina which extends to the midline of base and posterior process, giving lateral flare to basal region.

P element has erect cusp and is laterally compressed with flat outer lateral margin and flared inner lateral margin with carina on base. Antero-basal margin is concave. Outer lateral face is slightly concave along basal margin region where sheath extends between two sharp anterior and posterior cusp margins which taper distally.

Etymology.—Named after the Kechika Formation.

Discussion.—The adenticulate prioniodids described by McTavish (1973) included a trichonodelliform (Sa), tetraprioniodiform (Sd), oistodiform (M) and prioniodiform (P). Cooper (1981) illustrated five morphotypes in which he designated the tetraprioniodiform element as an Sb rather than an Sd. Therefore, the Sb element described herein has not yet been reported. Ethington and Clark (1982) illustrated an Sc element and noted that unlike the Australian material, the base of their elements is not as long. This is also observed in this collection in that the Sc and P elements are not the same as illustrated by McTavish (1973) and Cooper (1981). The Australian specimens have more slender cusps. As Ethington and Clark (1982) indicate, there are several species of *Acodus* diversifying in this interval and the elements among intermediate forms are very similar, particularly the S elements. However, this new species of *Acodus* is distinct and abundant, especially the P elements which bear a prominent inner lateral costa.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—271 M elements, 627 S elements, 301 P elements.

Repository.—GSC 119250, 119251, 119252, 119253, 119254, 119255

ACODUS LONGIBASIS McTavish, 1973

Plate 7, figs. 21-27

Acodus deltatus longibasis MCTAVISH, 1973, p. 40, pl. 1, figs. 16, 20, 22, 23, 25, 26, pl. 2, fig. 14, text-fig. 3I-L.

Emended Diagnosis.—A species of *Acodus* characterized by elongate posterior process of the S elements in which process is longer than lateral costae and anterior keel and its free portion is as long as cusp. The M and P elements have elongate posterior extensions of the base.

Description.—Pb elements are non-geniculate and compressed, broad based with erect cusp. One has wider base with extended postero-basal margin. Cusp has keeled anterior and posterior margins and inner lateral keel. Lateral keel is most strongly developed on the base, and bifurcates at medial basal margin. Outer lateral cusp face slightly concave. Basal cavity fills wide base, apex at point of curvature of cusp. Pa has posteriorly drawn out base and a slightly drawn out and arched anterior basal margin. Cusp is proclined with keeled anterior and posterior cusp margins. Inner lateral keel not as strong and becomes weaker distally along cusp. Inner lateral cusp face has lateral expansion under keel on basal portion. Outer lateral cusp face is slightly concave.

M element is geniculate and distinguished by its long, straight posterior extension of the base. Cusp is compressed and reclined with concave anterior cusp margin and slight antero-basal extension.

Sa element is symmetrical with erect cusp. Cusp bears strong posterior keel and two lateral keels. Posterior cusp face bears rounded keel. Anterior cusp face is flat.

Basal cavity confined under posterior keel; lateral keels are filled with white matter. Basal margin straight, basal cavity triangular.

Sb element is asymmetrical with three strong keels. Posterior keel is strongest and elongate, its free portion as long as cusp. Two lateral keels merge anteriorly above the point of curvature of cusp. Basal cavity is deep but narrow. Asymmetric variants have four keels; two lateral keels merge with anterior keel distally. Posterior keel is most prominent and elongate. Cusp is erect to reclined. Basal cavity is narrow and deep.

Sc element is laterally compressed with anterior and posterior keels. Posterior keel extends below the basal margin slightly. Cusp is proclined; element is broad-based with deep basal cavity. Basal margin is slightly arched, inner lateral surface has slight basal expansion.

Sd element bears four costae and is similar to Sb element.

Discussion.—McTavish (1973) originally described *Acodus deltatus longibasis* as a subspecies but it is herein raised to species level because it is distinct. In his description, elements described as tetraprionidiform and gothodiform are Sd and Sb elements (four-keeled and three-keeled) and the oistodiform and prioniodiform are M and P elements. The material from this collection suggests seven morphotypes are present in *Acodus longibasis*.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—34 M elements, 209 S elements, 63 P elements.

Repository.—GSC 119239, 119240, 119241, 119242, 119243, 119244, 119245.

ACODUS NEODELTATUS n. sp.

Plate 8, figs. 14-18

Diagnosis.—A new species of *Acodus* in which elements are thin walled, delicate and laterally compressed with strong development of keels (lateral, posterior and anterior).

Description.—Apparatus of three morphotypes (M, S, P).

S elements are characterized by the strong development of keels which are separated from each other by thin walls of element. Elements laterally compressed. Keels extend from base to cusp tip and are drawn out to basal margin as sharply rounded processes. No symmetrical Sa element was observed. Sb element has proclined cusp and long base, about half the height of the element. Anterior and posterior cusp margins sharp. Inner lateral cusp face bears strong postero-lateral costa. Antero- and postero-basal corners sharply rounded.

Sc element has sharp anterior and posterior cusp margins. Inner lateral cusp face bears weak costa on cusp above point of curvature of cusp. Outer lateral cusp face unornamented and flat. Base is long, about one-third height of element. Antero-basal corner sharp as anterior costa extends below basal margin as projection. Base expands posteriorly and postero-basal corner is sharply rounded and laterally compressed.

Sd element is similar to the Sb element but bears a lateral costa on each lateral cusp face in a medial position.

M element has expanded and sharply rounded antero-basal margin and less than 20 degrees angle between base and cusp.

P element has well defined central keel on inner lateral face. Outer lateral cusp face flat. Anterior and posterior cusp margins are thin, sharp keels. Area between inner lateral keel and posterior keel is concave. Postero-basal margin drawn out into well defined process. Basal corners sharply rounded. Basal margin slightly arched under lateral keel.

Etymology.—"Neo" refers to younger or newer.

Discussion.—Elements of this new species of *Acodus* differ from the others in their delicate nature and development of well defined keels into processes. This new species appears to be the direct ancestor of *Oepikodus communis*.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—34 M elements, 304 S elements, 59 P elements.

Repository.—GSC 119263, 119264, 119265, 119266, 119267.

ACODUS ONEOTENSIS Furnish, 1938

Plate 7; figs. 1-5

Acodus oneotensis FURNISH, 1938, p. 325, pl. 42, figs. 26-29, text-fig. 1N; ETHINGTON AND CLARK, 1971, p. 72, pl. 1, figs. 3, 6, 8; ETHINGTON AND CLARK, 1982, p. 20, pl. 1, fig. 16.

"*Acodus*" *oneotensis* Furnish, WANG, 1986, pp. 114-116, pl. 52, fig. 10, text-fig. 28.1 only.

Description.—Apparatus of slender, strongly keeled coniform elements.

M element is non-geniculate and has outer and inner lateral keels from base to cusp tip. Base is expanded slightly, gradually tapers to tip, laterally compressed. Antero- and postero-basal corners are sharp; basal outline is oval. Some are strongly compressed with inner lateral keel weakly developed at base and faint distally up cusp. Outer lateral cusp face bears very faint keel. Base is extremely compressed. Basal cavity lies just posterior of midline of element.

P element is similar to the M element but has more expanded base. It is non-geniculate and compressed with a slight flare on the inner basal margin.

Sa element has four strong costae, all extending from base to cusp tip. Cusp is erect and curved posteriorly. Cusp and basal cross-section are diamond shaped. Posterior cusp face has compression on both sides of the posterior costa. The base is expanded posteriorly and drawn out laterally.

Sb elements are characterized by four strong keels: two lateral, one anterior and one posterior. Cusp is reclined to recurved and twisted in some specimens. Cusp cross-section is diamond shaped. Anterior cusp face is smoothly rounded with a medial costa extending from base to tip. Posterior cusp face is concave with strong medial costa. Offset of the posterior and anterior costae occurs through symmetry transition series. Base is narrow and drawn out posteriorly and anteriorly producing diamond-shaped cross-section. Basal cavity is a right triangle in posterior view, apex lateral from midline, extends to point of curvature of cusp.

The Sc element is characterized by one strong lateral costa on outer face. Inner cusp face is flattened to slightly concave. Cusp is erect, laterally compressed and blade-like with keeled anterior and posterior margins. Base is narrow and triangular, drawn out slightly under lateral keel. Basal cavity is triangular, its apex located centrally in lateral view.

Discussion.—*Acodus oneotensis* is similar to *Acodus quentinenesis* n. sp. but is much more delicate and strongly costate. There is strong similarity among the M elements to e elements of *U. utahensis* but M elements can be distinguished by the position of the apex of the basal cavity which is extremely posterior in *U. utahensis*, but just posterior of the midline in *A. oneotensis*.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—42 M elements, 252 S elements, 40 P elements.

Repository.—GSC 119222, 119223, 119224, 119225.

ACODUS QUENTINENSIS n. sp.

Plate 7; figs. 8-12

Diagnosis.—The apparatus consists of S, M and P elements characterized by blade-like cusps with prominent costae and broad base. Sa element bears weak rounded anterior carina and strong posterior carina.

Description.—The compressed M element is non-geniculate and has laterally compressed cusp, erect to reclined, sharp anterior and posterior margins. Anterobasal corner is drawn out slightly, posterobasal corner is rounded. Inner lateral face is costate basally, giving flare to the inner basal margin, becoming fainter distally. Outer lateral face is flat to slightly concave at the base. Basal cavity is triangular, apex is anterior under inner lateral costa, cavity is oval to round, tapers anterior to anterior cusp margin. Transitions occur in the degree of inner lateral costae and drawn out postero-basal corner, and compression of the base. Most compressed element has erect, flexed cusp. Cusp margins are keeled posteriorly and anteriorly.

P element is non-geniculate and compressed. Inner lateral face bears short costa on the flare of the basal margin, extending faintly distally up to the cusp tip. Outer lateral face is smoothly round with faint costa extending from cusp tip to base. Outer lateral face of the base is concave. Base is slightly expanded posteriorly, basal cross-section is oval, expanding laterally. Basal cavity is a triangle, tip is anterior of the midline of cusp.

Sa element is symmetrical and has three strong costae, two lateral and one posterior. Anterior cusp face bears faint anterior costa. Posterior cusp face is concave with raised posterior costa, strongest at base. Cusp is erect and flexed posteriorly, compressed antero-posteriorly. Base is slightly rounded along anterior margin, drawn out slightly at lateral margins and flared where posterior costa joins basal margin. Base is wide, basal cavity is deep, extending to point of flexure of cusp, its apex is central.

The Sb elements are asymmetric variants in which cusp twists from midline, but all other characters are same as in Sa elements.

The Sc element is laterally compressed, lacks lateral costae, but is costate anteriorly and posteriorly. Cusp is erect, outer lateral basal margin is slightly round, inner lateral margin is flat. Cusp is gently flexed above apex of cavity, its cross-section is oval and cusp tapers anteriorly. Basal cavity is triangle in lateral view, the apex is anterior to the midline.

Etymology.—Named after the Quentin Member of the Kechika Formation.

Discussion.—*Acodus quentinensis* n. sp. is similar to *A. oneotensis* but its elements have broader bases and the Sa lacks a strong anterior costa. The P element is close to one type of e element of *Rossodus tenuis* and *Utahconus utahensis* however, the concavity of the outer lateral basal face and equality of the antero and postero-basal expansion distinguishes it from *R. tenuis* in which the outer lateral basal face is flattened and the basal margin is drawn out posteriorly.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—74 M elements, 171 S elements, 95 P elements.

Repository.—GSC 119227, 119228, 119229, 119230, 119231.

ACODUS WARENSIS n. sp.

Plate 8, figs. 7-13

Diagnosis.—A new species of *Acodus* in which base of all elements (M, S, P) is laterally expanded and elements are stout and robust, with cusp as long as base is wide.

Description.—Apparatus of three morphotypes (M, S, P).

S elements are laterally expanded, stout and robust, with cusp as long as base is wide. All bear three or four keeled processes. Sa element is symmetrical with thinly keeled lateral cusp margins which expand laterally at base. Cusp curved posteriorly. Posterior cusp face bear strong keel flanked by concave regions between keel and lateral keels. Anterior cusp face rounded. Basal margin flat. Basal cavity oval in posterior view, extends to, but not into lateral extensions.

Sb element is diagnostic in bearing sharp anterior and posterior cusp margins and strong lateral keel which arises at center of base and curves up to cusp tip in medial position. Outer lateral face slightly concave. Anterior keel extends below basal margin as laterally compressed projection. Base expands posteriorly as sharply rounded extension.

Sc element has cusp which is as long as base is wide. Anterior and posterior cusp margins are sharp. Lateral cusp faces lack costae. Base is expanded laterally, anteriorly and posteriorly. Basal margin concave, arched between anterior and posterior keels which extend below basal margin.

Sd element is similar to the Sb element but bears two lateral costae and is not as stout in lateral view as anterior cusp face is more rounded.

M element has wide, short base and cusp is as long as base is wide. Base is flared laterally. Oral margin rounded in lateral profile. Aboral margin also rounded, giving base oval shape. Antero-basal corner projects and tapers anteriorly such that it has a concavity on the oral and aboral surfaces of the projection.

P elements have wide bases, expanded laterally and posteriorly. Keel on inner lateral cusp face fades distally up cusp. Pa element has sharp keel on inner lateral base and is laterally compressed. Pb element has stronger inner lateral keel and wider base which is drawn out posteriorly and longer than in the Pa element.

Etymology.—Named after the Ware map area.

Discussion.—Compared to other species of *Acodus*, *A. warensis* n. sp. is distinct in its stout nature, expansion of the base and shortening of the cusp compared to *A. longibasis* in which the keels are exaggerated and elements are elongate. The M elements are distinct in the concave oral and aboral margins of the antero-basal corner which has straight margins in other species.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—3 M elements, 30 S elements, 9 P elements.

Repository.—GSC 119256, 119257, 119258, 119259, 119260, 119261.

Genus DIAPHORODUS Kennedy, 1980

Type species.—*Acodus delicatus* Branson and Mehl, 1933

Discussion.—The apparatus consists of six morphotypes as illustrated by Albanesi (1998). The genus is distinguished by its P element. The multielement description by Serpagli (1974) and Kennedy (1980) identified five morphotypes.

DIAPHORODUS RUSSOI (Serpagli, 1974)

Plate 8; figs. 24-28

Acodus? russoi SERPAGLI, 1974, pp. 35-37, pl. 8, figs. 1a-5b, pl. 20, figs 7-8, text-fig. 5 (contains synonymy to 1974); REPETSKI, 1982, p. 13, pl. 3, figs. 1-5;

Diaphorodus russoi (Serpagli) ALBANESI, 1998, pp. 147-148, pl. 4, figs. 11-15, text-fig. 20 (contains synonymy to 1998).

Discussion.—The elements of *D. russoi* have been adequately described previously, but the material in this collection supports a seximembrate apparatus plan proposed by Albanesi (1998). The elements are tiny and delicate, and characterized by the geniculate, modified pastinate P element. The S elements have tongue-like posterior processes as Serpagli (1974) described.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—6 M elements, 93 S elements, 8 P elements.

Repository.—GSC 119273, 119274, 119275, 119276, 119277.

?DIAPHORODUS n. sp.

Plate 6, figs. 21-24

Description.— A species of *?Diaphorodus* with slender cusps and slender, tongue-like basal processes extending from keeled cusp margins. Apparatus of at least five morphotypes which have lateral keels and tongue-like basal processes.

Sa element is symmetrical and delicate. Cusp is erect and flexed posteriorly. Anterior cusp face is rounded and bears faint carina along the midline. Posterior cusp face is concave and bears keel on base which extends to point of flexure of cusp. Lateral cusp margins are sharp and extend as basal keels which are compressed antero-posteriorly and rounded distally. Base is narrow and expands under posterior keel. Basal cavity is shallow.

Sb element bears three sharp keels. Cusp is slender and erect. Anterior and posterior cusp margins are keeled and extend as compressed keels below basal margin. Outer lateral face bears keel which is strongest basally and extends below basal margin, and fades distally to tip of cusp. Inner lateral cusp face is concave. Basal cavity is shallow and triangular in lateral profile, its apex is located centrally beneath lateral keel.

Sd element bears four sharp keels and is asymmetrical. Anterior cusp face is rounded and bears rounded keel. Posterior cusp face is concave and bears strong keel which extends below basal margin as tongue-like process. Lateral cusp margins are sharply keeled. Basal cavity is small with diamond-shaped cross-section.

P element is non-geniculate. Cusp is erect and bears outer lateral keel which extends below basal margin. Anterior and posterior cusp margins are sharp. Inner lateral cusp face is concave. Base is not well defined, its anterior and posterior margins are straight.

M element is geniculate and compressed. Cusp is concave on inner lateral side and convex on outer lateral side. Edge of base meets posterior edge of cusp at a 20 degree angle. Basal process is compressed and flexed inward; its upper surface is rounded. Base is curved toward process and inner basal margin is flared slightly.

Discussion.—The apparatus is complete except for an Sc element. The P element is similar to those in the *Diaphorodus* apparatus because it is oepikodiform, but non-geniculate unlike those in *D. russoi*, perhaps because it is an earlier species. Hence, the assignment of this new species of *Diaphorodus* is held in question at this stage.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—4 M elements, 8 S elements, 2 P elements.

Repository.—GSC 119211, 119212, 119213, 119214.

Genus TRIANGULODUS van Wamel, 1974

Type species.—*Scandodus brevibasis* (Sergeeva), sensu Lindström, 1971

Discussion.—The diagnoses of *Trigonodus* Nieper, *Triangulodus, Scandodus* Lindström, *Tripodus* Bradshaw and *Pterocontiodus* Harris and Harris have been problematic as discussed by Bauer (1987) and Stouge and Bagnoli (1990). Herein, *Triangulodus* is used for hyaline coniforms with keeled cusps which form a septimembrate apparatus. van Wamel (1974) described the apparatus as having scandodiform (P). oistodiform (M), drepanodiform (Sc) acodiform (Sb), and paltodiform and roundyaform (Sa) elements. The genus differs from *Pterocontiodus* in which the P element has 3 sharp edges but in the *Triangulodus* apparatus has 2 sharp edges. *Tripodus* includes elements which are albid but has a similar apparatus plan to both *Pterocontiodus* and *Triangulodus.*

TRIANGULODUS AKIENSIS n. sp.

Plate 15, figs. 8-15

Diagnosis.—A species of *Triangulodus* in which S and P elements have keels which are elongate and extend below basal margin. M element has extended antero- and postero-basal corners.

Description.—Pa and Pb elements have keeled anterior and posterior cusp margins which extend as antero- and postero-basal corners of element. Pa element is erect and. basal margin is straight. Pb element is proclined and bears inner lateral flare on base. Basal margin arched under anterior and posterior keels.

M element has broad, low base which is as long as cusp is tall. Cusp is compressed but somewhat convex on outer surface. Basal margins are extended as pointed keels.

Sa element is symmetrical and bears extremely elongate posterior keel and two extended lateral keels. Anterior cusp margin is costae and rounded. In some Sa elements, cusp strongly recurved (almost 90 degrees to base) and anterior margin projects (Pl. 15, fig. 10). Anterior cusp margin is concave above basal margin and a thin sheath joins the two lateral processes. Sb element also bears two extended lateral keels, strong posterior keels which projects below basal margin and rounded anterior cusp margin, but is asymmetrical.

Sc is laterlly compressed and has sharp anterior and posterior keels which extend below basal margin. Posterior keel thin and elongate and extends posteriorly. Basal margin straight between anterior and posterior extensions.

Sd element bears four keels—two lateral, one anterior and one posterior. Region between keels is thinly sheathed basally. All keels project below basal margin.

Etymology.—Named after the Akie River, south of the type section of the Ospika Formation.

Discussion.—The elements bear a resemblance to *Acodus longibasis* McTavish, but have much more distinct keels and are hyaline and not albid. The apparatus reconstruction is similar to that shown by Stouge and Bagnoli (1990) for *Trigonodus (=Triangulodus) brevibasis* (Sergeeva). *Occurrence*.—*Dzikodus tableheadensis* Zone, Ospika Formation.

Material.—4 M elements, 43 S elements, 17 P elements.

Repository.—GSC 119445, 119446, 119447, 119448, 119449, 119450, 119451, 119452.

Genus TROPODUS Kennedy, 1980

Type species.—*Paltodus comptus* Branson and Mehl, 1933

Discussion.—*Tropodus* has a septimembrate apparatus plan in which there is a symmetry transition of S elements bearing three to five costae, M elements with a characteristic arched and curved posterior process, and one or two P elements which have keeled anterior and posterior cusp margins which project below the basal margin as rounded flanges. The base of the element bears a process which fades distally. The genus was defined by Kennedy (1980) and Stouge and Bagnoli (1988) interpreted the apparatus as a prioniodontid-type containing M and P elements. Smith (1991) assigned the P elements to the genus *Chionoconus*, which has herein been synonymized with *T. sweeti*. The apparatus plan is similar to that of *Diaphorodus* in having a geniculate P element, but the costae of *Diaphorodus* are tongue-like.

TROPODUS AUSTRALIS (Serpagli, 1974)

Plate 10, figs. 7-10

Walliserodus australis SERPAGLI, 1974, pp. 89-91, pl. 19, figs. 9-10, pl. 29, figs. 8, 10, 14.

Tropodus australis (Serpagli). ALBANESI, 1998, p. 151, pl. 13, figs. 12-18 (contains synonymy to 1998).

Discussion.—The elements of *T. australis* are similar in overall morphology to those of *T. sweeti*, but have less well developed keels on the S elements. The M and P elements are distinct in have a rounded antero-basal margin which becomes much sharper and keeled in *T. sweeti*. A final difference between the two species is the development of a keel on the lateral basal margin of the M and P elements of *T. sweeti*, which in *T. australis* is a rounded carina.

Occurrence.—*Acodus kechikaensis* to *Oepikodus communis* Zone, Kechika and Skoki formations.

Material.—35 M elements, 160 S elements, 32 P elements.

Repository.—GSC 119313. 119314, 119315, 119316.

TROPODUS SWEETI (Serpagli, 1974)

Plate 18, figs. 11-19

"*Paltodus*"? *sweeti* SERPAGLI, 1974, pp. 58-59, pl. 14, figs. 13a-14b, pl. 24, figs. 8-10, text-fig. 12.

Tropodus sweeti (Serpagli) STOUGE AND BAGNOLI, 1988, p. 142, pl. 16, figs. 10-15 (contains synonymy to 1988); ALBANESI, 1998, p. 152, pl. 13, figs. 23-30; text-fig. 23 (contains synonymy to 1998).

Chionoconus avanga, SMITH, 1991, pp. 22-24, fig. 14a, b, c, d only.

Discussion.—Some elements of *Tropodus sweeti* have been adequately described previously. The Pa element was originally described as "*Paltodus*" *sweeti* Serpagli and the M as "*Scandodus*" *americanus* Serpagli. The material from this collection includes a Pb element which is a geniculate form with a recurved cusp. The cusp bears a sharper lateral costae than the Pa element and the costae extends to the cusp tip rather than just on the base as in the Pa. The longitudinal groove is deeper close to the anterior margin of the cusp. The anticusp is more prominent and the postero-basal margin is more drawn out and flattened.

The S elements were originally described as having three to five costae as represented by *Walliserodus australis* Serpagli; the five-costate form is the symmetrical Sc, the four-costate form is the Sd and the three-costate form is the Sb element. Albanesi (1998) figured an Sa element of the apparatus which is present in this collection, a symmetrical, antero-posteriorly compressed element with strong posterior and lateral keels. The Sa element is a broad based, strongly compressed erect element with strong posterior keel and two lateral keels. The anterior cups face is flat but conave basally. The two lateral costae extend below the base. The basal cross section is triangular.

Some elements, particularly the tricostate Sb elements, in which the postero-lateral keel is drawn out, have incipient denticles on the keel. Juvenile forms of the Sb, Sc and Sd have denticulate keels on the elements.

Occurrence.—Oepikodus communis Zone, Skoki Formation.

Material.—64 M elements, 155 S elements, 98 P elements.

Repository.—GSC 119534, 119535, 119536, 119537, 119538, 119539, 119540, 119541, 119542.

Family MULTIOISTODONTIDAE Harris, 1964

Genus MULTIOISTODUS Cullison, 1938

Type species.—Multioistodus subdentatus Cullison, 1938

? MULTIOISTODUS COMPRESSUS Harris and Harris, 1965

Plate 20, fig. 19

? *Neomultioistodus compressus* HARRIS AND HARRIS, 1965, p. 43-44, pl. 1, figs. 7a-c.

? *Multioistodus compressus* (Harris and Harris) ETHINGTON AND CLARK, 1982, pp. 58-59, pl. 6, fig.10 (only) (contains synonymy to 1981).

Discussion.—An element from the Skoki Formation observed in this collection is similar to the acodiform element illustrated by Ethington and Clark (1982) and is an asymmetrical Sb element within the quinquimembrate apparatus plan illustrated in Sweet (1988). The denticles are compressed and flexed posteriorly. The cusp bears four costae, the lateral ones which join the sharp edge of the denticle in a smooth curve.

One specimen from the Chesterfield Member occurs with *M. subdentatus* which is an Sc with an extremely slender, elongate cusp and posteriorly deflected denticle arising from the aboral basal margin. It differs from the Sc of *M. subdentatus* in the gracile nature of the element and the position of the denticle which arises higher on the base in *M. subdentatus*.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—2 elements.

Repository.—GSC 119601.

MULTIOISTODUS SUBDENTATUS Cullison, 1938

Plate 14, figs. 16-17

Multioistodus subdentatus CULLISON, 1938, p. 226, pl. 29, figs. 13a, b; ETHINGTON AND CLARK, 1982, pp. 59-60, pl. 6, figs. 12-14 (contains synonymy to 1982); CRAIG ET AL., 1986, p. 10, pl. 1, fig. 33, 34; BAUER, 1989, p. 97, fig. 4.11 to 4.13.

Discussion.—The apparatus is incompletely preserved, but a series of S elements can be recognized and possibly an oistodiform M, which has a denticle arising from the antero-basal corner. Ethington and Clark (1982) described four elemental morphotypes—cordylodiform (Sc), distacodiform (Sa), trichonodelliform (?P) and acodiform (Sb) and although the Sb was not illustrated, the elements in this collection are similar to the Sc and Sa.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—11 elements.

Repository.—GSC 119426 and 119427.

Family OISTODONTIDAE, Lindström, 1970

Genus GRACILOCONUS new genus

Type species.—*Graciloconus concinnus* n. gen. n. sp.

Diagnosis.—Extremely thin, delicate coniform elements with slender, elongate cusps that have sharply keeled anterior and posterior margins. Base is triangular with small, shallow basal cavity. Apparatus includes S elements, geniculate M elements and P elements.

Etymology.—Gracile + cone refers to thin, delicate nature of the elements.

GRACILOCONUS CONCINNUS n. gen. n. sp.

Plate 10, figs. 18-25

Diagnosis.—A species of *Graciloconus* with apparatus of three morphotypes (S, M, P) in which S elements are diagnostic in having long, slender, extremely compressed cusps and triangular base in which the basal cavity is small and shallow.

Description.—S elements are coniforms with erect cusps. Cusp is laterally compressed with sharp anterior and posterior cusp margins. In all S elements, base is short and triangular in lateral view. Basal cavity is small and confined to middle third of base; triangular shaped with concave anterior margin; apex lies just anterior to midline of cusp. Sa element has unornamented cusp faces, except for small inner lateral carina on base. Posterior cusp margin extends below basal margin as tongue-like projection. Antero-basal corner is rounded.

Sb element has smooth lateral cusp faces and and sharp anterior and posterior cusp margins. Postero-basal corner is sharp but does not project below basal margin. Antero-basal margin rounded. No inner carina on base.

Sc element has erect cusp in which sharp anterior and posterior cusp margins project below basal margin. Basal carina is small and basal margin is arched. Sc has broaded base of all S elements.

?Sd element is similar to the Sa but with a more pronounced basal carina and faint lateral costa from base to cusp tip. Antero-and postero-basal corners extend as tongue-like projects below basal margin.

M element is geniculate with slender, elongate, tapered cusp (pl. 10, fig. 23) and long tongue-like projection of posterior basal margin (Pl. 10, fig. 25). Antero-basal margin drawn out and compressed. Basal cavity shallow and small. Inner basal margin flared.

P element similar to S elements but has less sharp cusp margins and rounded basal margins. It is not as laterally compressed and bears an inner lateral flare on basal margin which expands the base more than in S elements.

Etymology.—Concinnus means elegant

Discussion.—This new genus and species has tentatively been placed within the Oistodontidae based on its apparatus structure which is similar to that of *Oistodus* but the gracile nature of the elements with posteriorly expanded bases could warrant placement among the Paracordylodontidae, however, *G. concinnus* is adenticulate.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—54 M elements, 163 S elements, 15 P elements.

Repository.—GSC 119324 to 119331.

Genus OISTODUS Pander 1856

OISTODUS sp.

Plate 8, fig. 29

Discussion.—Oistodiform elements which have a slender, twisted cusp and broad base with sinuous basal outline are not assigned to a known species of *Oistodus*. The lateral cusp faces lack costae and basal margins are rounded which distinguish it from *O. lanceolatus* and *O. multicorrugatus.*

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—3 elements.

Repository.—GSC 119278.

Genus ROSSODUS Repetski and Ethington, 1983

Emend. Ji and Barnes (1994)

Type species.—*Rossodus manitouensis* Repetski and Ethington, 1983

Discussion.—Ji and Barnes (1994) described the apparatus of *Rossodus* as containing four elemental morphotypes (a, b, c and e), based on the apparatus description by Repetski and Ethington (1983). Albanesi (1998) emended the genus by describing a later form, *R. barnesi*, which has seven elemental morphotypes. The material in this present study show that apparatuses of early species such as *R. tenuis* (Miller) have four elemental morphotypes and descended from *Utahconus utahensis* Miller. The evolutionary transition from *Utahconus* to *Rossodus* has been noted by Repetski and Ethington (1983) and Ji and Barnes (1994). All of the species of *Rossodus* in this collection are characterized by a elements which have blade-like cusps filled with white matter, which bear rounded anterior costae. There are up to three types of compressed morphotypes within each apparatus in which one is geniculate and the other two are non-geniculate.

ROSSODUS KWADACHAENSIS n. sp.

Plate 4, figs. 1-4

Diagnosis.—A species of *Rossodus* with laterally expanded base on c element and characterized by flared base on a, b and e elements.

Description.—The a elements are stout with inner postero-laterally expanded base and carina. Antero-lateral carina is weak. Cusp is erect. Antero-basal corner rounded. Anterior and posterior cusp margins are sharp. Base expanded under anterior carina and sharper basally. Base is rounded under posterior carina.

The c element is symmetrical and stout with erect cusp which is curved posteriorly at tip. Anterior cusp face is rounded and bears faint, rounded carina. Posterior cusp face is concave. Base is expanded laterally and is triangular in posterior view. Basal cavity is triangular, apex at midline. Basal cavity expands under posterior carina.

The b element is laterally compressed with posteriorly expanded base. Cusp bears antero-lateral carina. Basal cavity apex is close to anterior cusp margin. Anterior and posterior cusp margins are sharp. Basal cavity extremely compressed and slit-like.

The e element is geniculate with a 45 degree angle between cusp and base. Posterior base is flange-like and compressed, joins expanded base. Carina on inner lateral face. Faint outer lateral carina.

Etymology.—Named after Kwadacha Wilderness Park.

Discussion.—This species is close to *R. manitouensis* and R. *tenuis* but has an expanded base and poorly developed posterior carina.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—12 a elements, 4 b elements, 3 c elements, 5 e elements.

Repository.—GSC 119136, 119137, 119138, 119139.

ROSSODUS MANITOUENSIS, Repetski and Ethington, 1983

Plate 3, figs. 14-19; Plate 22, figs. 1-2

Rossodus manitouensis, REPETSKI AND ETHINGTON, 1983, pp. 289-301, figs. 1-5 (contains synonymy to 1983); JI AND BARNES, 1994, p. 56, pl. 17, figs. 1-9 (contains synonymy to 1994); JI AND BARNES, 1996, p. 882, fig. 13.13-13.20.

Discussion.—The apparatus of *R. manitouensis* was described adequately by Ji and Barnes (1994) as containing four morphotypes (a, b, c and e) In this collection, two additional compressed elements are recognized. The compressed elements comprise two non-geniculate forms and one geniculate form. The non-geniculate elements have a broad, laterally compressed cusp which is flexed laterally. Cusp margins are sharply keeled, the outer and inner lateral surfaces bear faint costae. The inner basal margin is carinate, more pronounced in one type in which the posterobasal margin is drawn out. The base is expanded and basal cross-section is oval, tapering posteriorly. Ji and Barnes (1994) described the compressed geniculate element.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation and Road River Group, Cassiar Terrane.

Material.—2297 a elements, 671 b elements, 123 c elements, 814 e elements.

Repository.—GSC 119118 to 119123 and 119640 and 119641.

ROSSODUS MUSKWAENSIS n. sp.

Plate 3, figs. 20-26

New Genus A, n. sp. A REPETSKI, 1982, pp. 56-57, pl. 28, figs. 1-4.

Diagnosis.—A species of *Rossodus* with extremely shallow and constricted basal cavity and broad, blade-like cusp.

Description.—Apparatus of four morphotypes (a, b, c, e) in which all elements have anterior or antero-lateral, rounded carina which extends from cusp tip to base. All elements have broad, gently tapering cusp.

The a elements are asymmetrical. Anterior cusp face rounded with rounded, laterally displaced carina. Posterior cusp face flat to slightly concave. Basal margin flat on inner surface with slight expansion. Basal cavity expands on outer lateral surface and is constricted by lateral keels extending on either side of central basal cavity.

The b element has proclined cusp with two lateral keels and anterior carina. Anterior basal margin is extended down. Basal cavity is laterally constricted, with elliptical outline. Element is compressed laterally with inner and outer lateral expansion of base.

The c element is symmetrical, with erect cusp. Anterior cusp face bears round, medial carina and cusp tapers gradually. Posterior cusp face flat to slightly concave. Lateral cusp margins keeled. Basal margin straight, expands anteriorly and posteriorly. Basal cavity oval in lateral view, its apex shallow and at midline.

There are three types of compressed (e) elements. Two are non-geniculate with broad proclined cusp which tapers gradually. Basal two-thirds of cusp is same width as base, tapers gently. Cusp is keeled anteriorly and posteriorly. Antero-lateral cusp face bears rounded carina from cusp tip to base. Postero-lateral cusp face is concave and twisted posteriorly. Basal cavity oblique, anterobasal margin is drawn out. Basal cavity apex is anterior to midline in postero-lateral view. More common, second compressed (e) element (Pl. 3, fig. 21) has broad, gently tapered, proclined cusp. Anterior cusp face bears carina; lateral cusp margins are sharp. Posterior cusp face concave. Base is straight with extremely shallow, small, circular cavity located centrally. Basal cavity is right triangle in posterolateral view, its apex anterior of midline. Base has slight inner lateral expansion.

Most compressed (e) element (Pl. 3, fig. 20) is geniculate with broad cusp and shallow basal cavity. Base meets cusp at less than forty-five degrees. Anterior and posterior cusp margins are sharp. Antero-lateral carina is faint on slightly rounded antero-lateral face. Base is flat with very faint inner flare.

Etymology.—Named for the Muskwa River.

Discussion.—Elements differ from *R. manitouensis* in the constriction of the base and in the straight broad cusps of all morphotypes. The compressed geniculate elements of the two species are close, but differ in that *R. manitouensis* has a well developed inner lateral basal expansion and sharper, more tapered cusp compared to the broad cusp of *R. muskwaensis* n. sp.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—241 a elements, 53 b elements, 20 c elements, 64 e elements.

Repository.—GSC 119124 to 119130.

ROSSODUS SHEFFIELDENSIS n. sp.

Plate 3, figs. 27-31

Rossodus manitouensis Repetski and Ethington. JI AND BARNES, 1996, p. 882, fig. 13.14 (b element), 13.16 (a element), 13.19, 13.20 (e element).

Diagnosis.—A species of *Rossodus* in which four morphotypes (a, b, c, e) bear strong posterior carinae extending from base to cusp tip and have lateral or antero/postero-lateral keels which extend below basal margin.

Description.—An apparatus of four elemental morphotypes (a, b, c, e) characterized by strong carina or keels. The a elements are part of symmetry transition series of elements with four strong keels (two lateral, one anterior, one posterior). Cusp is erect but curved posteriorly. Anterior cusp face bears strong rounded carina. Posterior cusp face is concave but with rounded posterior keel from cusp to base. Base is shallow and expands posteriorly and anteriorly under carinae. Base constricted under sharp lateral keels which extend below basal margin.

The b element is asymmetrical with laterally compressed cusp that is more compressed along postero-lateral margin. Cusp bears strong lateral keels which extend below basal margin. Anterior cusp face bears rounded carina that sharpens distally and extends below basal margin. Posterior cusp face bears two longitudinal grooves which flank a broad, rounded carina. Base is flared posteriorly and anteriorly under carinae.

The c element is symmetrical with same characteristics as a element but has less extension of lateral keels. It is characterized by strong, rounded posterior carina from base to cusp tip. Cusp is slightly recurved posteriorly.

The e element is compressed and geniculate. Cusp bears an inner and outer lateral rounded carina and sharp antero-lateral and posterior cusp margins. Base bears median carina extended down from cusp which is flanked by two longitudinal grooves on inner lateral surface.

Etymology.—Named after Mt. Sheffield.

Discussion.—Overall, the apparatus is similar to that of *R. manitouensis*, but the elements are much more robust with the strong development of the posterior or postero-lateral carinae and longitudinal grooves. These features also distinguish R. *sheffieldensis* from *R. muskwaensis*, the latter which has reduced development of carinae. All elements are also characterized by the strong development of lateral keels which extend below the basal margin in all but the c element. The e element is distinguished by its strong carina on the antero and postero-lateral cusp faces.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—54 a elements, 12 b elements, 4 c elements, 11 e elements.

Repository.—GSC 119131 to 119135.

ROSSODUS SUBTILIS n. sp.

Plate 4, figs. 8-11

Diagnosis.—A new species of *Rossodus* with apparatus of four morphotypes (a, b, c, e). Elements are small and compressed laterally or posteriorly with thin, flat, blade-like cusp, rounded basal margins and shallow basal cavity.

Description.—The a elements are subsymmetrical and rounded. Cusp has two strong postero-lateral and antero-lateral margins. Postero-lateral face is concave; antero-lateral face is convex and bears a rounded carina. Basal length is half cusp height.

The b element is laterally compressed. Cusp is erect, extremely thin and bears faint anterior carina. Basal cavity is right triangle in lateral view, its apex located at midline. Postero-basal corner is drawn down below basal margin.

The c element is symmetrical. Cusp is antero-posteriorly compressed with sharp lateral cusp margins. Anterior cusp face bears distinct carina from base to tip and is gently convex. Posterior cusp face is strongly concave. Base is two-thirds height of cusp. Basal cavity is confined to central part of element and expands only slightly under posterior carina.

The e element is geniculate. Cusp is close to postero-basal margin, almost fused, at a 20 degree angle to base. Postero-lateral face is concave. Antero-lateral face bears faint, broad carina.

Etymology.—Subtilis means thin, referring to delicate nature of all elements.

Discussion.—This species is distinguished from all other species of *Rossodus* by its small size and thin nature of elements. It is most similar to *R. kwadachaensis* but elements are much thinner with less broad bases.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—12 a elements, 5 b elements, 4 c elements, 4 e elements.

Repository.—GSC 119143, 119144, 119145, 119146.

ROSSODUS TENUIS (Miller, 1980)

Plate 3, figs. 8-13

Oistodus minutus MILLER, 1969, p. 443, pl. 66, figs. 5-7 only.

Utahconus tenuis (Miller). MILLER, 1980, p. 36-37, pl. 2, figs. 5-7, text-fig. 4T; TAYLOR AND LANDING, 1982, p. 189, text-fig. 5L; WANG, 1986, p. 241-242, pl. 2, fig. 3.

Rossodus tenuis (Miller). JI AND BARNES, 1994, p. 56, pl. 17, figs. 10-19.

Description.—Apparatus is characterized by a and c elements which have rounded anterior costae characteristic of the genus, and basal cavity outline is round in lateral view.

Three types of compressed e elements are long, slender, tiny coniform elements with shallow basal cavities. Two are geniculate, one is non-geniculate. Non-geniculate element (Pl. 3, fig. 13) has proclined cusp which is postero-laterally compressed. Anterior cusp margin is rounded and straight in lateral profile. Posterior basal margin is smoothly round. Inner antero-lateral margin bears faint carina and is flared along basal margin. Basal cavity is shallow, its apex under carina.

Second form (Pl. 3, fig. 9) has laterally compressed cusp with sharp anterior and posterior margins. Cusp is flexed laterally. Posterior basal corner is drawn out; angle between base and cusp is almost 90°. Basal margin is expanded on inner lateral side. Anterior basal margin smoothly joins cusp. Anterior cusp margin is straight. Basal margin outline is oval, drawn out anteriorly and posteriorly with slight expansion of inner lateral basal margin.

The most compressed, geniculate element (Pl. 3, fig. 8) is delicate with laterally compressed cusp with sharp anterior and posterio margins. Inner face bears rounded carina extending along midline to basal margin. Inner anterior base is compressed and slight carina gives expansion on middle of inner base. Base meets cusp at 45 degree angle and inner antero-basal corner is rounded.

The c element is symmetrical with erect cusp which bears anterior and posterior carina. Base expands posteriorly. Posterior cusp face is concave, gradually tapers distally. Basal outline round and expanded anteriorly.

The a element is asymmetrical. Base is wide and rounded but tapers laterally and antero-laterally. Cusp margins are strongly keeled laterally and antero-laterally. Cusp is long and slender, compressed anteriorly and posteriorly.

The b element is laterally compressed with sharp anterior and posterior cusp margin. Cusp bear faint anterior and posterior carina. Base is drawn out posteriorly, postero-basal margin flared. Basal cavity is shallow right triangle in lateral view, its apex near the anterior.

Discussion.—*R. tenuis* was partially described by Ji and Barnes (1994) and as indicated in the synonymy, some of its elements have been illustrated, characteristically the larger geniculate element. The material in this present study shows the apparatus is more complex than previously described and is an intermediate between *U. utahensis* and *R. manitouensis* by further elaboration of the costae on the cusp. The compressed elements are close to those of *U. utahensis* but are distinguished by the extension of the base and more central location of the basal cavity apex. The presence of a geniculate M element distinguished *R. tenuis* from *U. utahensis*. All morphotypes of *R. tenuis* are similar to *R. manitouensis* but small in size with more slender cusp and base and more rounded basal outline.

Occurrence.—*Rossodus tenuis* to *Rossodus manitouensis* Zone, Kechika Formation.

Material.—810 a elements, 213 b elements, 120 c elements, 350 e elements.

Repository.—GSC 119112 to 119117.

Genus TRICOSTATUS Ji and Barnes, 1994

Type species.—*Tricostatus glyptus* Ji and Barnes, 1994

TRICOSTATUS cf. T. GLYPTUS Ji and Barnes, 1994

Plate 4, figs. 12-15

cf. *Tricostatus glyptus* JI AND BARNES, 1994, p. 66, pl. 17, fig. 20-25.

Discussion.—An apparatus of three morphotypes is observed, however the a elements bear four costae, not three and are characterized by a strong posterior costa. The e elements are close to a compressed element of *R. tenuis*, but bear a postero-lateral costa on the basal expansion.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—61 a elements, 16 c elements, 5 e elements.

Repository.—GSC 119147, 119148, 119149, 119150.

TRICOSTATUS INFUNDIBULUM n. sp.

Plate 4, figs. 5-7

Diagnosis.—A new species of *Tricostatus* with apparatus of three morphotypes (a, b, c) which are characterized by prominent rounded posterior or postero-lateral costa and rounded basal carina which looks like an inverted funnel.

Description.—Apparatus of three morphotypes (a, c, e) which have prominent posterior or postero-lateral costa and round basal carina, which together look like inverted funnel.

The a elements are subsymmetrical with elongate, proclined to erect cusp. Antero-lateral cusp face bears faint carina from cusp to base. Postero-lateral cusp face is concave with sharp costa which fades distally and grades basally into basal carina. Anterior and posterior cusp margins are sharp. Base is oval and shallow, expanded postero-laterally.

The c element is symmetrical with erect cusp which is recurved posteriorly. Posterior cusp face is concave and bears sharp rounded costa which smoothes basally into basal carina. Lateral cusp margins are sharp. Anterior cusp face bears faint costa. Base is oval and expands posteriorly.

The e element is compressed and non-geniculate. Cusp bears posterior costa and anterior cusp face is rounded. Base extends postero-laterally and flares posteriorly.

Etymology.—Infundibulum means funnel-shaped, referring to shape of rounded posterior costae which joins rounded basal carina.

Discussion.—The elements are similar to those of *T. glyptus* but have a much more prominent costa and expanded base.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—23 a elements, 2 c elements, 8 e elements.

Repository.—GSC 119140, 119141, 119142.

TRICOSTATUS cf T. INFUNDIBULUM n. sp.

Plate 22, figs. 12-13

Discussion.—A few specimens from the Deadwood Lake section yield specimens which have the inverted funnel-shaped costae on the posterior cusp face, but the base is not as triangular nor wide.

Occurrence.—*Rossodus manitouensis* Zone, Road River Group, Cassiar Terrane.

Material.—4 elements.

Repository.—GSC 119651 and 119652.

TRICOSTATUS TERILINGUIS n. sp.

Plate 4, figs. 18-21

Diagnosis.—A new species of *Tricostatus* with an apparatus of four morphotypes (a, b, c, e) in which elements are characterized by a small, round basal cavity. The c element is diagnostic in bearing a tongue-like flange which is a projection of the anterior carina.

Description.—Apparatus of four elemental morphotypes: a (subround), b (drepanodiform), c (suberect, symmetrical) and e (compressed oistodiform). The elements are extremely compressed, elongate and blade-like and characterized by a small, round basal cavity.

The a element is compressed laterally with blade-like cusp and weakly developed anterior carina. Cusp is proclined to erect and broad, narrowing only slightly distally from base, flexed postero-laterally. Anterior face is smoothly rounded; carina is round and bulbous at its base, terminating at a point higher than that on posterior face. Posterior face is concave and weakly carinate; carina fades distally along cusp. Lateral cusp margins are sharply keeled, one longer than the other, producing tapered base. Base is small and shallow, broadened under anterior and posterior carinae.

The b element is extremely compressed antero-posteriorly and bladelike. Cusp has faint anterior and posterior carinae and sharply keeled lateral cusp margins. Cusp is elongate, narrowing slightly distally, flexed slightly posteriorly. Basal cavity is extremely compressed and shallow

The c element is symmetrical, elongate, compressed laterally. Cusp has rounded anterior and posterior carinae and sharp lateral cusp margins. Anterior cusp face is carinate, from base to tip, carina extends below basal margin as a flange. Posterior face flattened, rounded carina is raised, extends from base to tip. Basal cavity is small, circular and shallow.

The e element is oistodiform. Cusp bears faint carina on inner lateral face, posterior of midline. Outer lateral face is weakly carinate along midline. Cusp forms gentle acute angle to base. Basal margin joined by inner lateral carina.

Etymology.—Named for the straight (teri-), tongue-like (linguis) flange of the c element.

Discussion.—*T. terilinguis* n. sp. appears to be closely related to *R. manitouensis* in that it shares characterisitic features of the genus such as the anterior carina of the a, b, and c elements. The e element is close to that of *R. manitouensis*, but is more compressed and the cusp joins the base less acutely. Compared to other species of *Tricostatus*, *T. terilinguis* has less developed postero-lateral costae. The c element, although rare, is diagnostic in its anterior flange. The a element is also distinct in having a flange-like projection of posterior margin.

Occurrence.—*Rossodus manitouensis* Zone, Kechika Formation.

Material.—11 a elements, 4 b elements, 5 c elements, 2 e elements.

Repository.—GSC 119153, 119154, 119155, 119156.

Family PARACORDYLODONTIDAE Bergström, 1981

Genus PROTOPRIONIODUS McTavish, 1973

Type species.—*Protoprioniodus simplicissimus* McTavish, 1973

Discussion.—The description of the apparatus of *Protoprioniodus* McTavish by Stouge and Bagnoli (1988) as comprising M, S and P elements is herein followed. Most elements are extremely delicate and small. Analogies with the apparatus plans of *Paracordylodus* and *Oistodus* are clarified using the M, S, P notation, however, the apparatus plans of some species, such as *P. nyinti* Cooper may contain highly specialized P elements.

PROTOPRIONIODUS ARANDA Cooper, 1981

Plate 14, figs. 18-22

Protoprioniodus aranda, COOPER, 1981, pp. 175-176, pl. 29, figs. 1, 6, 7, 10, 12; ETHINGTON AND CLARK, 1982, pp. 86-87, pl. 9, figs. 24-30; REPETSKI AND ALBERSTADT, 1989, p. 234 figs. 8A, B; POHLER, 1994, p. 66, pl. 6, figs. 10-12; HARRIS ET AL, 1995, p. 27, pl. II, fig. R.

Discussion.—Apparatus is characterized by the P element which bears a short cusp and anterior process and a curved posterior process with a prominent notch between the posterior process and the cusp. Some P elements have a well developed lateral carina and a ledge along the lower basal margin. The upper margin of the posterior process is rounded. The M elements described by Cooper (1981) is more likely the P element, similar to those of *P. cowheadensis* as described by Stouge and Bagnoli (1988). The S elements comprise a symmetrical Sa element and asymmetrical Sb element, both characterized by the conspicuous notch between the curved posterior process and the cusp. The anterior and lateral processes are sharp and short.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—14 M elements, 22 S elements, 15 P elements.

Repository.—GSC 119428, 119429, 119430, 119431, 119432.

PROTOPRIONIODUS COWHEADENSIS Stouge and Bagnoli, 1988

Plate 21, figs. 23-25

Protoprioniodus cowheadensis STOUGE AND BAGNOLI, 1988, p. 137, pl. 14, figs. 1-5 (contains synonymy to 1990); ALBANESI, 1998, pp. 169-170, pl.10, figs. 19-21.

Discussion.—Stouge and Bagnoli (1988) described the apparatus as containing M, S and P elements, however only an Sa, Sb and Sc were recovered in this collection. The S elements have a characteristic blade-like posterior process which has an arched aboral margin and anticusp comprising the anterior basal margin.

Occurrence.—*Oepikodus communis* Zone, Skoki Formation.

Material.—7 S elements.

Repository.—GSC 119635, 119636, 119637.

PROTOPRIONIODUS NYINTI Cooper, 1981

Plate 21, figs. 16-22

Protoprioniodus nyinti COOPER, 1981, pp. 176-178, pl. 29, figs. 1-8, 11, 12.

Discussion.—A species with highly specialized P elements which Cooper (1981) described as an arched bar, swollen on one side and concave on the other. The swollen face bears a longitudinal ledge along the basal margin. The M elements illustrated by Cooper (1981) is likely a second type of P element with fusion of the cusp to the base along much of its length. The S elements differ from those described by Cooper (1981) in that they have strong, curved lateral costae and wider, arched posterior processes. An M element is included in the apparatus which is not illustrated by Cooper (1981) in which the arched posterior process and lateral cusp bear a rounded costae along their length. The cusp and process are thinly keeled and have curved posterior and upper margins, respectively.

Occurrence.—*Oepikodus communis* Zone, Skoki Formation to *Paroistodus originalis* Zone, Ospika Formation.

Material.—20 M elements, 51 S elements, 58 P elements.

Repository.—GSC 119628 to 119634.

PROTOPRIONIODUS n. sp.

Plate 21, figs. 26-27

Description.—An incomplete apparatus of S and P elements which bear strong costate "bar" along the base and posterior process and costa on the cusp.

P element is similar to that of *P. nyinti*, but has robust base which bears costate bar, comprising two rounded costae which converge posteriorly and are separated by groove. Fusion is strong between cusp and base and cusp bears strong rounded costae.

S element also has strong fusion of the keeled base and cusp. It too has two costae on the base which meet at the strong lateral keel and diverge posteriorly along the base.

Discussion.—The elements occur with *P. nyinti* and are similar, but the presence of the grooved bar on the base suggests this is a new species. However, there is not enough material to reconstruct the apparatus.

Occurrence.—***Jumudontus gananda*** Zone, Skoki Formation.

Material.—4 elements.

Repository.—GSC 119638 and 119639.

Family PERIODONTIDAE Lindström, 1970

Genus MICROZARKODINA Lindström 1971

Type species.—***Prioniodina flabellum*** Lindström, 1955

MICROZARKODINA n. sp.

Plate 18, figs. 20-22

Description.—P elements are different from species previously described because they bear a large anterior denticle and small posterior denticles. As so few elements were recovered, especially S elements, specific assignment is not attempted. Compared to *M. flabellum*, this new species has a larger anterior denticle and smaller posterior process and denticles.

Occurrence.—***Jumudontus gananda*** Zone, Skoki Formation.

Material.—8 M elements, 6 P elements.

Repository.—GSC 119543, 119544, 119545.

Family PRIONIODONTIDAE Bassler, 1925

Genus OEPIKODUS Lindström, 1955

Type species.—***Oepikodus smithensis*** Lindström, 1955

Discussion.—The apparatus plan of *Oepikodus* was emended by van Wamel (1974) as multielemental and comprises a series of S elements in which the Sa position is not readily distinguished which distinguishes it from *Prioniodus*. There are two P elements and one longiramiform M element.

OEPIKODUS n. sp.

Plate 17, figs. 5-6

Description.—A new species of *Oepikodus* characterized by P elements with large denticles of equal size which are fused at base. Cusp bears lateral adenticulate process which is deflected anteriorly and arises from cusp at point of curvature of cusp. Process extends up to cusp tip as a strong keel.

Discussion.—This new species of *Oepikodus* requires more material to determine the apparatus structure, but the nature of the denticulation distinguishes it from other species. The denticles are fewer in number and larger than in *O. evae, O. intermedius* and *O. communis*.

Occurrence.—*Jumudontus gananda* Zone, Skoki Formation.

Material.—4 P elements.

Repository.—GSC 119498 and 119499.

Genus PRIONIODUS PANDER, 1856

Type species.—*Prioniodus elegans* Pander, 1856

?PRIONIODUS n. sp.

Plate 19, figs. 16-19

Description.—An incomplete apparatus containing S elements are tentatively assigned to *Prioniodus*. The denticles are highly fused. The Sb elements have a lateral adenticulate process and a ledge along the posterior process. The Sd elements have a stronger lateral process and extension of the anterior cusp margin. The denticulate posterior process bears fused denticles on an arched process. Compared to *P. adami* and *P. elegans*, the arched posterior process with a ledge is the distinguishing feature.

Occurrence.—*Oepikodus communis* to *Jumudontus gananda* Zone, Skoki Formation.

Material.—2 M elements, 15 S elements, 2 P elements.

Repository.—GSC 119567 to 119570.TAXA OF UNKNOWN AFFINITY

Order UNKNOWN

Family NOV. 3 Aldridge and Smith, 1993

Genus LOXODUS Furnish, 1938

Type species.—Loxodus bransoni Furnish 1938

LOXODUS LATIBASIS Ji and Barnes, 1994

Plate 2, fig. 5-6

Loxodus latibasis JI AND BARNES, 1994, p. 46, pl. 12, figs. 14-17, text-fig. 29B.

Discussion.—As Ji and Barnes (1994) described, the apparatus is unimembrate, with left and right elements. The basal portion is large, occupying one half to two-thirds of the element. The denticulated portion comprises vaguely discrete denticles which are inclined posteriorly and confluent along their bases. The elements are laterally compressed and the denticulated portion is flexed along a line between the denticle row and basal portion, which is a distinguishing character from *L. bransoni* which shows no flexure in the element. A difference noted in this collection is that the anterior margin is concave at the point of flexure. Some elements have a small node which is anteriorly directed, originating from the point of concavity in the anterior margin. The anterior denticle is small and erect to slightly flexed posteriorly. The basal cavity is narrow and deep.

Occurrence.—Rossodus manitouensis Zone, Kechika Formation.

Material.—17 dextral elements, 14 sinistral elements.

Repository.—GSC 119072 and 119073.

Order UNKNOWN

NEW GENUS B, NEW SPECIES

Plate 18, figs. 23-26

Diagnosis.—Apparatus of at least three morphotypes (a, b, e) in which the a elements are diagnostic in bearing an elongate, erect cusp, small base and prominent antero-lateral keel.

Description.—The a element is laterally compressed with erect cusp. Cusp strongly keeled anteriorly and posteriorly. Outer lateral face bears strong antero-lateral keel which arises one-third length of cusp from basal margin as anterior cusp margin diverges.

Keel is deflected anteriorly. Divergence of anterior cusp margin gives basal outline a triangular profile. Base is deep.

The b element is laterally compressed with erect cusp and small base. Cusp is laterally compressed. Anterior and posterior cusp margins sharply rounded. Cusp twisted laterally. Base open laterally and is round in lateral view.

The e element is geniculate and compressed. Cusp is flexed inward and outer lateral cusp face is keeled. Antero-basal margin is rounded.

Discussion.—As so few elements were recovered, the assignment of this new genus is unknown. More material is needed to reconstruct the whole apparatus.

Occurrence.—***Oepikodus communis*** Zone, Skoki Formation.

Material.—6 elements.

Repository.—GSC 119546, 119547, 119548, 119549.

CONIFORM INDET. A

Plate 2, fig. 28

Description.—Simple coniform with proclined cusp, at least twice length of base. Cusp bears two strong costae, one along medial lateral cusp face, the other antero-lateral. Posterior and anterior cusp margins sharp. Base is square and angle between postero-basal edge and cusp is greater than 100 degrees.

Occurrence.—***Rossodus manitouensis*** Zone, Kechika Formation.

Material.—5 elements.

Repository.—GSC 119104.

CONIFORM INDET. B

Plate 4; figs. 16-17

Description.—Stout coniforms of two morphotypes which resemble elements of *Clavohamulus* and have shallow basal cavities. One morphotype (a) is stout with triangular cross-section and widely rounded base. Posterior cusp face deeply concave; anterior cusp face rounded. Posterior basal margin flat; anterior basal margin rounded. The e element is stout with slender, erect, bulbous cusp. Base is large and round with thickened rim. Above basal margin at point where cusp emerges are four pockets or concave regions separated by a rounded costae extending off cusp onto basal rim.

Occurrence.— ***Rossodus manitouensis***, Kechika Formation.

Material.—2 elements.

Repository.—GSC 119151 and 119152.

CONIFORM INDET. C

Plate 4, figs. 22-23

Description.—Stout coniforms which have a costate cusp and wide base with rounded rim. Cusp is erect and bears sharp costae flanked by deep concave regions which extend from cusp tip to basal rim.

Occurrence.— ***Rossodus manitouensis*** Zone, Kechika Formation.

Material.—10 elements.

Repository.—GSC 119157 and 119158.

CONIFORM INDET. D

Plate 6; fig. 14

Description.—Simple coniforms which are robust and stout with large, round, gaping basal cavity and sharply rounded to sharp posterior cusp margin. Three morphotypes are recognized in which a and c elements comprise first symmetry transition series and compressed e elements the second series.

The a element is rounded and asymmetrical to nearly symmetrical. Cusp is proclined and has straight anterior cusp margin. Posterior cusp margin is more sharply rounded. Base is slightly defined but not expanded. Basal cavity is deep and wide, opening posteriorly.

The c element is symmetrical, with erect cusp and posteriorly sharpened margin, flanked by slight concavity along postero-lateral sides of element. Base is expanded with rounded cross-section.

The e element is compressed and broad with oval cross section. Posterior cusp margin is sharply rounded. As in c element, outer and inner lateral faces have a slight concavity along posterior margin. Cusp is erect, bears faint lineation along antero-lateral margin. Basal margin bears inner lateral flare or carina.

Occurrence.— ***Rossodus manitouensis*** Zone, Kechika Formation.

Material.—5 elements.

Repository.—GSC 119207.

Coniform indet. E

Plate 6; figs. 28-30

Description.—Simple cones with erect to proclined cusp, compressed laterally, some more than others. Cusp margins sharply rounded. Base has characteristic shape in being drawn out posteriorly and shallow with flare on inner lateral basal margin producing small flange. Outer lateral cusp and base are flat. All specimens are asymmetrical.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—13 elements.

Repository.—GSC 119218, 119219, 119220.

Coniform indet. F

Plate 6; fig. 31

Description.—An apparatus characterized by elongate, simple cones with compressed, twisted cusps so that the round basal cavity gapes on inner lateral cusp face.

There are at least two morphotypes within two symmetry transition series. The a element is rounded and has a reclined cusp which is laterally compressed above base. Posterior and anterior cusp margins are sharply rounded. Inner lateral cusp face bears carina. Base is expanded laterally. Outer lateral face is smooth and bears faint carina along its length. Basal outline is circular and same width as cusp. Basal cavity is deep.

Compressed e element is erect and compressed along whole element. Inner lateral cusp face bears a costae along anterior cusp margin. Outer lateral cups face is smooth except for faint carina along anterior cusp margin. Basal outline is oval and constricted.

Occurrence.— *Rossodus manitouensis* Zone, Kechika Formation.

Material.—17 elements.

Repository.—GSC 119221.

Coniform indet. G

Plate 8; fig. 23

Description.—Simple cones with a slender, recurved cusp which bears fine striae over all cusp faces. Base is poorly defined but opens widely and has rounded margins.

Occurrence.—*Acodus kechikaensis* Zone, Kechika Formation.

Material.—19 elements.

Repository.—GSC 119272.

CONIFORM INDET. H

Plate 9, figs. 3-5

Description.—Elements are extremely laterally compressed simple cones, lacking any costae or carinae on elongate cusp, with rounded cusp margins. Compressed e element has sharp posterior cusp margin with more compression along posterior cusp margin. Basal cavity is narrow and extends to point of curvature of cusp, its apex located centrally. Some elements have a long base and concave anterior cusp margin.

Occurrence.—*Iapetognathus* Zone, Kechika Formation.

Material.—55 elements.

Repository.—GSC 119281, 119282, 119283.

CONIFORM INDET. I

Plate 10, figs. 1-2

Description.—Robust simple cones which bear faint, rounded postero-lateral costae on the cusp. One morphotype is laterally compressed with a broadly tapered cusp and slightly flared base. The other has a slender cusp and pronounced flare on inner lateral base.

Occurrence.—*Scolopodus subrex* Zone, Kechika Formation.

Material.—2 elements.

Repository.—GSC 119308.

CONIFORM INDET. J

Plate 18, figs. 27-28

Description.—Elements are simple coniforms which are laterally compressed with blade-like cusps. Anterior and posterior cusp margins and basal corners sharp. Basal cavity shallow with apex located anterior to midline. Elements have an overall similarity to the compressed elements of *Utahconus utahensis*.

Occurrence.— ***Jumudontus gananda*** **Zone, Skoki Formation.**

Material.—15 elements.

Repository.—GSC 119550 and 119551.

CONIFORM INDET. K

Plate 19, fig. 11

Description.—Simple coniform elements with broad, posteriorly expanded base with triangular profile. Cusp is slender and bears one strong lateral costae and minor striae posterior to costae. Overall morphology is similar to ***Walliserodus***.

Occurrence.— ***Oepikodus communis*** Zone, Skoki Formation.

Material.—4 elements.

Repository.—GSC 119562.

CONIFORM INDET. L

Plate 19, fig. 12

Description.—Some elements from the Skoki, in which simple hyaline coniforms have a large, circular base and small, tapering cusp which bears one weak to moderately strong longitudinal groove from the cusp tip to almost the basal margin. No suberect symmetrical elements or compressed elements were observed, only a elements The elements have affinities with ***Semiacontiodus*** or ***Acanthodus*** and could be placed tentatively among the Protopanderodontidae.

Occurrence.— ***Jumudontus gananda*** Zone, Skoki Formation.

Material.—6 elements.

Repository.—GSC 119563.

CONIFORM INDET. M

Plate 20, figs. 20-22

aff. *Aloxoconus* sp. A. SMITH, 1991, p. 20, fig. 12c.

Description.—Incomplete apparatus of hyaline elements which have rounded costae and rounded basal margins.

Symmetry transition of a elements in which symmetrical a element has rounded carinate posterior face and rounded anterior cusp margin. Lateral cusp margins are slightly costate. Asymmetrical elements have rounded inner lateral carina. Basal margin is rounded and base constricted.

Symmetrical suberect c element has sharp lateral cusp margins. Posterior cusp face is convex with central costae flanked by two rounded costae. Anterior cusp face is smooth. Base flares up under the central costae and has round basal outline.

Discussion.—The elements are similar to those of Coniform Indet. O, but have a constricted base and more rounded costae. The symmetrical element is more stout with costae instead of striae. The symmetrical element is somewhat similar to *Aloxoconus* sp. A of Smith (1991) but is broader and has more defined lateral cusp margins which flatten basally into keel-like projections. The overall morphology is similar, especially the shape of the basal cavity in posterior view on the c element.

Occurrence.— *Tripodus laevis* Zone, Skoki Formation.

Material.—15 elements.

Repository.—GSC 119602, 119603, 119604.

Coniform indet. N

Plate 20, figs. 25-27

Description.—Apparatus of possibly four morphotypes in which hyaline elements are characterized by a elements which have a long, straight edged posterior process.

The a element has laterally compressed cusp with sharper posterior cusp margin than anterior. Antero-basal corner is expanded and square. Postero-basal corner is drawn out into adenticulate process which has straight edges and is deflected below basal margin.

The symmetrical suberect c element is antero-posteriorly compressed. Base is small and cusp tapered. Anterior and posterior cusp faces bear faint costae. Lateral cusp margins are sharp.

The e element is geniculate and compressed with a sharp posterior cusp edge as in the other elements. The postero-basal corner has straight edges and joins the posterior cusp margin at a 20 degrees angle. Cusp is broader than width of base.

Occurrence.— *Tripodus laevis* Zone, Skoki Formation.

Material.—6 elements.

Repository.—GSC 119607, 119608, 119609.

CONIFORM INDET. O

Plate 20, figs. 28-30

Description.—Incomplete apparatus of at least three morphotypes (a, c, e).

The a element is subround and asymmetrical with four costae. Anterior cusp margin is costate and outer lateral cusp face smoothly costate. Inner lateral cusp face is flat between anterior and inner lateral costae. Lateral costae fades distally up the cusp. Posterior cusp margin sharp. Base is flared laterally. Basal cavity deep.

The symmetrical c element is suberect and has sharp lateral cusp margins. Posterior cusp face convex and bears faint striae which extend from the base to the cusp tip. Anterior cusp face is convex and smoothly rounded. Base is expanded laterally and antero-posteriorly. Basal cross-section is round.

A compressed element is non-geniculate and has sharp anterior and posterior cusp margins and faint costae laterally. The base is expanded posteriorly. Basal cavity is deep and base is flared laterally.

Discussion.—As there were only a few elements discovered, the apparatus may contain more elemental morphotypes, such as a symmetrical a element and a transitional b element.

Occurrence.— *Tripodus laevis* Zone, Skoki Formation.

Material.—9 elements.

Repository.—GSC 119610, 119611, 119612.

RAMIFORM INDET.

Plate 23, fig. 9

Description.—One broken specimen from Deadwood Lake Section is symmetrical ramiform element which has slender, laterally compressed cusp with keeled lateral cusp margins and keeled posterior cusp margin. Two lateral processes are compressed and denticulate.

Occurrence.—***Amorphognathus tvaerensis*** Zone, Road River Group, Cassiar Terrane.

Material.—1 element.

Repository.—GSC 119674.

PLATFORM INDET.

Plate 20, figs. 23-34

Description.—A few small platform elements from the Skoki Formation have a small recurved cusp tip and wide, deep basal cavity. Posterior face of element concave; anterior face rounded. Both faces ornamented by a series of nodose ridges which extend from base and fade distally, except for the lateral ridges which are strongest.

Occurrence.—***Oepikodus communis*** Zone, Skoki Formation.

Material.—4 elements.

Repository.—GSC 119605 and 119606.

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PLATES

For each figured specimen, the element morphotype, view, sample number, repository number and magnification are listed. The sample number abbreviates the locality and the year collected. Numbers may have a letter included for ridge sections measured and sampled in segments (E.g., 96-13-A6 is from Section 13 near Mt. Sheffield, collected in 1996 from segment A of the section). Appendix A gives the measurements and lithologic description of each sample and Appendix B shows the stratigraphic distribution of all species. All figured specimens are deposited in the National Type Collections of the Geological Survey of Canada (GSC). All specimens, unless otherwise indicated, are hypotypes and those held in open nomenclature are figured specimens.

Plates are arranged stratigraphically in which specimens figured on Plates 1 to 13 are from the Kechika Formation, 14-16 are from the Road River Group, 17-22 are from the Skoki Formation and 22 and 23 are from the Cassiar Terrane. Grouping of specimens by genus on one plate or successive plates was done to facilitate the comparison of species.

Plate 1

Figures 1-3. ***Eoconodontus notchpeakensis*** **(Miller)**
1. a element, inner lateral view, GP-94-6-6, GSC 119040, x 67
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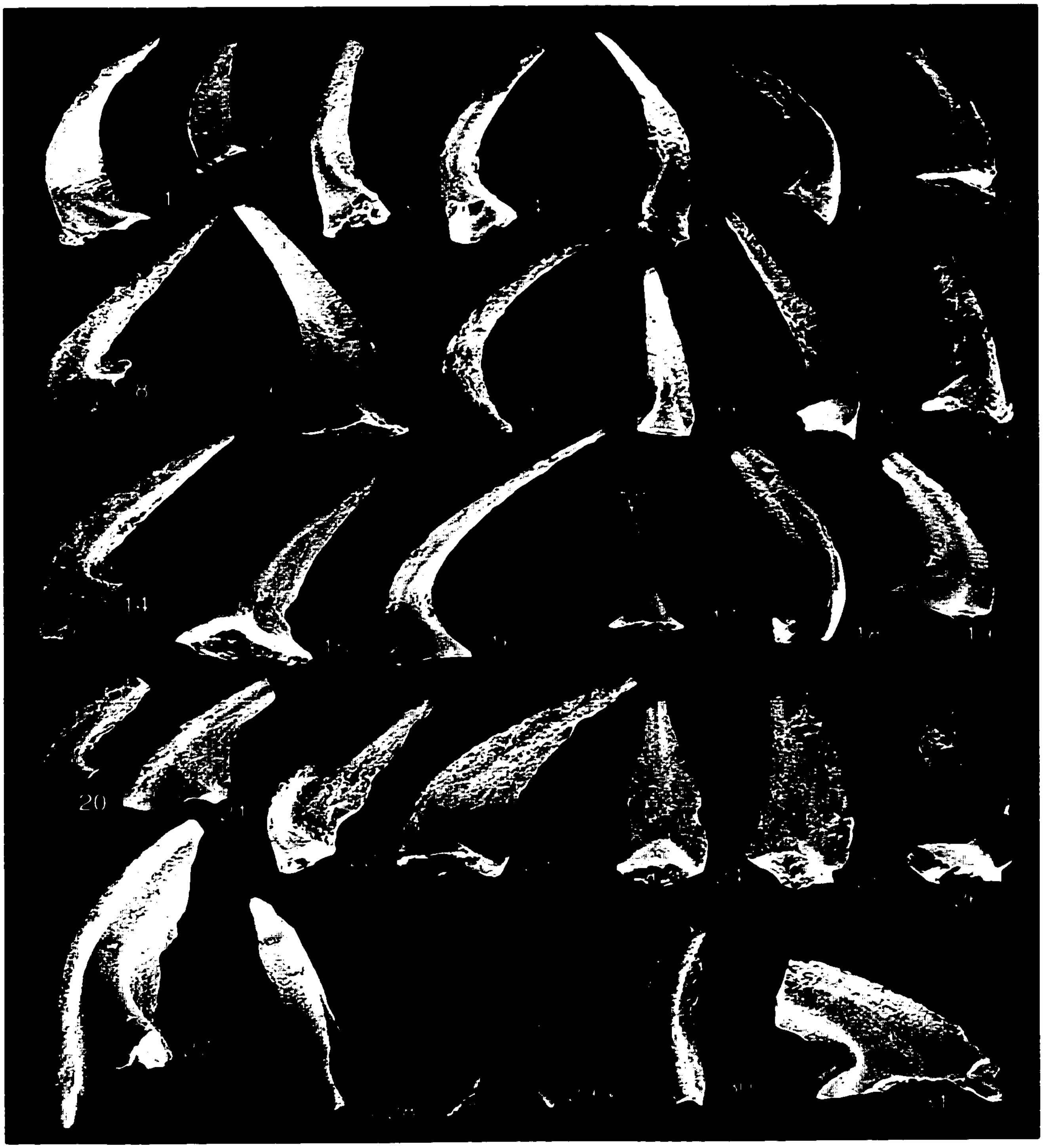

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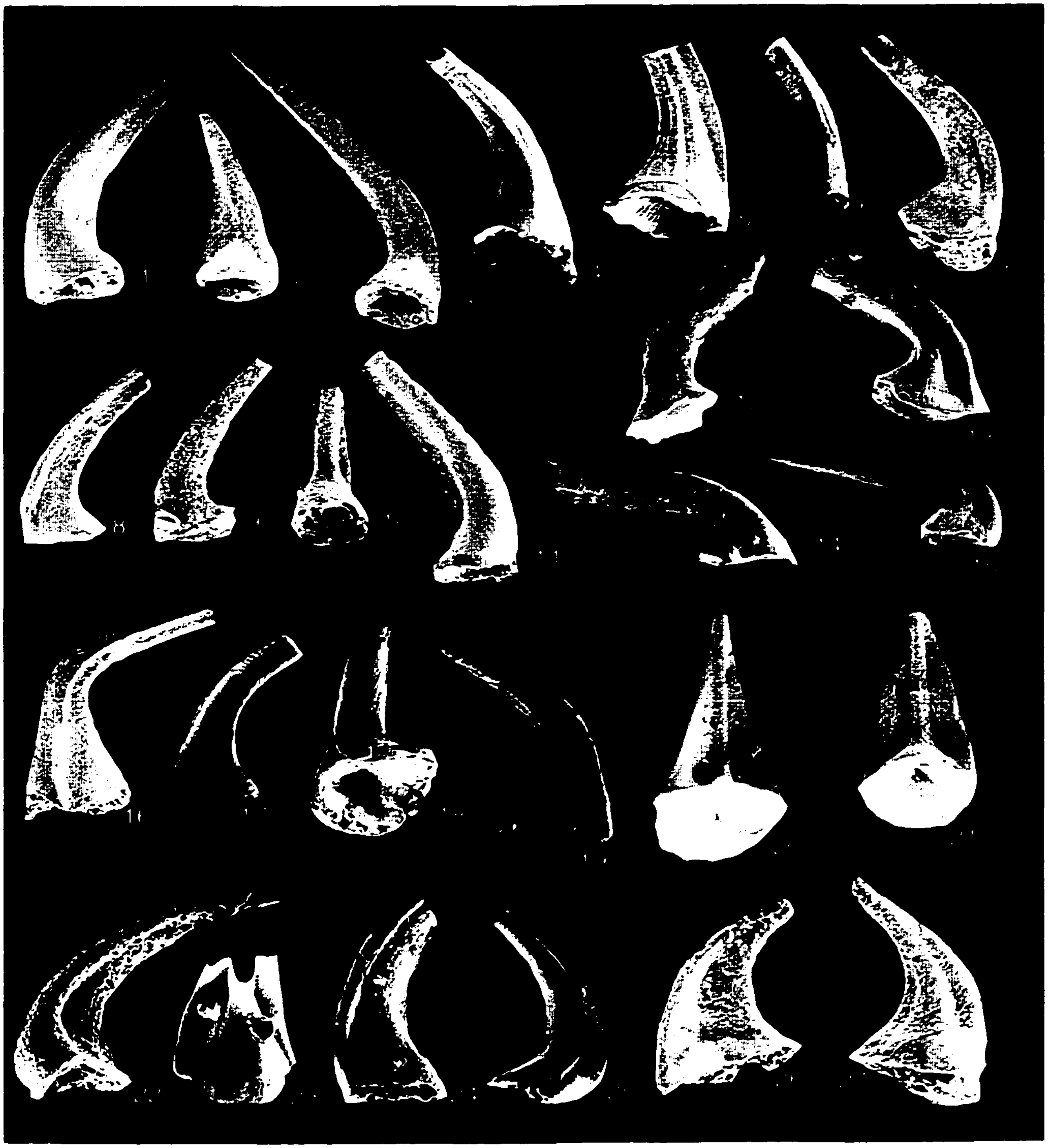

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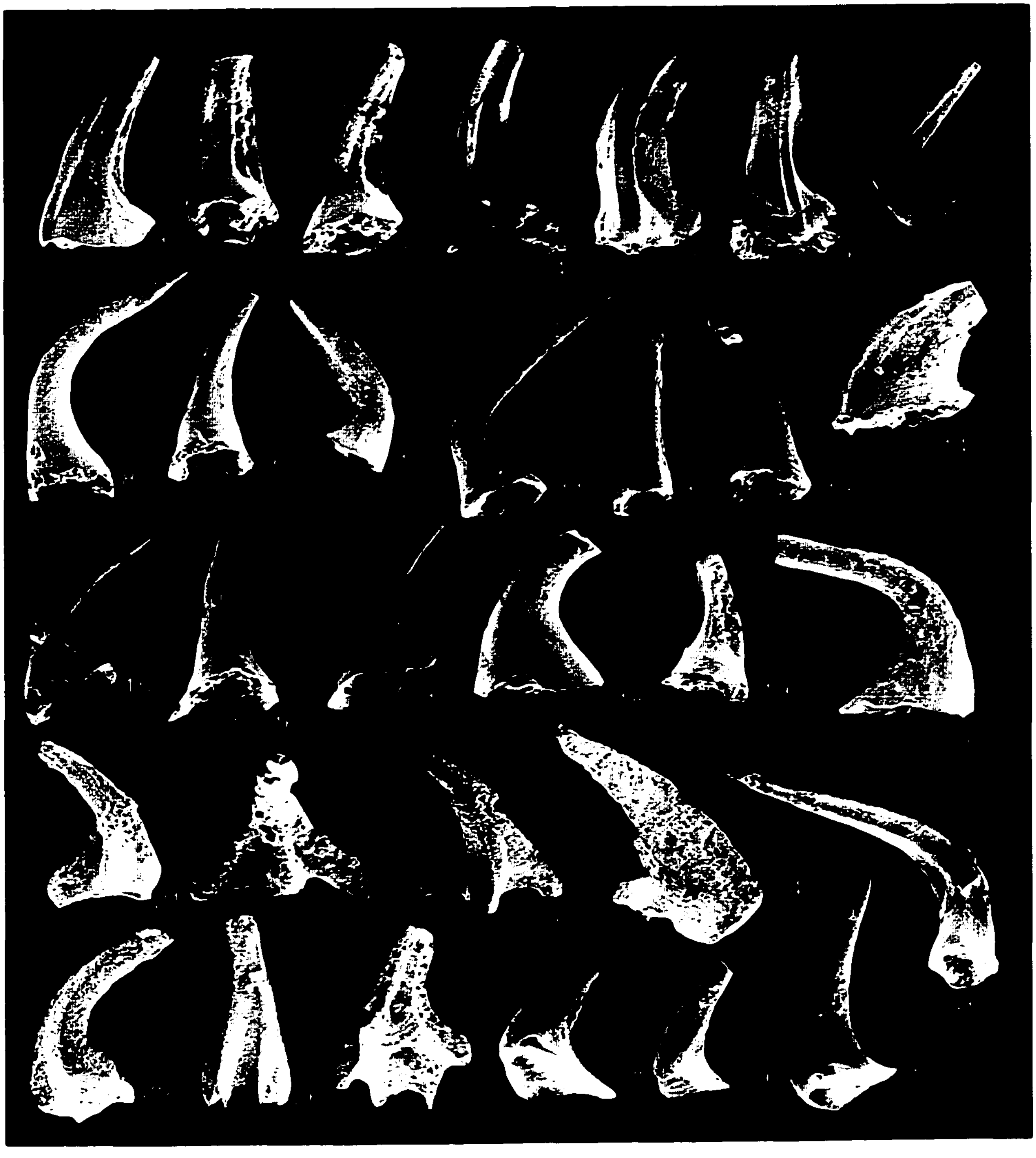

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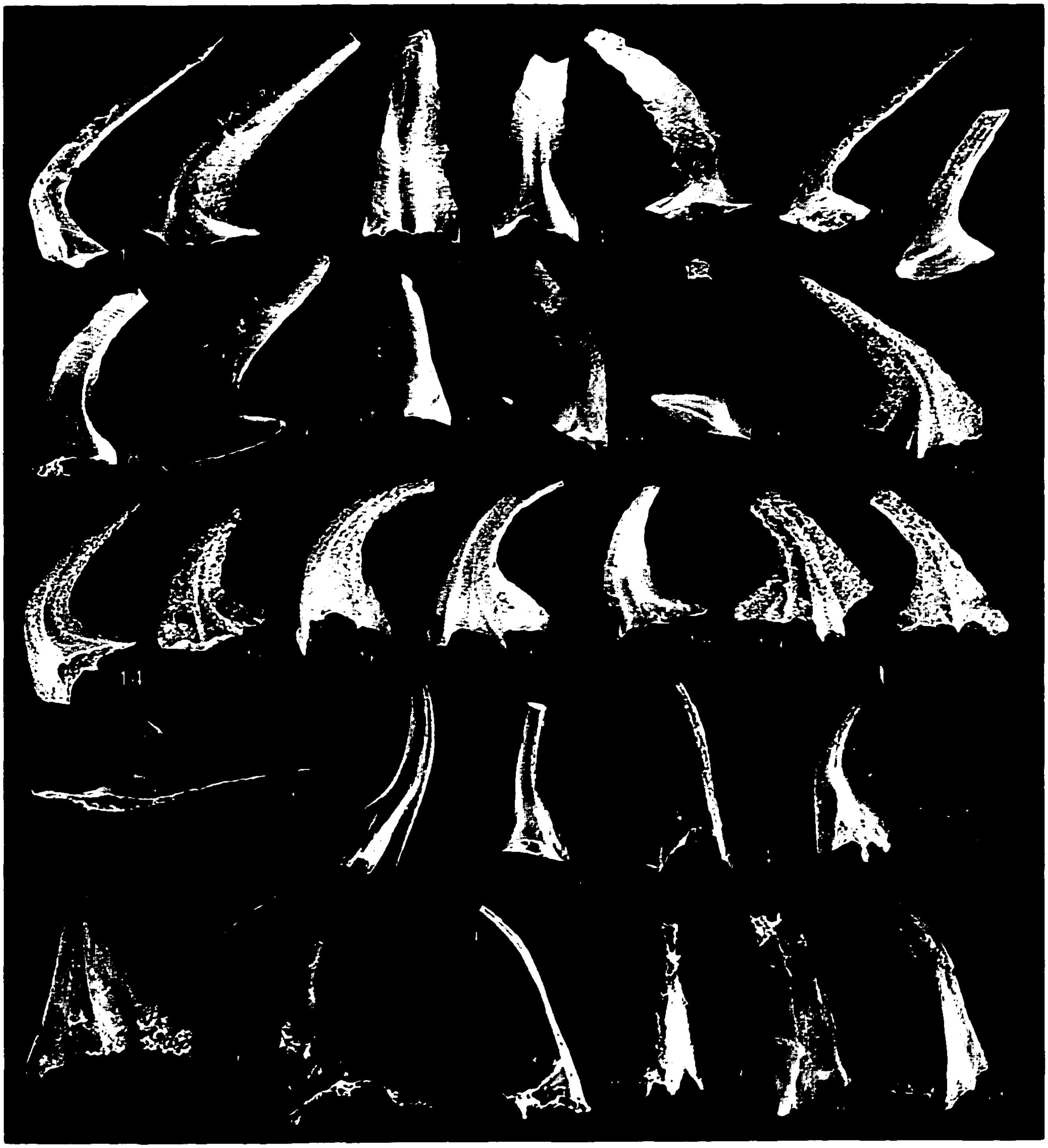

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Figures 3-5. Coniform Indet. H

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Figures 6-8. *Scolopodus subrex* Ji and Barnes (early form)

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9. e element, inner lateral view, 96-13-B14, GSC 119287, x 44
10. a element, inner lateral view, 96-13-B14, GSC 119288, x 44
11. b element, inner lateral view, 96-13-B14, GSC 119289, x 44

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18. c element, posterior view, 96-13-B17, GSC 119296, x 48
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21. e element, inner lateral view, 96-13-B16, GSC 119299, x 70
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5. Sd element, inner lateral view, 96-4-K4, GSC 119311, x 48
6. Sb element, inner lateral view, 96-4-K4, GSC 119312, x 48

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7. Sd element, inner lateral view, 96-13-B23, GSC 119313, x 60
8. Sb element, inner lateral view, 96-13-B23, GSC 119314, x 60
9. P element, inner lateral view, 96-13-B23, GSC 119315, x 60
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11. e element, inner lateral view, 96-4-K4, GSC 119317, x 46
12. b element, inner lateral view, 96-4-K4, GSC 119318, x 46
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15. Sa element, posterior view, 96-13-B25, GSC 119321, x 70
16. M element, inner lateral view, 96-13-B25, GSC 119322, x 70
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Figures 18-25. *Graciloconus concinnus* n. gen., n. sp.

18. Sc element, inner lateral view, GP-94-4-3, **paratype**, GSC 119324, x 77
19. Sa element, inner lateral view, GP-94-4-3, **paratype**, GSC 119325, x 77
20. Sb element, inner lateral view, GP-94-4-3, **paratype**, GSC 119326, x 77
21. P element, inner lateral view, GP-94-4-3, **paratype**, GSC 119327, x 77
22. ?Sd element, inner lateral view, GP-94-4-3, **holotype**, GSC 119328, x 77

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27. S element, 96-5-K1, **paratype**, GSC 119333, x 39
28. P element, 96-5-K1, **paratype**, GSC 119334, x 39

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6. S element, inner lateral view, 96-13-B24, **paratype**, GSC 119340, x 62
7. S element, inner lateral view, 96-13-B24, **paratype**, GSC 119341, x 62
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10. Pa element, oral view, 96-13-B24, **paratype**, GSC 119344, x 120
11. S element, posterior view, 96-13-B24, **paratype**, GSC 119345, x 60
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18. S element, inner lateral view, 96-13-B26, **paratype**, GSC 119352, x 44
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3. S element, antero-lateral view, 96-13-B25, **paratype,** GSC 119358, x 70
4. S element, inner lateral view, 96-13-B25, **paratype,** GSC 119359, x 145
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6, 7. S elements, inner lateral views, 96-13-B25, **paratype,** GSC 119361, x 50
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21. S element, inner lateral view, 96-4-K4, **paratype,** GSC 119375, x 50
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18. e element, inner lateral view, 96-13-B27, GSC 119395, x 35

19, 20. a elements, inner lateral views, 96-13-B27, GSC 119396, 119397, x 35, x 45

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32. a element, inner lateral view, GP-94-4-5, GSC 119409, x 67
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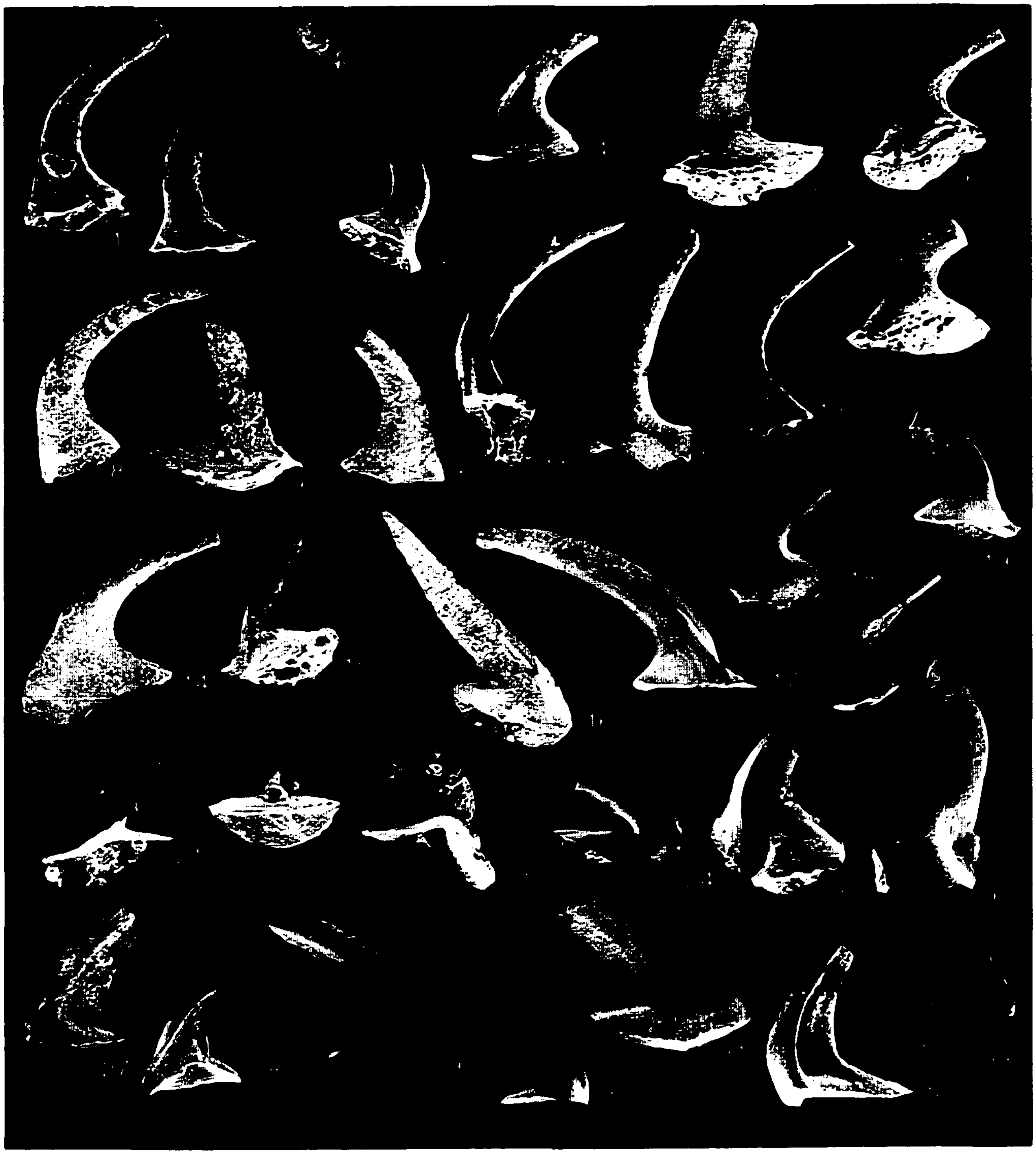

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1. e element, inner lateral view, GP-94-1-20, GSC 119411, x 35
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4. e element, inner lateral view, GP-94-1-20, GSC 119414, x 32
5. c element, inner lateral view, GP-94-1-20, GSC 119415, x 32
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7. e element, inner lateral view, GP-94-1-20, GSC 119417, x 27
8. c element, inner lateral view, GP-94-1-20, GSC 119418, x 32
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10. e element, inner lateral view, 96-4-3, GSC 119420, x 50
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14. Sc element, inner lateral view, GP-94-1-20, GSC 119424, x 50
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18. P element, inner lateral view, GP-94-1-19, GSC 119428, x 65
19. S element, inner lateral view, GP-94-1-19, GSC 119429, x 65
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23. M element, inner lateral view, GP-94-1-20, GSC 119433, x 42
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26. P element, inner lateral view, GP-94-1-23, GSC 119436, x 60
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2. Sa element, posterior view, 96-4-3, GSC 119439, x 56
3. Sb element, inner lateral view, 96-4-3, GSC 119440, x 60
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8. Sc element, inner lateral view, 96-4-3, **paratype**, GSC 119445, x 42
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19. M element, inner lateral view, 96-4-3, GSC 119456, x 35
20. P element, inner lateral view, 96-4-3, GSC 119457, x 35
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25. S element, inner lateral view, 96-4-3, GSC 119462, x 50
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2. P element, inner lateral view, GP-94-1-16, GSC 119466, x 62
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5. P element, inner lateral view, GP-94-1-20, GSC 119469, x 42
6. S element, inner lateral view, GP-94-1-20, GSC 119470, x 42

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8, 9. a elements, inner lateral views, GP-94-1-20, GSC 119472, 119473, x 21
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Figures 15-16. *Protopanderodus cooperi* (Sweet and Bergström)
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20. M element, inner lateral view, 96-4-6, GSC 119484 x 30
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5. P element, inner lateral view, 96-5-16, GSC 119498, x 77
6. P element, inner lateral view, 96-5-16, GSC 119499, x 77

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10. P element, antero-lateral view, 96-13-B34, GSC 119503, x 61
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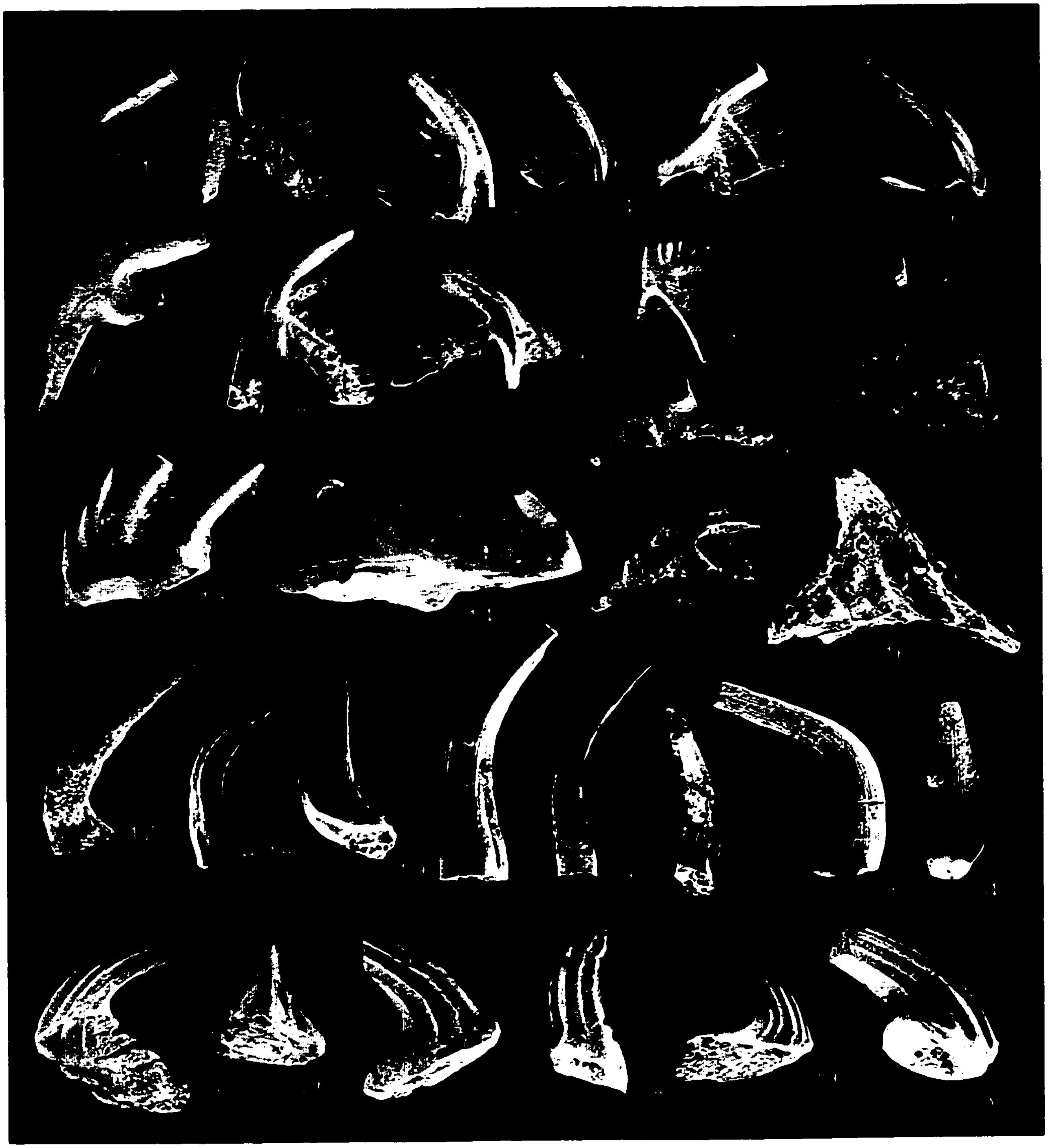
29. a element, inner lateral view, 96-5-7, **holotype**, GSC 119522, x 28
30. e element, inner lateral view, 96-5-7, **paratype**, GSC 119523, x 28



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Figures 1-5. *Oistodus multicorrugatus* Harris
1, 4. S elements, inner lateral view, 96-5-16A, GSC 119524, 119525, x 28
2. P element, inner lateral view, 96-5-16A, GSC 119526, x 28
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15. M element, inner lateral view, 96-13-B34, GSC 119538, x 25
16. Pb element, inner lateral view, 96-13-B34, GSC 119539, x 25
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18. Sc element, juvenile, postero-lateral view, 96-13-B34, GSC 119541, x 70
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Figures 20-22. *Microzarkodina* n. sp.
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23. e element, inner lateral view, 96-5-6, GSC 119546, x 54
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Figures. 27-28. Coniform Indet. J
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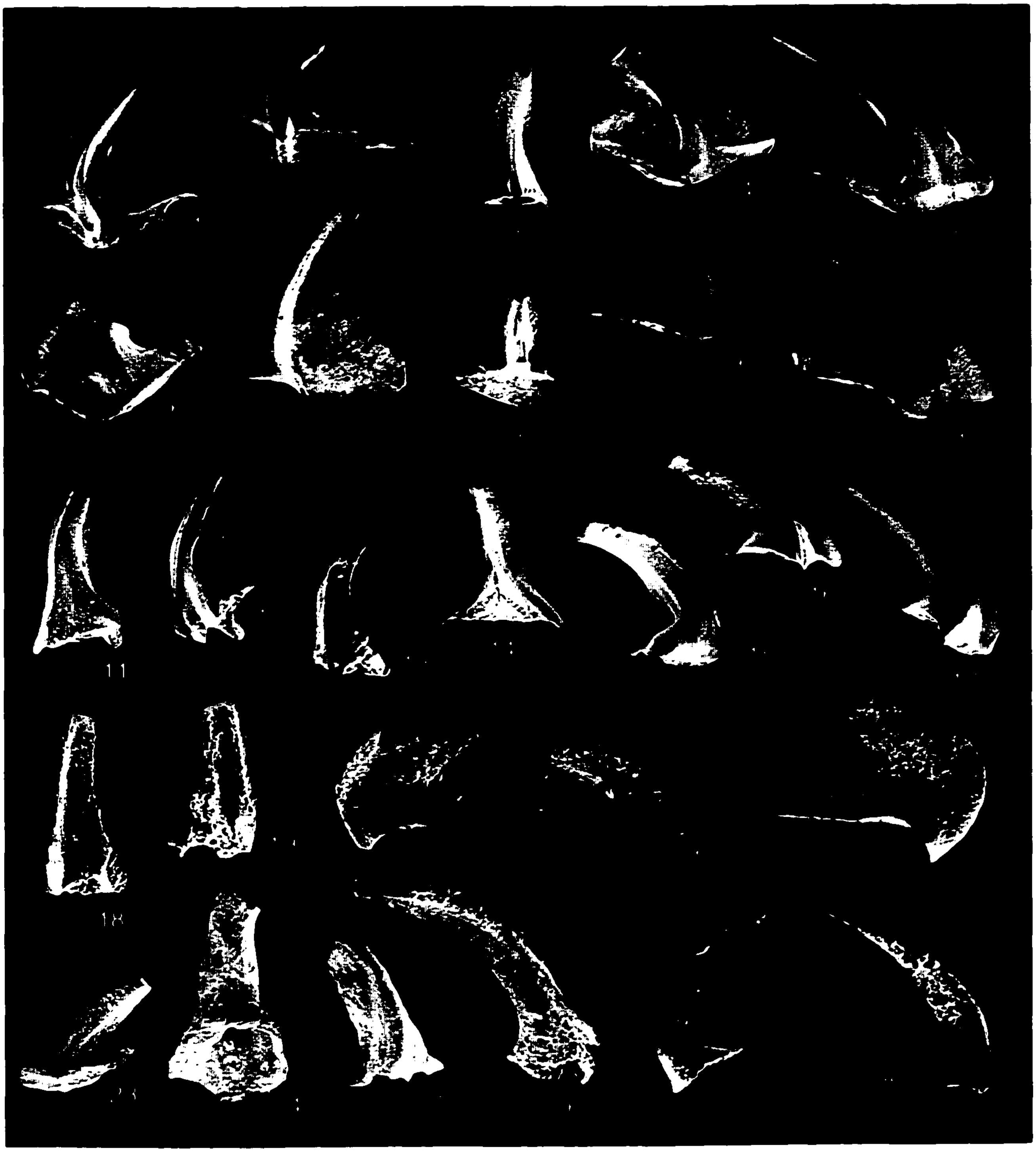
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Figures 1-4. *Juanognathus variabilis* Serpagli
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2. c element, posterior view, 96-5-16, GSC 119553, x 50
3. b element, inner lateral view, 96-5-16, GSC 119554, x 50
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Figures 5-8. *Juanognathus jaanussoni* Serpagli
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Figures 9-10. *Pariostodus* n. sp.
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Figure 11. Coniform Indet. K
11. inner lateral view, 96-13-B33, GSC 119562, x 67

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22. c element, inner lateral view, 96-13-B33, GSC 119573, x 62

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26. e element, inner lateral view, 96-5-16A, GSC 119577, x 28
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Figure 29-31. *Drepanoistodus* n. sp. E
29. a element, inner lateral view, 96-5-16, GSC 119580 x 46
30-31. e elements, inner lateral view, 96-5-16, GSC 119581, 119582 x 46

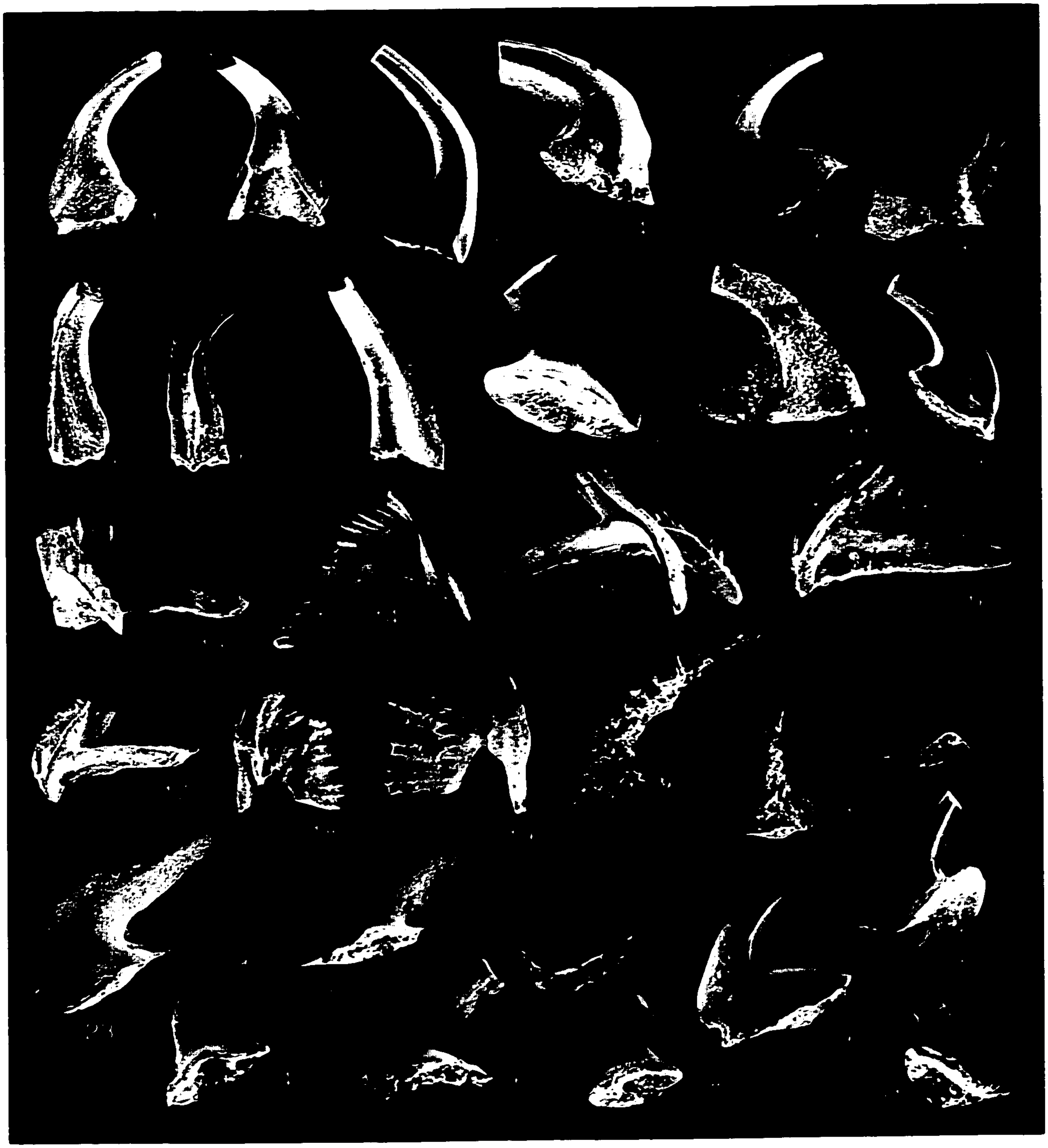

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Figure 1. *Tripodus laevis* Bradshaw

1. Sd element, inner lateral view, 96-5-16A, GSC 119583, x 42

Figures 2-3 *Pteracontiodus cryptodens* (Mound)

2. Sd element, inner lateral view, 96-5-18, GSC 119584, x 28
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Figures 4-7. New Genus C n. sp.

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8. a element, inner lateral view, 96-5-15A, **holotype**, GSC 119590, x 50
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12. a element, inner lateral view, 96-5-16, **paratype**, GSC 119594, x 53
13. c element, inner lateral view, 96-5-16A, **paratype**, GSC 119595, x 50
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19. Sa element, posterior view, 96-5-18, GSC 119601 x 80

Figures 20-22. Coniform Indet. M

20. a element, inner lateral view, 96-5-17, GSC 119602, x 80
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26. c element, posterior view, 96-5-18, GSC 119608, x 60
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Figures 28-30. Coniform Indet. O

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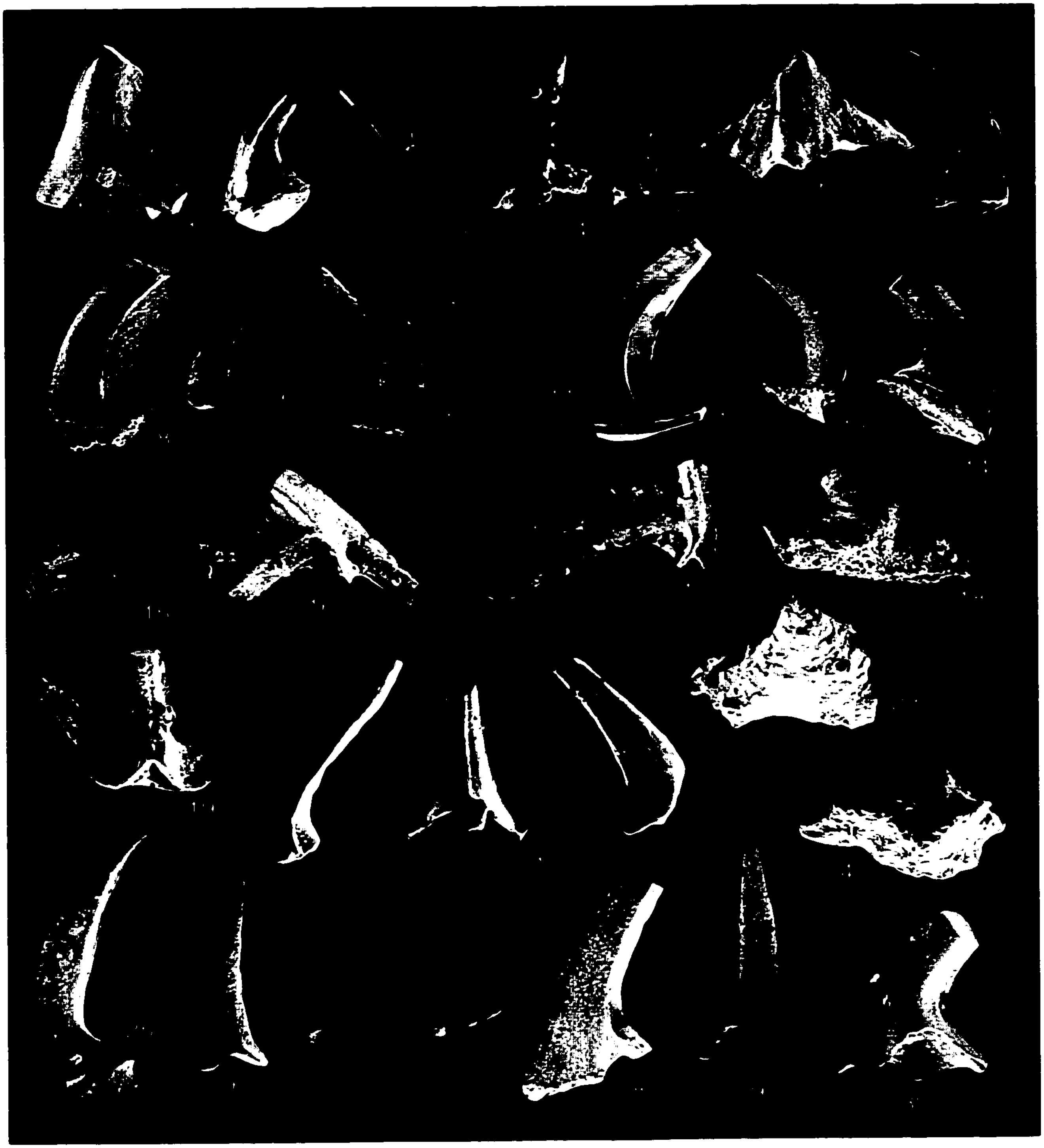
29. c element, posterior view, 96-5-18, GSC 119611, x 60
30. b element, inner lateral view, 96-5-18, GSC 119612, x 60



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Figures 1-3. *Ansella longicuspica* Zhang
1. S element, inner lateral view, 96-5-17, GSC 119613, x 77
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4. Pa element, inner lateral view, 96-5-15A, GSC 119616, x 77
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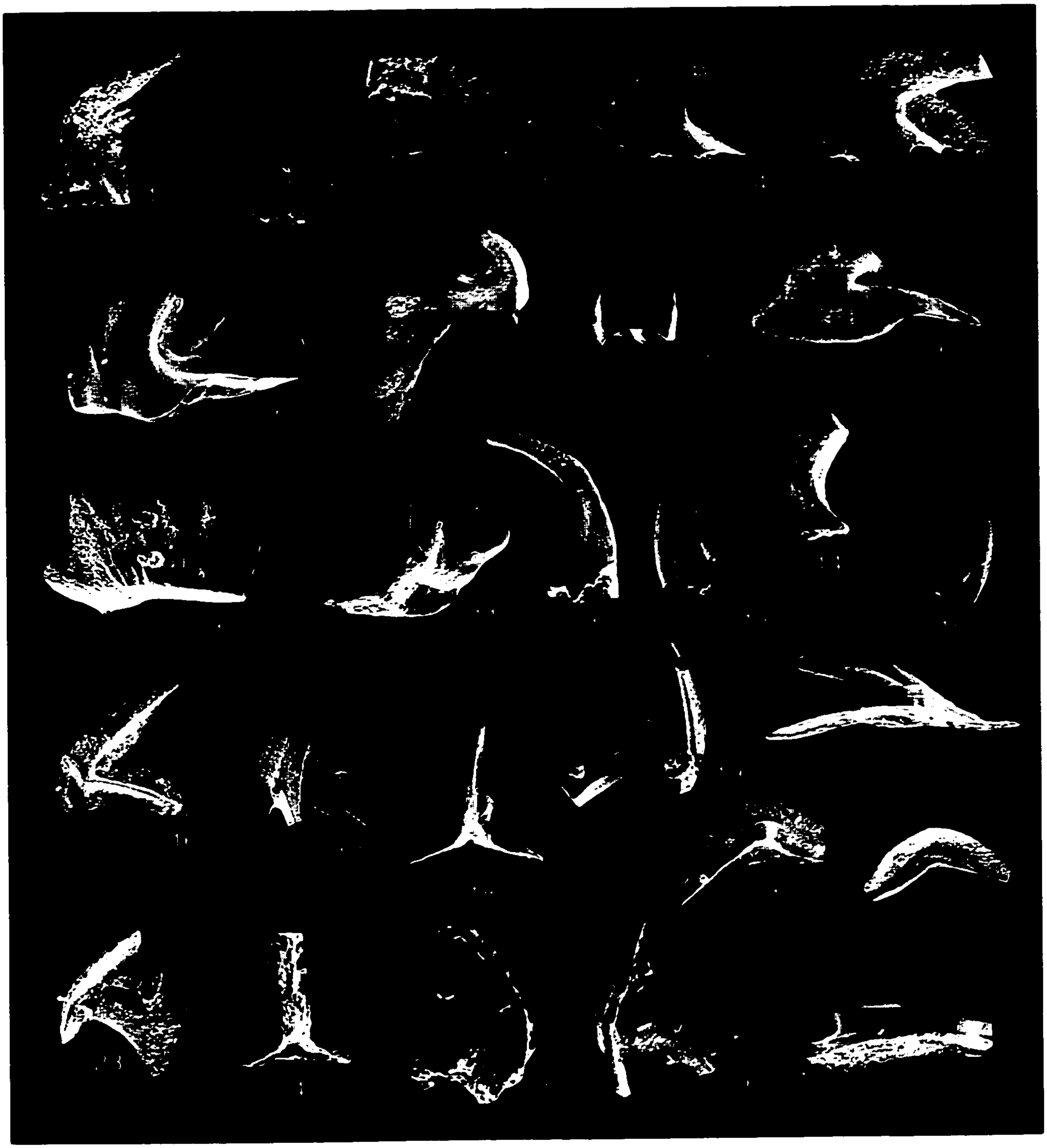
26. S element, inner lateral view, 96-5-15A, GSC 119638, x 56
27. P element, inner lateral view, 96-5-15A, GSC 119639, x 56



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Figures 1-2. *Rossodus manitouensis* Ethington and Clark
1. a element, postero-lateral view, DL-96-7, GSC 119640, x 50
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5. a element, inner lateral view, DL-96-7, **paratype**, GSC 119644, x 63

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6. a element, inner lateral view, DL-96-7, GSC 119645, x 88

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22. e element, inner lateral view, DL-96-3, GSC 119661, x 100

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Figure 26. *Striatodontus prolificus* Ji and Barnes
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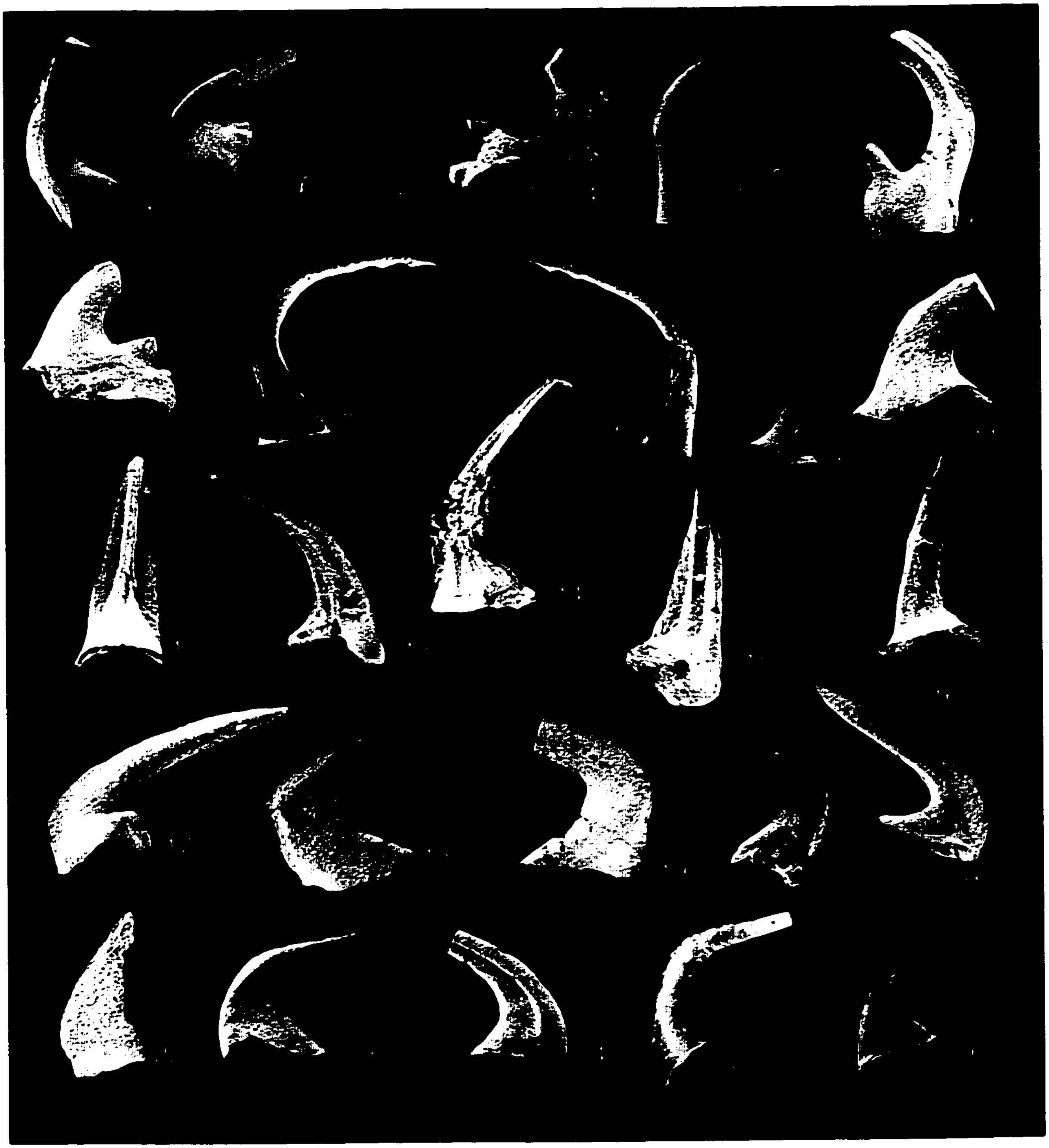

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Figure 1. ***Paroistodus proteus* (Lindström)**
1. S element, inner lateral view, DL-96-13, GSC 119666, x 39

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Figures 6-7. ***Protopanderodus liripipus* Kennedy, Barnes and Uyeno**
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16. Pb element, inner lateral view, DL-96-29, GSC 119681, x 88
17. Sc element, inner lateral view, DL-96-29, GSC 119682, x 50
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19. Pa element, inner lateral view, DL-96-29, GSC 119684, x 63
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APPENDIX A

The lithologies of twelve sections within the study area are described. The sample numbers of the conodont samples are placed in stratigraphic order, and their heights in metres above the base of the section are given. The sample numbers are not always in consecutive order due to methods in which ridge sections were measured and sampled in segments.

Section #1 (of Cecile and Norford, 1979)

Section is located 5km north of Muskwa River (94F/16; 57° 52'N, 124° 05'W). Camped in a cirque south of the east-west trending ridge measured and collected. The first unit of Kechika collected was an outcrop on the east ridge. Walked down a steep edge to examine the Cambrian unit and base of the Kechika.

Sample number	Description	Thickness (m) Sample	Total from Base
	Cambrian Unit		
	Quartzite, white to light grey, massive bedded, well rounded and sorted quartz grains, cross bedding prominent, sandy dolomite interbeds.		
	Quartzite and siltstone, grey, weathers brown.	8	8
	Kechika Formation		
	Comprises four distinct units within section which have gradational contacts.		
	Lloyd George Member	62	70
	Dolostone, silty with sandy laminae, light grey, weathers orange.		
	Quentin Member		
	Calcilutite, 70-80% of the lower part of the unit is light grey, weathers grey-yellow, thin bedded, infaunal indicators such as inarticulate brachiopods and Bathyurid trilobite. Other facies are dolomitic calcirudites with intraformational laminated clasts 4-8cm up to 10cm, flat and platy within trilobitic grainstones and calcirudites, some with lag surfaces of phosphate and borings, weathers orange, medium bedding. The upper part of the unit is more dolomitic and weathers orange, pale yellow-grey shale partings and interbeds throughout.		
96-1-1	CALCIRUDITE, intraclasts, medium grey, weathers darker grey than cleaved calcilutite interbeds, 6cm thick, medium crystalline, disseminated pyrite.	7.5	77.5
96-1-2	As –1; macrofossils are spar filled, upper bed 10cm thick atop another 10cm bed.	6	83.5
	Cleaved calcilutite interval.		
96-1-3	GRAINSTONE, weathers light orange, less intraclasts, 3cm bed, trilobite genal spines up to 10cm.	5	88.5
	Intraclastic bed weathers darker grey, lutites and cross-laminated dolomitic siltstones, weather brown to orange, thin to medium bedded.	0.5	89
	Abundant traces on bottom of bedding plane.	4	93

Cleaved calcareous shale interval and competent, silty lutites with traces and scours.		5	99
96-1-4	CALCIRUDITE, intraclastic, light grey, weathers light grey and orange, 0-5cm thick among shale, medium crystalline. shale interbedded with lutite.	1	100
96-1-5	GRAINSTONE- CALCIRUDITE, light grey, weathers light grey and orange, 5cm thick bed among competent shales and lutites, medium crystalline, slightly dolomitic.	9	109
Lutite, silty, light grey.		6	115
Covered interval of orange, dolomitic siltstone talus on north ridge. abundant traces.		10	125

Grey Peak Member

Abundant trace fossils in orange, silty dolostone alternating with limy intervals of shale, lutites, calcirudites which creates banding.

96-1-6	PACKSTONE-GRAINSTONE, medium grey, weathers dark grey and orange.	7.5	132.5
96-1-7	LIME MUDSTONE-CALCAREOUS SHALE, medium grey, weathers buff, argillaceous partings, limestone interbeds cleaved within shale.	16.5	149
Shale interval, weathers light grey.			
96-1-8	PACKSTONE, medium grey, weathers light grey, 1cm bed, platy, burrow mottled, horizontal burrows weather yellow. compact.	10	159
Interval of light grey, cleaved thin bedded shales-lutites and thin bedded silty beds, weather buff and grey.			
96-1-9	PACKSTONE-GRAINSTONE, medium grey, weathers buff-grey. 6cm compact bed.	9	168
Calcirudite interbedded with silty, argillaceous lime mudstone with abundant traces. Banded unit of grey and orange buff-brown beds alternating in packages.			
96-1-10	CALCIRUDITE, intraclastic, medium grey, weathers medium grey. medium crystalline.	15	183
Grey interval of slabby-platy intraclastic beds; less traces.			
96-1-11	WACKESTONE, medium grey, weathers light grey-buff, 10cm thick.	10	193
Intraclastic beds and hackly weathered beds, 1-2m scale of siltstones, weather darker buff-orange, less traces.			
96-1-12	WACKESTONE, medium grey, weathers grey-buff, compact 2cm	10.5	203.5

bed, uniform, silty.

Calcirudite alternating with meter scale units of intraclastic beds weathers rough; above interval of dark orange, silty dolostone with some traces.

96-1-13	CALCIRUDITE, compact, light grey, weathers light grey, platy.	13	216.5
Covered interval.		17	233.5

Mt. Sheffield Member

Largely grey weathered limestone intervals and grey to buff-orange dolostone intervals.

Grey and buff dolomitic beds.		3	236.5
96-1-14	PACKSTONE-WACKESTONE, light grey, dolomitic, thin bed, platy, burrow mottled.	1	237.5
Buff and orange dolostone interval.			
96-1-15	PACKSTONE, light grey, weathers light grey, thin bedded, platy.	9	246.5
Burrow mottled, cross laminated dolostone, weathers sandy brown.			
96-1-16	LIME MUDSTONE, medium grey, weathers buff-grey, argillaceous partings.	10.5	257
96-1-17	CALCISILTITE, medium grey, weathers with light grey-pale yellow, 2-3cm interval, burrow mottled, cross laminated, platy.	9	266
96-1-18	As –17.	10.5	276.5
Grey interval, burrow mottled.		36	312.5
Chert nodules and interbedded chert, black, in upper 30m of subunit; subtidal-intertidal, horizontal laminated silty dolostone, weathers sandy grey-brown, some beds comprise shell hash, medium to thick bedded (5-20cm), less traces, some burrow mottling.		54	396.5
Increased burrow mottling, medium to thick beds, laminated, dolomitic siltstone, and grey dolostone, weathers smooth, creamy grey-buff, with lighter colored clasts (buff) and black chert interval (0.5m).		16	412.5
Platy dolostone, weather darker grey and chert nodules, black.		2	414.5
96-1-19	CALCISILTITE, medium grey, weathers light grey finely laminated.	6	420.5
Buff-sandy beige dolostone overlain by light grey interval.			
96-1-20	WACKESTONE, medium grey, weathers light grey, compact, medium bed.	4.5	424.5
96-1-21	WACKESTONE, medium grey, weathers light grey, 2cm bed, rubbly.	7.5	432

Dolostone, grey, up to a zone of mineralization (pyritic)		9	441
96-1-22	PACKSTONE, medium grey, weathers light grey, 1cm bed, medium crystalline, gastropods on bedding surface, pyritic.	0	441
Thin beds, weather grey.			

Skoki Formation

96-1-23	WACKESTONE, medium grey, weathers buff, 6cm bed above thinner bedded ones.	10.5	451.5
To top of snow covered ridge.		29.5	481

Beaverfoot Formation

Although partially snow covered, the top of the ridge comprises dolostone, medium grey, weathers light grey-buff, massive bedded with some platy interbeds, laminated.

Section #5 (of Cecile and Norford, 1979)

Section is located 12km southwest of where the Prophet River bifurcates (94F/8; 57° 30'N, 124° 26'W). Camped in cirque, walked down to gully of Kechika and measured and collected the Skoki in creek beds toward camp and up the ridge behind camp.

Sample number	Description	Thickness (m) Sample	Total from Base

Kechika Formation, Uppermost Unit

The unit is largely light grey shale with few lenticular intervals of medium grey wackestone, weathers buff-orange and grey, thin bedded, disappears into the gully at tree line. Collected in cliff east of camp.

Sample number	Description	Sample	Total from Base
96-5-K1	WACKESTONE, medium grey, lenses up to 2cm thick, medium crystalline.	0	0
Contact with Skoki.		6	6

Skoki Formation

Comprises distinct units with gradational contacts, largely dolomitic limestone and shale, massive bedded. Moved from east cliff down to easternmost creek to begin measuring and collecting.

Sikanni Chief Member

Lowermost subunit of dolomitic shale, weathers orange, massive bedded, and dolostone-limestone lenses, 1cm long, weather dark grey among massive bedded shale, argillaceous partings within limestone.

Sample number	Description	Sample	Total from Base
96-5-1	WACKESTONE, medium grey, weathers dark grey, 0-10cm thick lenses, medium crystalline, dolomitic.	1	7
96-5-2	As -1; weathers orange.	20	27
96-5-3	WACKESTONE, medium grey, weathers light buff to grey, 1cm lenses, medium crystalline, dense.	17	44
More lenticular limestone in this interval within dolomitic shale.			
96-5-4	WACKESTONE, medium grey, weathers dark grey, 7mm-10mm lenses, medium crystalline.	24	68
Horizontal spar in interbeds.			
96-5-5	LIME MUDSTONE, weathers orange and dark grey, 5mm lenses.	16	84
96-5-6	WACKESTONE, medium grey, weathers buff, lenses up to 2cm thick, medium crystalline, argillaceous partings.	30	114
Dolostone, weathers dark grey and orange-yellow, mottled, spar interbeds, massive bedded.		15	129

96-5-7	WACKESTONE, medium grey, mottled, medium crystalline.	15	144
96-5-8	LIME MUDSTONE, medium grey, weathers buff, fine crystalline, argillaceous partings.	50	194
Subunit 2 is predominantly grey weathered and more calcareous, burrow mottled.			
96-5-9	LIME MUDSTONE–WACKESTONE, medium grey, weathers buff and light grey, mottled.	15	219
Covered interval; Fault in east bank, covered on west bank, overlain by massive dolomite.		20	239
96-5-10	WACKESTONE, medium grey, weathers light grey, massive bedded, medium crystalline.	7	246
Interval of dolostone, weathers light grey.			
96-5-11	WACKESTONE – PACKSTONE, light grey, weathers light grey, massive bedded, medium crystalline, argillaceous.	21.5	267.5
96-5-12	PACKSTONE, medium grey, weathers light grey.	11.5	279
Carried on up the creek to the base of first major cliff/waterfall.			
96-5-13	PACKSTONE, medium grey, weathers light grey and yellow, massive bedded.	14.5	293.5
96-5-14	As –13.	5	298.5
Dolostone, massive, weathers grey.		7	305.5
Covered interval.		7	312.5
Dolostone, 1m thick beds, weather blue-grey.		25.5	338
Subunit 3 comprises massive dolostone, weathers orange and grey, more carbonate, medium beds have hackly fracture, weather medium grey.			
96-5-15	WACKESTONE, light grey, weathers light grey and hackly, thick bedded, medium crystalline.	1	339
Fossiliferous zone of dolomitic limestone, medium grey, thick to massive bedded, medium crystalline.			
96-5-15A	PACKSTONE, dark grey, weathers light grey and hackly, massive bedded, some chert nodules, fossiliferous.	4.5	343.5
Fossiliferous zone of dolomitic limestone, medium grey, weathers light grey-yellow and hackly, macluritid gastropods prominent.			
96-5-16	PACKSTONE, medium grey, weathers light grey and yellow, hackly, macluritid gastropods.	4.5	348

96-5-16A	AS—5-16	5	353
Dolostone, medium grey, weathers light grey and rubbly, thick to massive bedded, north of camp toward ridge, 4.5m thick.		20	373
Covered interval.		54	427
Dolostone, blue-grey, thick of massive bedded, medium crystalline, base of first cliff outcrop.		15	442
Covered interval.		6	448
Keily Member Burrow mottled unit of dolostone, dark grey, weathers light grey, increasing yellow dolostone and less packstone upsection. Unit is rich in traces and bioclasts.		6	454
Dolostone, burrow-mottled, fossiliferous.		42	496
96-5-17	PACKSTONE, dark grey, weathers yellow and light grey, burrow mottled, massive, argillaceous partings, partly dolomitized, 1-5cm chert nodules.	94.5	590.5
96-5-18	PACKSTONE, dark grey, weathers yellow and light grey, burrow mottled.	12	602.5
96-5-19	WACKESTONE, dark grey, weathers light grey, burrow mottled, thick to massive beds, irregular shale partings, dolomitized in joints.	33	635.5
Dolostone, weathers light grey, rich in gastropods.		35.5	671
Gastropod subunit, doloarenite, weathers lighter grey, cross- laminated, trough cross-bedding, ooids and local brecciation.		40.5	711.5
Top of doloarenite unit. Overlain by dolostone subunit, light grey, weathers orange–grey, platy.		15	726.5
Dolomitic muds, light grey, pale yellow-grey, massive beds, fine regular laminae and rip up clasts, shallow subtidal, forms middle cliff of the mountain.		46.5	773
Subunit of dolostone, dark grey and massive.		21.5	794.5
Redfern Member Banded unit comprising massive dolostone, weathers dark grey and alternates with light grey-yellow beds.		108	902.5
Next cliff of dolostone, weathers dark grey.		60	962.5
Doloarenite, dark grey, weathers black, laminated with cross-bedding, overlies dolostone, weathers light grey.		30	992.5
Dolostone, weathers yellow-light grey, laminated.		87	1079.5
Upper light grey to buff unit of dolostone.		40.5	1119.5

Section #13 (of Cecile and Norford, 1979)

Section is located 4km southwest of Mount Sheffield, trending east-west toward 2 glacial lakes to the west (94F/10; 57° 42'N, 124° 35'W). Camp was located on a grassy area along creek running east from the glacial lakes. Section was collected in 3 parts, A, B and C.

Sample number	Description	Thickness (m) Sample	Total from Base
	Kechika Formation		
	Walked east along north side of the creek about 2km and then north along tree line to collect the basal parts of the Kechika. Contact with underlying Cambrian units was not observed. Started to collect at lowest main outcrop on north side of main gully.		
	Lloyd George Member Highly cleaved shale with rare limestone interbeds, generally boudinaged.		
96-13-C1	LIME MUDSTONE, medium to dark grey, weathers grey brown, fine crystalline, slightly folded, compact, within highly cleaved shale.	0	0
	Passed over compact, finely laminated, calcareous shale with very thin 0.3-1cm beds of limestone, partly talus covered.		
96-13-C2	LIME MUDSTONE–WACKESTONE, dark grey, 10-15cm thick, internal fine lamination., fine crystalline, compact silty beds (calcisiltite).	10.5	10.5
96-13-C3	LIME MUDSTONE–WACKESTONE, dark grey to black, weathers dark grey finely laminated, fine crystalline, compact, (calcisiltite).	31.5	42
96-13-C4	LIME MUDSTONE–WACKESTONE, dark grey to black, weathers dark grey, compact thin to medium bed, fine crystalline, (calcisiltite); less calcareous than early samples.	31.5	73.5
	Passed one similar medium bedded, compact black limestone beds, slightly recessive subunit in cliff north of creek, entered a more resistant unit of finely laminated, silty/argillaceous black limestone.	3.5	77
	Prominent buff-orange weathered fine dolostone bed, more structural flexure in creek bed.	1	78
	Quentin Member Base of "putty shale" unit; entered second cliff forming unit below top of cliff, light grey brown weathered massive unit, phyllitic grey brown to silver shale with interbeds (sparse) of 5-10cm compact limestone, often partly boudinaged.	12	90

96-13-C5	LIME MUDSTONE, dark grey, 5cm bed, fine crystalline, compact, partly boudinaged.	13.5	103.5
96-13-C6	LIME MUDSTONE–WACKESTONE, medium grey, weathers buff, 4cm bed, nodular, dense and compact.	22.5	126

Interval of buff, putty grey shale.

96-13-C7	PACKSTONE, medium grey, 3cm, finely laminated, dense and compact.	162	288
96-13-C8	LIME MUDSTONE–PACKSTONE, medium grey, 10cm interval, 2-4cm beds, laminated, grading into wackestone-packstone in cores.	31.5	319.5
96-13-C9	As –C8: but more homogenous packstone, dense lens.	18	337.5

Passed through interval of phyllitic putty grey shales which abruptly changed into orange weathered 1cm bedded limestone, laminated, dense forming upper waterfall.

96-13-C10	LIME MUDSTONE, weathers orange, 2 1cm beds.	64.5	402
96-13-C11	WACKESTONE–PACKSTONE, light grey, weathers orange, nodular.	31.5	433.5

Interval of phyllitic shale and light grey limestone packages.

96-13-C12	WACKESTONE–PACKSTONE, medium grey, 4cm interval.	27	460.5

Section A: Walked from camp down creek to tree line where Kechika was no longer prominent and made up south grassy and bush covered hill and the creek. Collected south side up creek and hill and noted slump breccias and folding in blocks of creek bed. Argillaceous, dolomitic to brown weathered beds and light grey weathered beds 1-2cm. Started collecting samples prefixed 96-13A where the creek takes a bend southward.

Quentin Member

Unit homogenous, undulatory, thin bedding of laminated calcilutites, siltites and 5% grey weathered, interstratified, argillaceous, silty and laminated, limestone comprising the beds collected.

96-13-A1	WACKESTONE, medium grey, weathers buff and light grey, dense 5cm bed, finely laminated, silty.	0	0
96-13-A2	WACKESTONE, medium grey, weathers buff and light grey, 10-15cm thick, medium crystalline.	27	27
96-13-A3	WACKESTONE, medium grey, 0-3cm medium crystalline, among thin beds of calcistiltite, undulating beds.	21	48
96-13-A4	WACKESTONE, medium grey, weathers buff to light grey, 4cm bed.	27	75

96-13-A5	WACKESTONE, light grey, weathers light grey, 2cm bed, laminated.	24	99
96-13-A6	PACKSTONE–GRAINSTONE, medium grey, 3cm bed, coarse crystalline.	21	120
96-13-A7	WACKESTONE–PACKSTONE, medium grey, weathers light grey, 3cm bed, medium crystalline.	34.5	154.5
96-13-A8	WACKESTONE, medium grey, weathers light grey, 2cm bed, medium crystalline.	27	181.5
96-13-A9	PACKSTONE, light to medium grey, weathers light grey, 2cm bed, thin bedded, cleaved and laminated.	27	208.5
Covered interval.		45	253.5

Walked up to exposure on north side of camp, collected –A10 1m above base. It is a mid-slope bluff on line with waterfall below camp and grassy knoll from which covered interval was recorded, on line with convergence of 2 creeks, last bit of outcrop before fault. Estimate 10m missing from base.

96-13-A10	WACKESTONE, medium grey, weathers light grey and buff, thin bedded interval up to 4cm thick beds, finely laminated.	11	264.5
96-13-A11	As –A10: light grey, 3 compact thin beds, 3cm each.	21	285.5
96-13-A12	PACKSTONE, medium grey, weathers buff, laminated.	20	305.5
96-13-A13	As –A10.	19.5	325

Covered interval to level of glacier south of main creek.

Grey Peak Member

Collected in east wall of creek bed trending N-S toward camp. Unit is made of alternating meter scale packages of resistant limestone, and recessive shale, in equal proportion, medium grey thin to medium beds, no longer laminated or silty.

96-13-A14	PACKSTONE, medium grey, weathers light grey and buff, 2cm thick.	105	430
96-13-A15	PACKSTONE, medium grey, weathers light grey, compact 4cm interval.	21	451
96-13-A16	GRAINSTONE, medium grey, weathers light grey, 1m thick series of beds with shale partings, trilobites.	20	471

Top of creek outcrop, after this is the grassy valley in which we are camped with no exposure, likely the fault zone.

96-13-A17	WACKESTONE–PACKSTONE, medium grey, weathers light grey, 4cm bed, pseudonodular, resistant, buff, argillaceous, dolostone partings, cleaved, trilobites and intraclasts.	20	491

Covered interval from camp to the south side of creek fed by glacial lakes the west.		185	676

Section B continues with the Grey Peak Member west of camp (likely repeated after the fault zone). Shale weathers buff to light grey with thin, competent interbeds of limestone up to 10cm.

96-13-B1	PACKSTONE–GRAINSTONE, weathers buff to light grey, (intraclasts?).	3	679
Interval of shale and laminated calcilutite, thin intraclastic beds and more calcareous packstone.			
96-13-B2	PACKSTONE, medium grey, weathers buff to light grey, medium crystalline.	37	716
96-13-B3	PACKSTONE–GRAINSTONE, medium grey, weathers buff-grey, up to 30cm thick, intraclastic-trilobitic.	20	736
96-13-B4	PACKSTONE, medium grey, weathers light grey-buff, 10cm bed.	20	756
96-13-B5	As –B4.	20	776
96-13-B6	As –B4; 30cm bed	34.5	810.5
96-13-B7	As –B4.	22.5	833
96-13-B8	As –B4.	30	863
Increasing shale upsection.			
96-13-B9	LIME MUDSTONE, medium grey, fine crystalline, laminated.	30	893
96-13-B10	PACKSTONE, medium grey, 2cm thick among thicker bedded carbonate and platy, cleaved shale.	30	923
Back down to creek to start up waterfalls, to outcrop in main creek bed, which contains cleaved shale.		27	950
Rubbly weathered limestone outcrop in creek with nodular appearance, light grey limestone and buff argillaceous partings, collected the basal part in the creek bed, overlain by a recessive unit before the Haworth Member comprising the waterfalls begins.			
96-13-B11	LIME MUDSTONE, medium grey, weathers light grey, fine crystalline, laminated, buff argillaceous partings.	21	971
96-13-B12	PACKSTONE, medium grey, weathers light grey, 3cm thick compact bed, rubbly.	69	1040

Haworth Member		19.5	1059.5
Base of waterfall, more resistant, massive unit of largely shale to argillaceous thin bedded limestone and nodular limestone.			
96-13-B13	LIME MUDSTONE–WACKESTONE, light grey, weathers buff, lenticular bed.	21	1080.5
At the top of next main waterfall, more calcareous grainstone, light grey beds and buff, argillaceous beds, rubbly, cleaved calcisiltite interbeds. This resistant unit continues until the 1st glacial lake.			
96-13-B14	GRAINSTONE, medium grey, weathers light grey.	82.5	1163
96-13-B15	LIME MUDSTONE–WACKESTONE, light grey, weathers grey-buff, 3cm bed forming lip of falls, laminated.	25	1188
96-13-B16	GRAINSTONE, light grey, weathers light grey, 3cm thick, dolomitic.	42	1230
96-13-B17	PACKSTONE, light grey, weathers buff and grey, bioclastic, rubbly.	45	1275
Mt. Sheffield Member		13.5	1288.5
Contact snow covered; unit comprises cleaved, lenticular limestone interbedded with buff, orange weathered shale surrounding limy cores, massive bedded.			
Covered interval, by snow and talus and by moraine from glacier to south of creek.		62	1350.5
96-13-B18	PACKSTONE, medium grey, weathers light grey, massive bedded, medium crystalline, cleaved limy cores appear nodular and lenticular, maybe once lenses or thin beds, laminated.	1	1351.5
Continued up creek to waterfalls and climbed moraines up to outcrop to south of creek rather than climb steep creekbed, toward cliff forming part of unit.			
96-13-B19	PACKSTONE, medium grey, weathers light grey, laminated, pyritic, cleaved.	30	1381.5
96-13-B20	LIME MUDSTONE–WACKESTONE, dark grey, weathers light grey and buff, 2cm up to 4cm thick, concoidal fracture.	30	1411.5
96-13-B21	LIME MUDSTONE, with packstone intraclasts, medium grey, weathers light grey.	33	1444.5
96-13-B22	LIME MUDSTONE, medium grey, weathers light grey, cores within shale, fine crystalline.	40.5	1485
Continued down to the top of the first lake's delta and head waters. At top of waterfall collected limestone interbedded with shale and lime mudstone.			
96-13-B23	PACKSTONE–GRAINSTONE, medium grey, weathers medium grey, 3cm thick fossiliferous (orthid brachiopod), black bioclasts.	33	1518

Light grey and buff shale interval along creekbeds; combination of lithologies in lenses, from lime mudstone to grainstone.

96-13-B24	LIME MUDSTONE–WACKESTONE, dark grey, weathers medium grey, lenticular, laminated.	37.5	1555.5
96-13-B25	WACKESTONE–PACKSTONE, dark grey, weathers medium grey, 2cm bed.	37.5	1593

In between the two lakes in top of grass covered cliff. More calcareous in this interval with more lime mudstone interbeds.

96-13-B26	PACKSTONE-GRAINSTONE, medium grey, weathers light and medium grey, nodular.	30	1623

Medium grey shale and talus weather orange.

96-13-B27	GRAINSTONE, medium grey, 10cm interval of thin beds.	37.5	1660.5

Limy beds more prominent with lots of fossils in orange scree; more orange up section

96-13-B28	GRAINSTONE, medium grey, weathers buff-orange-grey.	46	1706.5
96-13-B29	PACKSTONE-GRAINSTONE, medium grey, nodular 2cm bed.	34.5	1741

Skoki Formation, Sikanni Chief Member

A change to orange and burrow mottled unit with less fossils on weathered surface and beginning of jointing and platy breaking of massive beds (compared to thin bedded unit below), fossiliferous and burrow mottled.

96-13-B30	GRAINSTONE, medium grey, weathers orange, massive, coarse crystalline, slightly dolomitic, burrow mottled.	33	1774

Through interval of Skoki talus and change to platy weathered, orange and medium grey weathered dolomitic limestone, fossiliferous, vertical jointing.

96-13-B31	WACKESTONE-PACKSTONE, medium grey, weathers orange, medium crystalline.	37.5	1811.5
96-13-B32	As –31; massive without jointed surfaces.	58.5	1870

Subunit of massive bedded, burrow mottled limestone, weathers orange and light grey, dolomitic, and interbedded with hackly, rubbly, thin beds of medium grey wackestone, weathers light grey, less than 0.5m thick in intervals.

96-13-B33	WACKESTONE, medium grey, weathers orange and light grey, massive, burrow mottled.	58.5	1928.5

Change to rubbly weathered, platy, more grey and pale orange.

96-13-B34	PACKSTONE, weathers grey and pale orange.	42	1970.5

Hackly limestone; overlain by grey dolostone talus with macluritid gastropods.	18	1988.5

Grey Peak Section

The stratigraphic section at Grey Peak (94F/14; 57° 48' N, 125° 13' W) was sampled in 8 segments, beginning at the Kechika-Road River contact and progressing upward through the Ospika Formation, eastward along the ridge to the cliff-forming platformal carbonate debris of the Middle Recessive Member. The overlying orange weathering Kwadacha Formation was walked out over a spur to the east. The Kechika was then collected in 7 sections, working westward toward Grey Peak for sections 2 though 5 and then upwards from the Cambrian units in sections 6 though 8.

Sample number	Description	Thickness (m) Sample	Total from Base

Cambrian Strata, Unit 1

Sandstone, mostly conglomerate with large clasts (up to one meter) in thick to massive beds, coarse to granular, *Skolithos* present in one half of them, cross bedding in a few. Some beds have conglomeratic bases with rounded clasts up to 5cm. Overlain by thick to massive dolostone.

GP-94-6-1	LIMESTONE/SANDSTONE (4m), lowest 10cm of massive bed of sandy, oolitic limestone, some larger clasts visible up to 2cm across.	2	2
GP-94-6-2	OOLITE, top 10cm exposed, medium grey, medium sand-sized ooids, no clasts here, scattered quartz grains.	2	4
Covered interval.		40	44

Kechika Formation

The Kechika can be divided into units based on subtle changes in weathering colour of shale (70%) interbedded with thin bedded limestone. Unit contacts are gradational.

Lloyd George Member

Platy limestone within a largely massive bedded sequence of calcirudite.

GP-94-6-3	GRAINSTONE, medium grey, all beds are massive and oolitic, some prominently laminated, scattered quartz grains, attenuating with massive grey beds of conglomerate with intraformational limestone clasts of bedded grey limestone up to 1m across which were sampled.	2	46
GP-94-6-4	LIME MUDSTONE–WACKESTONE, medium grey, most likely matrix of conglomerate.	20	66
GP-94-6-5	OOLITE, black to grey, middle of slightly recessive thin bedded interval where beds are finely oolitic and pyritic.	22	88

GP-94-6-6	CONGLOMERATE, dark grey, fine intraclasts, clasts 2-4cm, some dolomitic veining.	24	112

Quentin Member

Change to brown weathering shale with thin lenticular, rather widely spaced pods of dolomitic limestone.

GP-94-6-7	LIME MUDSTONE–WACKESTONE, dark grey, weathers buff, 0-15cm bed, slightly dolomitic, ?scattered ooids.	30	142
GP-94-6-8	LIME MUDSTONE–WACKESTONE, medium grey, compact 4cm bed with slight lamination of limited lateral aspect (10cm thick, extends over 1m) few limestone beds or large lenses in this interval, sparse trilobite fragments.	30	172
GP-94-6-9	LIME MUDSTONE–WACKESTONE, medium grey, lens 0-4cm thick over 25cm interval, within black shale.	36	208
GP-94-6-10	As -6-9.	60	268
GP-94-7-8	LIME MUDSTONE, argillaceous, compact bed, more calcareous than calcareous shale in this interval.	130	398
GP-94-7-7	WACKESTONE, medium grey-brown, dolomitic, 3cm bed, most calcareous of the overlying beds.	45	443

Subunit of thin bedded shale, medium grey to grey-brown with thin 1-3cm platy to lenticular limestone beds, often laminated and argillaceous/dolomitic.

GP-94-7-6	LIME MUDSTONE–WACKESTONE, medium grey, 15cm compact bed breaking into 3-4 laminated beds.	19	462
GP-94-7-5	As -7-6; platy breakage.	24	486
GP-94-7-4	As -7-6.	19	505
GP-94-7-3	LIME MUDSTONE–WACKESTONE, medium grey, beds less argillaceous, 3 compact, 1cm beds.	20	525
GP-94-7-2	LIME MUDSTONE, medium grey, weathers yellow-brown grey, striped due to thin bedded to laminated bedding which is then cleaved to accentuate striped pattern, argillaceous.	20	545
GP-94-7-1	As -7-2.	15	560
GP-94-7-0	WACKESTONE, medium grey, compact 3cm bed in shale.	20	580

Subunit of shale weathers light grey and slightly buff locally, similar color when fresh with thin 2cm to thick lime mudstone beds at widely separated intervals, 1 to 3m.

GP-94-5-1	LIME MUDSTONE, medium grey, argillaceous, 2cm bed.	20	600
GP-94-5-2	LIME MUDSTONE, medium grey, finely laminated, compact 2cm bed.	20	620

GP-94-5-3	As –5-2; 3cm bed, more dolomitic in this interval.	20	640
GP-94-5-4	LIME MUDSTONE, medium grey, finely laminated not as argillaceous as below, compact 8cm bed.	20	660

Limestone beds rare in this interval.

GP-94-5-5	As –5-2; 1 cm bed, argillaceous top and bottom;	24	684
GP-94-5-6	LIME MUDSTONE, medium grey-brown, 3cm bed.	20	704

Grey Peak Member

Forms the core of Grey Peak, becoming more calcareous. Beds are dominantly thin bedded (1 to 2cm) lime mudstone to wackestone separated by thin grey shale partings with dolomitic stringers, the alternation giving banded appearance to unit.

GP-94-5-7	WACKESTONE, medium brown grey, 5cm compact bed, some fine laminations.	20	724
GP-94-5-8	As –5-7.	24	748
GP-94-5-9	WACKESTONE, medium brown-grey, slightly irregular bedded, compact 4cm bed breaking into 2 by 2cm blocks, with some trilobite fragments and rare pyrite, more shale towards the top of this unit.	20	768

Subunit forming platy talus of Grey Peak's east crest, limestone now weather brown but are not dolomitic and are predominant as in the previous unit except the limestone is brown as are the shale partings.

GP-94-5-10	WACKESTONE, medium brown-grey.	27	795

Bedded limestone interval.

GP-94-5-11	WACKESTONE, medium brown-grey, 3cm bed.	20	815
GP-94-5-12	LIME MUDSTONE–WACKESTONE, medium grey, finely laminated, compact 2 to 5cm bed.	24	839
GP-94-5-13	LIME MUDSTONE, medium grey, finely laminated 0 to 5cm bed, pinches out laterally.	20	859

Subunit begins as shale, weathers dominantly grey to silvery and light grey with widely spaced limestone beds in 1 to 3m intervals.

GP-94-5-14	LIME MUDSTONE, medium grey, 3cm compact bed, finely laminated.	23	882
GP-94-5-15	As –5-14; abundant trace fossils in shaly-limestone talus, weathers brown.	22	904
GP-94-5-16	LIME MUDSTONE, medium grey, 2cm bed, lots of trace fossils	29	933

in following interval.

Haworth Member

This part of the section contains almost no limestone, only small pods within largely grey to grey brown weathering medium grey shale, seen as a darker interval below samples numbered 4-.

GP-94-5-17	WACKESTONE, light to medium grey, irregular 4cm bed.	20	953
GP-94-5-18	As –5-17.	37	990

Unit consists of thin bedded grey shale with interbedded nodular limestone which are rare but prominent 10 to 20cm beds.

GP-94-4-1	CONGLOMERATE, medium grey brown, clasts up to 2cm, coarse packstone matrix, 10cm compact bed.	21	1011
GP-94-4-2	PACKSTONE–GRAINSTONE, light grey, 15cm compact bed, trilobite bioclasts.	20	1031
GP-94-4-3	As –4-2.	21	1052
GP-94-4-4	GRAINSTONE, light grey, 30cm fine pelmatozoan bed with 25cm of grainstone at the base and 5cm of mottled wackestone on top.	21	1073
GP-94-4-5	PACKSTONE – GRAINSTONE, light brown-grey, 15cm bed with some 2mm pelmatozoan ossicles, bed has dolomitized burrow mottled patches.	13	1086

Bioclastic beds are becoming rarer towards the top of this unit, occurring only every 5 to 6m instead of every 2 to 5m.

GP-94-4-6	GRAINSTONE, medium grey-brown, 15cm compact bed with slightly mottled surface, trilobite bioclasts.	13	1099
GP-94-3-1	WACKESTONE, medium brown-grey, thin10cm bed below which is a unit of fissile dark grey shale with very few carbonate beds.	20	1119

14m of a subunit of grey shales with 30% limestone beds, some of which are dolomitic and some are trilobite packstone. The next interval is of silver-grey weathering shale with thin, widely spaced limestone beds, only 1 to 2 cm thick and continues up to the Road River contact.

GP-94-3-2	PACKSTONE, medium grey, 5cm layer, trilobite bioclasts, part of a 1m interval of rich trilobite packstone-grainstone with some pelmatozoan ossicles.	14	1133

Interval of phyllitic shale, weathers white-silvery to pale yellow.

GP-94-3-3	LIME MUDSTONE, medium brown-grey, 2cm compact bed.	21	1154
GP-94-3-4	LIME MUDSTONE, medium grey, 3cm compact bed.	25	1179
GP-94-3-5	LIME MUDSTONE, medium grey, weathers grey-brown,	20	1199

	especially the bioclastic beds, thin 0 to 2cm beds in 10cm interval of lenticular beds.		
GP-94-3-6	LIME MUDSTONE, medium grey-brown, 2cm bed.	20	1219

Interval of 70% white weathering dark grey shale.

GP-94-3-7	LIME MUDSTONE, medium brown-grey, 2 cm bed.	23	1242

Subunit of pseudonodular dolomitic limestone and shales with rare 10 to 15 m beds of trilobite packstone to grainstone.

GP-94-3-8	PACKSTONE, compact bed, trilobite bioclasts and rare pelmatozoan ossicles and some calcite veins.	20	1262

Interval has been dominantly shale with a change from silver weathering to grey-brown weathering with thin limestone beds every 50 cm.

GP-94-3-9	LIME MUDSTONE, medium brown grey, 3cm bed.	23	1285

Fissile shale grey to medium brown with thin dolomitic limestone beds. Limestone beds are typically 1-4cm up to 10cm towards contact with Road River and separated by 10 to 30cm of shale, therefore shale is 70% of section. Shale has two cleavages which creates pencil shale talus and which may also cause the pseudonodular form of most limestones.

GP-94-2-1	LIME MUDSTONE, medium grey-brown, weathers grey-brown thin bedded, dolomitic.	5	1290

Change to brown weathering.

GP-94-2-2	LIME MUDSTONE, grey-brown, 2cm bed, dolomitic.	23	1313
GP-94-2-3	LIME MUDSTONE, medium grey-brown, 2cm bed, 10cm shale partings	21	1334
GP-94-2-4	As –2-3; 2 to 4cm bed.	20	1354
GP-94-2-5	LIME MUDSTONE, medium grey-brown, 5cm thick bed alternating with 10cm of grey shale.	19	1373

Limestone rare, calcareous 15cm vein in this interval.

GP-94-2-6	LIME MUDSTONE–WACKESTONE, medium brown-grey.	20	1393

Interval of 80% pseudonodular limestone beds 5 to 10cm thick interbedded with shale, dark grey, weathers brown-grey, dark grey two thinner intervals of predominantly dark grey shale.

GP-94-2-7	LIME MUDSTONE–WACKESTONE, medium brown- grey, top bed of Kechika Group.	15	1408

Road River Group
Ospika Formation

Conformably overlies Kechika and comprises several distinct units with gradational contacts.

Cloudmaker Member

Comprises dark grey, cleaved black shale and siltstone, weathers light brown and medium to dark grey. The cleavage makes the lime mudstone beds rubbly. Largely pencil shale, weathers dark brown and cleaved with interbedded thin lime mudstone beds and nodular lime mudstone and lime siltstone and the upper part of the unit comprises dark grey to light grey-brown shale.

GP-94-1-1	LIME MUDSTONE, dark grey, weathers dark grey, 10cm thick bed, fine crystalline, silty, cleaved, thin bed, among pencil shales.	5	1413
Weakly calcareous siltstone and shale, 10cm calcite veined silty limestone marker bed.		5	1418
GP-94-1-2	LIME SILTSTONE, dark grey, weathers dark grey, 10cm bed, fine crystalline, cleaved.	8	1426
GP-94-1-3	LIME MUDSTONE, medium grey, weathers grey-brown, fine crystalline, pseudonodular	1	1427

Nodular lithology present at the Kechika-Road River contact may be either a repeated lithology moved by faulting.
Marker bed of calcite, banded, weathers brown-grey to white and contrasts surrounding dark pencil shale. About 15cm thick on ridge, partially talus covered.

GP-94-1-4	LIME SILTSTONE, medium grey, weathers brown to medium grey, thin bed, weakly calcareous, compact/dense but due to cleavage it breaks quite easily.	8	1435
Veins of calcite form a prominent knob which could follow a fault, brecciated.		3	1438
GP-94-1-5	LIME MUDSTONE, medium grey, weathers grey-brown, compact nodular bed, fine crystalline, finely laminated, slightly recrystallized.	0	1438
GP-94-1-6	LIME MUDSTONE, medium grey, weathers brown-grey, nodular, fine crystalline, dense, almost concoidal fracture, recrystallized.	7.5	1445.5
Predominance of pseudonodular limestone beds and dark shale, white calcite vein.		10	1455.5
GP-94-1-7	As –1-6; widely spaced laminations.	2.5	1458
GP-94-1-8	LIME MUDSTONE–WACKESTONE, medium grey, weathers brown-grey, compact nodular bed, medium crystalline, uniform.	3	1461

Interval of siltstones and shale, with no strongly calcareous beds.

GP-94-1-9	LIME MUDSTONE, medium grey, weathers brown grey, pseudonodular, fine crystalline.	26	1487

Change of color of shale to light brown-grey.

GP-94-1-10	As –1-9.	9	1496

Finlay Limestone Member 34.5 1530.5

Color change to light brown-grey shale from dark grey shale, over a covered interval. Unit comprises a "sandwich" of lime mudstone, weathered dark grey, light grey and dark grey, marking the first thick, prominent limestone, laminated and form a resistant cap on the ridge.

GP-94-1-11	LIME MUDSTONE, dark grey, weathers medium-dark grey and light brown weathering, finely and evenly laminated, fine crystalline.	10	1540.5

A change in weathering color to light grey.

GP-94-1-12	LIME MUDSTONE, dark grey, weathers light grey, fine crystalline, slightly pyritic and laminated.	8.5	1549

Change back to dark grey weathering.

GP-94-1-13	As –1-11; 2m below top of unit.	9	1558

Chesterfield Member

A thick unit with bands of resistant limestone and platy limestone, shale and siltstones. Basal part is shale and platy limestone (A); overlain by tripart "sandwich" with dark middle between two lighter, buff platy limestone beds (B); overlain by a light band of shale and platy limestone and dark band (C); dolomitic conglomerate forming the second cap along the ridge (D); dark subunit of shale and platy, dolomitic limestone, weathers orange (E); top of unit is breccia, weathers yellow-grey.

GP-94-1-14	LIME MUDSTONE, dark grey, weathers buff, 1m thick bed, fine crystalline, platy.	11.5	1569.5

Shale, thin bedded limestone (**Subunit A**).	4.5	1574
Tripart limestone, lower part is limestone, dark grey, weathers yellow-grey, flaggy (1m) (**Subunit B**).	1	1575
Middle is dark grey, weathers medium grey (2.5m thick).	1.5	1576.5

GP-94-1-15	LIME MUDSTONE, dark grey, weathers buff, from middle of tripart bed.	1	1577.5

Top is limestone, dark grey, weathers pale buff, thin, platy (2m).	2	1579.5

Interval of darker weathered, platy limestone and shale (**Subunit C**).

GP-94-1-16	WACKESTONE, dark grey, weathers dark brown- grey, medium crystalline, bits of spar, compact, some calcite veining.	13	1592.5
GP-94-1-17	LIME MUDSTONE, medium grey, weathers brown buff, 1.5-2.0m thick, platy, minor calcite veining.	10	1602.5
GP-94-1-18	LIME MUDSTONE, dark grey fresh, weathers buff, thin, compact bed, fine crystalline.	10	1612.5
GP-94-1-19	WACKESTONE, dark grey, weathers medium grey, thin compact bed, medium crystalline.	20	1632.5
Thick polymictic conglomerate, dolomitized with chert clasts. The top of the conglomerate has slumped into a series of flow rolls (**Subunit D**).		10	1642.5
Dolomitic limestone and shale, orange, platy (**Subunit E**).			
GP-94-1-20	PACKSTONE, medium grey, weathers yellow-light grey, layer on top of orange weathered, laminated, dolomite, grain supported, medium crystalline, compact.	20	1662.5
GP-94-1-21	GRAINSTONE-CALCIRUDITE, medium grey, weathers yellow-brown, compact 20cm bed, coarse crystalline, bioclastic, compact lower half and planar laminated upper half (graded from –20).	0.5	1663
GP-94-1-22	CALCIRUDITE, polymictic, up to 2cm long clasts, weathers orange, 20cm thick bed, black lime granules and chert pebbles.	6	1669
	Breccia unit, weathers yellow-grey (**Subunit F**).		
GP-94-1-23	BRECCIA, grainstone and micritic clasts round to platy, up to 30cm long and 6cm wide, lime matrix, weathers yellow, at least 6m thick bed, cannot determine the base exactly.	9	1678
	To top of the breccia.	11	1689
Covered interval of breccia talus; **Subunit F** comprises four distinct bands of breccias with wavy bedding indicating slumping and/or scour and fill.		10	1699
GP-94-1-24	LIME MUDSTONE, dark grey, weathers light grey and orange along joints, fine crystalline.	1	1700
Interval of flow breccias, oligomictic, clasts weather dark grey, matrix weathers light grey.			
GP-94-1-25	LIME MUDSTONE, dark grey, weathers medium grey, laminated, uniform.	10	1710

GP-94-1-26	LIME MUDSTONE, dark grey, weathers light grey, fine crystalline, irregular, dolomitic with horizontal burrows and bioturbation.	7	1717
GP-94-1-27	CONGLOMERATE, oligomictic, clasts are round, 1-2cm in diameter, dark grey, weathers light brown and grey.	12	1729
GP-94-1-28	CONGLOMERATE, oligomictic, fine grained lime mudstone clasts up to 4cm long, well rounded, dark grey, weathers light grey.	10	1739
GP-94-1-29	CONGLOMERATE, fine grained limestone clasts, dark grey, weathers light grey.	10	1749

Finbow Shale Member

Interbedded dolostone-shale, weathers brown-orange.

Covered interval of shale.	10	1759
Bed with chert at the top and bottom.	0.5	1759.5
Shale, dark grey, weathers light grey-brown.	10	1769.5
Dolostone conglomerate with chert nodules.	2	1771.5
Shale and thin bedded dolostone.	7	1778.5
Dolostone with chert clasts, 4m thick, 20cm oolite bed 1m from the top of the bed and unit, dolomitized, weathers blue-grey, coarse crystalline. Top 10cm of the bed and unit consists of blue-black chert which also occurs throughout in the conglomerate. Subunit of mostly shale, weather brown, dark grey and orange-red, silty wackestone beds near the base of unit. A few blocks of lime mudstone are present, dark grey, bioturbated similar to –1-26, produce float in the gulley.	4	1781.5

GP-94-1-30	DOLOSTONE, light grey, weathers orange, thin bed.	2.5	1784
GP-94-1-31	DOLOWACKESTONE, light grey, weathers light grey-brown, medium grained-silty laminated, weakly calcareous.	33	1817

Kwadacha Formation 50 1867

Shale and siltstone, weather red, orange, grey and brown, carry on to the synclinal axis.

Section #4 (of Cecile and Norford, 1979)

The ridge section, located 6km north of the Akie River (94F/7; 57° 26'N, 124° 35'W), trends northeast to southwest with the Kechika exposed in a col to the northeast and the Road River making up the ridge peak to the southwest. Camp was established on a flat, grassy col within the Road River Group. Measurements and collections proceeded from the Kechika to the north up to the ridge to the south of camp.

Sample number	Description	Thickness (m) Sample	Thickness (m) Total from Base

Kechika Formation

Began collecting in the saddle north of camp as the Kechika is largely recessive shale and falls off into the next valley to the north. Comprises light grey, cleaved phyllitic shale and thin bedded limestone.

Sample number	Description	Sample	Total from Base
	Interval of light grey shale.	30	30
96-4-K1	LIME MUDSTONE, medium grey, weathers medium grey, 0.5cm thick, fine crystalline, lenses from 20cm interval of light grey shale.	0	30
	Light grey shale, interbedded with >2m outcrop of thin cm limestone beds and lenses.		
96-4-K2	PACKSTONE, medium grey, weathers buff-brown, 4cm thick lens, coarse crystalline, trilobite bioclasts.	108	138
	Outcrop of light grey-buff shale and thin lenses of limestone	1	139
96-4-K3	WACKESTONE–PACKSTONE, medium grey, 2 continuous beds, 1 irregular 2cm thick and 1cm bed overlying it, medium-coarse crystalline.	14	153
	Packstone, weathers buff, interbedded with increased number of thin limestone beds.		
96-4-K4	PACKSTONE, medium grey, weathers buff, 2 cm bed and 1cm bed above, coarse crystalline.	25.5	178.5

Road River Group, Ospika Formation

Comprises distinct units with gradational contacts; largely shale with limestone beds. The Cloudmaker Member is cut out by an unconformity.

Finlay Limestone Member

Platy limestone, weathers yellow, thin bedded (1 -2cm), argillaceous limestone weathers buff.

96-4-R1	WACKESTONE, medium grey, weathers yellow, 1-2cm bed, medium crystalline.	27	205.5

Interval of shale.

96-4-1	LIME MUDSTONE, medium grey, weathers grey-yellow, 10cm bed, fine crystalline, dense and resistant.	75	280.5

Dolomitic limestone interbeds, 1cm thick.

96-4-2	LIME MUDSTONE, dark grey, weathers medium grey, 10cm bed, fine crystalline.	60	340.5

Prominent, resistant cliff of limestone, coarser grained intraclasts in some beds.

96-4-3	WACKESTONE, medium grey, weathers orange-grey, 10cm bed, medium crystalline, graded and laminated with chert nodules and some chert layers.	13.5	354

Within grassy knob along strike with main cliff of Road River limestone, 3m wide, medium to thick bedded, next prominent knob is dolomitic and veined.

96-4-4	WACKESTONE, medium grey, weathers light grey, medium crystalline.	13.5	367.5

Chesterfield Member Recessive unit of dolomitic shale, dark grey to green with dolostone interbeds. Knob of veined dolostone (2m), white.	12	379.5
Dolostone, veined (2m), in float, within dark grey shale weathers green-buff to rust.	24	403.5
Dolostone (1m).	10.5	422.5
Finbow Shale Member Change to shale, weathers dark grey-orange. Dolostone, weathers buff and dark grey, 40cm thick, veined. At this point we are about 30m from our camp on a grassy saddle before the cliff forming rocks making up the ridge begin.	3	425.5
To another dolostone in float, 2m wide.	24	449.5
Ware Member Black shale interval, some weather orange among thick bedded dolostone and rarer quartzite, weathers blue-grey. The interval is partly grass covered, but mostly dolostone and quartzite.	42	491.5

96-4-5	DOLOSILTSTONE, brown-grey, weathers buff, 2 thin 1.5cm beds, weakly calcareous, medium crystalline.	24	515.5

Cross-bedded quartzite beds 50cm thick.	10	525.5
Interval of thick bedded quartzite ending with massive bedded ones; covered interval of snow.	108	633.5

Pesika Formation

Unit is mostly dolomitic lime mudstone and dark shale.

96-4-6	GRAINSTONE, medium grey, weathers buff, dolomitic, coarse crystalline, overlies a dark grey graptolitic shale.	192	825.5
96-4-7	LIME MUDSTONE, medium grey, 5-7cm bed, fine crystalline, weakly calcareous, compact.	9.5	835
Talus covered.		30	865
	Kwadacha Formation	23.5	888.5

Cliff-forming silty dolostone, weathers orange, abundant horizontal, fan-shaped traces in the talus.

Road River Core

Core from Inmet Mining was sampled at their core shack (94F/7; 57° 23'N, 124° 52'W) across the valley from a Repeater Station (57° 24'N, 124° 53'W), 5km north of the Akie River and 37km northeast of Finbow. The core is from hole A-95-19, "Cardiac Creek".

Sample number	**Description**	**Thickness (m) Sample**	**Total from Base**
	Road River Group, ?Kwadacha Formation		

Basal black graphitic, silty, rarely calcareous shale and siltstones, fine grained and foliated. Upper units of core contain varying amounts of siltstone and black shale and slate with rare calcareous siltstone beds, thin bedded throughout.

Shale, black, fine grained, foliated, graptolitic. Fault zone at 18m. Lime mudstone is medium grey.		65.0	65.0
RR-96-1	LIME MUDSTONE, dark grey, 35cm interval, fine crystalline.	0.0	65.0
RR-96-2	As –1.	22.7	87.7
RR-96-3	LIME MUDSTONE, medium grey, silty, laminae (1mm).	5.3	93.0
RR-96-4	As –3.	23.0	116.0
RR-96-5	As –3; quartz and calcite veins.	7.4	123.4
RR-96-6	As –3; slate partings.	28.8	152.2
RR-96-7	As –3; slate partings.	11.8	164.0
RR-96-8	As –3; slate partings.	12.4	176.4
RR-96-9	As –3; slate partings.	9.2	185.6

RR-96-10	As –3.	15.3	200.9

Interval of increased thin bedded limestone, calcareous siltstone, black shale.

RR-96-11	CALCAREOUS SILTSTONE, medium grey, medium crystalline, 1mm laminae.	18.1	219.0

Interval of black shale, minor limestone and lime siltstone, light to medium grey, rubbly and sheared, brecciated veins of quartz and calcite.

RR-96-12	CALCAREOUS SILTSTONE, medium grey, silty, graphitic, veined.	55.5	274.5

Unit is largely siltstone (70%), weakly calcareous, light to medium grey, 1cm beds interbedded with black shale/slate, sheared.

RR-96-13	SILTSTONE, medium grey, laminated, platy, dense, black slate interbeds (40%), slightly graphitic.	50.1	324.6
RR-96-14	As –13; largely black slate (80%) in this interval.	14.4	339.0
RR-96-15	CALCAREOUS SILTSTONE, light grey, thinly bedded with minor slate interbeds	16.0	355.0
RR-96-16	As –13; mainly slate, only minor siltstone.	47.0	402.0

Interval is mainly siltstone with 15% black shale and argillite.

RR-96-17	CALCAREOUS SILTSTONE, medium grey, thin bedded, pyrite laminae.	18.0	420.0
RR-96-18	As –17; increased shale interbeds.	20.7	440.7

Interval of black shale (80%).

RR-96-19	SILTSTONE, light grey, thin bedded, laminated, dense.	24.3	465.0
RR-96-20	As –19; medium grey.	47.0	512.0
RR-96-21	As –19; siltstone beds up to 20cm thick, less shale in this interval (15%).	39.5	551.5
RR-96-22	As –19; 1-2cm beds, 25% black shale.	50.5	602.0

Bluff Creek Section

Camp established in a grassy saddle (major animal crossing) at the top of the Cambrian sequence, north of Bluff Creek (94L/10 ; 58°34'N, 126°37' W). The nature of the Cambrian units, Kechika and Road River groups at this locality make lithologic boundaries difficult to discern. The samples of two sections are designated by A or B.

Sample number	Description	Thickness (m) Sample	Total from Base

Cambrian Strata

The Cambrian units comprise shale, weathers brown, with rare compact dolomitic siltstone and rare limestone and a few areas of quartz veining. Measuring began at the last main outcrop in ridge before slope falls away into the ravine.

Unit 1

Largely brown shale with rare limestone, bedded and lenticular; siltstone more common in upper part of unit.

BCN-95-A1	LIME MUDSTONE, medium-dark grey, 3cm bed, fine crystalline.	156	156
BCN-95-A2	As -A1; 4cm bed.	3	159
BCN-95-A3	As -A1; 0-5cm lenticular bed.	1	160
BCN-95-A4	As -A1; 1-2cm compact bed.	8	168

Descended small ridge, westward back to camp, over a poorly exposed area.

BCN-95-A5	WACKESTONE, light grey, weathers light grey, 7cm bed parting into 3, medium crystalline, silty.	45	213

Compact siltstones interbedded with brown weathering shale continues until siltstones get rarer.	57	270

Unit 2

Shale, dark grey, to outcrop which runs along west edge of gully that is the main animal trail leading up from Bluff Creek. Lithology changes to brown weathering shale interbedded with thin, platy, isolated limestone (5-10% of section).

BCN-95-A6	WACKESTONE, medium grey, lens of 4 or 5 beds, medium crystalline, folded.	21	291
BCN-95-A7	WACKESTONE, medium grey, compact but friable 3 to 5cm bed, fine crystalline, sandy, laminated.	0.5	291.5
BCN-95-A8	PACKSTONE, medium grey, top 3cm of 5cm platy bed,	7.5	299

fossiliferous.

Shale, weathers brown.	5	304
Covered interval, and highly micaceous/phyllitic shale with rare siltstones and fine, laminated sandstones.	45	349
White quartz vein and dark argillite/chert among blue-grey shale, weather silver grey and orange brown on weathered cliff outcrops.	20	369
Contact with black shale.	55	424

? Kechika Formation

Typical Kechika lithologies are not present; there are distinct units based on weathering colors of shale with minor limestone.

Unit 1 Blue grey platy shale, weathers orange, cleavage close to bedding. Located at the first knob with trees after Cambrian exposures.	13.5	437.5
Unit 2 Dark grey shale, lower top and bottom third unexposed; recessive forming first col, some weather orange, exposed part is dark.	16.5	454
Unit 3 Shale like Unit 1, lighter bluish grey and weathers orange, more resistant cliff of shale (phyllitic) and beyond over the grassy north slope; forms the second prominent ridge without trees. The goat trail goes about 3m from the edge of the cliff exposure on north face. The ridge has a small, (3m) long col separating the 2 knobs.	36	490
Unit 4 Shale, weathers orange, some compact beds of limestone. The first few meters are covered by grass and talus and found in a col. Shale, dark grey and grass covered along parts of the ridge. About 5-7m in grass covered on west face of first knob.	10	500

BCN-95-B0	SILTSTONE, dark grey, weathers light brown, weakly calcareous, finely laminated.	3	503
BCN-95-B1	WACKESTONE, brown-grey, weathers brown, 2cm thick, medium crystalline, darker laminae.	3	506
BCN-95-B2	CONGLOMERATE, 1cm dark grey clasts, medium grey, weathers brown, 3cm thick bed.	1.5	507.5
BCN-95-B3	WACKESTONE, dark grey, weathers brown, 2cm thick bed, fine crystalline.	2	509.5
BCN-95-B3A	WACKESTONE, dark grey, weathers light brown, 20cm lens, 0-8cm thick, finely laminated.	1	510.5
BCN-95-B4	CONGLOMERATE, 2mm up to 1cm long clasts, oriented parallel to beds, weathers brown, thin bed, medium crystalline, some laminae are coarser brown grey (intraclast packstone).	3.5	514
BCN-95-B4A	CONGLOMERATE, microclasts, medium grey, weathers brown, 3cm thick, laminated, silty.	0.5	514.5

?Road River Group

Base of unit is marked by a small tree; shale traced to this point forms third knob with trees. Occurrence of chert may indicate this is the start of the Road River.

	Unit 5	2.5	517

Unit comprises thicker bedded limestone, weathers medium grey, platy, limy siltstone, interbedded and bedded chert and shale, weathers black and brown.

BCN-95-B5	WACKESTONE, medium grey, weathers dark grey, 5cm compact bed, medium crystalline, calcite veining, fine lamination and small clasts.	2	519
BCN-95-B5A	PACKSTONE, dark grey, weathers medium grey, 5cm bed, laminated.	2	521
BCN-95-B5B	WACKESTONE, medium grey, weathers light brown, 2cm bed, medium crystalline, calcite veining.	2	523
BCN-95-B6	LIME MUDSTONE, dark grey, weathers medium grey, 5cm compact bed, fine crystalline, concoidal fracture, dense, deformation in beds, local slump.	2	525
BCN-95-B6A	WACKESTONE, medium grey, weathers brown, medium crystalline, pavement-like surface, possibly phosphatic.	0.25	525
BCN-95-B6B	MICROCONGLOMERATE, medium-dark grey, lime mudstone clasts up to 1cm long, fossiliferous matrix with grainstone in between clasts.	3	528
BCN-95-B7	WACKESTONE-PACKSTONE, composite bed of different grain sizes, fine laminae at bottom, coarser grain-supported at top.	3	531
BCN-95-B7A	WACKESTONE, medium grey, weathers light brown, thin bed, platy.	1.5	532.5

Unit has become more shaly.

BCN-95-B8	LIME MUDSTONE, medium grey, weathers brown, compact 4cm bed, medium crystalline.	3	535.5

Unit 6

Shale, weathers bluish grey, some black, bedded chert similar to Unit 1. □

BCN-95-B9A	CONGLOMERATE, medium grey, weathers light brown, 0-10cm thick lens, recrystallized.	5	540.5
BCN-95-9	CONGLOMERATE, medium grey, weathers brown, 15cm by 25cm, coarse grainstone.	1	541.5

Unit 7

Shale, weathers orange, with compact limestone beds, like Unit 4.

BCN-95-10	WACKESTONE-PACKSTONE, dark grey, weathers brown, 5cm thick bed, medium crystalline, calcite veining.	6	547.5

BCN-95-10A	WACKESTONE, medium-dark grey, weathers brown, 2 beds of 5cm breaking into parting 0.5cm to 1cm, argillaceous, laminated.	3	550.5
BCN-95-11	WACKESTONE, medium-dark grey, weathers brown, lenticular bed, silty, calcite veining.	3.5	554
BCN-95-11A	MICROCONGLOMERATE, clasts 2mm wide by 2mm long, medium grey, weathers light brown, 2cm bed.	2.5	556.5
Unit 8 Shale, weathers orange with compact limestone beds, like Unit 4. Some shale interbeds are grey, weather brown. Interbedded chert above sample –B15.		1.5	558
BCN-95-12	LIME MUDSTONE, dark grey, weathers brown, top 2cm of bed, fine crystalline, dense.	0.5	558.5
BCN-95-12A	WACKESTONE, dark grey, weathers medium grey, 2cm bed, medium crystalline, finely laminated.	1.5	560
BCN-95-13	WACKESTONE, medium grey-brown, weathers light brown, 10cm bed.	1.5	561.5
BCN-95-13A	WACKESTONE, medium grey, weathers light brown, 7cm bed breaks into laminated 0.5cm beds.	2	563.5
BCN-95-13B	WACKESTONE, medium-dark grey, weathers yellow-brown, compact 3cm bed, medium crystalline.	4.5	568
BCN-95-14	WACKESTONE, medium grey, weathers brown, 10-15cm lens, calcite veining.	1	569
BCN-95-15	GRAINSTONE, weathers light brown, 2cm bed, medium crystalline, black ?phosphatic grains and brown grains.	0.5	569.5
BCN-95-15A	WACKESTONE, medium grey, weathers light brown, from lens 0-10cm thick..	2.5	572
BCN-95-16	LIME MUDSTONE-WACKESTONE, medium grey, weathers orange-brown, 5cm bed, silty.	3.5	575.5
BCN-95-17	WACKESTONE, light-medium grey, weathers orange, 2cm bed, medium crystalline, laminated.	3	578.5
BCN-95-17A	WACKESTONE, medium grey, weathers buff, 5-10cm bed, compact and continuous.	2	580.5
BCN-95-18	LIME MUDSTONE, medium grey, weathers orange, 15cm thick lens, silty.	2.5	583
Unit 9 Dark grey shale again with resistant siltstone, weathers orange; a cliff of shale, weathers dark grey and orange.		4.5	587.5

	Unit 10	25.5	613
Prominent white vein of quartz or dolomite marks start of unit which is mostly black pencil shale, which become vertical or overturned and this, with the presence of the vein, may indicate a fault.			
Small white vein just before the last ridge of outcrop.		24	637
BCN-95-19	CONGLOMERATE, medium grey, weathers brown, 2cm bed, black clasts (phosphatic).	16.5	653.5
	Unit 11	33	686.5
Phyllite, weathers green to white with a ridge forming the last outcrop along the ridge collected, compact siltstone beds, weather silver.			
Flaggy siltstones cover the rest of the slope and talus forms a covered interval into the brush.		36	722.5

Gataga Mountain Section

The section is located 12 miles south of Terminus Mountain Camp, on the east side of Gataga Mountain (94L/10; 58° 38'N, 126° 55'W). Camp was established in a cirque east of the mountain. The section was measured in segments, beginning at the boundary of Kechika and Road River in a saddle marked by a 20m interval of frost-heaved volcanics. The section comprises ridges of the mountain below the overthrust Cambrian groups making up the main peak of Gataga Mountain. The Kechika was measured and sampled along the north-south ridge east of camp in two segments (GBK-95-A and B). The fault repeated sequence of Kwadacha Formation and Ospika Formation was measured toward Gataga Mountain from the volcanics. One lens of Ospika Formation was collected in a creek bed (GB-95-1). Two samples were taken from the top of section in the large bluff of light grey weathering Precambrian carbonates and volcanics.

Sample number	Description	Thickness (m) Sample	Total from Base
	Kechika Formation, Unit 1		
	Consists of cleaved and folded white-grey phyllitic shale with rare interbeds of platy lime mudstone, lenticular wackestone to packstone and some distal turbidite beds 1-2cm thick. The section is likely tectonically thickened.		
GBK-95-B1	WACKESTONE-PACKSTONE, medium grey, pitted weathering, compact 4cm bed, medium crystalline.	0	0
	Interval of fissile, cleaved, grey shale with thin compact 0-1cm, platy limestone beds. Becomes more shaly upsection, 80 to 90%.		
GBK-95-B2	LIME MUDSTONE, medium grey, 4 beds in 20cm interval, fine crystalline.	68	68
GBK-95-B3	As –B2; 0 to 3cm bed, lenticular and folded.	12	80
GBK-95-B4	As –B2; argillaceous.	40	120
GBK-95-B5	LIME MUDSTONE, medium grey, 0 to 2cm, argillaceous, folded and lenticular.	40	160
GBK-95-B6	WACKESTONE, medium grey, 5cm bed, medium crystalline, folded.	32	192
GBK-95-B7	As –B5.	48	240
GBK-95-B8	As –B5.	20	260

First outcrop along ridge that swings north toward Section A.

GBK-95-B9	LIME MUDSTONE, medium grey, 3 thin beds fine crystalline.	20	280
GBK-95-B10	As –B9; compact set of 3 beds.	20	300
GBK-95-B11	As –B9.	10	310
GBK-95-B12	As –B9; finely laminated.	30	340

Fissile, grey shale interval

GBK-95-B13	As –B9; 3 beds each 1cm thick, laminated.	30	370

Unit now comprises brown grey limestone and cleaved grey shale.

GBK-95-B14	WACKESTONE, medium grey-brown, 20cm composite bed.	38	408
GBK-95-B15	As –B14; 10cm bed.	22	430

Unit 2

Consists mainly of cleaved grey shale with rare limestone beds, boudinaged.

GBK-95-A1	WACKESTONE-PACKSTONE, medium brown-grey, 1cm bed, lenticular.	31	461

Interval of black and grey shale, minor calcareous distal turbidites.

GBK-95-A2	LIME MUDSTONE, medium grey, compact 2cm bed, fine crystalline.	20	481
GBK-95-A3	As –A2.	20	501
GBK-95-A4	LIME MUDSTONE, medium grey-brown, 0 to 2cm bed, fine crystalline, argillaceous, lenticular.	20	521
GBK-95-A5	As –A4; compact bed.	20	541

Interval of finely laminated, alternating shale and limestone.

GBK-95-A6	LIME MUDSTONE, medium to dark grey, rubbly, 2cm bed, fine crystalline, argillaceous.	11	552
GBK-95-A7	LIME MUDSTONE, medium grey, lenticular, argillaceous stringers separate lime mudstone.	21	573
GBK-95-A8	As –A7; 2-3cm bed.	24	597
GBK-95-A9	LIME MUDSTONE, medium grey, 5 1 to 2cm beds, fine crystalline, thin shale partings.	24	621

Scree covered interval of fissile dark grey shale, likely basal Road River.	80	701
Saddle contains interval of frost heaved, intermediate to basic volcanics, weather green.	20	721

Road River Group

Consists of poor exposures along the ridge of more resistant units of finely laminated dolomitic siltstone of the Kwadacha Formation which weather orange and recessive units of the Ospika Formation comprising black, cleaved pencil shale. The units are fault repeated.

Black shale, cleaved	27.5	748.5
Siltstone, weathers orange, laminated, dolomitic	22.5	771
Black shale	21	792
Siltstone	3	795
Black shale	63	858
Talus covered to thrust fault, black shale noted along strike.	120	978

One sample was taken in a black shale unit within a creek bed west of the cirque.

GB-95-1	WACKESTONE, medium grey, weathers medium grey, compact concretion (remobilized carbonate forming striations or a prismatic like alignment of carbonate), medium crystalline, some calcite veining.		

Precambrian Unit

Measured up west gully through fault repeated section up to overthrust strata (247.5 m). The vertical cliff weathers light grey, is massive and highly fractured. Samples were collected above base of outcrop of cliff.

GB-95-1C	LIME MUDSTONE, medium grey, weathers light grey, compact, fine crystalline, white marblized blebs, minor mottling.	1	1
GB-95-2C	LIME MUDSTONE, medium grey, weathers light grey, 1m thick, laminated, horizontal tectonic lineations.	2	3

Driftpile Creek Section

Located 5 km northwest of Driftpile camp on Driftpile Creek (94K/4; 58° 07'N, 125° 51'W). The section is part of an inverted sequence. A massive cliff of Cambrian dolostone forms a ridge which sheds talus obscuring the contact with the Kechika and covers the lower 45m of Kechika with grey talus. Measurements began at the obscured, talus covered Kechika contact with overthrust Cambrian dolostone.

Sample number	Description	Thickness (m) Sample	Total from Base

Kechika Formation

Largely brown shale with rare limestone, bedded and lenticular; siltstone more common in upper part of unit.

Unit 1

Dolostone, dark grey, weathers bright orange, finely crystalline with platy bedding 1-5cm thick with some lime mudstone beds. The lower unit of Kechika is covered by an orange weathered talus interval consisting of float from thinly bedded dolostone with some thin limestone interbeds. The top 2m exposed along the ridge are thin bedded, flaggy or platy. Along the ridge to the northeast, the grey Cambrian dolostone talus covers the orange talus, then the orange talus is prevalent as platy float extending to the top of Unit 2.

D-94-0	WACKESTONE, medium grey, weathers grey, thin bedded, medium crystalline.	20cm	20cm

Unit 2

Partly dolomitic shale and siltstone, weathers buff with isolated, thin, weakly calcareous lime mudstone which varies from fine to medium crystalline.

D-94-1	LIME MUDSTONE, dark grey, weathers light buff, 2cm thick bed, fine crystalline.	5	5
D-94-2	LIME MUDSTONE, medium grey, weathers buff, 2cm bed among thin dolostone beds separated by thin shale partings. Interbeds are cross laminated, fine grained carbonates.	3.5	8.5
D-94-3	LIME MUDSTONE, medium to dark grey, weathers buff, 1cm bed, medium crystalline, rough fracture.	9	17.5
D-94-4	LIME MUDSTONE -WACKESTONE, medium grey, weathers buff, 2cm bed, medium crystalline.	8	25.5

Unit 3

Change in lithology to less resistant darker, cleaved shale with lenticular beds of dolomitic limestone

Covered interval.		15	40.5
D-94-5	LIME MUDSTONE, medium grey, weathers light buff, fine crystalline.	3	43.5
D-94-6	LIME MUDSTONE, medium grey, weathers buff, fine crystalline, some calcite veining.	2	45.5
D-94-7	LIME MUDSTONE -WACKESTONE, light to medium grey, weathers buff, from a resistant lens, fine calcite veining.	15	60.5
D-94-8	LIME MUDSTONE, medium grey, weathers buff, 1cm thick lenses, fine crystalline, calcareous.	12	72.5
D-94-9	LIME MUDSTONE, light to medium grey, weathers darker buff than shale interbeds, 5 thin beds over a 0.5m interval, fine crystalline.	9	81.5
D-94-10	LIME MUDSTONE, medium grey, weathers buff, resistant 2cm bed.	18	99.5
D-94-11	As –10; 2cm bed, abundant trace fossils--horizontal burrows, some straight, branched, curved.	12	111.5
D-94-12	LIME MUDSTONE, medium to dark grey, weathers light buff, interval of several 1cm thick beds.	16.5	128
D-94-13	LIME MUDSTONE, medium grey, 2cm bed, lenticular, irregular, fine crystalline.	39	167

Road River Group

Colour changes to dark paper shale, folded, from lighter shale of Kechika.

D-94-14	LIME MUDSTONE -WACKESTONE, medium grey, weathers buff, 2cm bed among paper shale, medium crystalline, folded or kinked extensively, fracture upon breaking.	49.5	216.5
D-94-15	LIME MUDSTONE, medium grey, 2cm thick among paper shales, fine crystalline, slight folding.	13.5	230
D-94-15A	LIME MUDSTONE, medium grey, continuous limestone bed, not a lens, medium crystalline, calcareous, graptolite collected.	4	234
D-94-15B	LIME MUDSTONE, medium to dark grey, weathers light buff, continuous bed, medium crystalline, concoidal fracture.	4.5	238.5
D-94-16	LIME MUDSTONE, medium grey, continuous bed, fine crystalline, calcite veining, finely laminated shale, cleaved and crenulated.	2	240.5

CASSIAR TERRANE SECTIONS

Moodie Creek Section

Section is located west of the Northern Rocky Mountain Trench along a ridge 1km east of Moodie Creek. Camp was established near an old mining exploration cabin "Ewe Drop Inn", located past the Silurian Siltstone and intrusions (94L/12; 58° 44'N, 127° 33'W). Six kilometers of ridge was walked out, along a ridge trending SW-NE and swinging north toward Cambrian strata (94L/13; 58° 46'N, 127° 33'W) . The section was sampled in three sections, A, B and C.

Sample number	Description	Thickness (m) Sample	Total from Base

Rosella Formation

Outcrops as two resistant, thick bluffs in a col. The occurrence of slates and siltstones below and between the bluffs and extensive quartz veining suggests some minor faulting and repetition of the Cambrian Rosella.

Kechika Formation

Comprises a variety of lithologies and is badly sheared and metamorphosed with minor folding. There are 4 main lithologies: a low grade metamorphic pink and beige, strongly cleaved, sericitic shale with a soapy texture and splinter fracture; orange brown massive bedded dolostone often with quartz veins; compact, green ?volcaniclastic, argillaceous siltstones with some internal shearing; and grey weathered, thin bedded to massive parted limestone beds and dolomitic lime mudstones. The latter is the most common in the middle of the section and is the only lithology that can be sampled.

	Unit 1 Sericitic shale, weathers brown, compact siltstones, and dolomitized veins with zones of quartz veins.	240	240
	Unit 2 Sharp change to black and blue-black graphitic shale, interbedded with grey-brown weathering, argillaceous siltstone. Shale dark in the lowermost 20m and thereafter are blue-silver and predominate the unit. Quartz veining prominent midway through the unit and seems to relate to cores of broad folds and form along small faults. Limestones are rare and all dolomitized, weather buff.	147	387

Unit 3

Similar to the underlying material, mostly shale, but contains more resistant ridges of green-grey siltstone and a few compact limestone beds.

MC-95-C1	LIMESTONE, weathers dark grey, massive beds represented by 1 to 2cm beds with argillaceous partings, recrystallized, contains small augens of dolomite, giving the beds a striped appearance.	33	420

Shale and quartz veins.

MC-95-C2	LIMESTONE, 1 to 2cm isolated bed, not dolomitized completely.	87	507
MC-95-C3	As –C1; 1 to 1.5 m ridge, but metamorphosed into streaky white beds and blebs of calcite and dolomite.	12	519
MC-95-C4	As –C1; single compact bed, 5cm thick within dolomite.	52	571

Interbedded strata weather pink to tan; shale and siltstone weather silver to brown.

MC-95-C5	WACKESTONE, medium grey, weathers grey, 25cm compact bed, medium crystalline, fine lamination.	108	679

This interval is more calcareous with several grey weathering limestone beds.

MC-95-C6	WACKESTONE, medium grey, weathers light grey, compact beds up to 10 to 15cm thick, medium crystalline, laminated.	11	690

Dolomitic interval of platy (1cm) carbonates.

MC-95-C7	WACKESTONE, medium grey, medium crystalline, laminated.	21	711
MC-95-C8	WACKESTONE, light brown-grey to pink, compact bed breaking into 1cm interbeds.	18	729
MC-95-C9	LIME MUDSTONE-WACKESTONE, medium grey, medium crystalline, cores within shale.	21	750
Shale to top of Section C in base of saddle.		25	775
MC-95-B1	LIME MUDSTONE, 20cm bed of 1 to 2cm beds, dolomitic, separated by thin shale partings, weakly calcareous.	90	865

After an interval of sericitic shale, massive beds weather grey and develop large dolomite augen structures with thin dolomite extensions parallel to bedding.

MC-95-B2	LIMESTONE, weathers light grey and pink, massive bed consisting of 1 to 2cm, dolomitic beds, shale partings.	12	877

	Unit 4	81	958
Four dolomite ridges weather orange-brown with prominent quartz veins and interbedded argillaceous dolomitic scree, frost shattered.			
	Unit 5		
Grey shale and weakly calcareous lime mudstone. Grey scree largely covers next flat area before next small ridge of grey weathering siltstone.			
MC-95-B3	LIME MUDSTONE, medium grey, 5cm compact bed with 1cm interbeds, fine crystalline, all slightly folded and overlying grey shale.	1	959
MC-95-B4	LIME MUDSTONE-WACKESTONE, medium grey, 20cm bed, fine crystalline, traces of once fine laminae (recrystallized).	27	986
	Unit 6		
Sequence of brown weathering, splintered shale and siltstones without much resistant outcrop.			
MC-95-B5	WACKESTONE, medium grey, medium crystalline, silty.	16	1002
MC-95-B6	WACKESTONE, medium pink-grey, compact bed breaks into 1 to 2cm interbeds with thin argillaceous partings, recrystallized.	21	1023
	Unit 7		
Sequence includes fissile brown weathering shale, grey competent limestone, and brown weathering, ridge forming siltstones.			
MC-95-B7	WACKESTONE, medium grey, 10cm compact bed, medium crystalline.	13	1036
MC-95-B8	As –B7; finer, 1cm partings.	50	1086
MC-95-B9	As –B7.	20	1106
Major dolostone ridge with extensive white quartz veining.		20	1126
Small gully of argillaceous dolostone, and low siltstone ridge.		16	1142
MC-95-B10	LIMESTONE, medium grey, medium crystalline, oolite-like metamorphic texture.	3	1145
MC-95-B11	As –B10.	29	1170
	Unit 8	121	1295
Siltstone produces ridges, weather grey, serecitic shale weather buff; thin siltstone, dolostone and quartz veining throughout interval.			
MC-95-B12	LIMESTONE, weathers light grey to blue grey, 50cm package, medium crystalline, laminated, "oolitic".	2	1297

	Unit 9 Dominated by green-grey siltstone interspersed with recessive intervals of shale and siltstone, weather buff.	25	1322
MC-95-B13	LIMESTONE, light grey, medium crystalline, serecitic, micaceous fabric.	123	1445
MC-95-B14	LIME MUDSTONE-WACKESTONE, medium grey, parts into 1cm beds, fine to medium crystalline, recrystallized.	27	1472
	Unit 10 Interval of dolostone, weathers orange-brown, less siltstone and recessive regions of shale and limestone.	57	1529
MC-95-B15	As –B14.	53	1582
MC-95-B16	LIME MUDSTONE-WACKESTONE, medium grey, weathers dark grey, top 5cm of 50cm bed, parting into 1 to 2cm interbeds, recrystallized.	58	1640
MC-95-B17	As –B16; 15 cm bed within brown shale.	23	1663
	Unit 11 Resistant grey-brown siltstones (volcaniclastic or metamorphosed by carbonatite), and separated by recessive buff splintery shale and siltstone and some dolostone ridges.	36	1699
MC-95-B18	As –B16; a 10cm bed.	21	1720
MC-95-B19	WACKESTONE, light brown grey, weathers brown-grey to orange, medium crystalline, dolomitic, mildly calcareous.	28	1745
MC-95-B20	As –B19; 50cm bed.	21	1769
	Recessive shale and siltstone.	171	1940

Road River Group

Gradational contact with Kechika, base chosen as second crag or small cliff running off to west as a separate spur between 2 valleys. Comprises cleaved, grey and brown shale and recrystallized limestone and dolostone.

Unit 1

Dark grey shale, weathers light brown, phyllitic, cleaved and locally foliated. Dolostone, compact beds, weathers brown, resistant, recrystallized beds of silty limestone/ dolostone, coarsely crystalline or replaced secondarily, sometimes folded, contain shale partings. Metamorphosed due to local igneous activity (aureole).

MC-95-A1	SILTSTONE, medium grey, weathers light brown-orange, 3cm bed, swells to 8cm, dolomitized at one end.	1	1941
MC-95-A2	SILTSTONE, medium grey, weathers brown, 2cm bed, slightly	9	1950

	calcareous, augens of dolomite, almost gneissic texture, cut by dolomite veins.		
MC-95-A3	As –A2; 3cm bed, breaking into flaggy bits.	3	1953
Pale brown-white vein and white-green weathering dolomite.		3	1956
Slaty shale, weather light brown and dark grey.		6	1962
First cliff of more resistant beds, slate continues over cliff, dark shale partings continue into orange weathered shale/slate.			
MC-95-A4	MUDSTONE, medium grey, weathers brown, 1cm bed, argillaceous.	3	1965
MC-95-A5	MUDSTONE, medium grey, weathers brown-orange, 1-3cm bed.	15	1980
Dolomitic vein about 1m thick, weathers white-green.		1.5	1981.5
Unit 2 Color change to black shale, prominent in the bluff face in the valley below to the east. There are frost heaved striped beds.		4.5	1986
MC-95-A6	LIME MUDSTONE, dark grey, weathers grey-buff, 50cm thick, silty, fine laminae (1mm).	2.5	1988.5
Black shale, 8m thick with orange, argillaceous vein close to top. Above these are flaggy, dolomitic shale and thicker competent brown dolomitic beds, weather buff to orange.		7.5	1996
MC-95-A7	DOLOSTONE, medium grey, 10cm thick, laminated, silty, slightly calcareous, splintery breakage.	2	1998
Zone of alteration here, replacement. Prominent dolostone vein, weathers white-dark orange is overlain by siltstone and blue-grey shale (all slightly metamorphosed).		6	2004
Dark shale, bands of silty dolostone, white, weathers light orange.		4.5	2008.5
Dolostone, 3m thick.		1.5	2010
Unit 3 Dark black slaty shale and dolostone, weathers orange.		10.5	2020.5
Silty dolostone, pink and grey.		9	2029.5

Sandpile Formation

Orange weathering silty dolostone.

Deadwood Lake Section

Section was reached by driving south on Highway 37 from Watson Lake to Centerville and fly camping at the southwest end of Deadwood Lake (104P/1; 59° 01'N, 128° 23'W) in a cleared area east of a major creek in which the section is exposed. The creek runs almost north-south and bends to the southwest to drain into the southernmost tip of the lake. Measurements and collections began just above tree line.

Sample number	Description	Thickness (m) Sample	Total from Base
	Kechika Formation, Unit 1		
	Comprises grey, thin bedded limestone and cleaved, folded grey shale, weathers light grey and buff, veining.		
DL-96-1	WACKESTONE, medium grey, weathers light grey-buff, 1-3cm bed, dense and compact.	3	3
	Collecting on the east side of the creek bed and will need to cross to get continuous outcrop. Through a largely shale interval.		
DL-96-2	WACKESTONE-PACKSTONE, medium grey, weathers light grey-buff, 3cm.	10	13
DL-96-3	As –2; nodular and discontinuous.	15	28
	Interval of light grey-buff calcareous shale.		
DL-96-4	WACKESTONE, medium grey, weathers light grey-buff, 1-3cm beds, discontinuous nodules.	12	40
DL-96-5	WACKESTONE-PACKSTONE, medium grey, weathers light grey-buff, 10cm interval of 1-2cm beds, veining.	25.5	65.5
	Road River Group		
	Distinguished by dark grey weathering, comprises several units which have gradational contacts.		
	Unit 1 Lenticular limestone and shale, weathers orange-grey. Largely shale/slate, weathers orange-buff, in packages up to 1m thick, with lenses of wackestone-packstone, weather light grey.	1	66.5
DL-96-6	PACKSTONE-GRAINSTONE, medium grey, weathers black, 5-10cm bed, coarse crystalline.	12.5	79
DL-96-7	GRAINSTONE, medium grey, weathers dark grey, 25cm thick bed, coarse crystalline.	17	97

DL-96-8	WACKESTONE, light grey, weathers light grey, 1-2cm beds, medium crystalline.	10	107
DL-96-9	WACKESTONE, dark grey, weathers light grey, 1.5cm compact bed, laminated.	30	137
Increased amount of lenses, more continuous within orange shale.			
DL-96-10	WACKESTONE-PACKSTONE, medium grey, weather light grey, 0-3cm thick, 4cm long lenses.	10	147
DL-96-11	As –10; 1-2cm thick continuous lens.	10	157
DL-96-12	As –11.	15	172
Section on west side of creek bed is faulted, continue collecting on east side.			
DL-96-13	As –11.	9	181
Unit 2 Quartzite, grey, weathers light orange cut by quartz veins and interbedded with dolostone.		1.5	182.5
Quartz vein, 7.5m thick.		7.5	190
Black slate, weathers orange, 1-2cm beds of dolostone.		16.5	206.5
Covered interval of black slate.		24	236.5
Quartzite outcrop, grey, weathers bright orange-red, massive bedded, interbedded with black slate at meter-scale intervals.		6	242.5
Top of quartzite-slate unit.		55.5	298
Unit 3 Covered interval of orange lichen covered siltstone, grey, weathers brown-black and buff, medium to thick bedded, dolomitized, black slate interbeds: largely black slate talus. In west cliff face, see beginnings of more limestone beds, weather light buff and folded.		18	316
Black slate and buff dolomitic siltstone.			
DL-96-14	LIME MUDSTONE-WACKESTONE, medium grey, weathers orange-buff, 5cm bed, folded.	21	337
DL-96-14A	LIME MUDSTONE, medium grey, weathers buff, 6cm bed, fine crystalline, slate partings.	13.5	350.5
Unit 4 Bedded limestone, grey, continuous and interbedded with 30-50% slate. Collected on east side of creek. Slate becomes less abundant up section.			
DL-96-15	WACKESTONE, medium grey, weathers buff, 10cm bed.	9	359.5

DL-96-16	GRAINSTONE, medium grey, weathers buff, top 3cm of 20cm bed, allochems are bryozoans and graptolites.	10	369.5

Limestone beds 10-25cm thick, slates as 10cm interbeds and meter-scale intervals.

DL-96-17	GRAINSTONE, medium grey, weathers buff, 10cm thick.	4.5	375
DL-96-18	As –17.	13.5	388.5
DL-96-19	PACKSTONE, medium grey, weathers buff, 10cm bed, medium crystalline, laminated.	10	398.5

Crossed back to west side of creek bed.

DL-96-20	PACKSTONE-GRAINSTONE, medium grey, weathers buff, 5-10cm interval of 2 beds.	9	407.5

Largely grey limestone, only cm-scale slate interbeds.

DL-96-21	GRAINSTONE, medium grey, weathers medium grey, top 5cm of 20cm bed.	10	417.5
DL-96-22	As –21; 15cm bed.	10	427.5

Less than 5% slate, uniform bedding of grey weathered limestone. Chert nodules and some undulatory, discontinous interbeds.

DL-96-23	PACKSTONE-GRAINSTONE, medium grey, weathers medium grey, 5cm bed, dense.	10	437.5
DL-96-24	PACKSTONE, medium grey, weathers light grey, 5cm bed, dense, laminated.	10	447.5

Beds are up to 25cm thick and undulatory, chert nodules, abundant grainstones with black weathered allochems, trilobitic, bryozoans.

DL-96-25	PACKSTONE-GRAINSTONE, medium grey, weathers buff, 1-3cm bed.	10	457.5
DL-96-26	GRAINSTONE, black, weathers dark grey, 10cm bed, black allochems.	10	467.5

Buff interval, beds are more fine crystalline, up to 20cm thick..

DL-96-27	BRECCIA, clasts of packstone and lime mudstone intraclasts, dark grey, weathers dark grey, 4cm bed.	11	478.5

Back to east side of creek, more argillaceous beds, weather buff.

DL-96-28	PACKSTONE, medium grey, weathers buff, 3cm bed, dense, fossiliferous.	7	485.5

Covered interval, to top of Road River.

DL-96-29	LIME MUDSTONE, medium grey, weathers buff and light orange, 25cm bed, fine crystalline.	8.5	494

Ramhorn Formation

Disconformably overlies the Road River; dolostone, light grey, weathers light orange. massive bedding. Walked out the unit, but not measured. Other lithologies include dark grey, veined, blocky dolostone, and uppermost brecciated dolostone, weathers light grey.

Mount McDame Sections

From the Cassiar-Stewart Highway 37 south, turned west at the sign "Jade Lake 2km". The road continued to the town of Cassiar, now abandoned. Collected in two creek beds of the west face of Mt. McDame (104P/5; 59° 17'N, 129° 47'W). One creek is the one located farthest west on Mt. McDame, and was collected as Section A. Section B was collected in a second major creek about 1 km east from Section A. To get to both, crossed the creek running north-south on the east side of town.

Sample number	Description	Thickness (m) Sample	Total from Base
	Section A, Road River Group		
	Walked up the creek bed for 30 minutes and started measuring at brown and black outcrop; small limy beds and nodules weather grey, within black shale, weathers black.		
	Unit 1 Basal part of section where small waterfalls begin. Nodular limestone, weathers blue-grey, interbedded with black shale.	12	12
C-95-A1	LIME MUDSTONE, dark grey, weathers blue-grey, nodules over a 20cm interval, laminated.	10	22
Covered interval.		18	40
	Unit 2 Compact and cooked nodular limestone weather medium grey within black shale.		
C-95-A2	LIME MUDSTONE, dark grey, weathers medium grey, 10cm thick bed and nodule (bits), mildly calcareous.	4.5	44.5
C-95-A3	LIME MUDSTONE, dark grey, weathers medium grey, nodule about 4cm thick, 12cm long, fine to medium crystalline, finely disseminated pyrite.	1	45.5
C-95-A4	LIME MUDSTONE, medium grey, weathers medium grey, lens about 6cm wide and 24cm long.	8.5	54
C-95-A5	As –A4, but large lens body continuous across creek about 0.5m across, quartz vein through it.	0.5	54.5
C-95-A6	As –A4; lens about 3cm thick, 6cm wide.	12	66.5
C-95-A7	As –A4; lens about 10cm wide and thick, 30cm long.	12	78.5
C-95-A8	As –A4; lens about 2cm thick, jutting out of lighter grey weathering shale.	6	84

Intrusive body (dioritic, fine grained), weathers green.		17.5	101.5
C-95-A9	As –A4; lens 6cm thick, 10cm wide, with recrystallized veins of coarser crystalline material and pyritic veins.	8	109.5
Dike, weathers pink-dark grey, quartz veining.		9	118.5
	Sandpile Group	8	127.5
Sand bodies, 4m thick (uppermost one). First occurrence is grey weathered, fine grained, sandstone, weakly calcareous with quartz veining, weathers grey-buff. Interbedded with dark grey platy shale.			
To white quartz (not in place) in north cliff.		14	141
Covered interval to another quartz body in south face.		63	204

Sample number	Description	Thickness (m) Sample	Total from Base

Section B, Road River Group, Unit 1

As Section –A; lenses of resistant lime mudstone within cooked black shale. Base of outcrop has lenses, folding and white veining.

C-95-B1	LIME MUDSTONE, dark grey, weathers blue-grey.	1.5	1.5
C-95-B2	LIME MUDSTONE, dark grey, weathers blue-grey, lens about 1.5cm thick and 15cm long.	1	2.5
Covered interval.		9	11.5
To next outcrop forming a waterfall. At the top of the waterfall, the green pile of the asbestos tailings is visible.		6	17.5
C-95-B3	As –B2; 8cm long, 15cm wide, quartz veining.	6	23.5
Black shale.		2	25.5
Covered interval.		12	37.5
C-95-B4	As –B2; a larger lens about 10cm wide and thick; beds may be caught up in microfolds.	0.5	38
C-95-B5	LIME MUDSTONE, medium grey, weathers medium grey, bed about 30cm across, laminated, a bit more argillaceous than	9	47

	others, breaking up into platy bits, deformational features.		
C-95-B6	LIME MUDSTONE, dark grey, weathers dark grey, a 30cm thick series beds, some resistant nodules.	24	71
Outcrop is rubbly and folding in veins is evident.			
C-95-B7	LIME MUDSTONE, dark grey, weathers brown, thin bedded, finely laminated within little folds, veining, argillaceous.	35	106
Unit 2 Base of large waterfall made of highly folded, massive, argillaceous, lime mudstone and shale.		15	121
C-95-B8	LIME MUDSTONE, dark grey, weathers buff, massive but breaks into thin beds, argillaceous, folded with quartz veining.	10	131
To a small waterfall about 2m high.		69	200
To another 2m waterfall. A shaly interval with much more outcrop exposed than Section A, however, the limestone beds are not as pristine.		17	217
C-95-B9	LIME MUDSTONE, medium grey, weathers brown 2cm bed, fine crystalline, dolomitic.	2	219
Sandpile Formation		51	270
Sandstone, siltstone and shale intervals. Sands are dolomitic, weather orange-grey. Massive sand bodies.			
C-95-B10	LIME MUDSTONE, medium grey, weathers orange-brown, 20cm interval, argillaceous.	33	303
Sand body, coarse clasts weather out, 2cm long, polymictic, weathers buff-green.		1	304

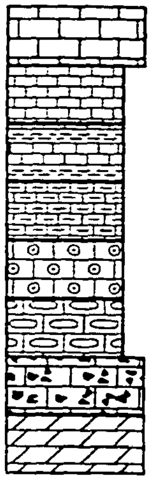
APPENDIX B

Appendix B contains stratigraphic logs and conodont zonations of the 12 sections described in Appendix A. Conodont sample numbers are given to the right of the log and are not always in consecutive order due to methods in which ridge sections were measured and sampled in segments. The ranges of conodont taxa are plotted to the right of each log. The height in metres above the base of the section for each sample is given in Appendix A.

Appendix B contains the following:

Appendix B-1-1 to B-1-5	Section #13
Appendix B-2	Section #1
Appendix B-3-1 to B-3-2	Section #5
Appendix B-4-1 to B-4-4	Grey Peak Section
Appendix B-5-1 to B-5-2	Section #4
Appendix B-6	Driftpile Section
Appendix B-7	Road River Core
Appendix B-8	Bluff Creek Section
Appendix B-9	Gataga Mountain Section
Appendix B-10-1 to B-10-2	Moodie Creek Section
Appendix B-11	Deadwood Lake Section
Appendix B-12	Mount McDame Sections A & B

Legend to Accompany Appendix B



thick to massive limestone

thin limestone

limestone and shale

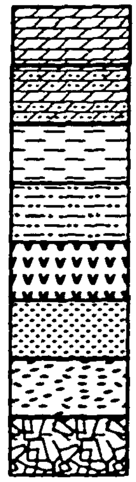
argillaceous limestone/
shaly limestone

oolitic limestone

nodular limestone

limestone breccia

thick to massive dolostone



thin dolostone

silty dolostone

shale or phyllite

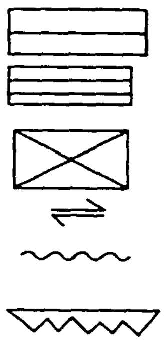
siltstone

volcanics

quartzite or sandstone

chert (lenses, nodules or bedded)

veining or brecciation



Thick to massive bedded

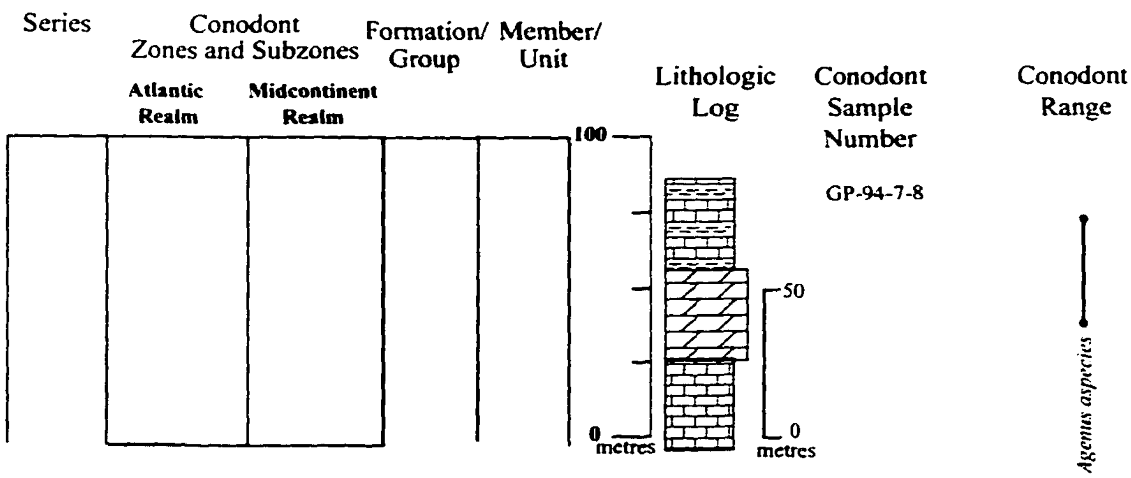
Thin to medium bedded

Covered interval

Fault contact

Unconformity

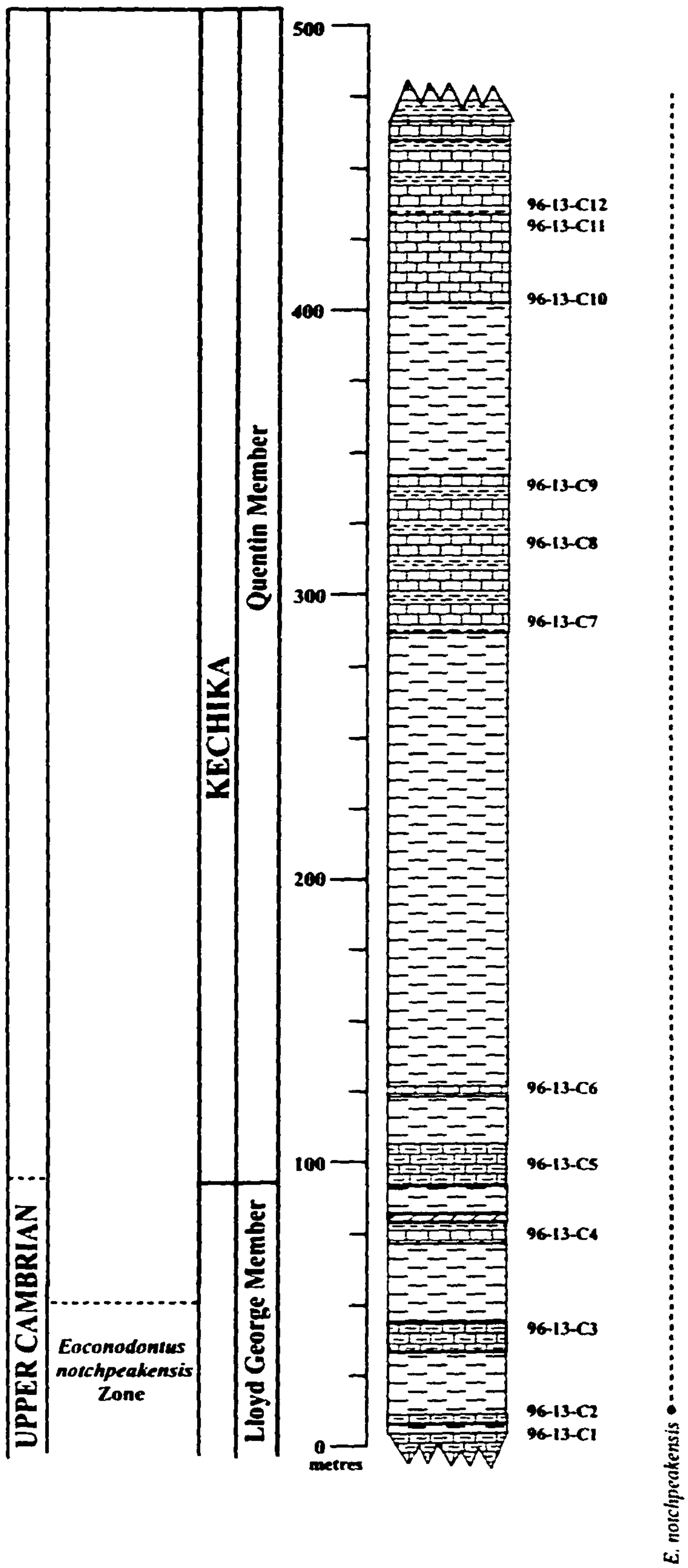
Section break



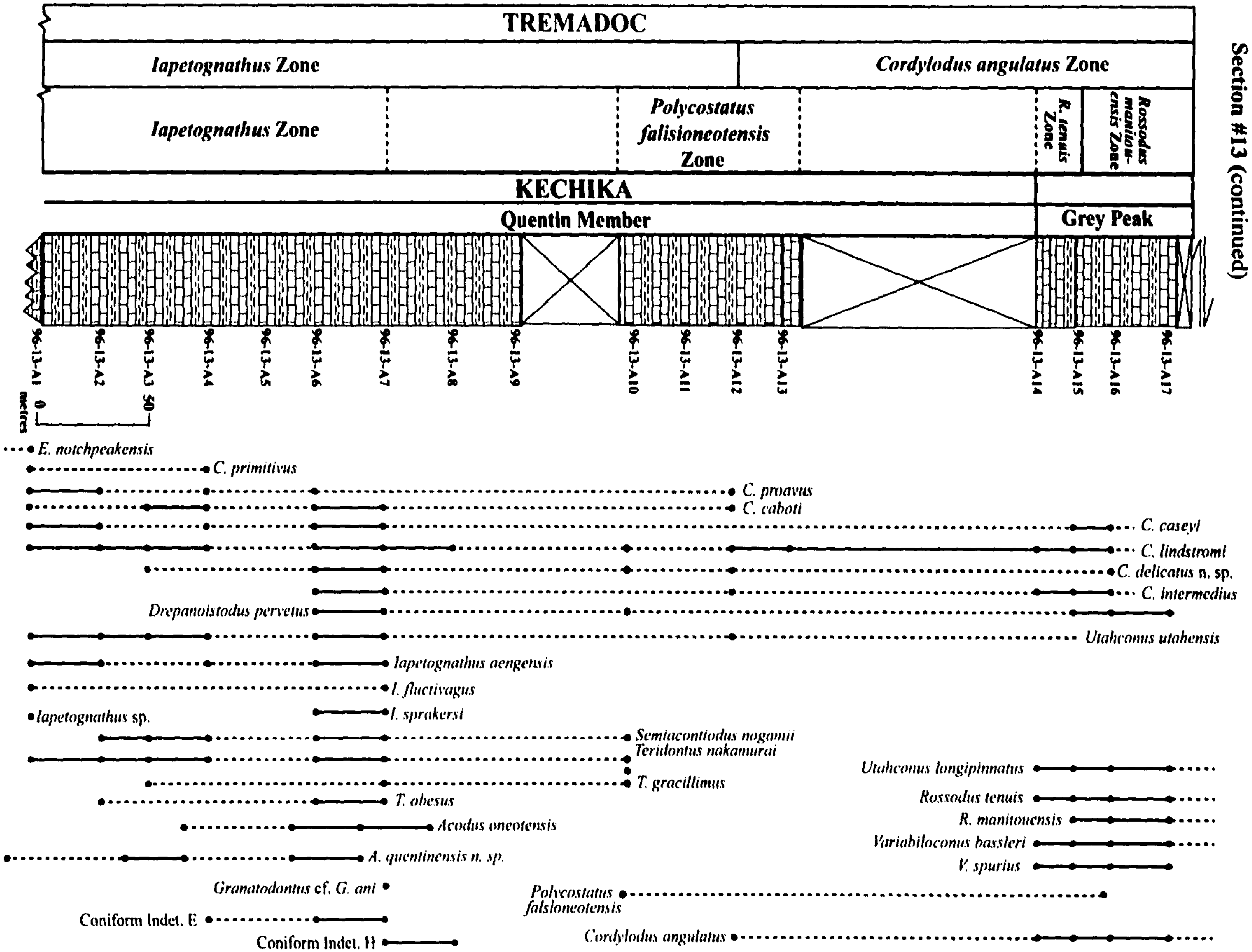
Note: Sample number abbreviates the locality (see Fig. 1) and the year collected. Numbers are not always in consecutive order due to methods in which ridge sections were measured and sampled in segments (numbered or lettered). E.g., 96-13-A1 is Section 13, 1996, sample 1 of segment A.

Appendix B-1-1

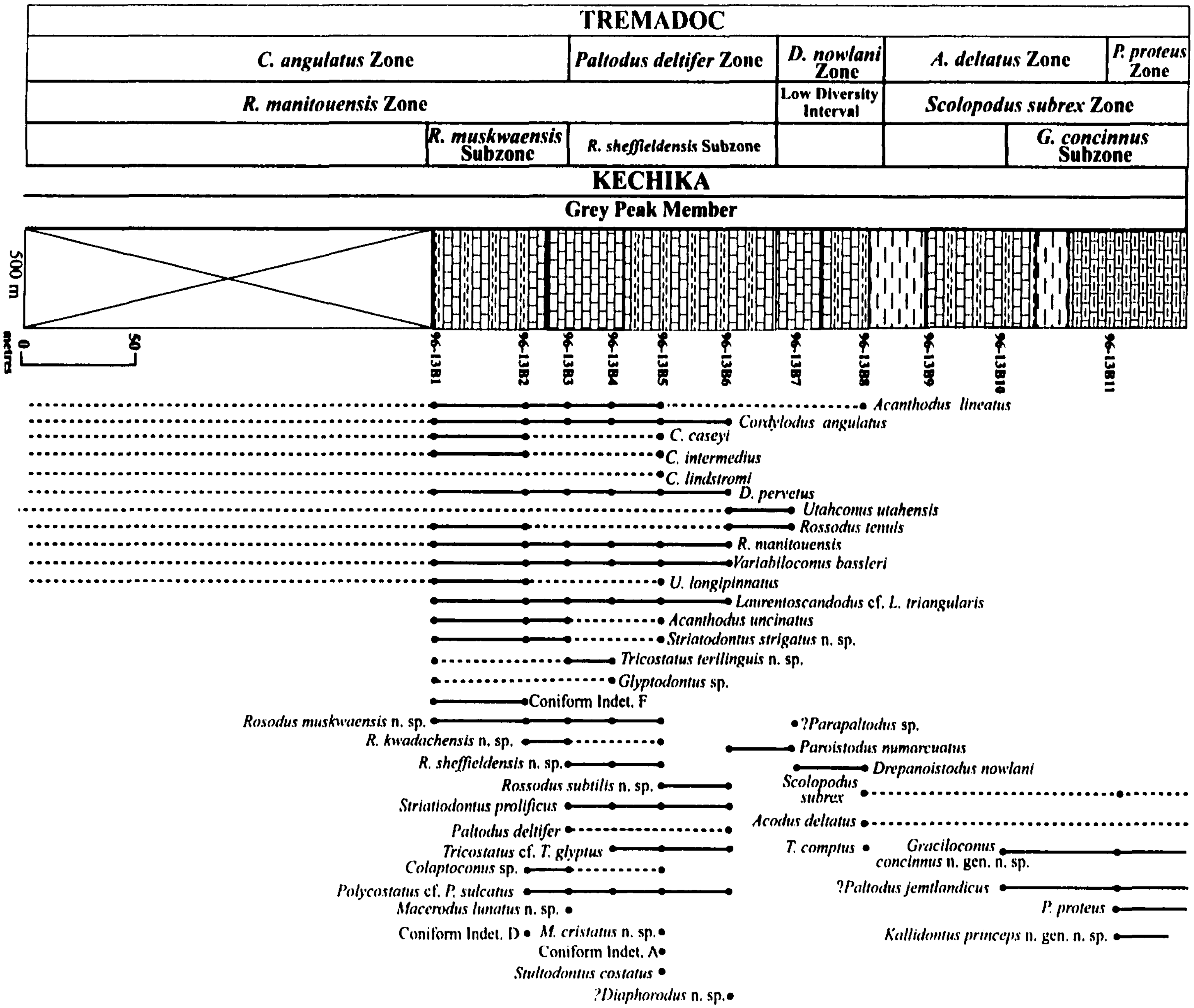
Section #13 (of Cecile and Norford, 1979)
57° 42'N, 124° 35'W
(Section located 4km SW of Mt. Sheffield, trending east-west toward two glacial lakes to the west)



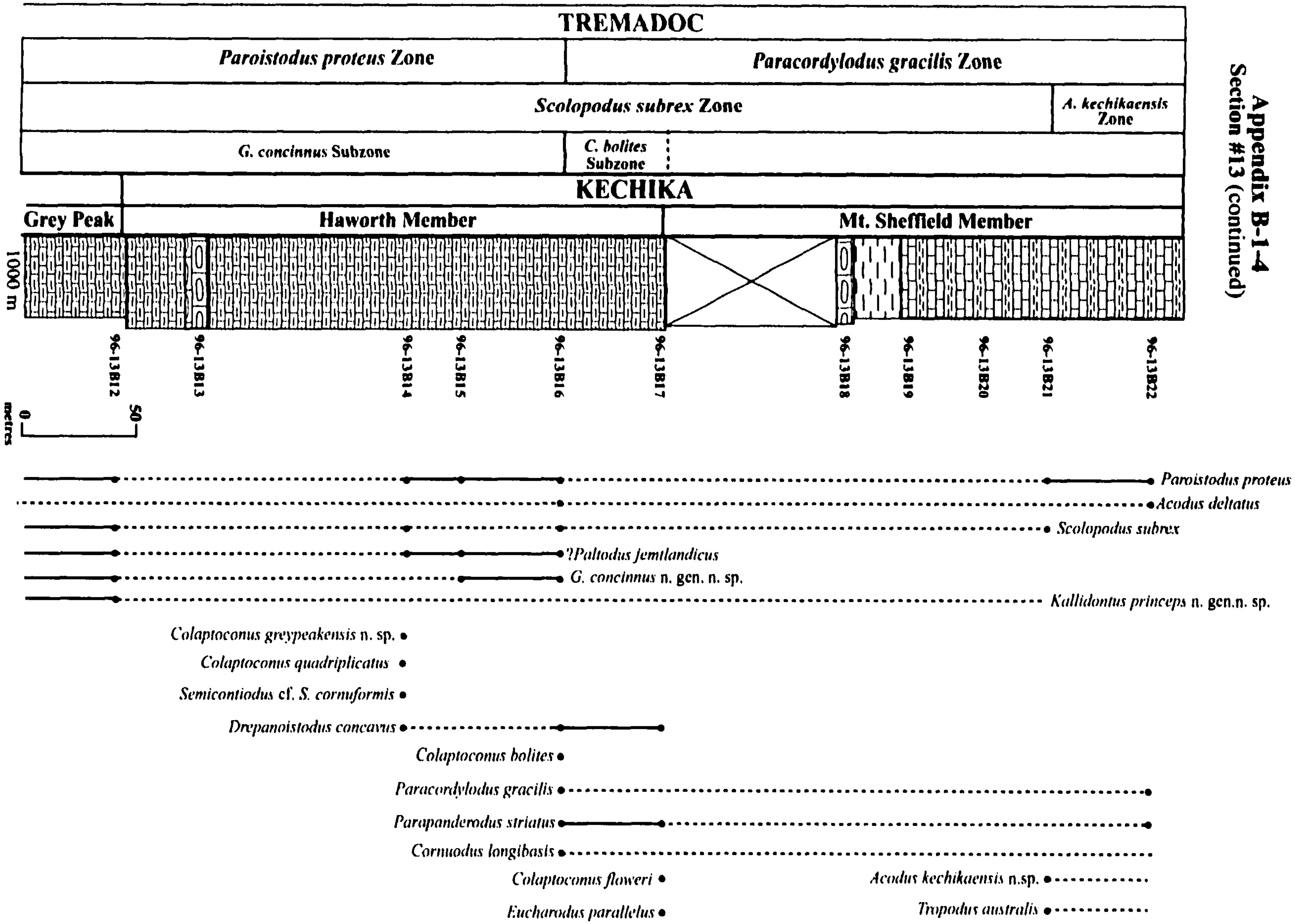
Appendix B-1-2
Section #13 (continued)



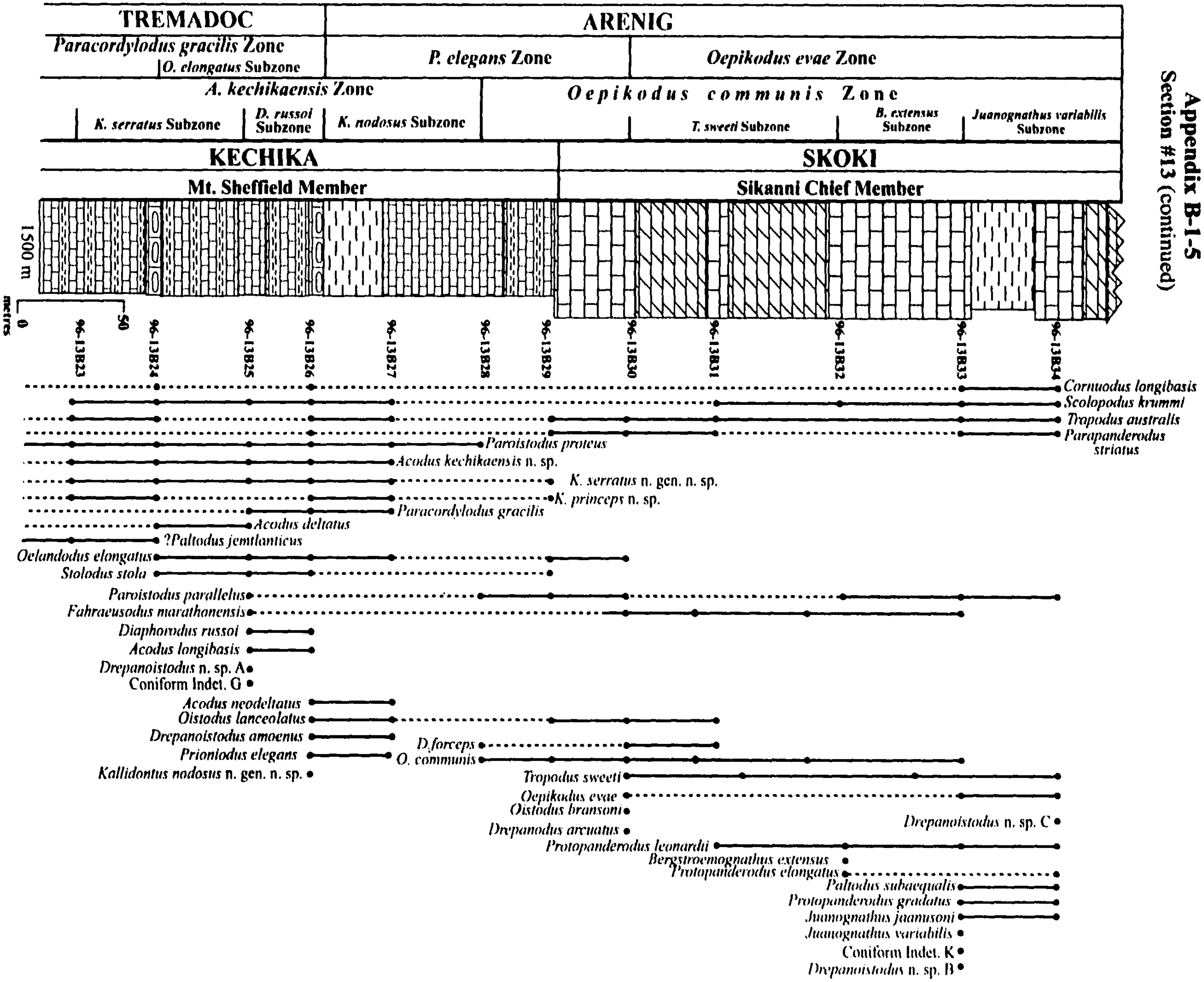
Appendix B-1-3
Section #13 (continued)



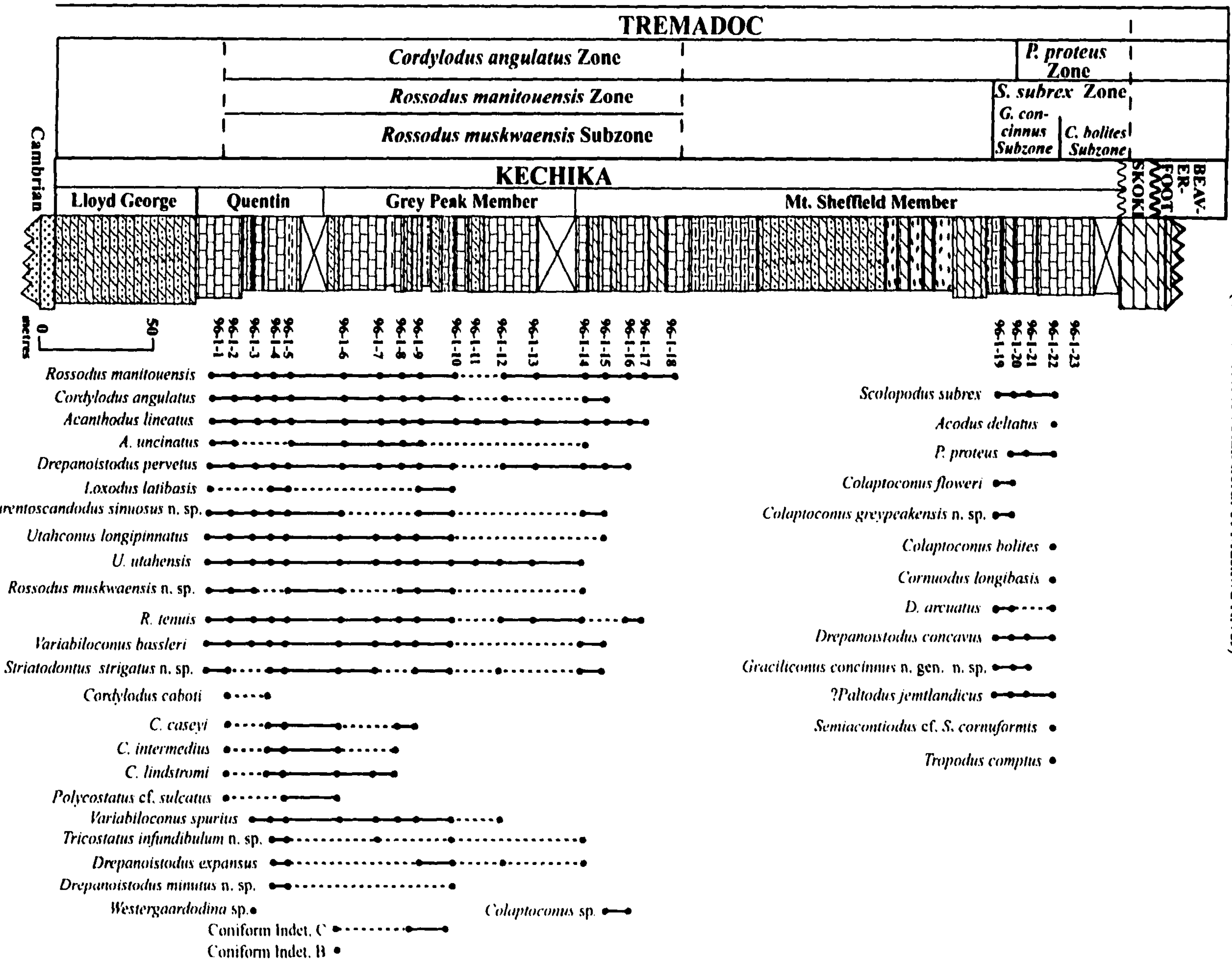
Appendix B-1-4
Section #13 (continued)



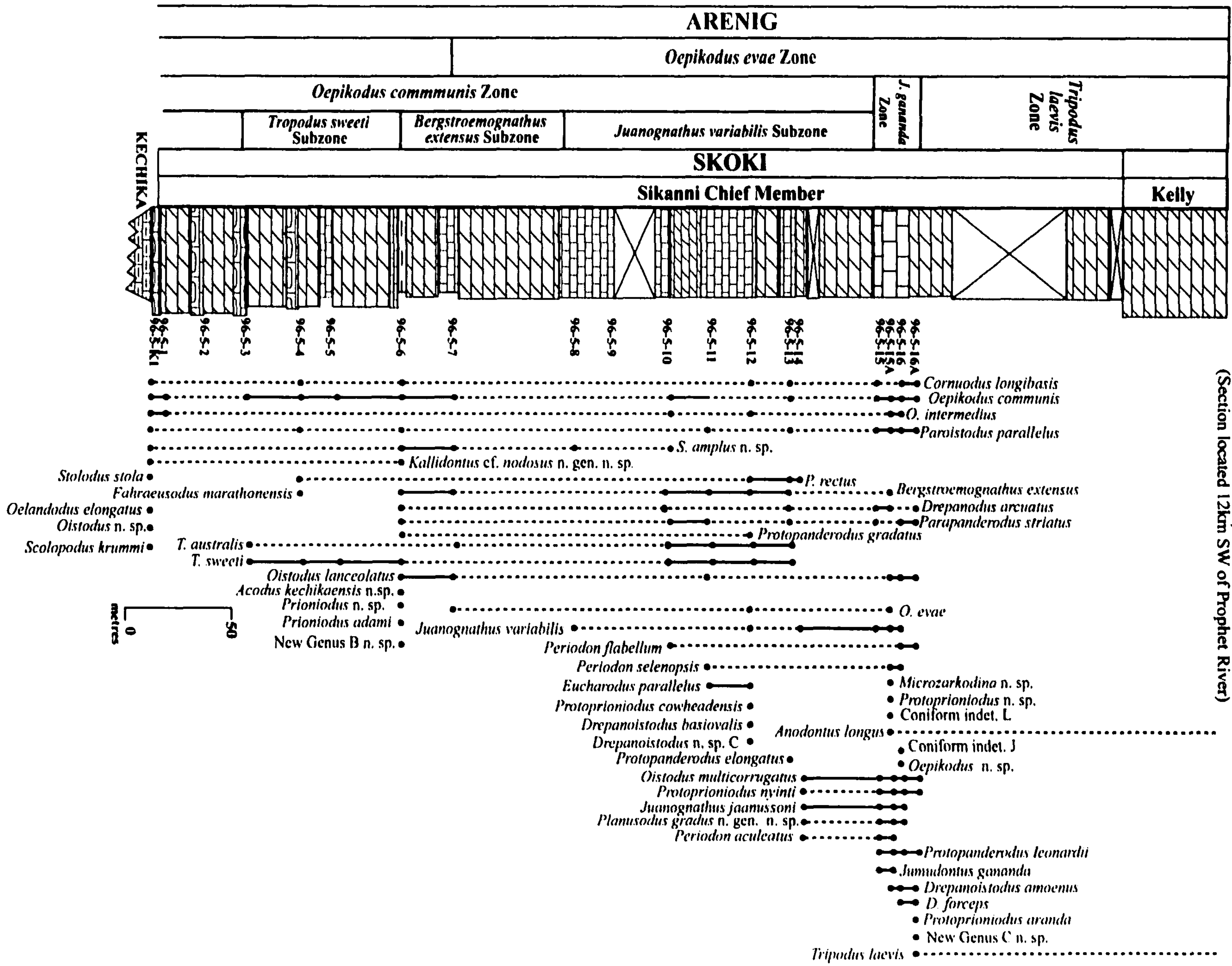
Appendix B-1-5
Section #13 (continued)



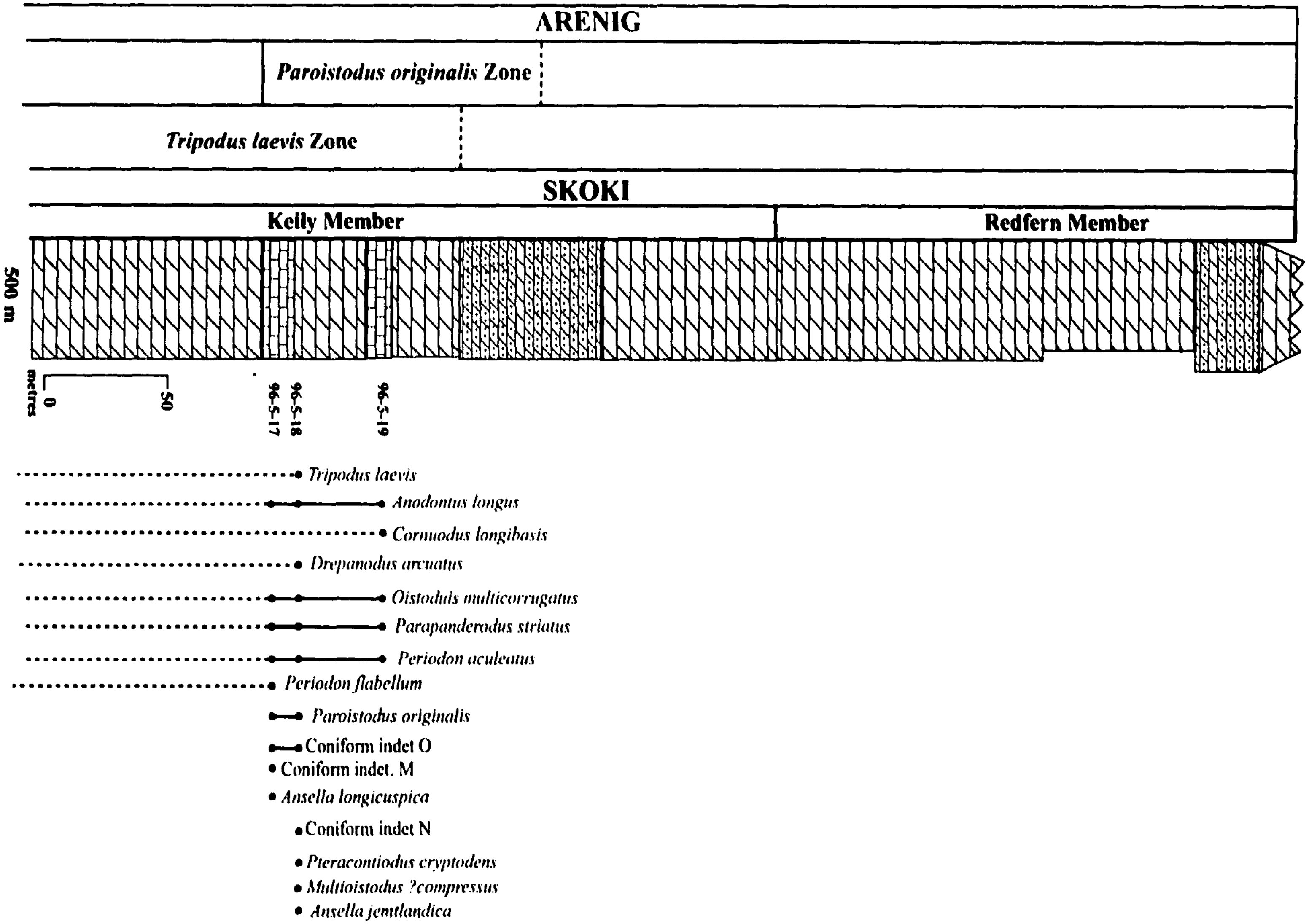
Appendix B-2
Section #1 (of Cecile and Norford, 1979)
57° 52'N, 124° 05'W
(Section located 5km north of Muskwa River)



Appendix B-3-1
Section #5 (of Cecile and Norford, 1979)
57° 30'N, 124° 26'W
(Section located 12km SW of Prophet River)



Appendix B-3-2
Section #5 (continued)

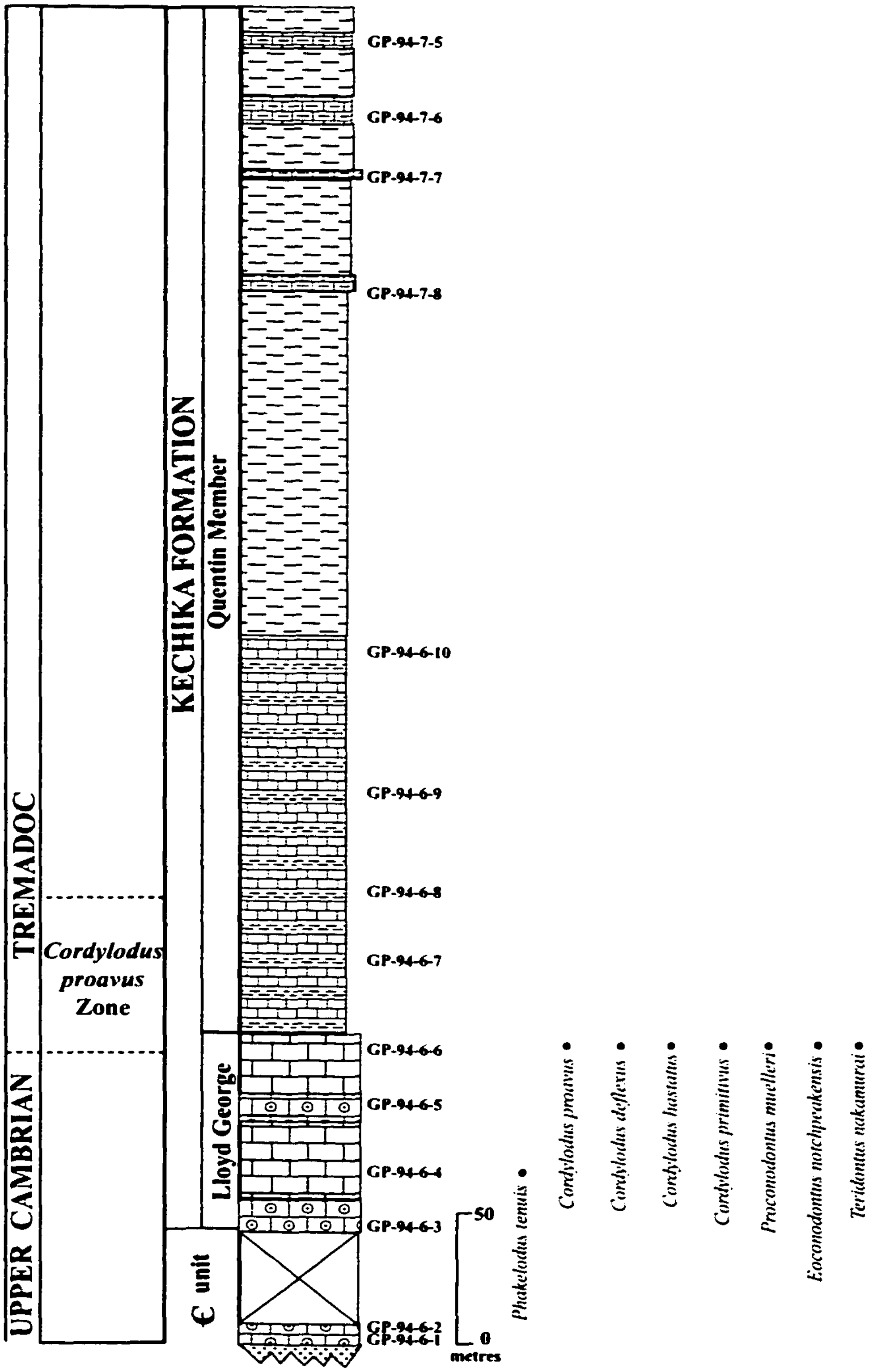


Appendix B-4-1

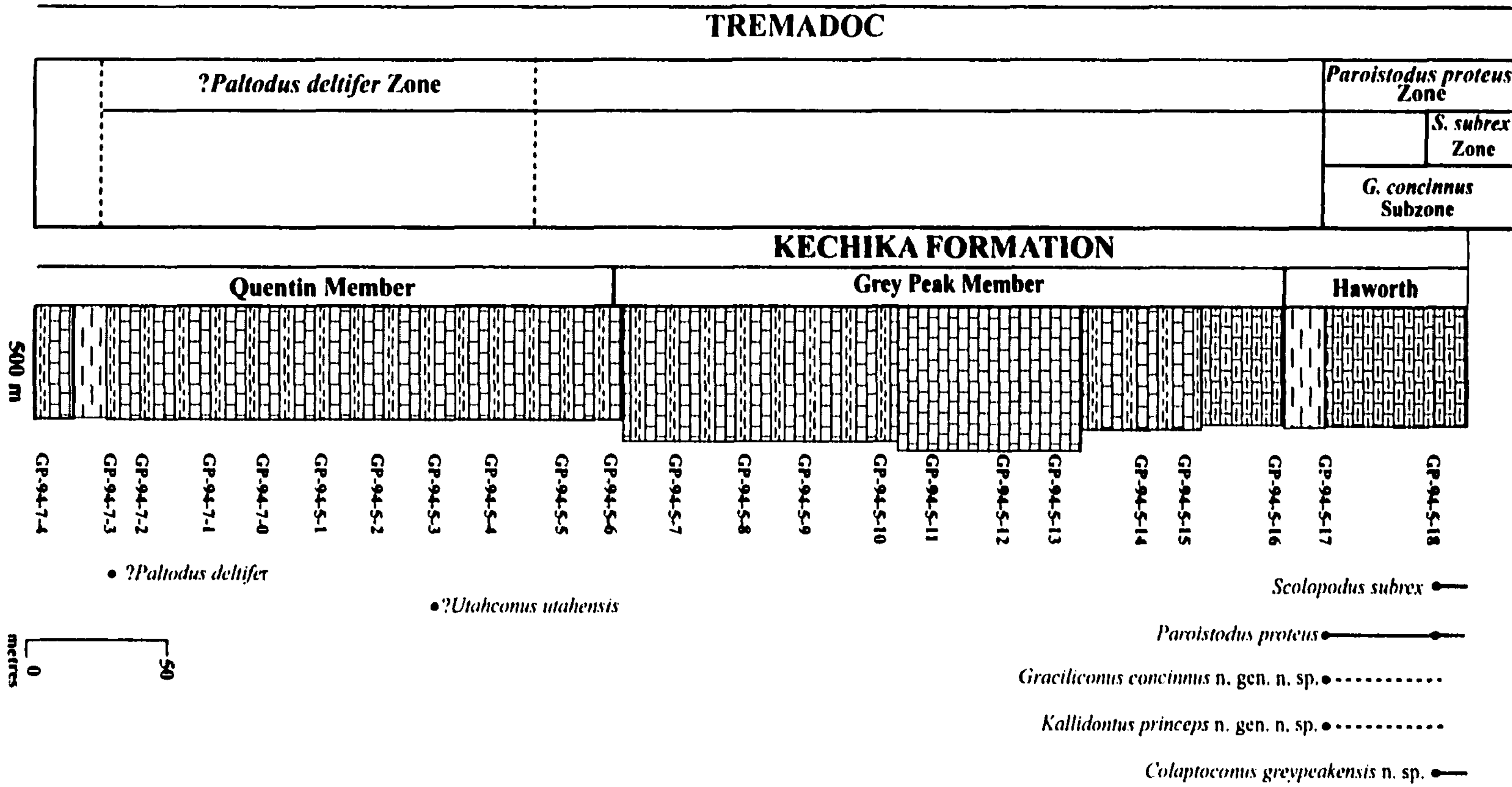
Grey Peak Section (Section 11 of Cecile and Norford, 1979)

57° 48'N, 125° 13'W

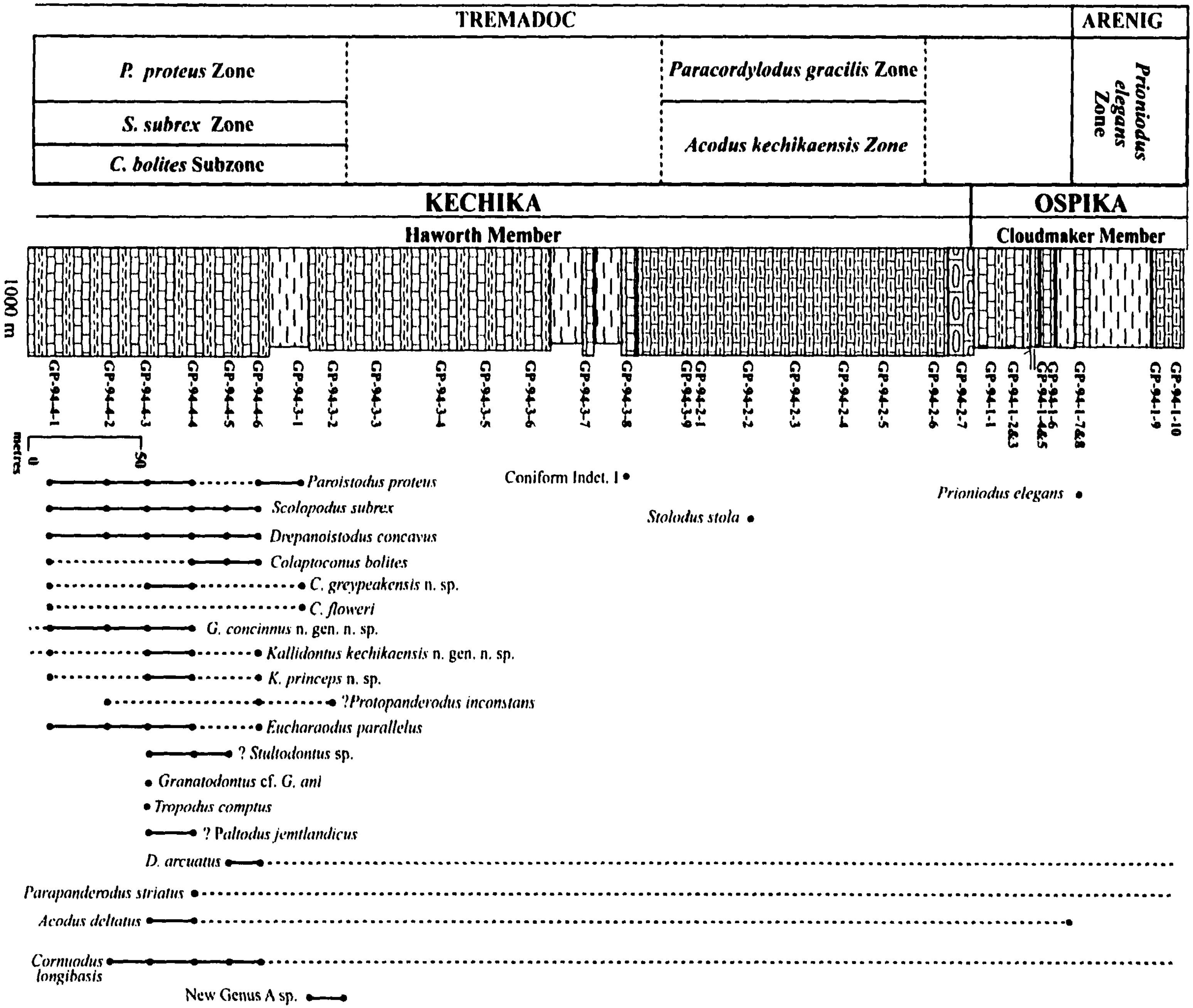
(Ridge section collected from creekbed SW of base of secondary peak of Grey Peak, north up spur of peak and east alongwest-east trending section of ridge)



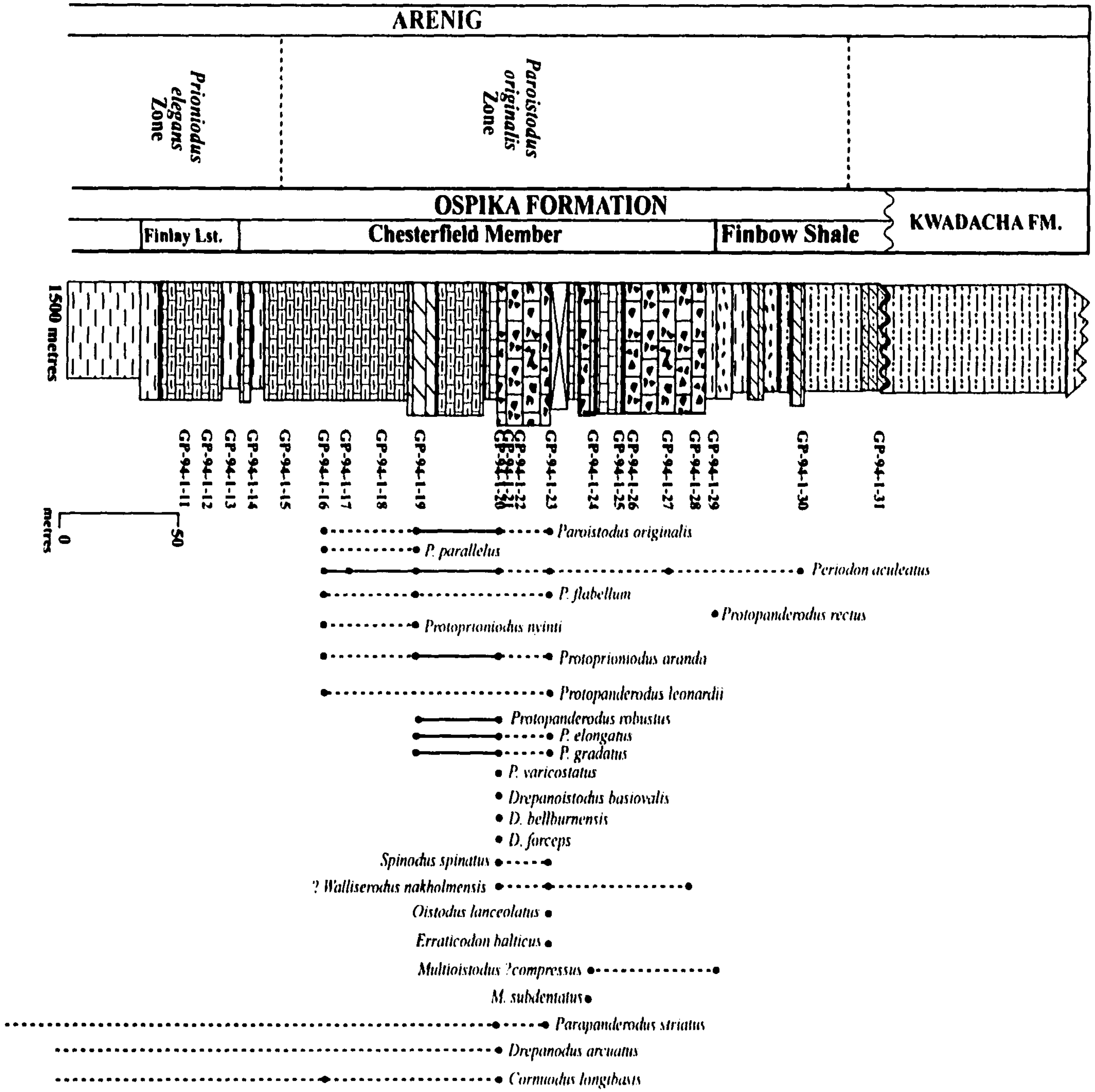
Appendix B-4-2
Grey Peak Section (continued)



Appendix B-4-3
Grey Peak Section (continued)



Appendix B-4-4
Grey Peak Section (continued)

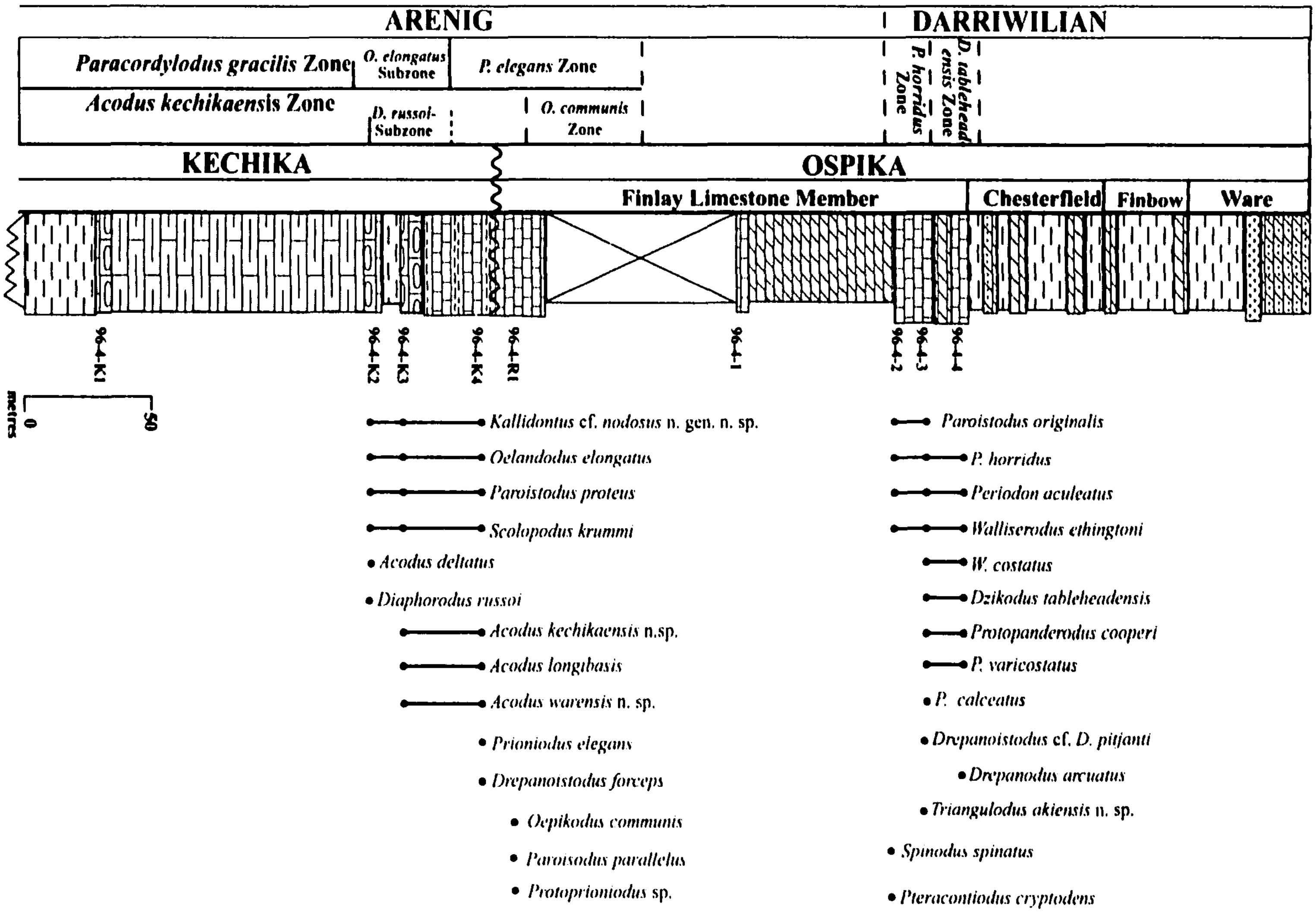


Appendix B-5-1

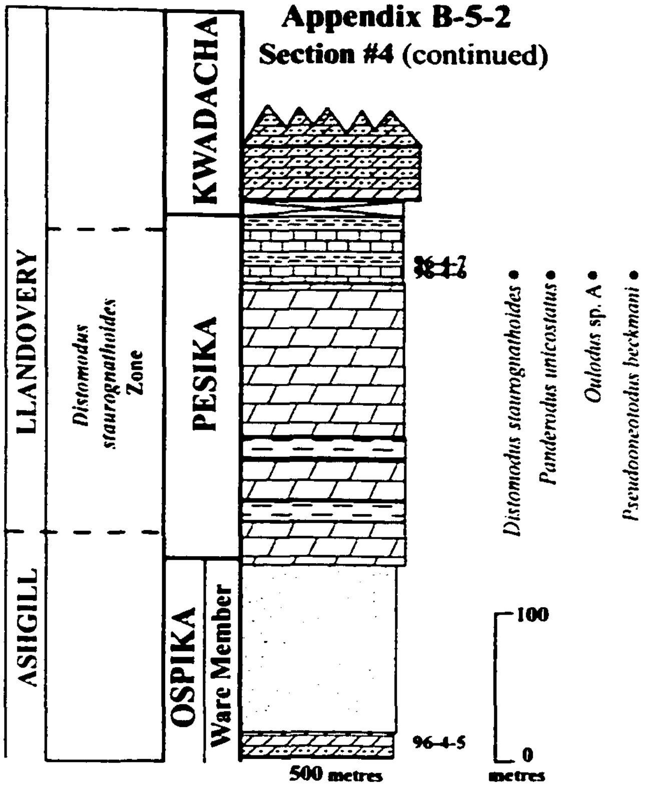
Section #4 (of Cecile and Norford, 1979)

57° 26'N, 124° 35'W

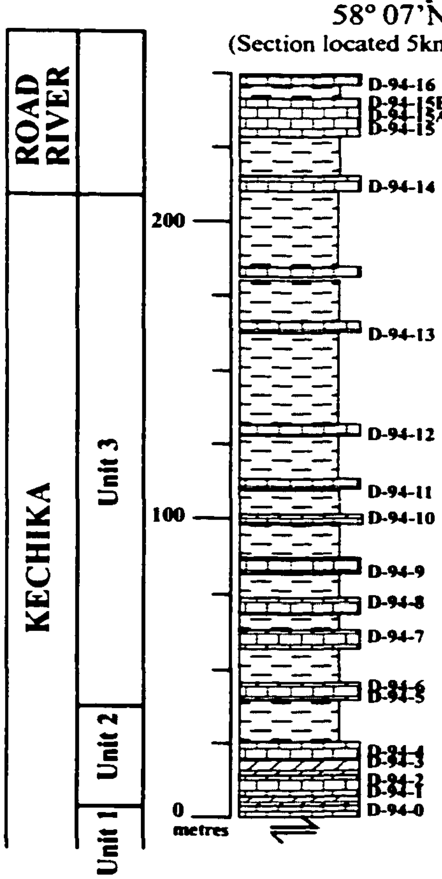
(Ridge section located about 8km north of Akie River, ridge section trends NE-SW)



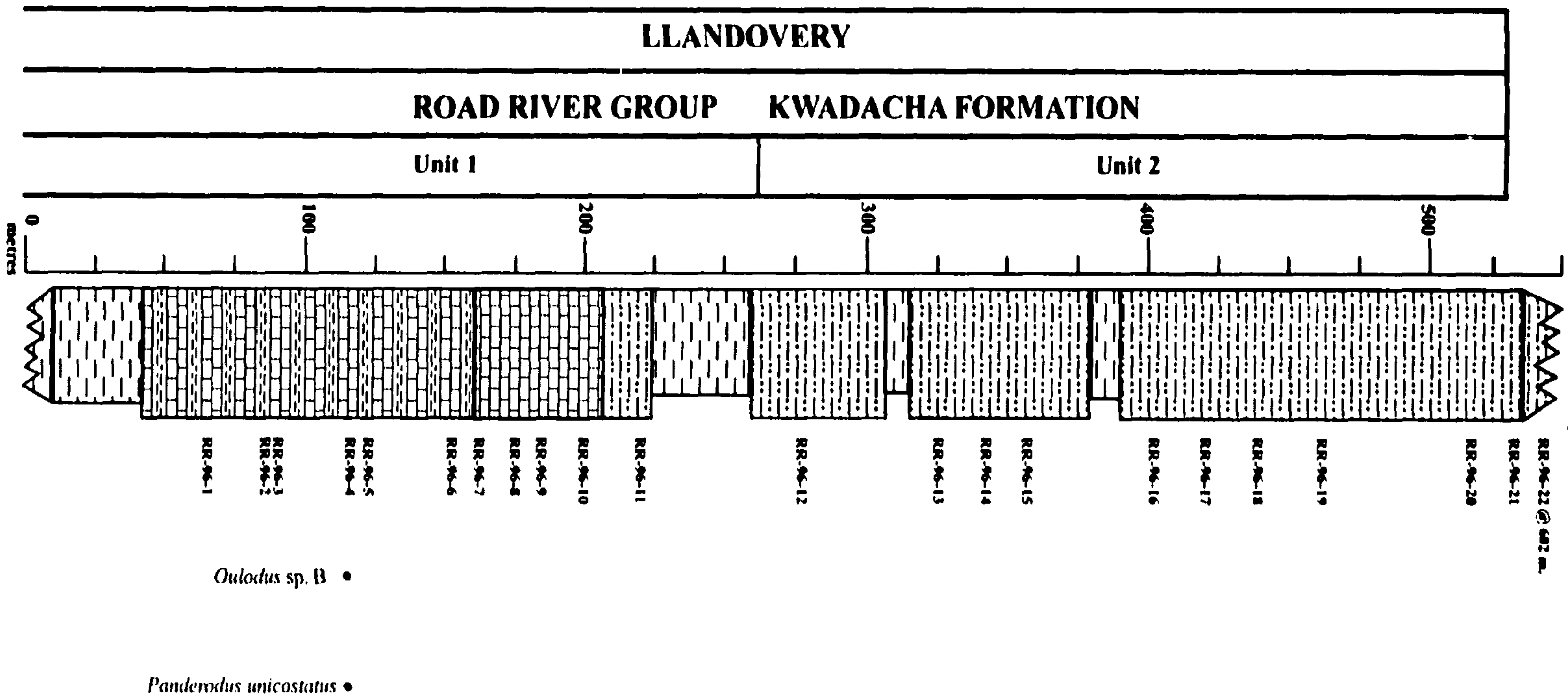
Appendix B-5-2
Section #4 (continued)



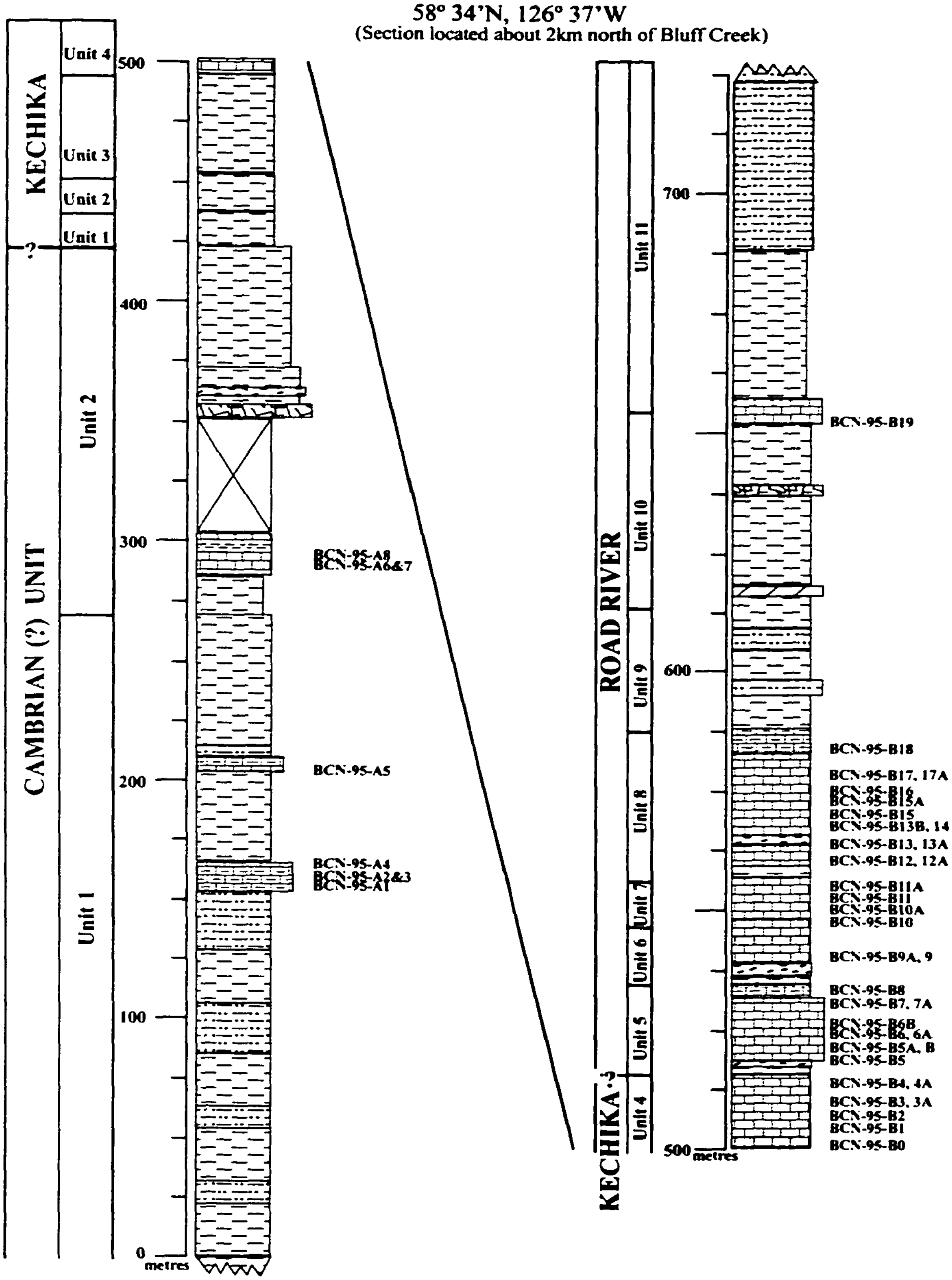
Appendix B-6
Driftpile Section
58° 07'N, 125° 51'W
(Section located 5km NW of Driftpile Creek)



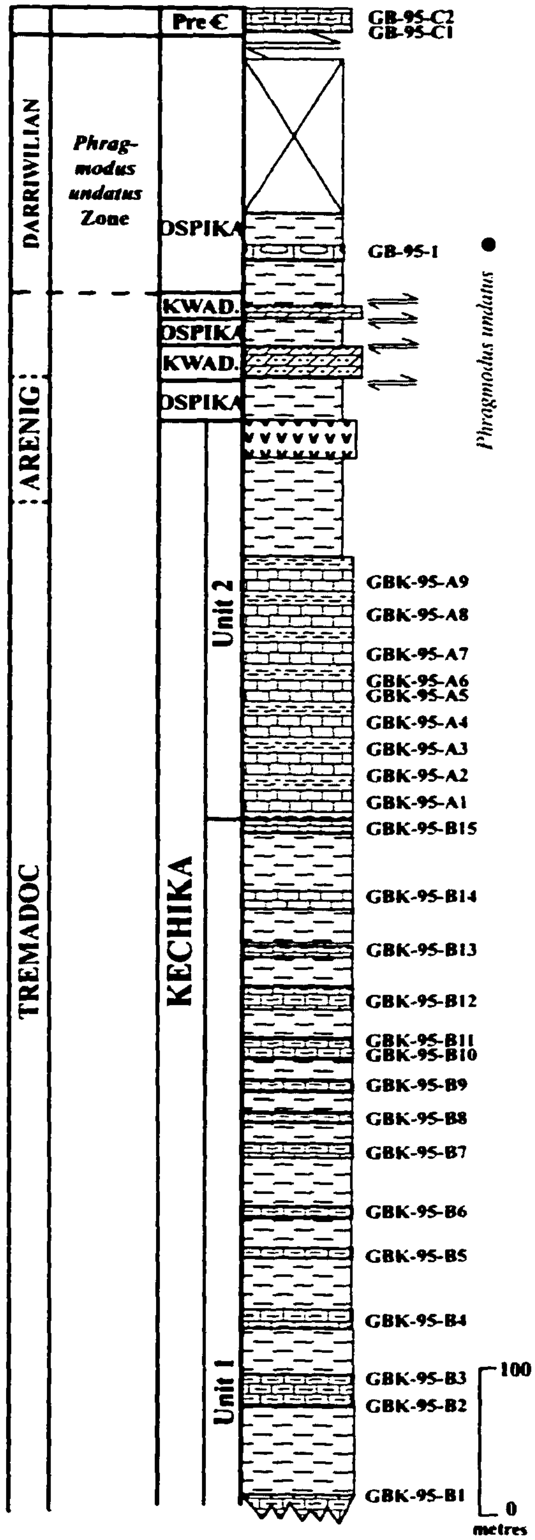
Appendix B-7 Road River Core
57° 23'N, 124° 52'W
(Core supplied by Inmet Mining)



Appendix B-8
Bluff Creek Section
58° 34'N, 126° 37'W
(Section located about 2km north of Bluff Creek)

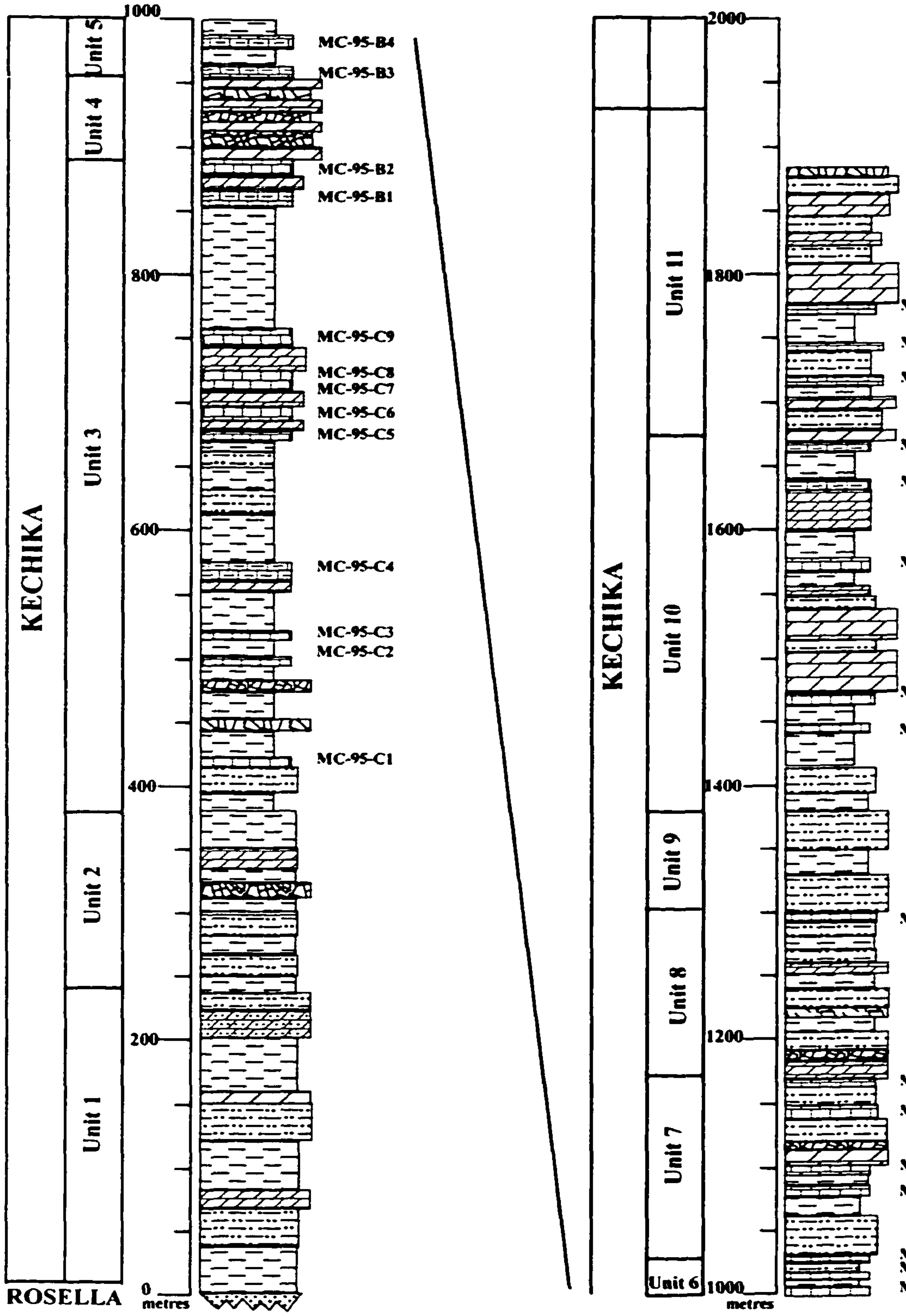


Appendix B-9
Gataga Mountain Section
58° 38'N, 126° 55'W
(Section located east of Gataga Mountain on spur trending east-west, then north-south)

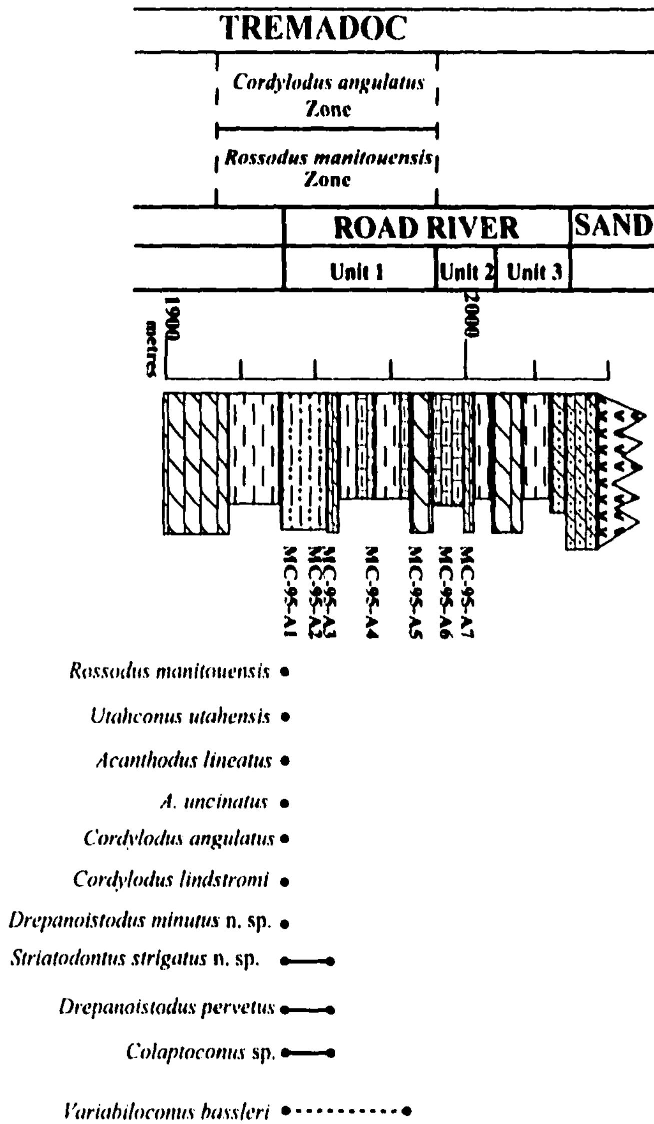


Appendix B-10-1
Moodie Creek Section
58° 46'N, 127° 33'W

(Section located 1km E of Moodie Creek, 7km S-SE of Moodie Lakes; 6km of ridge trending SW-NE, then N; section strongly deformed, possible stratigraphic repetition or omission due to faulting)



Appendix B-10-2
Moodie Creek Section

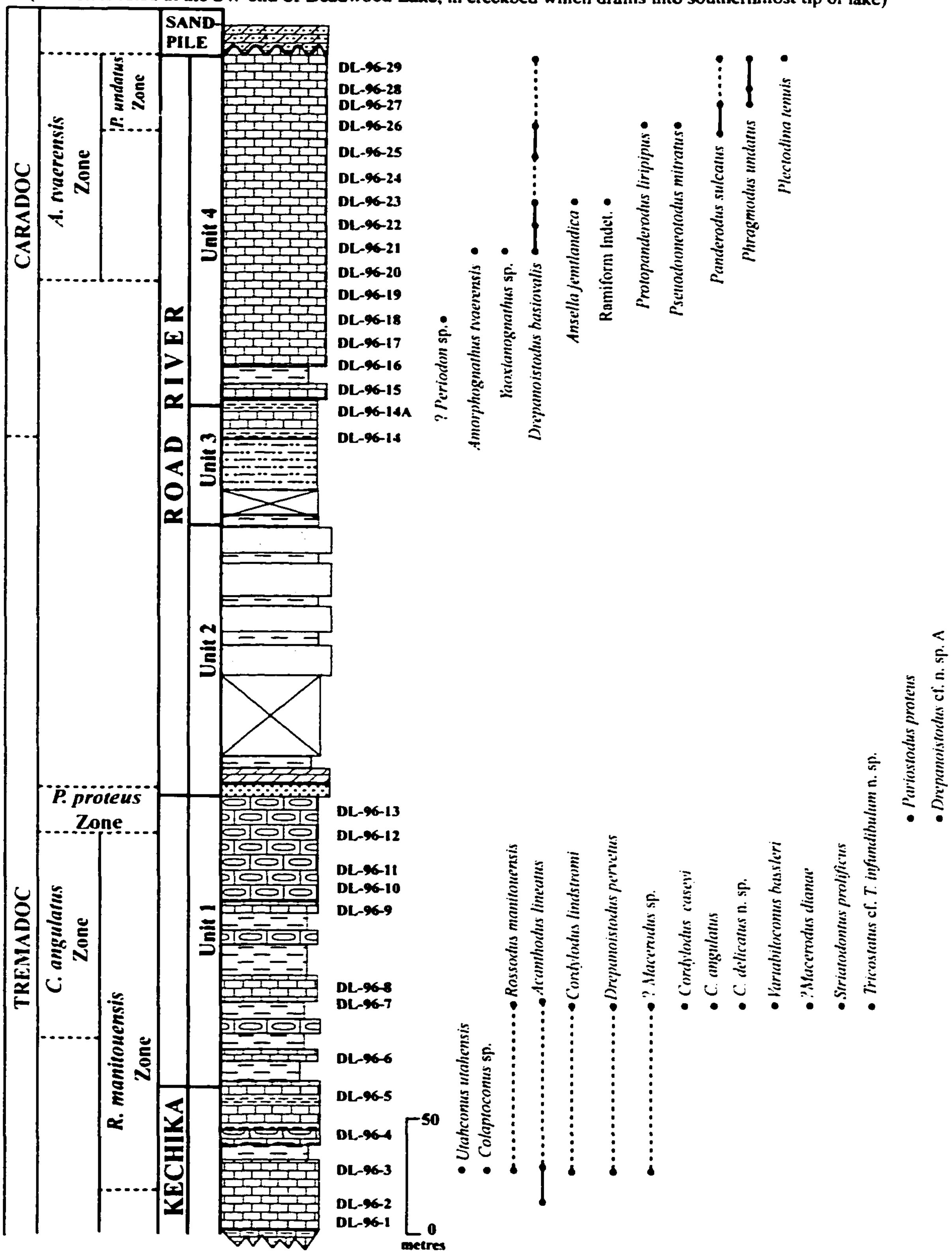


Appendix B-11

Deadwood Lake Section

59° 01'N, 128° 23'W

(Section located at the SW end of Deadwood Lake, in creekbed which drains into southernmost tip of lake)

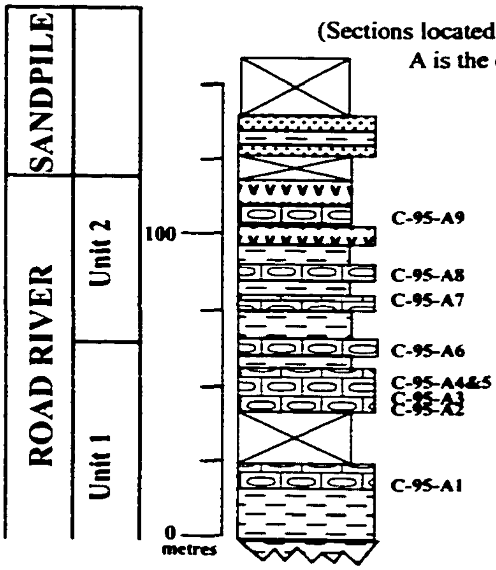


Appendix B-12

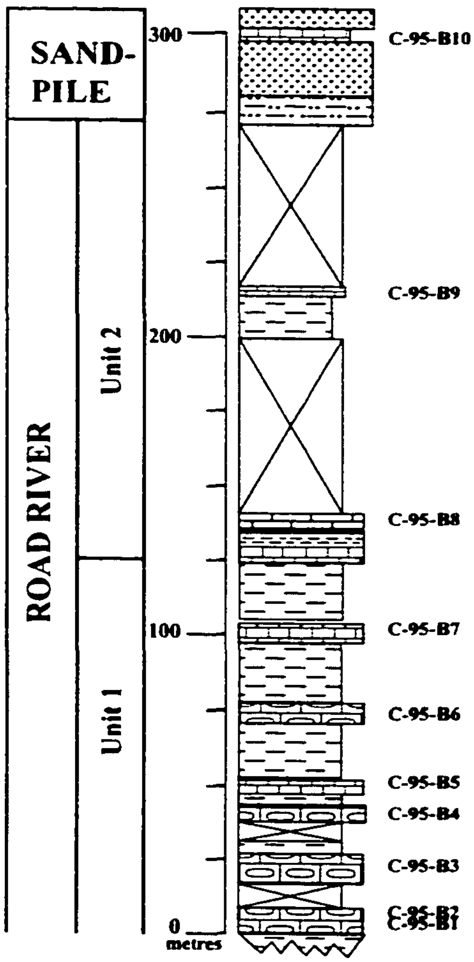
Mount McDame Section A

59° 17'N, 129° 47'W

(Sections located in two creekbeds in the west face of Mt. McDame; A is the creekbed farthest west, B is 1km east of A)



Mount McDame Section B



APPENDIX C

Appendix C contains the numerical distribution of conodont species from productive sections and samples. Genera and species are listed alphabetically in the left hand column. Sample numbers, including the measured distance above the base of each section, the mass of rock processed in grams and the weight of the undissolved residue in grams for each sample is listed in ascending stratigraphic order from left to right.

The tables include:

Section 13	Tables 1 to 4
Section 1	Tables 5 and 6
Section 5	Tables 7 and 8
Grey Peak Section	Tables 9 to 11
Section 4	Table 12
Moodie Creek Section	Table 13
Road River Core	Table 14
Gataga Mountain Section	Table 15
Deadwood Lake Section	Table 16 and 17
Summary Table	Table 18
Table showing twenty most abundant species	Table 19
Table showing ten most abundant genera	Table 20

Section 13, KECHIKA FORMATION		Lloyd George Member	Quentin Member											
Distance above base (m)		10.5	0	27	48	75	120	154.5	181.5	264.5	305.5	325		
Species	Sample No.	96-13-C2	96-13-A1	96-13-A2	96-13-A3	96-13-A4	96-13-A6	96-13-A7	96-13-A8	96-13-A10	96-13-A12	96-13-A13		
	Mass (g)	2000	2500	2500	2500	2500	2000	2000	2500	2500	2500	2000		
	Undiss. Mass (g)	437	984	1807	350	1543	154	804	1127	1199	1717	1171	*Subtotal*	*Total*
Acodus oneotensis	M					4	10	28	0				42	334
	S					8	135	106	3				252	
	P					4	9	26	1				40	
Acodus quentinensis n. sp.	M		2		0	6	60	6					74	340
	S		0		1	0	145	25					171	
	P		6		3	5	75	6					95	
Cordylodus angulatus	a										1		1	1
	c										0		0	
	e										0		0	
C. caboti	a		4		5	7	4	8			13		41	391
	c		1		0	0	2	0			0		3	
	e		24		9	13	278	23			0		347	
C. caseyi	a		1	0		16	27	1					45	66
	c		0	0		0	2	0					2	
	e		0	1		14	4	0					19	
C. delicatus n. sp.	a				0		20	2		1	1		24	43
	c				2		3	1		0	0		6	
	e				0		11	1		1	0		13	
C. intermedius	a						23	2			4		29	33
	c						0	0			0		0	
	e						4	0			0		4	
C. lindstromi	a		62	4	41	177	572	295	1	11	14	1	1178	1807
	c		2	0	1	2	16	4	0	0	1	0	26	
	e		9	0	19	20	318	227	1	3	6	0	603	
C. primitivus	a		0				0						0	3
	c		1				1						2	
	e		1				0						1	
C. proavus	a		2	1		5	17				1		26	27
	c		0	0		0	0				0		0	
	e		0	0		0	1				0		1	
Drepanoistodus pervetus	a						13	16		3			32	52
	c						2	3		0			5	
	e						5	7		3			15	

Continued

		96-13-C2	96-13-A1	96-13-A2	96-13-A3	96-13-A4	96-13-A6	96-13-A7	96-13-A8	96-13-A10	96-13-A12	96-13-A13	*Subtotal*	*Total*
E. notchpeakensis	a	0	32										32	39
	c	4	3										7	
Iapetognathus aengensis	Sb		2	1		1	1	8					13	19
	Sc		0	0		0	2	1					3	
	Sd		0	0		1	0	2					3	
I. fluctivagus	Sb		1					2					3	5
	Sc		0					2					2	
I. sprakersi	Sb						1	1					2	13
	Sc						11	0					11	
I. sp.			1										1	1
Granatodontus cf. *G. ani*								6					6	6
Polycostatus falsioneotensis	a									12			12	16
	c									2			2	
	e									2			2	
Semiacontiodus nogamii	a			0	1	8	15	11		0			35	76
	b			1	0	1	12	4		0			18	
	c			0	1	0	2	1		0			4	
	e			0	0	2	9	7		1			19	
Teridontus gracillimus	a				0			4		1			5	17
	b				2			5		0			7	
	c				0			1		0			1	
	e				0			4		0			4	
T. nakamurai	a		15	1	1	41	107	13		2			180	288
	b		2	0	1	9	41	5		4			62	
	c		0	0	0	2	9	0		0			11	
	e		5	0	0	2	28	0		0			35	
T. obesus	a		0				8	13					21	52
	b		1				7	5					13	
	c		1				1	8					10	
	e		2				4	2					8	
Utahconus utahensis	a		11	2	7	0	14	12		1	3		50	167
	b		3	3	2	0	3	6		1	0		18	
	c		0	0	2	1	9	5		0	0		17	
	e		4	1	2	3	29	42		1	0		82	
Coniform Indet. E						4	5	4					13	13
Coniform Indet. H								54	1				55	55
Total		4	198	15	100	356	2075	1015	7	49	44	1	3864	3864

Table 1

Section 13		KECHIKA FORMATION, Grey Peak Member												
Distance above base (m)		430	451	471	491	679	716	736	756	776	810.5	833		
Species	Sample No	96-13-A14	96-13-A15	96-13-A16	96-13-A17	96-13-B1	96-13-B2	96-13-B3	96-13-B4	96-13-B5	96-13-B6	96-13-B7		
	Mass (g)	2500	3000	2500	3000	3000	2500	2000	2500	2400	3000	2000		
	Undiss. Mass (g)	226	1023	537	908	791	517	353	363	490	1150	382	*Subtotal*	*Total*
Acanthodus lineatus	a	13	60	82	112	63	98	165	282	766			1641	2190
	e	4	4	68	32	31	54	34	106	216			549	
A. uncinatus	a					1	0	11		6			18	42
	c					0	0	0		0			0	
	e					2	2	20		0			24	
Colaptoconus sp							5	10		24			39	39
Cordylodus angulatus	a	4	1	12	14	2	4	10	11	9	10		77	121
	c	0	1	0	1	0	0	1	0	1	1		5	
	e	0	2	5	1	2	2	4	2	17	4		39	
C. caseyi	a		1	5		1	1			2			10	12
	c		0	0		1	0			1			2	
	e		0	0		0	0			0			0	
C. delicatus n. sp.	a			2									2	2
	c			0									0	
	e			0									0	
C. intermedius	a	4	2	36		1	2			2			47	61
	c	0	0	2		0	0			1			3	
	e	0	9	2		0	0			0			11	
C. lindstromi	a	3	4	2						5			14	27
	c	0	0	0						1			1	
	e	4	8	0						0			12	
?*Diaphorodus* n. sp.	M										4		4	14
	S										8		8	
	P										2		2	
Drepanoistodus nowlani	a											2	2	12
	c											1	1	
	e											9	9	
D. pervetus	a		5	36	41	19	56	24	16	40	11		248	478
	c		2	5	2	2	5	4	1	5	2		28	
	e		2	25	17	5	50	22	15	53	13		202	
Glyptodontus sp						1			4				5	5
Laurentoscandodus cf. *L. triangularis*	a					8	6	3	11	8	1		37	87
	b					4	8	3	9	9	1		34	
	c					1	0	0	2	4	2		9	
	e					1	0	2	0	4	0		7	

Continued

		A14	A15	A16	A17	B1	B2	B3	B4	B5	B6	B7	*Subtotal*	*Total*
Macerodus cristatus n sp										5			5	5
Macerodus lunatus n sp								3					3	3
?*Parapaltodus* sp												24	24	24
Paltodus deltifer	M							4			2		6	10
	S							0			4		4	
	P							0			0		0	
Paroistodus numarcuatus	M										0	8	8	24
	S										6	7	13	
	P										0	3	3	
Polycostatus falsioneotensis	a			0									0	2
	c			2									2	
	e			0									0	
Polycostaus cf. *sulcatus*	a							1	1	1	4		7	15
	b							1	2	0	1		4	
	c							1	0	0	0		1	
	e							2	1	0	0		3	
R. kwadachaensis n sp	a						8	3		1			12	24
	b						1	1		2			4	
	c						1	1		1			3	
	e						2	1		2			5	
Rossodus manitouensis	a		2	37	128	60	67	190	147	209	67		907	1445
	b		0	9	15	10	16	48	26	70	25		219	
	c		1	0	7	3	8	11	5	11	6		52	
	d		3	15	37	17	21	35	59	58	22		267	
R. muskwaensis n sp	a					1	3	5	3	4			16	27
	b					0	1	0	2	1			4	
	c					0	0	0	0	1			1	
	e					1	0	0	1	4			6	
R. sheffieldensis n sp	a							15	2	37			54	81
	b							3	1	8			12	
	c							0	0	4			4	
	e							1	1	9			11	
Rossodus subtilis n sp	a									2	10		12	25
	b									3	2		5	
	c									1	3		4	
	e									3	1		4	
R. tenuis	a	1	12	28	10	2	20			23	6		102	190
	b	0	7	9	5	1	3			7	2		34	
	c	0	3	4	1	1	4			5	1		19	
	e	0	5	13	10	1	2			2	2		35	

Continued

		A14	A15	A16	A17	B1	B2	B3	B4	B5	B6	B7	*Subtotal*	*Total*
Striatodontus prolificus	a							1	0	10	2		13	34
	b							0	1	10	2		13	
	c							1	0	4	1		6	
	e							0	0	1	1		2	
Striatodontus strigatus	a					20	30	1		14			65	100
n. sp.	b					3	4	0		2			9	
	c					6	7	1		2			16	
	e					3	4	0		3			10	
Stultodontus costatus	a									6			6	9
	e									3			3	
Tricostatus cf. *T. glyptus*	a								37	10	14		61	82
	c								7	5	4		16	
	e								5	0	0		5	
Tricostatus terilinguis n. sp.	a					7		3	1				11	22
	b					2		0	2				4	
	c					3		1	1				5	
	e					0		0	2				2	
Utahconus longipinnatus	a	4	4	19	40	0	1			3			71	118
	c	0	0	0	0	0	0			0			0	
	e	0	7	18	19	2	1			0			47	
U. utahensis	a	1	3	12						2	4		22	146
	b	0	0	0						0	0		0	
	c	0	0	0						0	0		0	
	e	2	23	82						2	15		124	
Variabiloconus bassleri	a	1	3	19	9	38	41	16	27	88	69		311	685
	b	1	1	2	20	5	20	11	31	89	15		195	
	c	0	1	2	5	2	5	4	3	6	1		29	
	e	2	2	3	11	5	17	28	13	52	17		150	
V. spurius	a			42	27								69	136
	b			33	31								64	
	c			0	2								2	
	e			1	0								1	
Coniform Indet. F						11	6						17	17
Coniform Indet. D							5						5	5
Coniform Indet. A										5			5	5
Total		44	178	632	597	349	591	706	840	1960	368	54	6319	6319

Table 2

Section 13, KECHIKA FM.		Grey Peak Member				Haworth Member							
Distance above base (m)		863	923	971	1040	1163	1188	1230	1275	1444.5	1485		
Species	Sample No.	96-13-B8	96-13-B10	96-13-B11	96-13-B12	96-13-B14	96-13-B15	96-13-B16	96-13-B17	96-13-B21	96-13-B22		
	Mass (g)	3000	2000	2500	2500	2500	2500	2500	2500	2500	2000		
	Undiss. Mass (g)	608	199	1215	963	860	188	282	351	1435	1271	*Subtotal*	*Total*
Acanthodus lineatus	a	147										147	167
	e	20										20	
Acodus deltatus	M	267						10			0	277	1853
	S	1253						34			3	1290	
	P	282						2			2	286	
A. kechikaensis n. sp.										1		1	1
Colaptoconus bolites	a							60				60	65
	c							3				3	
	e							2				2	
C. greypeakensis n. sp.	a					7						7	9
	b					2						2	
	c					0						0	
	e					0						0	
C. floweri	a								33			33	47
	b								8			8	
	c								4			4	
	e								2			2	
C. quadraplicatus	a					15						15	24
	b					3						3	
	c					5						5	
	e					1						1	
Cornuodus longibasis								72				72	72
Drepanoistodus concavus	a					58		56	24			138	194
	c					7		3	2			12	
	e					27		6	11			44	
D. nowlani	a	69										69	70
	c	1										1	
	e	0										0	
Eucharodus parallelus									4			4	4
?Paltodus	M		7	3	1	0	0	145				156	923
jemtlandicus	S		52	7	5	142	1	480				687	
	P		2	1	1	69	0	7				80	
Paracordylodus gracilis	M							9			1	10	22
	S							8			0	8	
	P							4			0	4	
Parapanderodus striatus								8	3			11	11

Continued

		96-13-B8	96-13-B10	96-13-B11	96-13-B12	96-13-B14	96-13-B15	96-13-B16	96-13-B17	96-13-B21	96-13-B22	*Subtotal*	*Total*
Paroistodus proteus	M		0	0	12	4	1	39	18	0		74	133
	S		1	3	8	4	2	25	9	2		54	
	P		0	0	0	0	0	4	1	0		5	
Graciliconus concinnus	M		3	0	14		0	1				18	52
n. gen. n. sp	S		1	2	21		1	5				30	
	P		0	0	3		0	1				4	
Kallidontus princeps	M			0	0							0	6
n. gen. n. sp	S			2	4							6	
	P			0	0							0	
Scolopodus subrex	a	18		1	5	179		35		2		240	355
	b	3		0	2	82		5		6		98	
	e	0		1	0	14		1		1		17	
Semiacontiodus aff. S. cornuformis						7		16				23	23
Tropodus australis	M									0		0	2
	S									2		2	
	P									0		0	
T. comptus	M	0										0	18
	S	18										18	
	P	0										0	
	Total	2078	66	20	76	626	5	1041	119	14	6	4051	4051

Table 3

Section 13		KECHIKA FM., Mt. Sheffield Member							SKOKI FORMATION						
Distance above base (m)		1518.0	1555.5	1593.0	1623.0	1660.5	1706.5	1741.0	1774	1811.5	1870	1928.5	1970.5		
Species	Sample No.	96-13-B23	96-13-B24	96-13-B25	96-13-B26	96-13-B27	96-13-B28	96-13-B29	96-13-B30	96-13-B31	96-13-B32	96-13-B33	96-13-B34		
	Mass (g)	2500	2500	2000	3000	2500	2000	2500	2000	2000	2000	2500	2500		
	Undiss. Mass (g)	768	1425	885	1591	1428	1268	1301	481	546	395	336	145	*Subtotal*	*Total*
Acodus deltatus	M		1	0										1	15
	S		3	9										12	
	P		2	0										2	
A. kechikaensis n. sp.	M	71	9	85	32	21								218	866
	S	122	14	204	69	2								411	
	P	69	7	112	40	9								237	
A. longibasis	M			5	7									12	111
	S			52	27									79	
	P			7	13									20	
A. neodeltatus n. sp.	M				4	30								34	397
	S				124	180								304	
	P				12	47								59	
Bergstroemognathus extensus	M										4			4	6
	S										2			2	
	P										0			0	
Cornuodus longibasis	a-b		3		12							2	2	19	20
	c		0		1							0	0	1	
	e		0		0							0	0	0	
	f		0		0							0	0	0	
Diaphorodus russoi	M			4	2									6	100
	S			84	2									86	
	P			4	4									8	
Drepanodus arcuatus									2					2	2
Drepanoistodus amoenus	a				20	13								33	36
	c				0	0								0	
	e				0	3								3	
D. forceps	a						1		1	1				3	8
	c						1		1	1				3	
	e						0		0	2				2	
Drepanoistodus n. sp. A	a			7										7	17
	c			3										3	
	e			7										7	
Drepanoistodus n. sp. B												1		1	1
Drepanoistodus n. sp C													5	5	5

Continued

		96-13-B23	96-13-B24	96-13-B25	96-13-B26	96-13-B27	96-13-B28	96-13-B29	96-13-B30	96-13-B31	96-13-B32	96-13-B33	96-13-B34	*Subtotal*	*Total*
Fahraeusodus	M			0					1	2	1	1		5	62
marathonensis	S			6					5	15	0	16		42	
	P			0					3	8	1	3		15	
Juanognathus	a-b											5	19	24	27
jaanusoni	c											0	2	2	
	c											0	1	1	
Juanognathus	a-b											35		35	44
variabilis	c											7		7	
	c											2		2	
Kallidontus	S	2	6	68	30	3		1						110	142
serratus n. gen. n. sp.	P	0	4	21	5	2								32	
K. nodosus	S				8									8	18
n. gen. n. sp.	P				10									10	
K. princeps n. gen. n. sp.		3	3		4	8		2						20	20
Oelandodus	M		0	10	1	3		0	0					14	117
elongatus	S		1	56	8	11		0	8					84	
	P		0	12	1	2		3	1					19	
Oepikodus communis	M						2	4	2	6	6	3	7	30	345
	S						11	32	37	35	41	3	72	231	
	P						3	15	13	12	19	0	22	84	
O. evae	M								1			5	2	8	73
	S								3			33	11	47	
	P								1			13	4	18	
Oistodus bransoni									3					3	3
Oistodus lanceolatus	M				0	1		0	2	2				5	15
	S				1	1		1	3	3				9	
	P				0	0		0	1	0				1	
?Paltodus jemtlandicus		32	7											39	39
Paltodus subaequalis												4	5	9	9
Paracordylodus gracilis	M			1	4	19								24	100
	S			1	0	45								46	
	P			0	4	26								30	

Continued

		96-13-B23	96-13-B24	96-13-B25	96-13-B26	96-13-B27	96-13-B28	96-13-B29	96-13-B30	96-13-B31	96-13-B32	96-13-B33	96-13-B34	*Subtotal*	*Total*
Parapanderodus	a				2			1	1	3		1	10	18	23
striatus	b				0			1	0	1		0	3	5	
	c				0			0	0	0		0	0	0	
	e				0			0	0	0		0	0	0	
Paroistodus parallelus	M			0			0	0	0		0	1	2	3	39
	S			4			1	1	6		3	5	16	36	
	P			0			0	0	0		0	0	0	0	
P. proteus	M	1	0	2	0	3	0							6	392
	S	41	23	162	77	23	1							327	
	P	7	3	32	9	8	0							59	
Prioniodus elegans					1	3								4	4
Protopanderodus	a-b										1		10	11	18
elongatus	c										1		4	5	
	e										0		2	2	
P. gradatus	a-b											5	28	33	50
	c											1	9	10	
	e											1	6	7	
P. leonardi	a-b									6	4	1	10	21	27
	c									2	1	0	2	5	
	e									0	0	0	1	1	
Scolopodus krummi	a	10	2	20	16	4				2	2	6	12	74	196
	b	49	17	8	16	1				0	0	0	1	92	
	e	19	2	4	2	1				1	0	0	1	30	
Stolodus stola			2	29	11			2						44	44
Tropodus australis	M	6	2		1	0		0	4	3	2	3	5	26	179
	S	8	6		6	6		2	14	14	17	6	45	124	
	P	10	7		5	6		0	0	1	0	0	0	29	
T. sweeti	M								5	2	8	7	33	55	243
	S								5	6	7	17	78	113	
	P								3	2	3	9	58	75	
Platform Indet.												4		4	4
Coniform Indet. G				19										19	19
Coniform Indet. K												4		4	4
	Total	450	124	1038	591	481	20	65	126	130	123	204	488	3840	3840

Table 4

Section 1, KECHIKA FM.		Quentin Member					Grey Peak Member								
Distance above base (m)		77.5	83.5	88.5	100	109	132.5	149	159	168	183	193	203.5		
Species	Sample No	96-1-1	96-1-2	96-1-3	96-1-4	96-1-5	96-1-6	96-1-7	96-1-8	96-1-9	96-1-10	96-1-11	96-1-12		
	Mass (g)	3000	3000	3000	2500	2500	3000	2500	2500	2500	2500	2500	2500		
	Undiss. Mass (g)	1128	1062	1488	558	394	955	1393	376	300	738	1628	1289	*Subtotal*	*Total*
Acanthodus lineatus	a	251	212	216	561	399	191	54	141	553	106	1	9	2694	3245
	c	44	37	72	119	103	27	10	33	59	43	0	4	551	
A. uncinatus	a	11	6			4	4	2	1	3				31	51
	c	2	2			0	0	0	0	0				4	
	e	8	5			2	1	0	0	0				16	
Cordylodus angulatus	a	329	168	80	160	44	37	3	16	43	24		2	906	1225
	c	22	3	16	7	6	6	0	2	3	1		1	67	
	e	82	15	40	54	16	20	0	8	11	5		1	252	
C. caboti	a		11		0									11	18
	c		1		0									1	
	e		3		3									6	
C. caseyi	a		4		4	2	2		1	1				14	17
	c		2		1	0	0		0	0				3	
	e		0		0	0	0		0	0				0	
C. intermedius			2		2	2	2		2					10	10
C. lindstromi			5		1	2	0	6	4					18	18
Drepanoistodus minutus n. sp.	a				8	12					5			25	52
	c				3	4					5			12	
	e				7	5					3			15	
D. pervetus	a	260	130	64	129	89	88	4	18	96	62		3	943	1640
	c	9	1	8	12	1	10	0	4	7	3		0	55	
	e	241	80	48	105	20	39	1	28	23	56		1	642	
D. expansus	a				8	2				14	3		4	31	79
	c				3	3				5	3		2	16	
	e				7	7				10	7		1	32	
Laurentoscandodus sinuosus n. sp.	a	38	16	24	4	1	4			14	1			102	168
	b	18	12	8	0	0	2			2	0			42	
	c	5	3	0	2	0	1			1	0			12	
	e	5	0	0	2	1	2			2	0			12	
Loxodus latibasis	dextral	0			14	0				2	1			17	31
	sinistral	1			10	2				1	0			14	
Polycostatus cf. *sulcatus*			3			3	1							7	7

Continued

		96-1-1	96-1-2	96-1-3	96-1-4	96-1-5	96-1-6	96-1-7	96-1-8	96-1-9	96-1-10	96-1-11	96-1-12	*Subtotal*	*Total*
Rossodus manitouensis	a	103	59	80	6	54	1	3	212	600	82		5	1205	2184
	b	10	16	16	5	24	1	0	86	222	29		2	411	
	c	1	2	8	0	3	0	0	14	27	5		0	60	
	e	11	10	72	3	28	5	0	79	159	136		5	508	
R. muskwaensis n. sp.	a	52	3	16		16	4		11	110	11			223	347
	b	7	2	0		13	0		2	24	1			49	
	c	5	1	0		1	0		2	8	1			18	
	d	4	1	8		2	0		2	34	6			57	
R. tenuis	a	2	13	24	30	63	0	0	59	179	308		8	686	1271
	b	0	9	24	12	18	1	1	13	59	37		2	176	
	c	0	2	8	6	8	1	0	16	38	19		1	99	
	e	0	10	0	6	26	1	1	77	143	44		2	310	
Striatodontus strigatus n. sp.		3	5		3	2	6	9		18	11		1	58	58
?*Stultodontus* sp.							1			8				9	9
Tricostatus	a			1	23		1			0				25	35
infundibulum n. sp.	c			0	2		0			0				2	
	e			0	5		1			2				8	
Utahconus longipinnatus	a	71	25	88	49	52	29	8	16	31	9			378	639
	c	8	7	8	3	3	5	2	1	5	0			42	
	e	60	13	48	29	14	31	6	4	12	2			219	
U. utahensis	a	1	8	48	48	51	10	2	5	26	48	0	3	250	1068
	b	0	2	16	21	38	8	1	4	3	24	0	0	117	
	c	1	2	16	7	9	3	2	1	10	20	0	0	71	
	e	2	15	104	140	172	50	2	1	43	91	1	9	630	
Variabiloconus bassleri	a	20	22	32	26	27	17	1	20	39	8			212	609
	b	27	20	24	13	33	15	1	28	30	9			200	
	c	5	5	8	2	1	1	0	0	13	1			36	
	e	7	12	16	12	42	19	11	24	14	4			161	
V. spurius	a			32	14	14	17	1	14	5	39		3	139	244
	b			0	15	15	13	3	15	5	35		1	102	
	c			0	1	2	0	0	0	0	0		0	3	
	e			0	0	0	0	0	0	0	0		0	0	
Westergaardodina sp.				1										1	1
Coniform Indet. B							2							2	2
Coniform Indet. C							2			6	2			10	10
Total		1726	985	1274	1707	1461	682	134	964	2723	1310	2	70	13038	13038

Table 5

Section 1		Grey Peak Member	Mt. Sheffield Member										
Distance above base (m)		216.5	237.5	246.5	257	266	276.5	420.5	424.5	432	441		
Species	Sample No	96-1-13	96-1-14	96-1-15	96-1-16	96-1-17	96-1-18	96-1-19	96-1-20	96-1-21	96-1-22		
	Mass (g)	2500	2000	2000	2500	2000	2500	2500	2500	2500	2500		
	Undiss. Mass (g)	239	205	42	877	1007	1072	924	436	713	407	*Subtotal*	*Total*
Acanthodus lineatus	a	1	58	12	51	4						126	147
	e	0	9	3	8	1						21	
A. uncinatus	a		6									6	13
	c		2									2	
	e		5									5	
Acodus deltatus											2	2	2
Colaptoconus bolites											8	8	8
C. floweri								2	5			7	7
C. greypeakensis n. sp.								4	6		19	29	29
Colaptoconus sp.				2	2							4	4
Cordylodus angulatus	a		7	0								7	11
	c		1	0								1	
	e		1	2								3	
Cornuodus longibasis											2	2	2
Drepanodus arcuatus								14	3		2	19	19
Drepanoistodus concavus	a							4	6	1	81	92	120
	c							0	1	1	9	11	
	e							0	2	1	14	17	
D. pervetus	a	2	6	23	12							43	60
	c	0	0	1	1							2	
	e	1	2	5	7							15	
D. expansus	a		1									1	2
	c		0									0	
	e		1									1	
Graciliconus concinnus	M							4	1	0		5	12
n. gen. n. sp.	S							3	3	1		7	
	P							0	0	0		0	
Laurentoscandodus	a		0	4								4	15
sinuosus n. sp.	b		0	8								8	
	c		0	1								1	
	e		1	1								2	

Continued

		96-1-13	96-1-14	96-1-15	96-1-16	96-1-17	96-1-18	96-1-19	96-1-20	96-1-21	96-1-22	*Subtotal*	*Total*
?Paltodus jemtlandicus	M							0	1	0	4	5	25
	S							7	1	2	2	12	
	P							2	4	2	0	8	
Paroistodus proteus									1	1	8	10	10
Rossodus manitouensis	a	1	5		5	0	0					11	40
	b	2	1	3	2	0	1					9	
	c	0	0	2	1	1	0					4	
	e	3	4	7	2	0	0					16	
R. muskwaensis n. sp.	a		2									2	4
	b		0									0	
	c		1									1	
	e		1									1	
R. tenuis	a	2	17		3	0						22	32
	b	0	2		0	1						3	
	c	0	1		0	1						2	
	e	2	3		0	0						5	
Scolopodus subrex	a							29	2	5	13	49	65
	b							8	0	1	1	10	
	c							4	1	1	0	6	
Semiacontiodus aff. S. cornuformis											20	20	20
Striatodontus strigatus n. sp.			1	3								4	4
Tropodus comptus											3	3	3
Utahconus longipinnatus	a			1								1	1
	c			0								0	
	e			0								0	
U. utahensis	a	1	3									4	11
	b	0	2									2	
	c	0	0									0	
	e	1	4									5	
Variabiloconus bassleri	a		1	3								4	9
	b		1	2								3	
	c		0	1								1	
	e		0	1								1	
Total		16	149	85	94	8	1	81	37	16	188	675	675

Table 6

Section 5		UPPER KECHIKA FM.	SKOKI FORMATION, Sikanni Chief Member												
Distance above base (m)		0	7	27	44	68	84	114	144	194	246	267.5	279		
Species	Sample No.	96-5-K1	96-5-1	96-5-2	96-5-3	96-5-4	96-5-5	96-5-6	96-5-7	96-5-8	96-5-10	96-5-11	96-5-12		
	Mass (g)	2500	2000	1500	2500	2500	2500	2500	2500	2500	3000	3000	2500		
	Undiss. Mass (g)	1001	1066	463	830	1231	850	579	378	434	489	455	16	*Subtotal*	*Total*
Acodus kechikaensis n. sp.								27						27	27
Bergstroemognathus	M							0	0		0	0	0	0	8
extensus	S							2	1		2	2	1	8	
	P							0	0		0	0	0	0	
Cornuodus longibasis	a-b	1				1		5					4	11	13
	c	0				0		0					0	0	
	e	1				0		0					1	2	
Drepanodus arcuatus								2			3		1	6	6
Drepanoistodus	a												2	2	3
basiovalis	c												1	1	
	e												0	0	
Drepanoistodus n. sp. C												1		1	1
Eucharodus parallellus												3	15	18	18
Fahraeusodus	M					2								2	8
marathonensis	S					5								5	
	P					1								1	
Juanognathus	a-b									1			13	14	19
variabilis	c									0			3	3	
	e									0			2	2	
Kallidontus	S	1						0						1	5
cf. *nodosus*	P	2						2						4	
Oelandodus elongatus		6												6	6
Oepikodus communis	M	25	0		0	1	1	0	1		0	0		28	301
	S	171	1		2	26	2	7	15		1	2		227	
	P	31	1		0	6	0	2	4		0	2		46	
O. evae	M								1				4	5	30
	S								3				13	16	
	P								2				7	9	
O. intermedius	M	1	0								1		6	8	159
	S	3	1								32		91	127	
	P	1	1								9		13	24	
Oistodus lanceolatus	M							3	0			1		4	18
	S							10	1			1		12	
	P							2	0			0		2	
Oistodus sp.		3												3	3

Continued

		96-5-K1	96-5-1	96-5-2	96-5-3	96-5-4	96-5-5	96-5-6	96-5-7	96-5-8	96-5-10	96-5-11	96-5-12	*Subtotal*	*Total*
Parapanderodus	a/b							7			1	3		11	11
striatus	c							0			0	0		0	
	e							0			0	0		0	
Paroistodus parallelus	M	0				0		0				0		0	20
	S	7				0		7				2		16	
	P	1				1		2				0		4	
Periodon flabellum	M										2			2	6
	S										4			4	
	P										0			0	
P. selenopsis	M											3		3	3
	S											0		0	
	P											0		0	
Prioniodus adami								9						9	9
Prioniodus n. sp.								11						11	11
Protopanderodus	a-b							24					3	27	41
gradatus	c							6					2	8	
	e							4					2	6	
Protopanderodus rectus	a-b					1							3	4	8
	c					0							2	2	
	e					0							2	2	
Protoprioniodus	M												0	0	7
cowheadensis	S												7	7	
	P												0	0	
Scolopodus	a-b	1						4	3	1	3			12	19
amplus n. sp.	c	0						1	0	0	1			2	
	e	0						1	1	0	2			4	
	f	0						0	1	0	0			1	
Scolopodus krummi	a-b	2												2	3
	e	1												1	
Stolodus stola		2												2	2
Tropodus australis	M					2			0		3	1	1	7	21
	S					4			1		4	1	3	13	
	P					0			0		0	0	1	1	
T. sweeti	M				1	0	1	0			0	0	0	2	35
	S				0	6	2	5			5	3	4	25	
	P				1	1	0	0			0	2	4	8	
New genus B n. sp.	a/b							3						3	6
	c							0						0	
	e							3						3	
	Total	260	4	0	4	57	6	149	34	2	73	27	211	827	827

Table 7

Section 5		**SKOKI FORMATION**, Sikanni Chief Member						Keily Member				
Distance above base (m)		293.5	298.5	339	343.5	348	353	590.5	602.5	635.5		
Species	Sample No.	96-5-13	96-5-14	96-5-15	96-5-15A	96-5-16	96-5-16A	96-5-17	96-5-18	96-5-19		
	Mass (g)	3000	3000	3000	3000	3000	3000	3000	3000	2500		
	Undiss. Mass (g)	183	345	391	398	172	375	1036	1147	600	*Subtotal*	*Total*
Anodontus longus	a-b					3		2	1	0	6	11
	c					0		0	0	0	0	
	e					1		2	1	1	5	
Ansella jemtlandica	M								1		1	4
	S								2		2	
	P								1		1	
Ansella longicuspica	M							3			3	6
	S							2			2	
	P							1			1	
Bergstroemognathus extensus	M	1			14						15	15
	S	0			0						0	
	P	0			0						0	
Cornuodus longibasis	a-b	4		4		14	3			2	27	37
	c	0		0		4	0			1	5	
	e	0		0		2	0			1	3	
	f	1		0		0	0			1	2	
Drepanodus arcuatus		2		6	6		7		2		23	23
Drepanoistodus amoenus					6	5	19				30	30
Drepanoistodus forceps	a					4	3				7	14
	c					0	2				2	
	e					4	1				5	
Drepanoistodus n. sp. D							3				3	3
Drepanoistodus n. sp. E						11					11	11
Juanognathus jaanussoni	a-b			2	8	27					37	42
	c			0	0	2					2	
	e			2	0	1					3	
Juanognathus variabilis	a-b		1	10	46	121					178	342
	c		0	14	14	21					49	
	e		0	76	26	13					115	
Jumudontus gananda	P			1	2						3	3
Microzarkodina n. sp.	M				8						8	14
	S				0						0	
	P				6						6	
?Multioistodus compressus									1		1	1

Continued

		96-5-13	96-5-14	96-5-15	96-5-15A	96-5-16	96-5-16A	96-5-17	96-5-18	96-5-19	*Subtotal*	*Total*
Oepikodus communis	M	0		6	16	30					52	487
	S	7		10	106	169					292	
	P	3		4	40	96					143	
O. evae					4						4	4
O. intermedius	M				16	3					19	71
	S				8	7					15	
	P				18	19					37	
Oepikodus n. sp.						4					4	4
Oistodus lanceolatus	M				8	2	1				11	25
	S				6	5	1				12	
	P				0	1	1				2	
O. multicorrugatus	M		1	2	0	5	1	1	2	0	12	69
	S		1	10	4	11	12	7	5	1	51	
	P		0	2	0	1	2	0	1	0	6	
Parapanderodus	a	7		4		4	9	2	2	2	30	45
striatus	b	4		0		0	0	0	1	2	7	
	c	0		0		0	1	1	0	0	2	
	e	2		0		0	1	0	1	2	6	
Paroistodus originalis	M							1	1		2	6
	S							2	2		4	
	P							0	0		0	
P. parallelus	M	0		0	6	5	2				13	52
	S	2		4	16	5	8				35	
	P	0		0	4	0	0				4	
Paroistodus n. sp.						4					4	4
Periodon aculeatus	M	0		6	2			5	0	1	14	84
	S	1		2	12			18	1	20	54	
	P	1		0	10			3	0	2	16	
P. flabellum	M					6	14	3			23	79
	S					13	25	6			44	
	P					0	8	4			12	
P. selenopsis	M				2	3					5	12
	S				0	0					0	
	P				2	5					7	
Planusodus gradus	a-b		1	0	20	15					36	75
n. gen. n. sp.	c		0	0	12	11					23	
	e		0	1	6	9					16	
Prioniodus n. sp.	M				2						2	8
	S				4						4	
	P				2						2	

Continued

		96-5-13	96-5-14	96-5-15	96-5-15A	96-5-16	96-5-16A	96-5-17	96-5-18	96-5-19	*Subtotal*	*Total*
Protopanderodus	a-b	2									2	5
elongatus	c	1									1	
	e	2									2	
	f	0									0	
P. leonardii	a-b			2	18	32	12				64	107
	c			2	4	11	5				22	
	e			0	12	3	4				19	
	f			0	2	0	0				2	
P. rectus	a-b	1	2			?2					3	4
	c	0	0								0	
	e	0	1								1	
Protoprioniodus	M						8				8	18
aranda	S						5				5	
	P						5				5	
P. nyinti	M	0		0	4	1	15				20	125
	S	6		6	8	5	25				50	
	P	2		2	12	4	35				55	
Protoprioniodus n. sp.					4						4	4
Pteracontiodus cryptodens									2		2	2
Tripodus laevis							3		1		4	4
Tropodus australis	M	2									2	25
	S	21									21	
	P	2									2	
T. sweeti	M	7									7	39
	S	17									17	
	P	15									15	
New Genus C n. sp.							4				4	4
Coniform Indet. J							15				15	15
Coniform Indet. L						6					6	6
Coniform Indet. M								4			4	4
Coniform Indet. N									6		6	6
Coniform Indet. O								3	6		9	9
Total		113	7	178	526	728	260	70	40	36	1958	1958

Table 8

Grey Peak Section, KECHIKA FM.		Lloyd George Member		Quentin Member		Grey Peak Member				Haworth			
Distance above base (m)		66	112	525	640	768	933	953	990	1011	1031		
Species	Sample No	GP-94-64	GP-94-66	GP-94-7-3	GP-94-5-3	GP-94-5-9	GP-94-5-16	GP-94-5-17	GP-94-5-18	GP-94-4-1	GP-94-4-2		
	Mass (g)	2000	2500	2500	2500	2500	2000	2500	2500	3000	2500		
	Undiss. Mass (g)	240	78	123	343	436	1070	1240	569	808	746	*Subtotal*	*Total*
Cordylodus deflexus	a		2									2	2
C. hastatus	a		2									2	13
	c		2									2	
	e		9									9	
C. primitivus	a		47									47	59
	c		4									4	
	e		8									8	
C. proavus	a		26									26	34
	c		3									3	
	e		5									5	
Colaptoconus bolites										2		2	2
C. floweri	a									83		83	106
	b									20		20	
	c									3		3	
	e									0		0	
Colaptoconus	a								8	66		74	107
greypeakensis n. sp.	b								1	13		14	
	c								0	2		2	
	e								0	17		17	
Cornuodus longibasis											4	4	4
Drepanoistodus concavus	a									6	7	13	21
	c									4	1	5	
	e									0	3	3	
Eoconodontus	a		72									72	87
notchpeakensis	e		15									15	
Eucharodus parallelus										8	12	20	20
Graciliconus concinnus	M							3		9	2	14	78
n. gen. n. sp.	S							17		23	21	61	
	P							2		1	0	3	
Kallidontus serattus n. gen. n. sp.										4		4	4
K. princeps n. gen. n. sp.							1	4		17		22	22
?Paltodus deltifer				4								4	4
Paroistodus proteus	M							6	2	0	2	10	41
	S							10	4	3	14	31	
	P							0	0	0	0	0	
Phakelodus tenuis		3										3	3

Continued

		GP-94-6 4	GP-94-6 6	GP-94-7-3	GP-94-5-3	GP-94-5-9	GP-94-5-16	GP-94-5-17	GP-94-5-18	GP-94-4-1	GP-94-4-2	*Subtotal*	*Total*
Proconodontus muelleri	a		3									3	7
	e		4									4	
?Protopanderodus inconstans											8	8	8
Scolopodus subrex	a								16	49	22	87	100
	b								2	5	2	9	
	e								2	2	0	4	
Teridontus nakamurai	a		15									15	20
	b		3									3	
	c		1									1	
	e		1									1	
Tropodus comptus											2	2	2
?Utahconus utahensis					7							7	7
Total		3	222	4	7	0	1	42	35	337	100	751	751

Table 9

Grey Peak Section		**KECHIKA FM.**, Haworth Member									
Distance above base (m)		1052	1073	1086	1099	1119	1133	1262	1313		
Species	Sample No	GP-94-4-3	GP-94-4-4	GP-94-4-5	GP-94-4-6	GP-94-3-1	GP-94-3-2	GP-94-3-8	GP-94-2-2		
	Mass (g)	2500	2500	2500	2500	2500	2500	2500	3000		
	Undiss. Mass (g)	516	209	296	424	966	251	460	1000	*Subtotal*	*Total*
Acodus deltatus		2	9							11	11
Colaptoconus bolites			1	2	2					5	5
C. floweri	a					4				4	5
	b					0				0	
	c					1				1	
	e					0				0	
C. greypeakensis	a	1	7			5				13	21
n. sp	b	1	7			0				8	
	c		0			0				0	
	e		0			0				0	
Cornuodus longibasis		8	40	6	14					68	68
Drepanodus arcuatus				2	10					12	12
Drepanoistodus	a	16	29	14	32					91	123
concavus	c	1	2	2	5					10	
	e	7	6	3	6					22	
Eucharodus parallelus		60	20		8					88	88
Graciloconus	M	17	0							17	90
concinnus	S	60	5							65	
n. gen. n. sp	P	8	0							8	
Granatodontus cf. *G. ani*		2								2	2
Kallidontus serratus n. gen. n. sp		3	1		8					12	12
K. princeps n. gen. n. sp.		29	1		39					69	69
?Paltodus jemtlandicus		29	14							43	43
Parapanderodus striatus			7							7	7
Paroistodus proteus		8	13		2	2				25	25
?Protopanderodus inconstans					7		11			18	18
Scolopodus subrex	a	23	28	11	16			0		78	112
	b	3	6	4	6			1		20	
	e	2	6	1	5			0		14	
Stolodus stola									2	2	2
?Stultodontus sp.		2	5	6						13	13
New Genus A n. sp	M					2	5			7	35
	S					2	7			9	
	P					5	14			19	
Coniform Indet. 1								2		2	2
Total		282	207	51	160	21	37	1	2	761	761

Table 10

Grey Peak Section, OSPIKA FM.		Cloud-maker Member	Chesterfield Member									Finbow Shale Member		
Distance above base (m)		1461	1592.5	1602.5	1632.5	1662.5	1678	1700	1729	1739	1749	1784		
Species	Sample No.	GP-94-1-8	GP-94-1-16	GP-94-1-17	GP-94-1-19	GP-94-1-20	GP-94-1-23	GP-94-1-24	GP-94-1-27	GP-94-1-28	GP-94-1-29	GP-94-1-30		
	Mass (g)	3000	3000	3000	3000	2900	3000	2925	3000	3000	3000	3000		
	Undiss. Mass (g)	670	64	1254	617	756	896	728	697	703	945	923	*Subtotal*	*Total*
Acodus deltatus		1											1	1
Cornuodus longibasis	a-b		0			1							1	2
	c		1			0							1	
	e		0			0							0	
	f		0			0							0	
Drepanodus arcuatus	a/b					5							5	11
	c					1							1	
	e					5							5	
	f					0							0	
Drepanoistodus suberectus	a					3							3	12
	c					1							1	
	e					8							8	
D. bellburnensis	a					3							3	6
	c					1							1	
	e					2							2	
D. forceps	a					14							14	20
	c					3							3	
	e					3							3	
Erraticodon balticus							2						2	2
Multioistodus subdentatus								10			1		11	11
?M. compressus								1					1	1
Oistodus lanceolatus	M						0						0	1
	S						1						1	
	P						0						0	
Parapanderodus striatus	a					6	1						7	10
	b					2	0						2	
	c					0	0						0	
	e					1	0						1	

Continued

		GP-94-1-8	GP-94-1-16	GP-94-1-17	GP-94-1-19	GP-94-1-20	GP-94-1-23	GP-94-1-24	GP-94-1-27	GP-94-1-28	GP-94-1-29	GP-94-1-30	*Subtotal*	*Total*
Paroistodus originalis	M		8		15	13	4						40	158
	S		21		32	47	2						102	
	P		2		2	11	1						16	
P. parallelus	M		15		2								17	32
	S		12		2								14	
	P		0		1								1	
Periodon aculeatus	M		2	0	86	6	5		0			0	99	477
	S		10	1	281	13	11		2			1	319	
	P		4	0	46	4	4		1			0	59	
P. flabellum	M		11		32		1						44	100
	S		24		22		4						50	
	P		3		3		0						6	
Prioniodus elegans		1											1	1
Protopanderodus elongatus	a-b				2	1	0						3	5
	c				0	0	1						1	
	e				1	0	0						1	
P. gradatus	a/b				1	18	0						19	26
	c				0	2	1						3	
	e				0	4	0						4	
P. leonardii	a-b		2				0						2	4
	c		1				1						2	
	e		0				0						0	
P. rectus											1		1	1
P. robustus	a/b				1	25							26	31
	c				0	2							2	
	e				0	3							3	
P. varicostatus						2							2	2
Protoprioniodus aranda	M		3		3	0	0						6	33
	S		6		8	1	2						17	
	P		1		8	1	0						10	
P. nyinti	M		0		0								0	4
	S		0		1								1	
	P		2		1								3	
Spinodus spinatus						2	1						3	3
?Walliserodus nakholmensis						6	1			3			10	10
Total		2	128	1	550	220	43	11	3	3	2	1	964	964

Table 11

Section 4		KECHIKA FM. Haworth Member			OSPIKA FM. Finlay Limestone Member				PESIKA FM.		
Distance above base (m)		138	153	178.5	205.5	340.5	354	367.5	825.5		
Species	Sample No	96-4-K2	96-4-K3	96-4-K4	96-4-R1	96-4-2	96-4-3	96-4-4	96-4-6		
	Mass (g)	2500	2500	3000	3000	3000	3000	3000	3000		
	Undiss. Mass (g)	1036	733	1068	351	324	435	1025	907	*Subtotal*	*Total*
Acodus deltatus	M	0								0	2
	S	2								2	
	P	0								0	
A. kechikaensis n. sp.	M		23	30						53	305
	S		100	88						188	
	P		48	16						64	
A. longibasis	M		6	16						22	195
	S		92	38						130	
	P		23	20						43	
A. warensis n. sp.	M		1	2						3	42
	S		8	22						30	
	P		5	4						9	
Ansella jemtlandica							4			4	4
Diaphorodus russoi		7								7	7
Distomodus	M								3	3	9
staurognathoides	S								3	3	
	P								3	3	
Drepanodus arcuatus	a-b							2		2	4
	c							0		0	
	e							2		2	
Drepanoistodus forceps	a			4						4	5
	c			1						1	
	e			0						0	
Drepanoistodus cf.	a						10			10	13
D. pitjanti	c						1			1	
	e						2			2	
Dzikodus tableheadensis	M						0	0		0	23
	S						11	0		11	
	P						10	2		12	
Kallidontus cf. *nodosus* n. gen. n. sp.		4	8	7						19	19
Oepikodus communis					2					2	2
Oelandodus elongatus		2	1	4						7	7
Oulodus sp. A									9	9	9
Panderodus unicostatus									22	22	22

Continued

		96-4-K2	96-4-K3	96-4-K4	96-4-R1	96-4-2	96-4-3	96-4-4	96-4-6	*Subtotal*	*Total*
Paroistodus horridus	M					2	16	1		19	72
	S					3	23	1		27	
	P					2	22	2		26	
Paroistodus originalis	M					3	14			17	53
	S					2	24			26	
	P					2	8			10	
P. parallelus					1					1	1
P. proteus	M	0	1	1						2	86
	S	2	20	47						69	
	P	0	4	11						15	
Periodon aculeatus	M					14	67	22		103	384
	S					39	106	44		189	
	P					12	61	19		92	
Prioniodus elegans	M			2						2	9
	S			6						6	
	P			1						1	
Protopanderodus calceatus	a-b						38			38	46
	c						5			5	
	e						2			2	
	f						1			1	
P. cooperi	a-b						18	3		21	39
	c						11	3		14	
	e						2	1		3	
	f						1	0		1	
P. varicostatus	a-b						5	1		6	6
	c						0	0		0	
	e						0	0		0	
	f						0	0		0	
Protoprioniodus sp.					1					1	1
Pseudooneotodus beckmanni									2	2	2
Pteracontiodus cryptodens						1				1	1
Scolopodus krummi	a	2	20	28						50	74
	b	0	8	10						18	
	c	0	2	4						6	
Triangulodus akiensis n. sp.	M						4			4	64
	S						43			43	
	P						17			17	
Walliserodus costatus	a-b						1	1		2	4
	c						1	1		2	
W. ethingtoni	a-b					2	21	3		26	35
	c					0	3	0		3	
	e					1	5	0		6	
Spinodus spinatus						1				1	1
Total		19	370	362	4	84	557	108	42	1546	1546

Table 12

Moodie Creek Section, Road River Group							
Distance above base (m)			1	13	40		
Species	Sample No.		MC-95-A1	MC-95-A3	MC-95-A5		
	Mass (g)		2500	2000	2500		
	Undiss. Mass (g)		655	252	614	*Subtotal*	*Total*
Acanthodus lineatus		a	16			16	19
		e	3			3	
A. uncinatus		a	4			4	7
		e	3			3	
Colaptoconus sp.			5	1		6	6
Cordylodus angulatus		a	1			1	3
		c	1			1	
		e	1			1	
C. lindstromi		a	2			2	2
		c	0			0	
		e	0			0	
Drepanoistodus minutus n. sp.			6			6	6
D. pervetus		a	11	1		12	15
		c	0	0		0	
		e	3	0		3	
Rossodus manitouensis		a	15			15	20
		b	2			2	
		c	1			1	
		e	2			2	
Striatodontus strigatus n. sp.			2		15	17	17
Utahconus utahensis		a	7			7	11
		b	2			2	
		c	2			2	
		e	0			0	
Variabiliconus bassleri		a	5		0	5	22
		b	2		0	2	
		c	0		15	15	
		e	0		0	0	
		Total	96	2	30	128	128

Table 13

Road River Core, KWADACHA FM.			
Distance above base (m)		116	
Species	Sample No.	RR-96-4	
	Mass (g)	2000	
	Undiss. Mass (g)	38	*Total*
Panderodus unicostatus		8	8
Oulodus sp. B		5	5
	Total	13	13

Table 14

Gataga Mountain Section, OSPIKA FM.		
Distance above base (m)		c. 40-60
Species	Sample No.	GB-95-1
	Mass (g)	2500
	Undiss. Mass (g)	273
Phragmodus undatus		4

Table 15

Deadwood Lake Section		KECHIKA		ROAD RIVER GP.					
Distance above base (m)		13	28	97	181	388.5	417.5		
Species	Sample No	DL-96-2	DL-96-3	DL-96-7	DL-96-13	DL-96-18	DL-96-21		
	Mass (g)	2500	2500	2500	2500	2500	3000		
	Undiss. Mass (g)	627	263	419	993	1067	750	*Subtotal*	*Total*
Acanthodus lineatus	a	0	8	140				148	181
	e	4	1	28				33	
Amorphognathus tvaerensis							64	64	64
Colaptoconus sp.			7	18				25	25
Cordylodus angulatus	a			8				8	18
	c			2				2	
	e			8				8	
C. caseyi				2				2	2
C. delicatus n. sp.				2				2	2
C. lindstromi	a		3	6				9	9
	c		0	0				0	
	e		0	0				0	
D. basiovalis							4	4	4
Drepanoistodus pervetus	a		9	24				33	46
	c		0	0				0	
	e		1	12				13	
D. minutus n. sp.			3	2				5	5
Drepanoistodus cf. n. sp. A					8			8	8
?Macerodus dianae				2				2	2
?Macerodus sp.			1	12				13	13
Paroistodus proteus					7			7	7
?Periodon sp.						3		3	3
Rossodus manitouensis	a		41	118				159	216
	b		10	20				30	
	c		0	6				6	
	e		1	20				21	
Striatodontus prolificus				3				3	3
Tricostatus cf. *T. infundibulum* n. sp.			2	2				4	4
Utahconus utahensis	a		1					1	5
	b		2					2	
	c		0					0	
	e		2					2	
Variabilioconus bassleri	a			18				18	48
	b			16				16	
	c			2				2	
	e			12				12	
Yaoxianognathus sp							3	3	3
Total		4	92	483	15	3	71	668	668

Table 16

Deadwood Lake Section		ROAD RIVER GP.								
Distance above base (m)		427.5	437.5	457.5	467.5	478.5	485.5	494		
Species	Sample No.	DL-96-22	DL-96-23	DL-96-25	DL-96-26	DL-96-27	DL-96-28	DL-96-29		
	Mass (g)	3000	2500	3000	3000	3000	2500	2500		
	Undiss. Mass (g)	1415	285	1474	620	1104	1191	1122	*Subtotal*	*Total*
Ansella jemtlandica			1						1	1
Drepanoistodus basiovalis		3	1	2	2			3	11	11
Panderodus sulcatus					1	1		7	9	9
Phragmodus	M					0	1	2	3	86
undatus	S					6	23	38	67	
	P					3	5	8	16	
Plectodina	M							1	1	13
tenuis	S							7	7	
	P							5	5	
Protopanderodus liripipus					5				5	5
Pseudooneotodus mitratus					4				4	4
Ramiform Indet.			1						1	1
	Total	3	3	2	12	10	29	71	130	130

Table 17

Table 18 (Note: * indicates species not illustrated)

Species	Total Number of Elements	% of Total Fauna (Species)	% of Total Fauna (Genus)
Acanthodus lineatus	5949	15.05	15.34
Acanthodus uncinatus	113	0.29	
Acodus deltatus	1884	4.77	11.39
Acodus kechikaensis n. sp.	1199	3.03	
Acodus longibasis	306	0.77	
Acodus neodeltatus n. sp	397	1.00	
Acodus oneotensis	334	0.85	
Acodus quentinensis n. sp.	340	0.86	
Acodus warenis n. sp	42	0.11	
Amorphognathus tvaerensis	64	0.16	0.16
Anodontus longus	11	0.03	0.03
Ansella jemtlandica	9	0.02	0.04
Ansella longicuspica	6	0.02	
Bergstroemognathus extensus	29	0.07	0.07
Colaptoconus bolites	80	0.20	1.24
Colaptoconus greypeakensis n. sp.	166	0.42	
Colaptoconus floweri	147	0.37	
* *Colaptoconus quadraplicatus*	24	0.06	
Colaptoconus sp.	74	0.19	
Cordylodus angulatus	1379	3.49	10.21
Cordylodus caboti	409	1.03	
Cordylodus caseyi	97	0.25	
Cordylodus deflexus	2	0.01	
Cordylodus delicatus n sp	47	0.12	
Cordylodus hastatus	13	0.03	
Cordylodus intermedius	104	0.26	
Cordylodus lindstromi	1863	4.71	
Cordylodus primitivus	62	0.16	
Cordylodus proavus	61	0.15	
* *Cornuodus longibasis*	218	0.55	0.55
?*Diaphorodus* n sp	14	0.04	0.31
Diaphordus russoi	107	0.27	
Distomodus staurognathoides	9	0.02	0.02
* *Drepanodus arcuatus*	77	0.19	0.20
Drepanoistodus amoenus	66	0.17	8.05
Drepanoistodus basiovalis	18	0.05	
Drepanoistodus bellburnensis	6	0.02	
Drepanoistodus concavus	458	1.16	
Drepanoistodus expansus	81	0.20	
Drepanoistodus forceps	47	0.12	
Drepanoistodus minutus n sp.	63	0.16	
Drepanoistodus nowlani	82	0.21	
Drepanoistodus pervetus	2291	5.80	
Drepanoistodus cf. *D. pitjanti*	13	0.03	
Drepanoistodus suberectus	12	0.03	
Drepanoistodus n sp. A	17	0.04	
Drepanoistodus cf. n sp A	8	0.02	
Drepanoistodus n. sp B	1	0.00	
Drepanoistodus n. sp. C	6	0.02	
Drepanoistodus n sp D	3	0.01	

Species	Total Number of Elements	% of Total Fauna (Species)	% of Total Fauna (Genus)
* ?*Parapaltodus* sp	24	0.06	0.06
Parapanderodus striatus	107	0.27	0.27
Paroistodus horridus	72	0.18	2.92
* *Paroistodus numarcuatus*	24	0.06	
Paroistodus originalis	217	0.55	
Paroistodus parallelus	144	0.36	
Paroistodus proteus	694	1.76	
Paroistodus n. sp.	4	0.01	
Periodon aculeatus	945	2.39	2.90
Periodon flabellum	185	0.47	
Periodon selenopsis	15	0.04	
?*Periodon* sp.	3	0.01	
Phragmodus undatus	90	0.23	0.23
* *Phakelodus tenuis*	3	0.01	0.01
Planusodus gradus n. gen. n. sp	75	0.19	0.19
Plectodina tenuis	13	0.03	0.03
Polycostatus falsioneotensis	18	0.05	0.10
Polycostatus cf. sulcatus	22	0.06	
Prioniodus adami	9	0.02	0.11
Prioniodus elegans	14	0.04	
Prioniodus n. sp	19	0.05	
Proconodontus muelleri	7	0.02	0.02
Protopanderodus calceatus	46	0.12	1.14
Protopanderodus cooperi	39	0.10	
* *Protopanderodus elongatus*	28	0.07	
?*Protopanderodus inconstans*	26	0.07	
Protopanderodus gradatus	117	0.30	
Protopanderodus leonardi	138	0.35	
Protopanderodus liripipus	5	0.01	
Protopanderodus rectus	13	0.03	
Protopanderosus robustus	31	0.08	
Protopanderodus varicostatus	8	0.02	
Protoprioniodus aranda	51	0.13	0.49
Protoprioniodus cowheadensis	7	0.02	
Protoprioniodus nyinti	129	0.33	
Protoprioniodus n. sp	4	0.01	
* *Protoprioniodus* sp	1	0.00	
Pseudooneotodus beckmanni	2	0.01	0.02
Pseudooneotodus mitratus	4	0.01	
Pteracontiodus cryptodens	3	0.01	0.01
Rossodus kwadachaensis n sp	24	0.06	14.94
Rossodus manitouensis	3905	9.88	
Rossodus muskwaensis n. sp	378	0.96	
Rossodus sheffieldensis n. sp.	81	0.20	
Rossodus subtilis n. sp.	25	0.06	
Rossodus tenuis	1493	3.78	
Scolopodus amplus n. sp	19	0.05	2.34
Scolopodus krummi	273	0.69	
Scolopodus subrex	632	1.60	
Semiacontiodus aff. S. cornuformis	43	0.11	0.30

Drepanoistodus n. sp. E	11	0.03	
Dzikodus tableheadensis	23	0.06	0.06
Eoconodontus notchpeakensis	126	0.32	0.32
Erraticodon balticus	2	0.01	0.01
Eucharodus parallelus	130	0.33	0.33
Fahraeusodus marathonensis	70	0.18	0.18
Iapetognathus aengensis	19	0.05	0.10
Iapetognathus fluctivagus	5	0.01	
Iapetognathus sprakersi	13	0.03	
Iapetognathus sp.	1	0.00	
* *Glyptodontus* sp.	5	0.01	0.01
Graciliconus concinnus n. gen. n. s	232	0.59	0.59
Granatodontus cf. G. ani	8	0.02	0.02
Juanognathus jaanusoni	69	0.17	1.20
Juanognathus variabilis	405	1.02	
Jumudontus gananda	3	0.01	0.01
Kallidontus nodosus n. gen. n. sp.	18	0.05	0.80
Kallidontus cf. *nodosus* n. gen. n.	24	0.06	
Kallidontus princeps n. gen. n. sp.	117	0.30	
Kallidontus serratus n. gen. n. sp.	158	0.40	
Laurentoscandodus cf. *L. triangula*	87	0.22	0.68
Laurentoscandodus sinuosus n. sp.	183	0.46	
Loxodus latibasis	31	0.08	0.08
Macerodus cristatus n. sp.	5	0.01	0.06
?*Macerodus dianae*	2	0.01	
Macerodus lunatus n. sp.	3	0.01	
?*Macerodus* sp.	13	0.03	
Microzarkodina n. sp.	14	0.04	0.04
?*Multioistodus compressus*	2	0.01	0.03
Multioistodus subdentatus	11	0.03	
Oelandodus elongatus	130	0.33	0.33
Oepikodus communis	1135	2.87	3.73
Oepikodus evae	107	0.27	
Oepikodus intermedius	230	0.58	
Oepikodus n. sp.	4	0.01	
Oistodus bransoni	3	0.01	0.34
Oistodus lanceolatus	59	0.15	
Oistodus multicorrugatus	69	0.17	
Oistodus n. sp.	3	0.01	
Oulodus sp. A	9	0.02	0.04
Oulodus sp. B	5	0.01	
* *Paltodus deltifer*	10	0.03	2.66
* ?*Paltodus deltifer*	4	0.01	
?*Paltodus jemtlandicus*	1030	2.61	
* *Paltodus subaequalis*	9	0.02	
Panderodus sulcatus	9	0.02	0.10
Panderodus unicostatus	30	0.08	
Paracordylodus gracilis	122	0.31	0.31
Subtotal	23566	59.62	59.62

Semiacontiodus nogamii	76	0.19	
Spinodus spinatus	4	0.01	0.01
Stolodus stola	48	0.12	0.12
Striatodontus prolificus	37	0.09	0.55
Striatodontus strigatus n. sp	179	0.45	
Stultodontus costatus	9	0.02	0.08
?*Stultodontus* sp.	22	0.06	
Teridontus gracillimus	17	0.04	0.95
Teridontus nakamurai	308	0.78	
Teridontus obesus	52	0.13	
Triangulodus akiensis n. sp.	64	0.16	0.16
Tricostatus cf. *T. glyptus*	82	0.21	0.36
Tricostatus infundibulum n. sp	35	0.09	
Tricostatus cf. *T. infundibulum*	4	0.01	
Tricostatus terlinguis n. sp.	22	0.06	
Tripodus laevis	4	0.01	0.01
Tropodus australis	227	0.57	1.43
Tropodus comptus	23	0.06	
Tropodus sweeti	317	0.80	
Utahconus longipinnatus	758	1.92	5.50
Utahconus utahensis	1408	3.56	
?*Utahconus utahensis*	7	0.02	
Variabiloconus bassleri	1373	3.47	4.44
Variabiloconus spurius	380	0.96	
Walliserodus costatus	4	0.01	0.12
Walliserodus ethingtoni	35	0.09	
?*Walliserodus nakholmensis*	10	0.03	
* *Westergaardodina* sp.	1	0.00	0.00
Yaoxianognathus sp.	3	0.01	0.01
Coniform Indet. A	5	0.01	0.01
Coniform Indet. B	2	0.01	0.01
Coniform Indet. C	10	0.03	0.03
Coniform Indet. D	5	0.01	0.01
Coniform Indet. E	13	0.03	0.03
Coniform Indet. F	17	0.04	0.04
Coniform Indet. G	19	0.05	0.05
Coniform Indet. H	55	0.14	0.14
Coniform Indet. I	2	0.01	0.01
Coniform Indet. J	15	0.04	0.04
Coniform Indet. K	4	0.01	0.01
Coniform Indet. L	6	0.02	0.02
Coniform Indet. M	4	0.01	0.01
Coniform Indet. N	6	0.02	0.02
Coniform Indet. O	9	0.02	0.02
New Genus A	35	0.09	0.09
New Genus B	6	0.02	0.02
New Genus C	4	0.01	0.01
Platform Indet.	4	0.01	0.01
Ramiform Indet.	1	0.00	0.00
	15960	40.38	40.38

TOTAL	**39526**	100.00

Species	Total Number of Elements	% of Total Fauna by Species
Acanthodus lineatus	5949	15.05
Rossodus manitouensis	3905	9.88
Drepanoistodus pervetus	2291	5.80
Acodus deltatus	1884	4.77
Cordylodus lindstromi	1863	4.71
Rossodus tenuis	1493	3.78
Utahconus utahensis	1408	3.56
Cordylodus angulatus	1379	3.49
Variabiloconus bassleri	1373	3.47
Acodus kechikaensis n. sp.	1199	3.03
Oepikodus communis	1135	2.87
?*Paltodus jemtlandicus*	1030	2.61
Periodon aculeatus	945	2.39
Utahconus longipinnatus	758	1.92
Paroistodus proteus	694	1.76
Scolopodus subrex	632	1.60
Drepanoistodus concavus	458	1.16
Cordylodus caboti	409	1.03
Juanognathus variabilis	405	1.02
Acodus neodeltatus n. sp.	397	1.00

Table 19

Genus	Total Number of Elements	% of Total Fauna by Genus
Acanthodus	6062	15.34
Rossodus	5906	14.94
Acodus	4502	11.39
Cordylodus	4037	10.21
Drepanoistodus	3183	8.05
Utahconus	2173	5.50
Variabiloconus	1753	4.44
Oepikodus	1476	3.73
Paroistodus	1155	2.92
Periodon	1148	2.90

Table 20