Conodont biostratigraphy of the Lower to Middle Devonian Deserters Formation (new), Road River Group, northeastern British Columbia

Leanne J. Pyle, Michael J. Orchard, Christopher R. Barnes, and Michelle L. Landry

Abstract: A new Lower to Middle Devonian basinal unit of the Road River Group, herein formally named the Deserters Formation, contains argillaceous, crinoidal limestone and black shale deposited in a linear sub-basin of the Ospika Embayment, southern Kechika Trough. The abrupt lateral facies changes in the region, facies thickness, and occurrence of volcanics indicate a period of extensional tectonism. A total of 53 (4–5 kg each) samples from the Deserters Formation yielded 7766 conodont elements assigned to 14 genera representing 33 species. The formation ranges from the Lochkovian (*eleanorae* Zone, or lower part of the *delta* Zone of the Cordilleran Region) to Eifelian (*australis* Zone). The temporal constraints established by conodont biostratigraphy allow correlation to the Grizzly Bear Formation, a regionally restricted Lower to Middle Devonian unit in the Selwyn Basin to the north.

Résumé : Une nouvelle unité de bassin du Groupe de Road River, Dévonien inférieur à moyen, ci-après désigné formellement sous le nom de Formation de Deserters, contient du calcaire argileux, à crinoïdes, et du shale noir déposé dans un sous-bassin linéaire de la baie d'Ospika, dans la fosse sud de Kechika. Les changements abrupts de faciès latéral dans la région, l'épaisseur du faciès et l'occurrence de volcaniques indiquent une période tectonique d'extension. Un total de 53 échantillons (4–5 kg chacun) de la Formation de Deserters a fourni 7766 éléments de conodontes assignés à 14 genres représentant 33 espèces. La formation s'étend du Lochkovien (Zone à *eleanorae* ou la partie inférieure de la Zone à *delta* de la région de la Cordillère) à l'Éifilien (Zone à *australis*). Les restrictions temporelles imposées par la biostratigraphie des conodontes permet une corrélation avec la Formation de Grizzly Bear, une unité régionale restreinte au Dévonien inférieur à moyen dans le bassin de Selwyn, au nord.

[Traduit par la Rédaction]

Introduction

The well-exposed lower Paleozoic stratigraphic succession in northeastern British Columbia (Halfway River, Ware and Trutch map areas, 94B, 94F, 94G; Fig. 1) records the evolution of the western North American margin. From the Late Cambrian to Middle Devonian, carbonates of the Macdonald Platform were bordered to the west by basinal facies of the Kechika Trough and its southern extension, the Ospika Embayment (Fig. 2). There have been few detailed stratigraphic studies in the southern Ware map area (94F).

In this present study, a new Lower to Middle Devonian unit of the basinal Road River Group, herein formally named the Deserters Formation, was measured, described in detail and sampled for conodont microfossils at a section east of the Ospika River and west of McCusker Creek in the southeast corner of the Ware map area (94F/1, Fig. 1). Collection began in the core of an anticline at 6319500N, 0427500E and continued southwest to 6318000N, 0429700E (Universal Transverse Mercator (UTM) coordinates based on North American Datum (NAD) 27). The section, 1800 m thick (fault-repeated), contains units of argillaceous, crinoidal limestone, black shale, siltstone, coral-rich limestone debris flow deposits, and intervals of tuff. Based on the abundant and moderately well-preserved conodont fauna, an age range of Early Devonian (Lochkovian) to early Middle Devonian (Eifelian), *eleanorae* Zone (= lower part of the *delta* Zone of the Cordilleran Region) to *australis* Zone, has been determined.

The Devonian strata of the Road River Group form the upper part of the basinal succession in the Ospika Embayment. The platform-to-basin transition remained well defined from the Early Ordovician (early Arenigian) through the Silurian (Pyle and Barnes 2000, 2001) and persisted into the Early Devonian. The eastern margin of the Ospika Embayment

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Fig. 1. Map showing location of Ospika River section (OR = section 9, located at *), line of cross-section in Fig. 3 and location of platform margin from Late Silurian to mid-Devonian (teeth point toward shelf; after Thompson 1989). Sections 1–8 and 10 are described by Pyle and Barnes (2001).

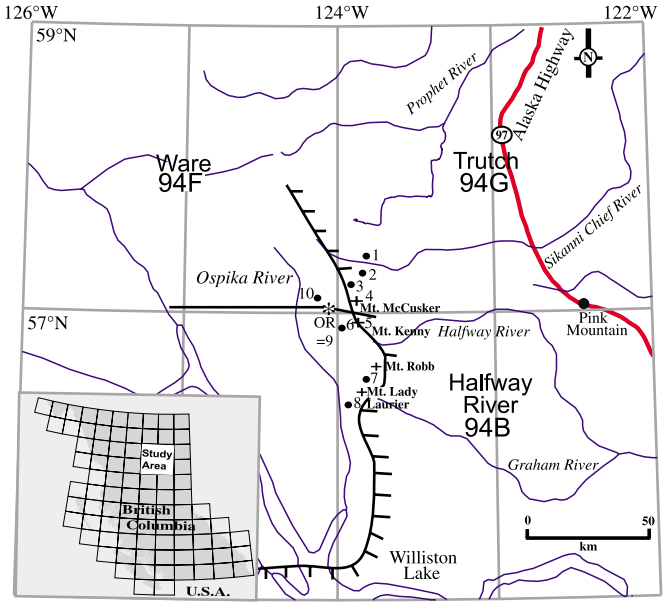
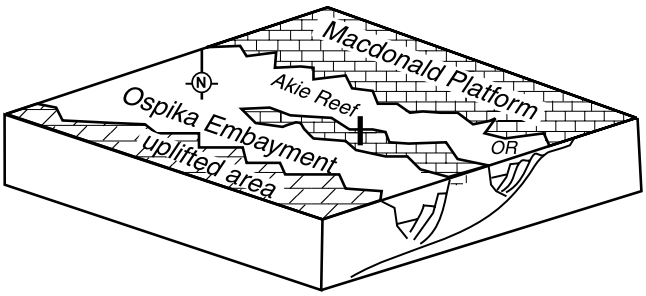


Fig. 2. Paleogeographic reconstruction of the Ospika Embayment in the Middle to Late Devonian. OR, Ospika River section locality (modified from MacIntyre 1992).



migrated east during the interval (Fig. 1). This study improves the correlation of Lower to Middle Devonian units from the Ospika Embayment to the MacDonald Platform. It is also significant in describing strata that elsewhere in the Cordillera, especially south of latitude 56°N, are absent beneath a sub-Upper Devonian unconformity (Fritz et al. 1991). The local preservation of strata from the Ospika Embayment (Fig. 2) allows for correlation to similar, regionally restricted units in the Selwyn Basin, the continuation of the Kechika Trough north of latitude 60°N.

Previous work

There have been few detailed stratigraphic studies in the Ware map area. Taylor et al. (1979) completed geological reconnaissance mapping of Ware East Half at 1 : 250 000. In the south central Ware map area, the regional geology has been outlined by Cecile and Norford (1979), Gabrielse (1981), Gabrielse et al. (1977), and Taylor et al. (1979). More detailed local mapping (1 : 50 000) of the Cirque area (Gataga mineral district, 94F/1, 94F/2, 94F/6, 94F/7, 94F/10, 94F/11) by MacIntyre (1980, 1981, 1983, 1992, 1998) and Pigage (1986) occurred during a phase of mineral exploration. In the Driftpile and Gataga areas of the northern Kechika Trough (Kechika map area, 94L), detailed mapping and structural geology were completed by McClay and Insley (1986), McClay et al. (1988), and the British Columbia Geological Survey (Ferri et al. 1995, 1996, 1997).

The present study was part of the Geological Survey of Canada's Central Foreland National Mapping (NATMAP) Project. It compliments detailed stratigraphic studies north and east by Pyle and Barnes (2000, 2001) that established the stratigraphic framework for the uppermost Cambrian through Lower Silurian succession in the Macdonald Platform and Kechika Trough and provided precise conodont biostratigraphic ages for correlation. Pyle and Barnes (2002, 2003) studied the taxonomy and evolution of these lower Paleozoic conodonts and produced a revised conodont biozonation for the northern Canadian Cordillera. The Lower to Middle Devonian succession, however, is poorly known and had insufficient paleontologic control for correlation of the abrupt facies changes from MacDonald Platform to the Kechika Trough and also for correlation farther north to the Selwyn Basin.

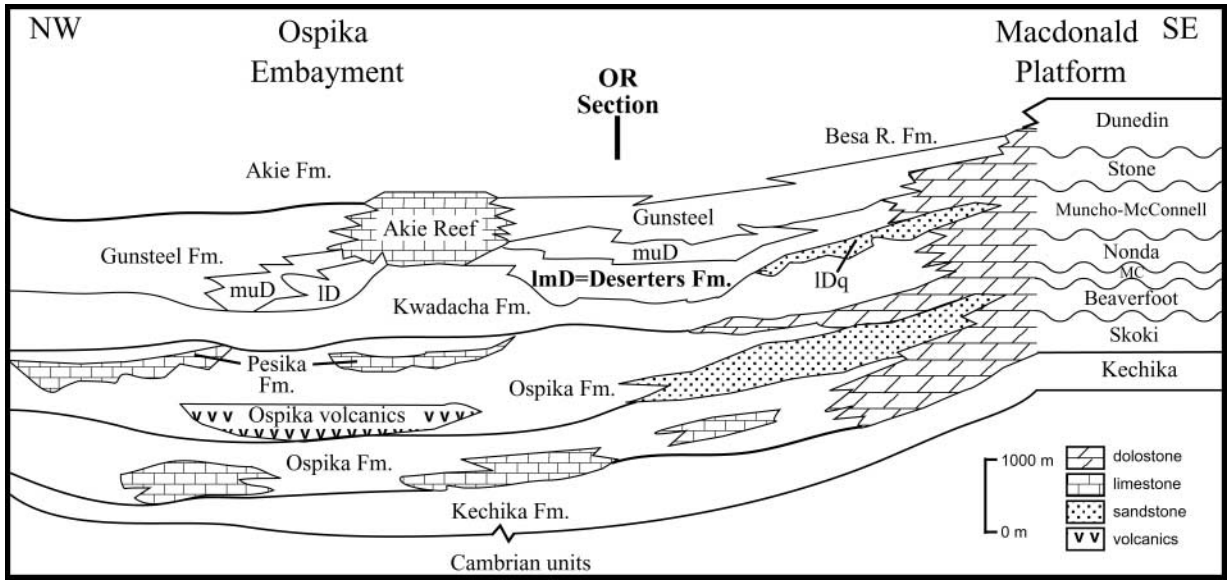
Conodonts from the study area have been reported from reconnaissance studies and from the overlying Upper Devonian – Mississippian Earn Group. The present study provides biostratigraphic constraints on the Deserters Formation (new) within the Road River Group that lies stratigraphically above the Silurian Pesika and Kwadacha formations (Pyle and Barnes 2000) and below the Devono-Mississippian Earn Group (Irwin and Orchard 1989). In the study area the Deserters Formation is in fault contact with the underlying Silurian units at the Ospika River section and is overlain unconformably by the Earn Group regionally (Fig. 3).

Regional and economic geology

From the late Neoproterozoic to Early Devonian, the rifted western margin of Laurentia experienced several phases of extension, rifting, and post-rift subsidence (Bond et al. 1985; Thompson et al. 1987; Ross 1991; Cecile and Norford 1993; Lickorish and Simony 1995; Cecile et al. 1997; Pyle and Barnes 2000, 2001). During the Cambrian to Early Silurian shallow water carbonates accumulated on the Macdonald Platform, while deep-water shales and rare carbonates characterize the slope and basin facies of the adjacent Kechika Trough and the Ospika Embayment to the south (Fig. 2). The tectonic setting and pattern of continental margin sedimentation changed in the Late Devonian through Early Mississippian as the Kechika Trough filled and deposition of northerly and westerly derived clastics was initiated (Gordey et al. 1987; Fritz et al. 1991). Associated with Devonian sedimentation are second-order sub-basins bounded to the northeast by Early and Middle Devonian reefs, such as the Kwadacha and Akie reefs (Pigage 1986; MacIntyre 1992). The sub-basins record abrupt facies changes to slope and basin debris flows and turbidites.

Devonian basinal facies within both the Selwyn Basin and Kechika Trough are characterized by stratiform mineral deposits. The well-defined lower Paleozoic platform-to-basin transition

Fig. 3. Schematic cross-section across the Ospika Embayment, showing inferred stratigraphic relationships of units and approximate location of Ospika River section (modified from MacIntyre 1992). lD, Lower Devonian Paul River formation; muD, Middle–Upper Devonian rusty silty shale ("Brown siltstone"); lDq, Lower Devonian wacke and siltstone (map units of MacIntyre 1992); lmD, Deserters Formation (Fm.). The succession of the Macdonald Platform (MC, McCusker Formation) is after Pyle and Barnes (2001).



zone is the site of sedimentary exhalative (Sedex) mineral deposits, particularly the carbonate-hosted Mississippi Valley-type lead–zinc deposit at Robb Lake, Halfway River map area (Macqueen and Thompson 1978; Paradis et al. 1999). Stratiform barite–lead–zinc deposits are hosted in sub-basins along the platform margin within Middle Ordovician, Lower Silurian and Upper Devonian strata, Ware and Kechika map areas (Ferri et al. 1997; MacIntyre 1998) and include the Cirque, Fluke and Elf deposits in the Gataga district (MacIntyre 1992).

Lithostratigraphy

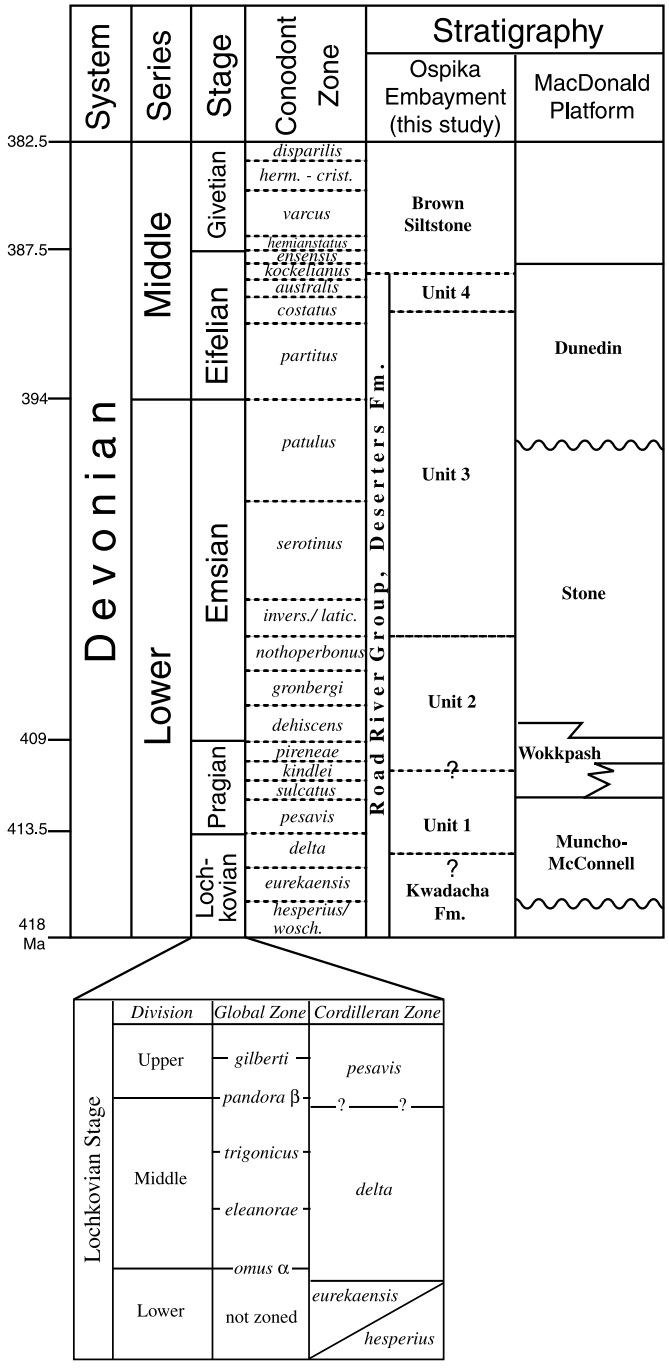
The Road River Group is an extensive lithostratigraphic unit recognized from the Halfway River map area (94B) (Thompson 1989) northwestward to the Selwyn Basin in the Yukon (Gordey 1981; Cecile 1982). In the Kechika Trough, the succession ranges in age from Early Ordovician (early Arenigian) to Middle Devonian, but much older strata are included in the Selwyn Basin. Jackson and Lenz (1962) described the type section of the Road River Formation in the Richardson Mountains (Richardson Trough), northern Yukon as a succession of dark graptolitic shale, argillaceous limestone, and minor chert, dolostone, siltstone, and sandstone. Fritz (1985) raised the Road River to group level and redefined its base at a level in the Early Cambrian. The stratigraphy of Lower Ordovician to Lower Silurian basinal facies of the Road River Group and the Middle Ordovician to Lower Silurian transitional facies preserved along the ancient shelfbreak have been formally described by Pyle and Barnes (2000, 2001). The regional correlation of the Road River Group is illustrated in charts in Barnes et al. (1981) and Gabrielse and Yorath (1991).

The section of Road River Group exposed east of the Ospika River is an 1800 m-thick, fault-repeated succession of predominantly argillaceous, crinoidal limestone, black shale, and siltstone. The part of the section, from 303 m above section base to 1217 m above section base, is proposed as the type section for the Lower–Middle Devonian Deserters Formation. The Deserters Formation is named after the Deserters Range southwest of the Ospika River. The Deserters Formation is at least 914 m thick and contains four distinct units. It overlies the Kwadacha Formation (Pyle and Barnes 2000) and is overlain by an informally named brown siltstone unit (Thompson 1989). The lower boundary of unit 1 and upper boundary of unit 4 are fault contacts. The dominant lithology of the Deserters Formation is dark grey, thin-bedded, laminated, argillaceous, crinoidal limestone that weathers dark grey. Interbeds consist of black shale, siltstone, dolostone, quartz arenite, tuff, and coral-rich debris flow deposits. The Deserters Formation lies within a regionally restricted facies belt and was deposited within a linear sub-basin of the Kechika Trough. Based on conodont data, the Deserters Formation ranges in age from Lockhovian to Eifelian (Early to Middle Devonian; Fig. 4).

Unit 1 is the oldest (Lochkovian–Pragian) and occurs at 303 m above the section base (Fig. 5*a*) and repeated again at 1217 m above the section base where it overlies a fault contact with unit 4 (Fig. 5*c*). It is overlain by units 2, 3, and 4 in the lower part of the section, up to 1217 m (Figs. 5*a*–5*c*). Unit 2 (363–818 m above the base) is Emsian in age and is overlain abruptly by unit 3 (818–950 m above the base) which is Emsian to Eifelian in age. Unit 4 (950–1217 m above the base) is the youngest (Eifelian) and conformably overlies unit 3. Unit 4 contains an interval of tuff at 1144 m that occurs within the fault repetition of the unit at 1644 m. In the upper part of the section (1299–1800 m above the base), unit 1 is overlain by a fault repetition of units 3 and 4 that are in turn overlain by the unnamed brown siltstone unit at 1695 m (Fig. 5*d*).

Unit 1 (82 m thick; Fig. 5*c*) contains a subunit (1217–1280 m above the base) of 50% shale and 50% thin bedded, compact

Fig. 4. Conodont biostratigraphy of the Lower and Middle Devonian (chronostratigraphy after Tucker et al. 1998) and stratigraphy of the Ospika Embayment (this study) and Macdonald Platform (after Gabrielse and Yorath 1991). The revised global zonation for the Lochkovian is after Valenzuela-Ríos and Murphy (1997).



sandstone at the base that is brown weathering, fine to medium grained with poor to medium sorted, subrounded quartz grains. At the top of the subunit is a thick bedded (4 m thick), fossiliferous sandstone debris flow containing crinoid stems, favositid coral, rare brachiopods, and chert fragments. The thick sandstone grades laterally to light-grey weathering packstone containing fenestrate bryozoans and abundant pelmatozoan ossicles. Overlying the sandstone subunit is flaggy, brown-grey weathering, argillaceous limestone to calcareous mudstone. The lower boundary of the unit is a fault, and its upper contact is covered in the lower part of the section (Fig. 5*a*) and unconformable with unit 3 at 1299 m above section base (Fig. 5*c*). Conodonts from unit 1 range from Lochkovian *delta* Zone of the Cordilleran region, or more specifically, within the global *eleanorae* Zone, to Pragian, within the *kindlei* Zone.

The base of unit 2 is covered at 363 m above section base. The upper contact with unit 3 at 818 m above section base is obscured by talus on the ridge, but appears sharp (Fig. 6A) as there is an abrupt change in lithology to dark grey and black weathering limestone. Unit 2 is brown-orange weathering, silty, laminated dolostone and dolomudstone (Figs. 5*a*, 5*b*; 6A). It is Early Devonian in age, older than the overlying *inversus–laticostatus* Zone at the base of unit 3.

Unit 3 lies at the section base, from 26–229 m and at 818–1299 m above the section base. Measurement of the section began in the core of an anticline. The unit contains rare limestone beds and is predominantly grey weathering, laminated, dolomitic siltstone and brown-orange weathering, feldspathic sandstone interbedded with thin beds of laminated, flaggy, brown and tan weathering dolomitic mudstone and shale (Fig. 5*a*). The fault repetitions of unit 3 (up to 272 m thick) consist of dark grey to black weathering limestone with up to 10% black shale. The limestone varies from medium to thick beds of black, compact, fine crystalline, finely laminated lime mudstone to medium crystalline, argillaceous wackestone to packstone containing small pelmatozoan ossicles (0.5–1.5 mm diameter) and planar lamination (Figs. 5B, 6A). The base of unit 3 is in sharp contact with unit 2 at 818 m and with unit 1 at 1299 m above section base. The unit is Emsian to Eifelian in age, ranging from the *inversus–laticostatus* Zone into the *costatus* Zone.

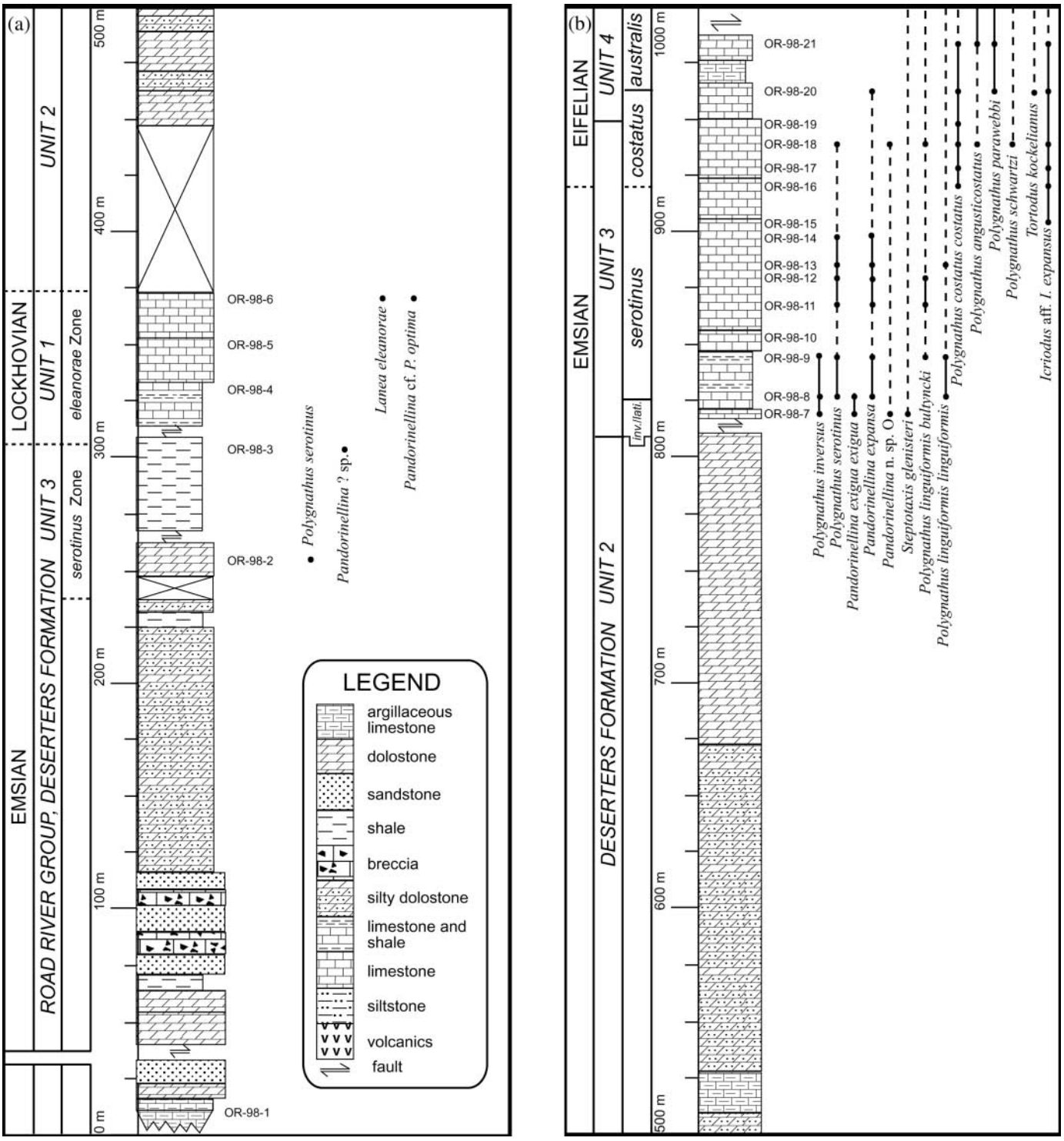
Unit 4 is recessive and overlies unit 3 conformably at 950 m above the section base and is in fault contact with unit 3 at 1560 m above the section base. Its upper contacts with unit 1 and the brown siltstone unit are also fault contacts. The base of the unit consists of thin bedded, medium to dark grey, laminated packstone, some of which contain pelmatozoan ossicles as the main allochem. The upper part of the unit contains thick beds of quartz arenite, weathering brown-grey and interbedded with dolomitic and silty shale. Unit 4 is at least 330 m thick and contains less than 10% thin bedded argillaceous limestone and shale. At 1144 m above the base of the section, a 24 m-thick interval of green-grey weathering, altered alkalic volcanics occurs, which is overlain by dolostone, dolomitic siltstone, and medium bedded, laminated sandstone (Fig. 5*c*). A similar, but thinner interval of volcanics occurs within unit 4 at 1644 m above section base (Fig. 5*d*). Unit 4 is Eifelian in age, ranging from within the *costatus* Zone into the *australis* Zone (Fig. 4).

Unit 4 is abruptly overlain by a brown siltstone unit (Figs. 5*d*, 6B) that was not measured. The siltstone unit is homogenous, unfossiliferous, brown to orange weathering, dolomitic siltstone and mudstone that grades into orange weathering siltstone and shale.

Conodont biostratigraphy

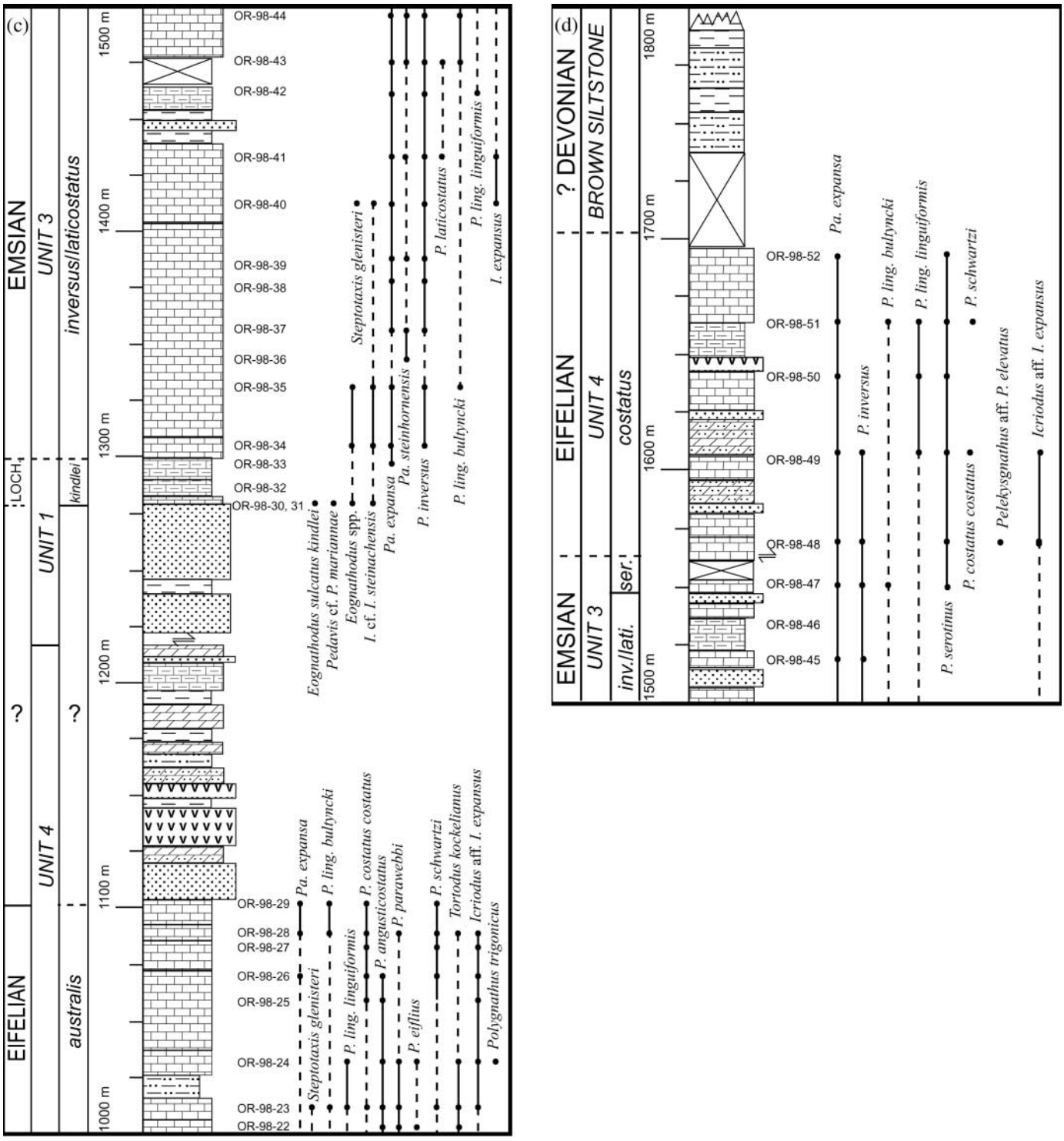
From the measured section of the Deserters Formation

Fig. 5. Distribution of conodont species through the Deserters Formation, Road River Group, Ospika River section (124°11′W, 57°01′N).



(1695 m), a total of 53 conodont samples (4–5 kg each) were taken from carbonate beds at 10–20 m intervals (Figs. 5a–5*d*). The conodonts are moderately well preserved with a colour alteration index of 3-5, indicating burial temperatures of 110°C to over 300°C. A total of 7766 conodont elements are assigned to14 genera representing 33 species (Tables 1 and 2). Elements referred to as "non-platform elements" in the tables include ramiform elements and coniform elements, such as those of the *Icriodus* apparatus. All of the conodont species recovered from the Deserters Formation have been adequately described in previous papers. This paper illustrates representatives of the fauna and the key zonal species. The figured specimens in Plates 1 and 2 are housed in the National Type Collection of the Geological Survey of Canada (GSC), Ottawa, Ontario. The conodont fauna indicates the Deserters Formation is Lochkovian to Eifelian in age, based on the occurrence of

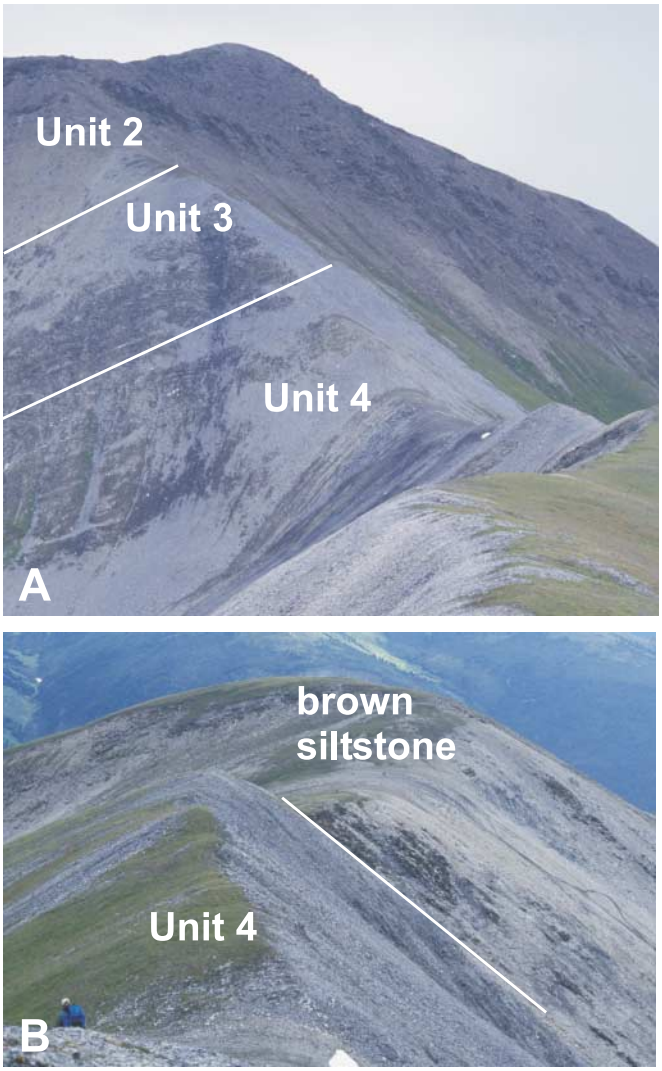
Fig. 5 (concluded).



the nominate species of the *eleanorae, kindlei, inversus–laticostatus, serotinus, costatus*, and *australis* zones (Fig. 4).

Specimens assigned to *Lanea eleanorae* (Lane and Ormiston 1979; Pl. 1, fig. 1) occur within unit 1 (Fig. 5A). This species was revised by Murphy and Valenzuela-Ríos (1999) and assigned to the new genus *Lanea*. Two species of *Lanea, L. omoalpha* (Murphy and Matti 1983) and *L. eleanorae*, are used to designate global zones in the middle Lochkovian (Valenzuela-Ríos and Murphy 1997) (Fig. 4, inset). *Eognathodus sulcatus kindlei* Lane and Ormiston 1979 (Pl. 1, figs. 2–4) is a zonal species for the Pragian and occurs within the beds adjacent to the debris-flow deposits of unit 1 at 1280 m above section base (Fig. 5*c*). *Pedavis* cf. *P. mariannae* Lane and Ormiston 1979 (Pl. 1, fig. 18) also occurs in this zone. *Icriodus* cf. *I. steinachensis* Al-Rawi

Fig. 6. (A) View of the lower part of the ridge section Deserters Formation, looking east, showing the resistant nature of the dolostone of the upper part of unit 2 and recessive nature of units 3 and 4. (B) View of the upper part of the ridge section, looking west, showing the fault repeated unit 4 overlain sharply by the brown siltstone unit.



1977 (Pl. 1, fig. 7) first occurs in the *kindlei* Zone in unit 1 and ranges into the *inversus–laticostatus* Zone within unit 3. The specimens differ from *I. steinachensis* in having only two rows of denticles. The species range is also different from that of *I. steinachensis*, which ranges no higher than the *kindlei* Zone.

Icriodus is more abundant than *Polygnathus* in units 3 and 4, from the *serotinus* Zone to *australis* Zone. The dominance of *Icriodus* over *Polygnathus* in the conodont fauna (Tables 1, 2) indicates a biofacies shift that has been documented in the Lower Devonian in Nevada (Klapper and Johnson 1975) and in Germany (Weddige and Ziegler 1976). Within units 3 and 4, the pulses of increased abundance of *Icriodus* correspond to laminated packstone beds and may indicate shallowing. Two forms are illustrated and assigned to *Icriodus* aff. *I. expansus* Branson and Mehl 1938 (Pl. 1, figs. 5, 6). They are similar to those illustrated by Chatterton (1978) from the *serotinus* Zone of the Dunedin Formation in northern British Columbia. The species is variable and exhibits elements with a strongly expanded base and either subtransverse rows of fused nodes that become more V-shaped posteriorly or three distinct rows of nodes.

The next zonal species to occur in the succession are *Polygnathus inversus* Klapper and Johnson 1975 (Pl. 2, figs. 5–6) and *Polygnathus laticostatus* Klapper and Johnson 1975 (Pl. 2, figs. 7–8), which indicate an Emsian age (Fig. 4). *Polygnathus inversus* is more abundant than *Po. laticostatus* throughout unit 3 and occurs at both levels in the section where the unit is fault-repeated (Figs. 5*b*, 5*c*). From the *inversus–laticostatus* Zone to the overlying *serotinus* Zone within unit 3, the evolutionary transition from *Pandorinellina exigua exigua* Philip 1966 (Pl. 1, figs. 10–11) to *Pa. expansa* Uyeno and Mason 1975 (Pl. 1, figs. 12–13) occurs. *Pandorinellina expansa* is distinguished from *Pa. exigua exigua* based on the outline of the basal cavity, which in the former shows less constriction at midlength. *Pa. exigua exigua* bears a cavity that is narrowly expanded under the entire blade posterior of the lobes that differentiates it from *Pa. exigua philipi* Klapper 1969, which bears only a narrow groove. Another species that occurs in unit 3 is *Pandorinellina* n. sp. O Philip 1966 (Pl. 1, figs. 14–15), in which the upper margin bears many small, nearly discrete denticles, with the anterior denticles not markedly higher as in *Pa. exigua exigua*. *Steptotaxis glenisteri* Klapper 1969 (Pl. 1, fig. 17) occurs in the *inversus–laticostatus* Zone and extends into the *australis* Zone.

Unit 3 ranges through the *serotinus* Zone (Emsian) and into the *costatus* Zone (Eifelian) (Fig. 4), based on the appearances of the nominate species of *Polygnathus* (Pl. 2, figs. 1–2, 14–15). Associated species that occur through both zones and into unit 4 include *Po. linguiformis bultyncki* Weddige 1977 (Pl. 2, figs. 9–10) and *Po. linguiformis linguiformis* Hinde 1879 (Pl. 2, fig. 11). A few specimens of *Pelekysgnathus* aff. *Pe. elevatus* Branson and Mehl 1938 (Pl. 1, figs. 19–20) were recovered from the *serotinus* Zone.

Unit 4 is Eifelian in age and yielded species indicative of the *costatus* Zone. *Po. angusticostatus* Wittekindt 1966 (Pl. 1, figs. 21–22), *Po. parawebbi* Chatterton 1974 (Pl. 2, figs. 12–13), and *Po. schwartzi* Chatterton 1978 (Pl. 2, figs. 16–17) occur within the *costatus* Zone and range into the *australis* Zone.

Unit 4 ranges into the *australis* Zone, based on the occurrence of *Tortodus kockelianus* Bischoff and Ziegler 1957 (Pl. 2, figs. 19–22), which occurs within unit 4 at 965 m above the section base (Fig. 5*b*). The distinction between subspecies of *kockelianus*, based on platform development and degree of twisting of the element, was not made due to the limited material in the present collection. Pa elements of *Polygnathus trigonicus* Bischoff and Ziegler 1957 (Pl. 2, fig. 18) are characterized by their triangular platform, ornamented with nodes and the species is restricted to the late Eifelian (Klapper and Johnson 1980).

Regional correlation

In the Ware map area, a regionally restricted, undefined, Lower Devonian unit flanking the Kwadacha Reef (map unit Drs of MacIntyre 1998) is informally known as the Paul River formation, and is excluded from both the Road River

Table 1. Distribution of conodont elements recovered from Ospika River (OR) section, Deserters Formation, Road River Group.

	Sample Number (OR-98-)																					
Species	**2**	**3**	**6**	**7**	**8**	**9**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**Total**
Belodella resima				1	6	1	2									2				38	1	**51**
Belodella triangularis				2			1								1					22	7	**33**
Dvorakia klapperi			2	3																		**5**
Icriodus aff. *I. expansus*							1				3	52	59	148	15	209	4		22	2	11	**526**
Lanea eleanorae			6																			**6**
Panderodus recurvatus			1																			**1**
Panderodus unicostatus				19	18	2	9		3									1			1	**53**
Pandorinellina exigua exigua				69	4															2		**75**
Pandorinellina expansa					9	3	16	2	2	1						5						**38**
Pandorinellina cf. *P. optima*			6																4			**10**
Pandorinellina n. sp. O				10										1					8			**19**
Pandorinellina? sp.		1																				**1**
Polygnathus angusticostatus														5			1	8	22	88	1	**125**
Polygnathus costatus costatus												5	7	53	1	29	2		60		5	**162**
Polygnathus eiflius																		1		10		**11**
Polygnathus inversus				32	12	6																**50**
Po. linguiformis bultyncki						3	112	1						2					16			**134**
Po. linguiformis linguiformis					3	3			12										116	26		**160**
Polygnathus parawebbi																1	19	32	142	178		**372**
Polygnathus robusticostatus														6								**6**
Polygnathus serotinus	25				151	14	1007	7	5	7				2								**1218**
Polygnathus schwartzi														8					60			**68**
Polygnathus trigonicus																				24		**24**
Steptotaxis glenisteri				2															6			**8**
Tortodus kockelianus																1		1	8	66		**76**
Non-platform elements	53	0	6	56	64	67	101	6	9	5	7	10	10	137	12	42	5	10	59	449	32	**1140**
Total	**78**	**1**	**21**	**194**	**267**	**99**	**1249**	**16**	**31**	**13**	**10**	**67**	**76**	**362**	**29**	**289**	**31**	**53**	**523**	**905**	**58**	**4372**

Table 2. Distribution of conodont elements recovered from Ospika River (OR) section, Deserters Formation, Road River Group.

	Sample Number (OR-98-)																								
Species	**26**	**27**	**28**	**29**	**30**	**31**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**47**	**48**	**49**	**50**	**51**	**52**	**Total**
Belodella devonicus	5								1		3			15	2		20	9		2						**57**
Belodella resima	10	10	1			11		3	1		5			7	2		10	3		4	10		4	4		**85**
Belodella triangularis	11	4						3			1			6	2		3	1		5	1			1		**38**
Eognathodus sulcatus kindlei						63																				**63**
Eognathodus spp.					1	43		24	5																	**73**
Icriodus aff. *I. expansus*	119	119	62											2	1						144	2				**449**
Icriodus cf. *I. steinachensis*					4	6		12	3					2												**27**
Panderodus unicostatus							1	24	11		3	1	3	63	3		9	4	1	7	2	10	6	2		**150**
Pandorinellina expansa	1		23	8			27	204	11		11	34	9	79	28	3	20	22	4	5	9	21	9	4	1	**533**
Pandorinellina steinhornensis										1	17		2		3		15	5								**43**
Pedavis cf. *P. mariannae*						9																				**9**
Pelekysgnathus aff. *P. elevatus*																					7					**7**
Polygnathus angusticostatus	13																									**13**
Polygnathus costatus costatus																						43				**43**
Polygnathus inversus								27	12		6	5	3	105	32	2	24	12	3	44	7	40				**322**
Polygnathus laticostatus															3		2									**5**
Po. linguiformis bultyncki			16	2					2								1	2		2				2		**27**
Po. linguiformis linguiformis																1						254	79	26		**360**
Polygnathus parawebbi			30																							**30**
Polygnathus serotinus																				99	10	20	97	154	2	**382**
Polygnathus schwartzi	28	9	20	4																				6		**67**
Pseudooneotodus sp.						6																				**6**
Steptotaxis glenisteri														3												**3**
Tortodus kockelianus			3																							**3**
Non-platform elements	92	15	23	2		48	4	45	19	3	15	16	4	22	14	4	47	15	4	45	61	53	28	19	1	**599**
Total	**279**	**157**	**178**	**16**	**5**	**186**	**32**	**342**	**65**	**4**	**61**	**56**	**21**	**304**	**90**	**10**	**151**	**73**	**12**	**213**	**251**	**443**	**223**	**218**	**4**	**3394**

Plate 1. All specimens are from the Ospika River section, Deserters Formation. All views are upper unless otherwise noted. **fig. 1.** *Lanea eleanorae* (Lane and Ormiston 1979) P element, OR-98-6, GSC 120670, × 45. **figs. 2–4.** *Eognathodus sulcatus kindlei* Lane and Ormiston 1979. (figs. 2–3) P element, upper and lower views, respectively, OR-98-31, GSC 12671, ×40. (Fig. 4) P element, lateral view, OR-98-31, GSC 12672, ×40. **figs. 5–6.** *Icriodus* aff. *I. expansus* Branson and Mehl 1938. (fig. 5) I element, OR-98-20, GSC 120673, ×75. (Fig. 6) I element, OR-98-20, GSC 120674, ×50. **fig. 7.** *Icriodus* cf. *I. steinachensis* Klapper and Johnson 1980. I element, OR-98-34, GSC 120675, ×50. **figs. 8–9.** *Eognathodus* spp., upper and lateral views, respectively, OR-98–31, GSC 120676, 120677, ×60. **figs. 10–11.** *Pandorinellina exigua exigua* Philip 1966. P element, upper and lateral views, respectively, OR-98-7, GSC 120680, ×35. **figs. 12–13.** *Pandorinellina expansa* Uyeno and Mason 1975. P element, upper and lateral views, respectively, OR-98-23, GSC 120678, 120679, ×60. **figs. 14–15.** *Pandorinellina* n. sp. O Philip 1966. P element, upper and lateral views, respectively, OR-98-7, GSC 120681, ×50. **fig. 16.** *Pandorinellina*? sp. Pa element, OR-98-3, GSC 120682, ×40. **fig. 17.** *Steptotaxis glenisteri* Klapper 1969. I element, OR-98-23, GSC 120685, ×75. **figs. 18.** *Pedavis* cf. *P. mariannae* Lane and Ormiston 1979. I element, OR-98-31, GSC 12683, ×40. **fig. 19–20.** *Pelekysgnathus* aff. *P. elevatus* Branson and Mehl 1938. I element, upper and lateral views, respectively, OR-98-48, GSC 120684, ×60. **figs. 21–22.** *Polygnathus angusticostatus* Wittekindt 1966. P element, lower and upper views, respectively, OR-98-24, GSC 120686, ×35.

and Earn groups (Pigage 1986). The unit also underlies and flanks the Akie Reef (lD on Fig. 3 = map unit lD of MacIntyre 1992). It contains interfingering limestone debris flows, crinoid-rich beds, black chert, rusty weathering dark grey siltstone and silty shale, and interbedded black shale of Pragian age, based on graptolites (Norford 1969). Irwin and Orchard (1990) reported Lockhovian conodonts from the unit.

MacIntyre (1998) mapped additional limestone turbidites and debris flows as unit DRs (Paul River formation) in two linear belts separating carbonates of the Early to Middle Devonian Kwadacha, Akie, and Pesika reefs (Gabrielse 1975) and carbonates of the Macdonald Platform. Unit DRs represents turbidite deposits and extends south to the Ospika River along the platform to basin transition zone, thinning basinward. The unit onlaps Early to Middle Devonian carbonates of the Akie and Kwadacha reefs (Fig. 3). Orange to green weathering tuffs also occur within the Early Devonian section (MacIntyre 1998).

The Deserters Formation is partly equivalent to the Paul River formation and similarly represents a regionally restricted facies belt that unconformably overlies the Kwadacha Formation of the Road River Group and in turn is overlain by the Gunsteel formation of the Earn Group (Fig. 3). The Earn Group consists of three informal members, the Gunsteel, Akie, and Warneford, which were deposited during a transgression that terminated reef growth (MacIntyre 1998). It is proposed that both the Paul River formation and the Deserters Formation be included within the Road River Group. The lithology of the Deserters Formation is similar to that of the Paul River formation and represents flows from the Akie Reef into a linear sub-basin of the Ospika Embayment between the carbonate banks of the reef and carbonates of the MacDonald Platform represented by the Stone and Dunedin formations (Figs. 2, 3).

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 in age (Orchard in Ferri et al. 1995). The upper boundary of the Kwadacha Formation throughout the northern Kechika Trough was not observed, but Ferri et al. (1995) described the upper part of the formation as a limestone and chert succession overlain abruptly by siltstone and slate of the Earn Group. The Gunsteel formation ranges in age from the late Middle – early Late Devonian to Early Mississippian (Orchard in MacIntyre 1998).

The lithologic- and time-equivalent strata on the Macdonald Platform are the Stone and Dunedin formations that are Early to Middle Devonian in age (Figs. 3, 4). The carbonate terrace comprising the Muncho–McConnell and Stone formations built up from the Silurian to Middle Devonian. The Stone Formation is overlain unconformably by the transgressive shelf carbonates of the Dunedin Formation that is overstepped by shale of the Besa River Formation of Late Devonian to Mississippian age (Fritz et al. 1991).

Basinal equivalents of the Road River Group within the northwestern part of the Halfway River map area are exposed within the Laurier Anticlinorium (Thompson 1989). An informally named brown siltstone unit ranges in age from Early Silurian to Early and Middle Devonian, based on graptolites (Davies 1966; Thompson 1989). It was mapped separately as the Silurian Siltstone in the Ware and Trutch map areas (Cecile and Norford 1979) and was named formally as the Kwadacha Formation by Pyle and Barnes (2000). The informal brown siltstone, described herein and mapped by Thompson (1989) as unit SDbs, is lithologically similar to the Kwadacha but is younger (post-*australis* Zone).

Regionally, south of 56°N, Lower and Middle Devonian strata are preserved only locally beneath a sub-Upper Devonian unconformity (Fritz et al. 1991). In the northern Cordillera, Nahanni map area, Yukon and Northwest territories, the Deserters Formation correlates to the Grizzly Bear Formation (Gabrielse et al. 1973) based on the lithology and conodont fauna. The Grizzly Bear is a succession of off-shelf, argillaceous, crinoidal limestone, deposited along an off-shelf shoal west of the main carbonate platform of the Mackenzie Platform and ranges in age from late Early Devonian (*gronbergi* Zone) to early Middle Devonian (*australis* Zone), based on conodonts (Orchard in Gordey and Anderson 1993).

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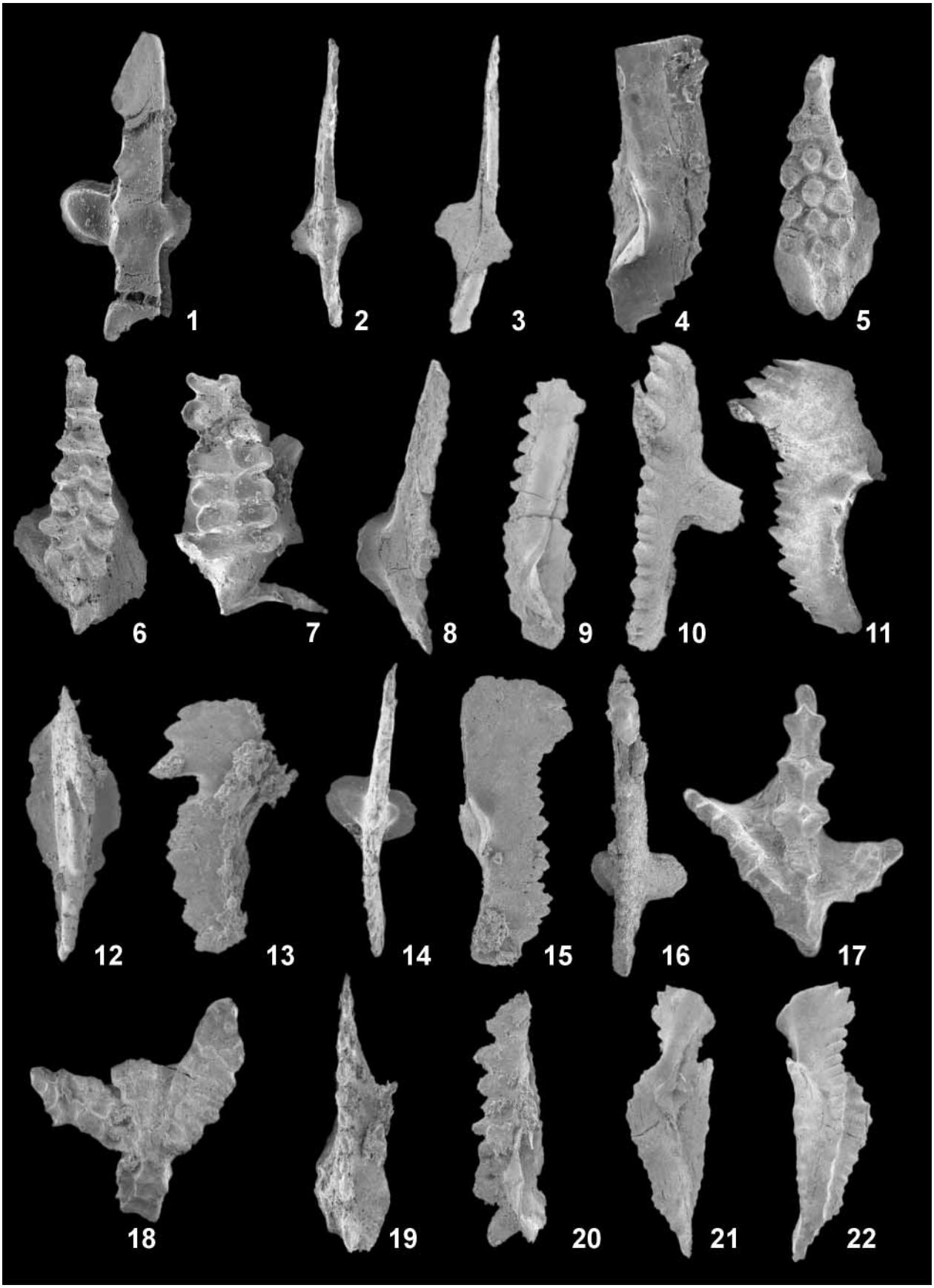

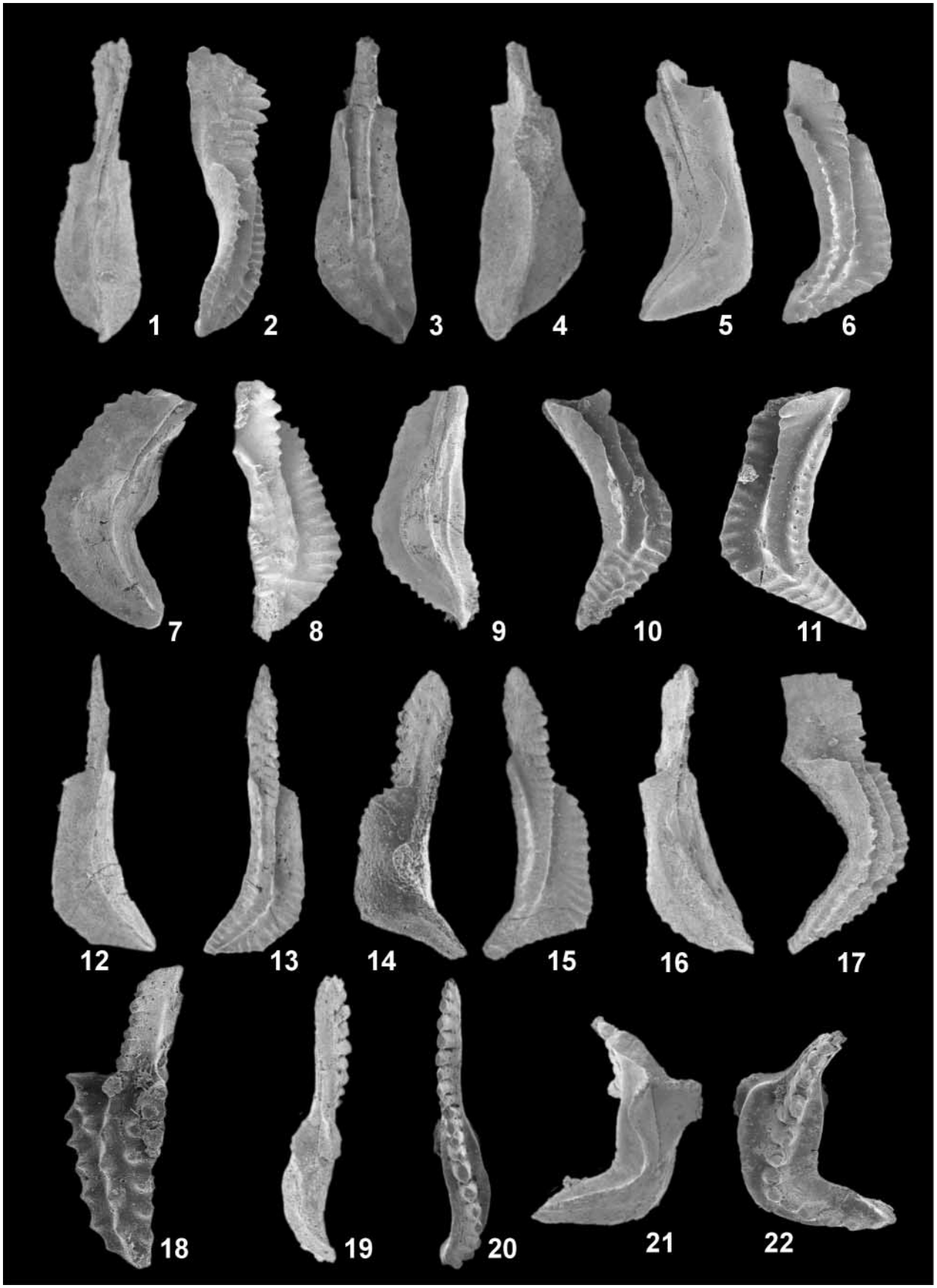

Plate 2. All specimens are P elements, in lower and upper views, respectively, from the Ospika River section, Deserters Formation. **figs. 1–2.** *Polygnathus costatus costatus* Klapper 1971. OR-98-18, GSC 120687, 120688, ×45. **figs. 3–4.** *Polygnathus eiflius* Bischoff and Ziegler 1957. OR-98-24, GSC 120689, ×80. **figs. 5–6.** *Polygnathus inversus* Klapper and Johnson 1975. OR-98-40, GSC 120690, 120691, ×60. **figs. 7–8.** *Polygnathus laticostatus* Klapper and Johnson 1975. OR-98-41, GSC 120692, 120693, ×40. **figs. 9–10.** *Polygnathus linguiformis bultyncki* Weddige 1977. OR-98-49, GSC 120694 ×40. **fig. 11.** *Polygnathus linguiformis linguiformis* Hinde 1879. OR-98-49, GSC 120695 ×45. **figs. 12–13.** *Polygnathus parawebbi* Chatterton 1974. OR-98-26, GSC 120696, ×40. **figs. 14–15.** *Polygnathus serotinus* Telford 1975. OR-98-11, GSC 120697, ×50. **figs. 16–17.** *Polygnathus schwartzi* Chatterton 1978. OR-98-18, GSC 120698, ×55. **fig. 18.** *Polygnathus trigonicus* Bischoff and Ziegler 1957. OR-98-24, GSC 120699, ×95. **figs. 19–22.** *Tortodus kockelianus* Bischoff and Ziegler 1957. (figs. 19–20) OR-98-24, GSC 120700, ×60. (figs. 21–22) OR-98–24, GSC 120701, ×65.

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References

Al-Rawi, D. 1977. Biostratigraphische Gliederung der Tentaculiten-Schichten des Frankenwaldes mit Conodonten und Tentaculiten (Unter- und Mittel-Devon; Bayern, Deutschland). Senckenbergiana Lethaea, **58**: 25–79.

Barnes, C.R., Norford, B.S., and Skevington, D. 1981. The Ordovician System in Canada, International Union of Geological Sciences, Publication no. 8.

Bischoff, G., and Ziegler, W. 1957. Die Conodontenschronologie des Mitteldevons und des tiefsten Oberdevons. Abhandlungen des Hissischen Landesamtes für Bodenforschung, Heft 22, pp. 1–136.

Bond, G.C., Christie-Blick, N., Kominz, M.A., and Devlin, W.J. 1985. An early Cambrian rift to post-rift transition in the Cordillera of western North America. Nature (London), **315**: 742–745.

Branson, E.B., and Mehl, M.G. 1938. The conodont genus *Icriodus* and its stratigraphic distribution. Journal of Paleontology, **12**: 156–166.

Cecile, M.P. 1982. The Lower Paleozoic Misty Creek Embayment, Selwyn Basin, Yukon and Northwest Territories. Geological Survey of Canada, Bulletin 335, pp. 78.

Cecile, M.P., and Norford, B.S. 1979. Basin to platform transition, Lower Paleozoic strata of Ware and Trutch map areas, northeastern British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 79-1A, pp. 219–226.

Cecile, M.P., and Norford, B.S. 1993. Ordovician and Silurian. *In* Sedimentary cover of the craton in Canada. *Edited by* D.F. Stott and J.D. Aitken. Geological Survey of Canada, Geology of Canada, no. 5, Subchapter 4C, (Also Geological Society of America, The Geology of North America, Vol. D-1), pp. 125–149.

Cecile, M.P., Morrow, D.W., and Williams, G.K. 1997. Early Paleozoic (Cambrian to Early Devonian) tectonic framework, Canadian Cordillera. Bulletin of Canadian Petroleum Geology, **45**: 54–74.

Chatterton, B.D.E. 1974. Middle Devonian conodonts from the Harrogate Formation, southeastern British Columbia. Canadian Journal of Earth Sciences, **11**: 1461–1484.

Chatterton, B.D.E. 1978. Aspects of late Early and Middle Devonian conodont biostratigraphy of western and northwestern Canada. *In* Western and Arctic Canadian biostratigraphy. *Edited by* C.R. Stelck and B.D.E. Chatteron. Geological Association of Canada, Special Paper 18, pp. 161–231.

Davies, E.J.L. 1966. Ordovician and Silurian of the northern Rocky Mountains between Peace and Muskwa Rivers, British Columbia. Unpublished Ph.D. thesis, University of Alberta, Edmonton, Alta.

Ferri, F., Nelson, J., and Rees, C. 1995. Geology and mineralization of the Gataga River Area, northern Rocky Mountains (94l/7,8,9 and 10). *In* Geological fieldwork 1995. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1995-1, pp. 277–295.

Ferri, F., Rees, C., and Nelson, J. 1996. Geology and mineralization of the Gataga Mountain Area, northern Rocky Mountains (94L/10, 11, 14 and 15). *In* Geological fieldwork 1995. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1996-1, pp. 137–154.

Ferri, F., Rees, C., Nelson, J., and Legun, A. 1997. Geology of the Northern Kechika Trough (NTS 94L/14,15; 94M/3, 4, 5, 6, 12, 13; 104P/8, 9, 15, 16). *In* Geological fieldwork 1996. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1997-1, pp. 125–144.

Fritz, W.H. 1985. The basal contact of the Road River Group—a proposal for its location in the type area and in other selected areas in the Northern Canadian Cordillera. *In* Current research, part B, Geological Survey of Canada, Paper 85-1B,, pp. 205–215.

Fritz, W.H., Cecile, M.P., Norford, B.S., Morrow, D., and Geldsetzer, H.H.J. 1991. Cambrian to Middle Devonian assemblages. *In* Geology of the Cordilleran Orogen in Canada. *Edited by* H. Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, no. 4, pp. 151–218.

Gabrielse, H. 1975. Geology of Fort Grahame East half map area, British Columbia. Geological Survey of Canada, Paper 75-33.

Gabrielse, H. 1981. Stratigraphy and structure of Road River and associated strata in Ware (west half) map area, Northern Rocky Mountains, British Columbia. *In* Current research, part A, Geological Survey of Canada, Paper 81-1A, pp. 201–207.

Gabrielse, H., and Yorath, C.J. 1991. Geology of the Cordilleran Orogen in Canada. Geological Survey of Canada, Geology of Canada no. 4 (Also Geological Society of America, The Geology of North America, Vol. G-2).

Gabrielse, H., Blusson, S.L., and Roddick, J.A. 1973. Geology of Flat River, Glacier Lake, and Wrigley Lake map-areas, District of Mackenzie and Yukon Territory, Geological Survey of Canada, Memoir 366, pp. 1–153.

Gabrielse, H., Dodds, C.J., and Mansy, J.L. 1977. Geology of Toodoggone (94E) and Ware (94F, west half) map areas, British Columbia. Geological Survey of Canada, Open File 483.

Gordey, S.P. 1981. Stratigraphic cross-section, Selwyn Basin to Mackenzie Platform, Nahanni map-area, Yukon Territory and District of Mackenzie. *In* Current research, part A, Geological Survey of Canada, Paper 80-1A, pp. 353–355.

Gordey, S.P., and Anderson, R.G. 1993. Evolution of the northern Cordilleran miogeocline, Nahanni map area (105I), Yukon and Northwest Territories, Geological Survey of Canada Memoir 428, pp. 1–214.

Gordey, S.P., Abbott, J.G., Templeman-Kluit, D.J., and Gabrielse, H. 1987. "Antler" clastics in the Canadian Cordillera. Geology, **15**: 103–107.

Hinde, G.J. 1879. On conodonts from the Chazy and Cincinnati group of the Cambro-Silurian and from the Hamilton and Genesee Shale divisions of the Devonian, in Canada and the

United States. Quarterly Journal of the Geological Society of London, **35**: 351–369.

Irwin, S.E.B., and Orchard, M.J. 1989. Conodont biostratigraphy and constraints on Upper Devonian mineral depostis in the Earn Group, northern British Columbia and Yukon. *In* Current research, part E, Geological Survey of Canada, Paper 89-1E, pp. 13–19.

Irwin, S.E.B., and Orchard, M.J. 1990. Conodont ages of stratiform mineral deposits. Geological Survey of Canada, Open File Report, 2225, p. 59.

Jackson, D.E., and Lenz, A. 1962. Zonation of Ordovician and Silurian graptolites of northern Yukon, Canada. Bulletin of American Association of Petroleum Geologists, **46**: 30–45.

Klapper, G. 1969. Lower Devonian conodont sequence, Royal Creek, Yukon Territory and Devon Island, Canada. Journal of Paleontology, **43**: 1–27.

Klapper, G. 1971. Sequence within the conodont genus *Polygnathus* in the New York lower Middle Devonian. Geologica et Palaeontologica, **5**: 59–79.

Klapper, G., and Johnson, D.M. 1975. Sequence in conodont genus *Polygnathus* in Lower Devonian at Lone Mountain, Nevada. Geologica et Paleontologica, **9**: 65–83.

Klapper, G., and Johnson, J.G. 1980. Endemism and dispersal of Devonian conodonts. Journal of Paleontology, **54**: 400–455.

Lane, H.R., and Ormiston, A.R. 1979. Siluro-Devonian biostratigraphy of the Salmontrout River area, east-central Alaska. Geologica et Paleontologica, **13**: 39–96.

Lickorish, W.H., and Simony, P.S. 1995. Evidence for late rifting of the Cordilleran margin outlined by stratigraphic division of the Lower Cambrian Gog Group, Rocky Mountain Main Ranges, British Columbia and Alberta. Canadian Journal of Earth Sciences, **32**: 860–874.

MacIntyre, D.G. 1980. Driftpile Creek-Akie River Project. Geological fieldwork 1979. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1980-1, pp. 55–67.

MacIntyre, D.G. 1981. Akie River Project, B.C. Geological fieldwork 1980. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1981-1, pp. 32–45.

MacIntyre, D.G. 1983. Geology and stratiform barite sulphide deposits in the Gataga district, northeastern British Columbia. *In* Sediment hosted stratiform lead–zinc deposits. *Edited by* D.G. Sangster. Mineralogical Association of Canada, Short Course Notes 9, pp. 85–120.

MacIntyre, D.G. 1992. Geological setting and genesis of sedimentary exhalative barite and barite-sulfide deposits, Gataga District, northeastern British Columbia. Exploration and Mining Geology, **1**: 1–20.

MacIntyre, D.G. 1998. Geology, geochemistry and mineral deposits of the Akie River Area, northeast British Columbia. British Columbia Ministry of Energy and Mines, Bulletin 103, pp. 1–91.

Macqueen, R.W., and Thompson, R.I. 1978. Carbonate-hosted lead–zinc occurrences in northeastern British Columbia with emphasis on the Robb Lake deposit. Canadian Journal of Earth Sciences, **15**: 1737–1762.

McClay, K.R., and Insley, M.W. 1986. Structure and mineralization of the Driftpile Creek Area northeastern British Columbia (94E/16, 94F/14, 94K4, 94L/1). *In* Geological fieldwork 1985. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1986-1, pp. 343–350.

McClay, K.R., Insley, M.W., Way, N.A., and Anderton, R. 1988. Tectonics and mineralization of the Kechika Trough, Gataga area, northeastern British Columbia. *In* Current research, part E, Geological Survey of Canada, Paper 88-1E, pp. 1–12.

Murphy, M.A., and Matti, J.C. 1983. Lower Devonian conodonts (*hesperius–kindlei* zones), Central Nevada. University of California Publications, Geological Sciences, 123, pp. 1–83.

Murphy, M.A., and Valenzuela-Ríos, J.I. 1999. *Lanea* new genus, lineage of Early Devonian conodonts. Bollettino della Società Paleontologica Italiana, **37**: 321–334.

Norford, B.S. 1969. Ordovician and Silurian stratigraphy of the southern Rocky Mountains, Geological Survey of Canada, Bulletin 176, pp. 1–90.

Norford, B.S. 1980. Geological Survey of Canada, Paleontological Report 2-1980-BSN.

Paradis, S., Nelson, J.L., and Zantvoort, W. 1999. A new look at the Robb Lake carbonate-hosted lead-zinc deposit, northeastern British Columbia. *In* Current research 1999-A. Geological Survey of Canada, pp. 61–71.

Philip, G.M. 1966. Lower Devonian conodonts from the Buchan Group, eastern Victoria. Micropaleontology, **12**: 441–460.

Pigage, L.C. 1986. Geology of the Cirque barite–zinc–lead–silver deposits, northeastern British Columbia. *In* Mineral deposits of the northern Cordillera. *Edited by* J.A. Morin. Canadian Institute of Mining and Metallurgy, Montréal, Que., Special Vol. 37, pp. 71–86.

Pyle, L.J., and Barnes, C.R. 2000. Upper Cambrian to Lower Silurian stratigraphic framework of platform-to-basin facies, northeastern British Columbia. Bulletin of Canadian Petroleum Geology, **48**: 123–149.

Pyle, L.J., and Barnes, C.R. 2001. Ordovician–Silurian stratigraphic framework, Macdonald Platform to Ospika Embayment transect, northeastern British Columbia. Bulletin of Canadian Petroleum Geology, 49.

Pyle, L.J., and Barnes, C.R. 2002. Taxonomy, evolution and biostratigraphy of conodonts from the Kechika Formation, Skoki Formation and Road River Group (Upper Cambrian to Lower Silurian), northeastern British Columbia. National Research Council of Canada, Monograph Series, 44461, pp. 1–227.

Pyle, L.J., and Barnes, C.R. 2003. Conodonts from a platform-to-basin transect, Lower Ordovician to Lower Silurian, Northeastern British Columbia, Canada. Journal of Paleontology, **77**: 146–171.

Ross, G.M. 1991. Tectonic setting of the Windermere Supergroup revisited. Geology, **19**: 1125–1128.

Taylor, G.C., Cecile, M.P., Jefferson, C.W., and Norford, B.S. 1979. Stratigraphy of Ware (east half) map area, northeastern British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 79-1A, pp. 227–231.

Telford, P.G. 1975. Lower and Middle Devonian conodonts from the Broken River Embayment, North Queensland, Australia. Special Papers in Paleontology 15, Paleontological Association of London, pp. 1–96.

Thompson, R.I. 1989. Stratigraphy, tectonic evolution and structural analysis of the Halfway River map area (94B), northern Rocky Mountains, British Columbia. Geological Survey of Canada, Memoir 42, pp. 1–119.

Thompson, R.I., Mercer, E., and Roots, C. 1987. Extension and its influence on Canadian Cordilleran passive-margin evolution. *In* Continental extension tectonics. *Edited by* M.P. Coward, J.F. Dewey and P.L. Hancock. Special Publication of the Geological Society of London, 28, pp. 407–417.

Tucker, R.D., Bradley, D.C., Ver Straeten, C.A., Harris, A.G., Ebert, J.R., and McCutcheon, S.R. 1998. New U–Pb zircon ages and the duration and division of Devonian time. Earth and Planetary Science Letters, **158**: 175–186.

Uyeno, T.T., and Mason, D. 1975. New Lower and Middle Devonian conodonts from northern Canada. Journal of Paleontology, **49**: 710–723.

Valenzuela-Ríos, J.I., and Murphy, M.A. 1997. A new zonation of middle Lochkovian (Lower Devonian) conodonts and evolution of *Flajsella* n. gen. (Conodonta). *In* Paleozoic sequence stratigraphy, biostratigraphy, and biogeography: studies in honor of J. Granville ("Jess") Johnson. *Edited by* G. Klapper, M.A. Murphy and J.A. Talent. Geological Society of America, Boulder, Colo., Special Paper 321, pp. 131–144.

Weddige, K. 1977. Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten. Senckenbergiana lethaea, **58**: 271–419.

Weddige, K., and Ziegler, W. 1976. The significance of *Icriodus:Polygnathus* ratios in limestones from the type Eifelian, Germany. *In* Conodont paleoecology. *Edited by* C.R. Barnes. Geological Association of Canada, Special Paper 15, pp. 187–199.

Wittekindt, H. 1966. Zur Conodontenchroonooloogie des Mitteldevons. *In* Das Mitteldevon des Rheinischen Schiefergebirges, Ein Symposium. Fortschritte in der Geologie von Rheinland und Westfalen, 9, pp. 621–646.