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CONODONT FAUNA AND BIOSTRATIGRAPHY OF THE OUTRAM, SKOKI, AND OWEN CREEK FORMATIONS (LOWER TO MIDDLE ORDOVICIAN), WILCOX PASS, ALBERTA, CANADA

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ABSTRACT—A collection of 60,886 conodonts was recovered from 141 samples of the Outram, Skoki and Owen Creek Formations (Lower to Middle Ordovician) that outcrop through the Wilcox Pass section, Jasper National Park, Alberta, Canada. This section represents the standard reference section for the Lower-Middle Ordovician of the Southern Canadian Cordillera. The well preserved fauna is assigned to 75 species representing 48 genera. The species are representative of both the Midcontinent and Atlantic faunal realms, but dominantly the former. Nine Midcontinent Realm zones are recognized in the upwards shallowing carbonate platform succession including the *Scolopodus subrex*, *Acodus kechikaensis*, *Oepikodus communis*, *Jumudontus gananda*, *Tripodus laevis*, *Histiodella altifrons*, *Histiodella sinuosa*, *Histiodella holodentata*, and *Phragmodus* ''*pre-flexuosus*'' zones. Zones recognized that are characteristic of the Atlantic Realm include *Paroistodus proteus*, *Paracordylodus gracilis*, *Oepikodus evae*, *Paroistodus originalis*, and *Microzarkodina flabellum*. A new genus, *Filodontus*, is proposed for elements assigned previously to the form genus ''*Scolopodus*'' *filosus*. A new species, *Leptochirognathus wilcoxi*, is described and one new species, left in open nomenclature, is assigned to *Rossodus*?.

INTRODUCTION

THE WILCOX Pass section lies in Jasper National Park, Alberta, within the Main Ranges of the southern Canadian Rocky Mountains. Over 1,000 m of Lower to Middle Ordovician strata are accessible, well exposed and overlie more resistant Cambrian strata. This section has become the standard reference section for Lower-Middle Ordovician strata in the Southern Canadian Cordillera. The lithostratigraphic units in ascending order are the Survey Peak, Outram, Skoki and Owen Creek Formations (Fig. 1). The conodont biostratigraphy of the Survey Peak Formation (313.5 m thick) was established by Ji and Barnes (1996). The purpose of this paper is to establish the conodont biostratigraphy for the overlying Outram (269.5 m thick), Skoki (250 m thick) and Owen Creek (205 m thick) Formations. From a total of 141 samples, averaging 2.5 kilograms each, 60,886 conodont elements were recovered. Samples were taken, where possible, about every 3 m. The conodonts are well preserved with a colour alteration index (CAI) of 3.0. A total of 75 species, representing 48 genera were identified. This paper illustrates and documents the conodont fauna and the biostratigraphic distributions. Most species present are well known and require only brief taxonomic remarks.

The Lower to Middle Ordovician Midcontinent Realm conodont zonation established by Pyle and Barnes (2002) in correlative strata of the Northern Canadian Cordillera is recognized for the succession. The Outram Formation ranges from within the upper *Scolopodus subrex* Zone (uppermost Tremadocian) to the *Jumudontus gananda* Zone (middle Arenigian). The Skoki Formation ranges from the *Jumudontus gananda* Zone to *Histiodella altifrons* Zone (lower Darriwilian). Within the Outram and Skoki Formations there are strong influxes of Atlantic Realm species, but no deeper or cooler water species were discovered in the Owen Creek Formation. The Owen Creek Formation contains species representative of the *Histiodella sinuosa*, *Histiodella holodentata* and *P.* ''*pre-flexuosus*'' zones (Darriwilian).

This study of the Lower-Middle Ordovician conodonts from the platform facies of the Southern Canadian Cordillera complements two other transects in the Northern Canadian Cordillera (Pyle and Barnes, 2000, 2001, 2002, 2003) and earlier work synthesized by Ross et al. (1997) for correlative strata in the Great Basin of Utah-Nevada. Together, these studies have allowed a refinement of the Midcontinent Realm biozonation, its ties into the Atlantic Realm biozonation, and an understanding of the evolution and paleobiogeography of Laurentian conodonts.

LITHOSTRATIGRAPHY

The Lower to Middle Ordovician strata represent an upwards shallowing, carbonate platform succession. The Survey Peak and Outram Formations were established by Aitken and Norford (1967) at the type locality, Mount Wilson, 35 km southeast of Wilcox Pass. The Survey Peak Formation overlies the Mistaya Formation (Upper Cambrian) and was divided into four informal members described by Dean (1978, 1989) and Ji and Barnes (1996).

The Outram Formation ranges from 170 to 443 m thick within the Southern Rocky Mountains. The lower contact with the Survey Peak Formation is gradational. The upper contact with the Skoki Formation is gradational (Aitken and Norford, 1967) and at Wilcox Pass contains alternations of the dominant lithologies of each formation such that the base of the Skoki is estimated at 583 m above section base.

The Outram Formation (313.5 m above section base; 269.5 m thick; Fig. 2) contains several lithologies that were detailed graphically by Dean (1989). It is a succession of limy shale, silty shale, calcareous siltstone, nodular, laminated, fossiliferous and intraclastic limestone. The dominant lithology is nodular limestone that weathers darker grey than the underlying shale and limestone of the Survey Peak Formation. The Outram Formation is recessive overall and corresponds to the base of a grand cycle, but contains beds of more resistant, thick-bedded limestone and calcareous siltstone that manifest themselves as strike-oriented crests through the pass. The conodont collections were made from bioclastic wackestone, packstone and grainstone, dolomitic lime mudstone, and argillaceous lime mudstone.

The Skoki Formation was named by Walcott (1928) and has been divided into four formal members by Pyle and Barnes (2000, 2001). The formation ranges from a minimum of 62 m thick in the Southern Rockies to over 1,000 m thick in the Northern Rockies (Pyle and Barnes, 2000, 2001). Its lower contact with the Outram Formation is gradational and its upper contact with the Owen Creek Formation is paraconformable. The formation is 250 m thick at Wilcox Pass and is divided into two members recognized in the Northern Rocky Mountains, the Sikanni Chief and Keily members. The Redfern Member (of Pyle and Barnes, 2000)

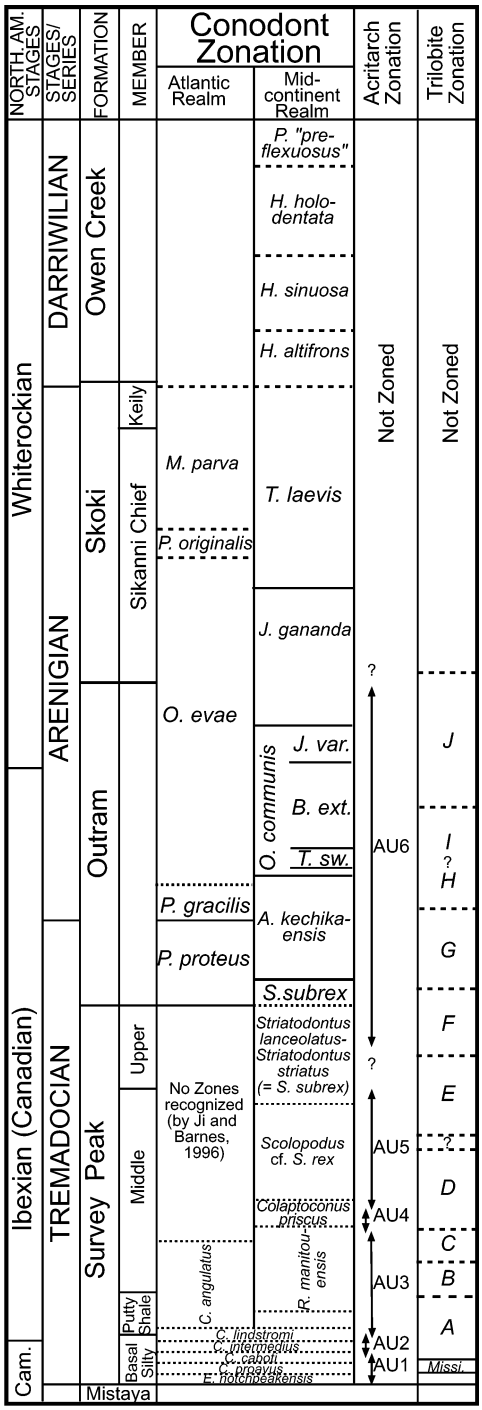

FIGURE *1*—Conodont biostratigraphy of the Wilcox Pass Section. Conodont zonation of the Survey Peak Formation after Ji and Barnes (1996), and therefore does not show the revised zonation for the Cambro-Ordovician boundary defined by Cooper et al. (2001) nor the revisions to the Tremadocian by Pyle and Barnes (2002). Conodont zonation of the Outram, Skoki and Owen Creek Formations is from this study and is based on revisions to the standard Lower Ordovician zonation (of Ross et al., 1997) by Pyle and Barnes (2002). Acritarch zonation after Martin (1992) and trilobite zonation after Dean (1998).

in the Northern Rocky Mountains is equivalent in lithology and conodont fauna to the Owen Creek Formation.

Based on the Wilcox Pass Section, the Sikanni Chief Member (583 m above section base; 126 m thick; Fig. 3) is medium grey, rubbly weathering, thin to thick-bedded dolostone with thin interbeds of lime mudstone to grainstone. Chert occurs as discontinuous beds and as stringers. Abundant, large macluritid gastropods (described by Rohr et al., 1995) and large oncolites 1.5 to 2.0 cm in diameter are abundant in the upper part of the member. A lithologic change to dark grey weathering lime mudstone and yellow-grey weathering and mottled, massive dolostone of the Keily Member (124 m thick) occurs at 709 m above the base of the section (Fig. 3).

The Owen Creek Formation was formally defined by Norford (1969) at its type locality, Mount Wilson, southwest Alberta. Regionally, the formation ranges in thickness from 46 to 199 m and its contact with the underlying Skoki Formation is paraconformable with evidence of channel filling and karstification at some sections. At Wilcox Pass, the Formation is 205 m thick and has a conformable lower contact with the Skoki Formation (at 833 m above section base; Fig. 4), marked by a change in weathering color from grey to yellow-grey. The dominant lithology is well bedded, aphanitic dolostone and thick-bedded dolostone in upward shallowing cycles about 10 m thick that contain alternations of shallow subtidal to intertidal, thin-bedded, mottled dolostone to supratidal, laminated and mudcracked dolostone. Interbeds of sandy dolostone that contain scattered, round quartz grains are common and minor chert stringers occur in some beds. The upper beds of the formation contain dolomitic sandstone with cross-laminae. The upper contact with the light grey to white, thin to thick-bedded, partly cross-stratified quartz sandstone of the Mount Wilson Formation is conformable but erosional surfaces between the two formations are locally developed (Norford, 1969).

In summary, the succession represents a carbonate sequence that accumulated in shallow platformal, subtidal and supratidal environments. The trilobite fauna and acritarch assemblages reflect deposition inboard from the continental margin (Dean, 1989; Martin, 1992) and the conodont fauna shows similar influences of deeper (and probably cooler) water species through the Outram and Skoki Formations and predominantly faunas indicative of shallow, hypersaline environments in the Owen Creek Formation.

CONODONT ZONATION

The excellent exposure, simple structure, relatively conformable succession, close sampling, and abundant conodont faunas of the Wilcox Pass section have provided strong biostratigraphic control and allowed integration with other faunal studies. This study establishes eight Midcontinent Realm conodont zones and three subzones, from the *Scolopodus subrex* Zone (uppermost Tremadocian) to *Phagmodus ''pre-flexuosus''* Zone (Darriwilian), through the Outram, Skoki and Owen Creek Formations (Fig. 1). The Upper Cambrian to Early Ordovician biostratigraphy of the Survey Peak, Outram and lowermost Skoki Formations at Wilcox Pass was established using trilobites (Dean, 1978, 1989) and acritarchs and chitinozoans (Dean and Martin, 1982; Martin, 1992). Dean (1989) recognized trilobite zones A to J. Zone J extended into only the basal 6.4 m of the Skoki Formation. Martin (1992) established six floral assemblage zones that range from Upper Cambrian to the Lower Ordovician. Zone AU 6 extended into the lower 46.1 m of the Skoki Formation and the overlying part of the Skoki Formation was not zoned (Fig. 1). Rohr et al. (1995) documented biostratigraphically significant gastropod genera that occur in the Skoki Formation at Nigel Peak, southwestern Alberta, which indicate a latest Ibexian to lower Whiterockian age. The intensive sampling for conodonts through the Wilcox Pass section,

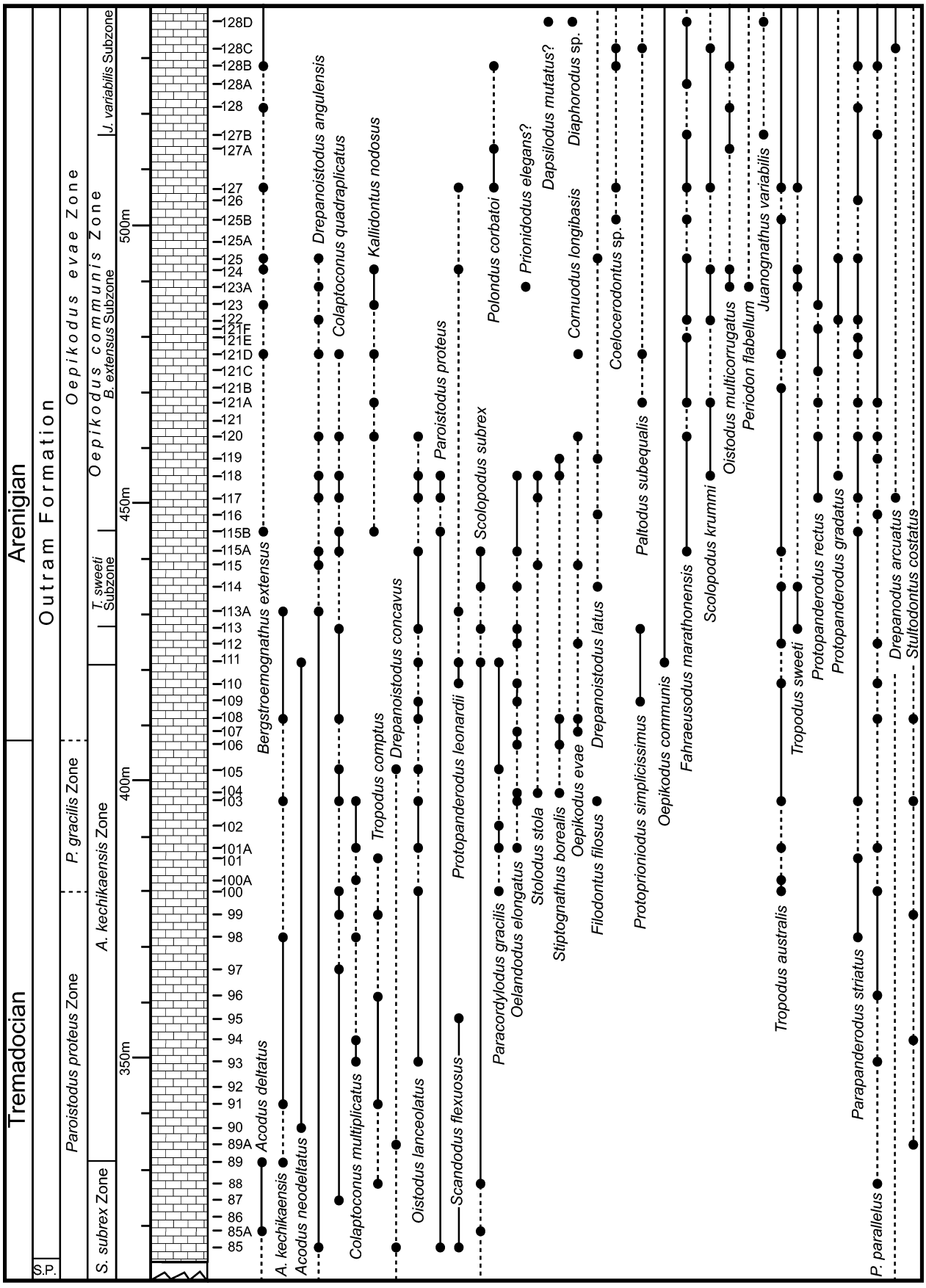

FIGURE 2—Distribution of samples and conodont species from the Outram Formation (S. P. = Survey Peak Formation).

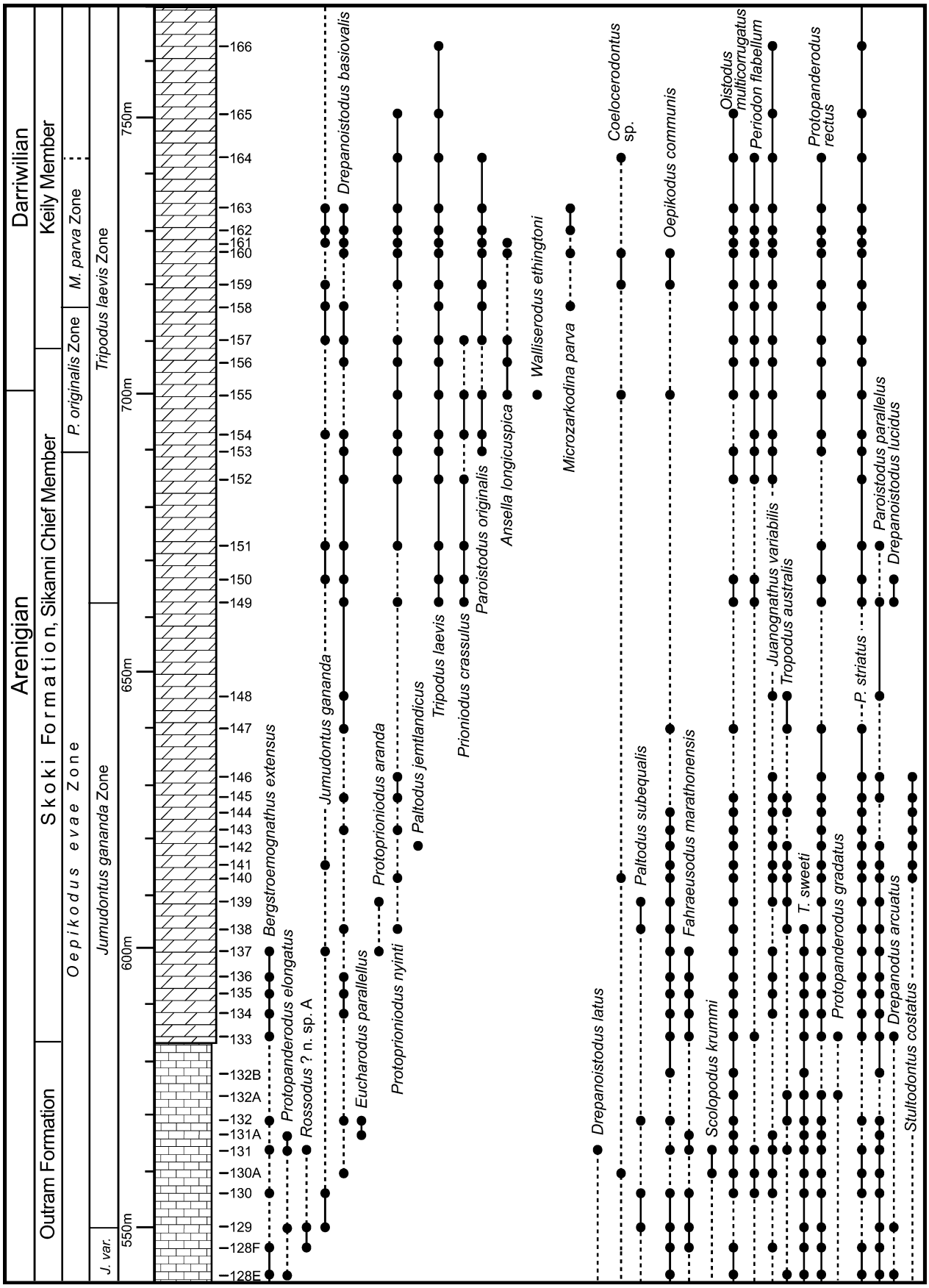

FIGURE 3—Distribution of samples and conodont species from the uppermost Outram and Skoki Formations.

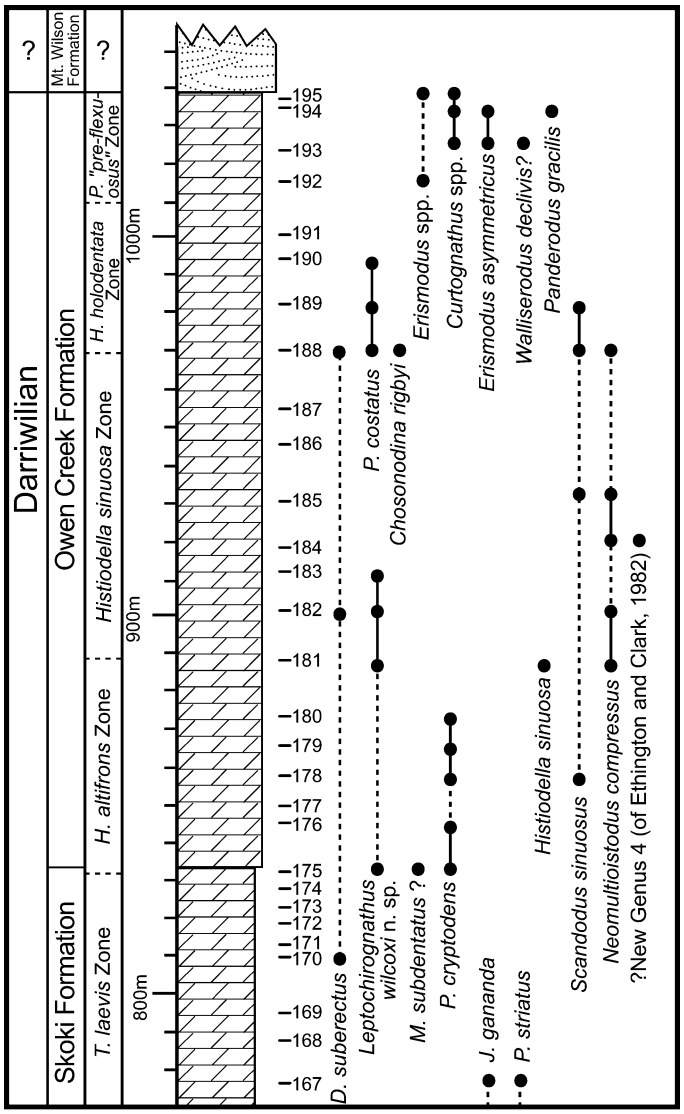

FIGURE 4—Distribution of samples and conodont species from the uppermost Skoki and Owen Creek Formations.

especially in the dolostones of the Skoki and Owen Creek Formations, provides the most precise means of correlation through this stratigraphic interval where virtually no other zonal fossils are preserved. An increase in abundance and diversity of conodonts correlates with a similar situation for trilobites reported by Dean (1989) that is associated with the lithologic change from the Survey Peak to Outram Formation. Of the total fauna recovered, 48,087 elements are from the Outram Formation, 12,799 are from the Skoki Formation and 331 are from the Owen Creek Formation.

Some preliminary studies on the conodont fauna from the Wilcox Pass section were completed by Ethington and Clark (1965), Derby et al. (1972) and Landing (1981). Ji and Barnes (1996) established the zonation for the Survey Peak Formation based on 87 productive samples collected through the lower 313 m of the measured section. Their uppermost zone was *Striatodontus lanceolatus-Striatodontus striatus* (Fig. 1).

The fauna of the basal part of the Outram Formation (313.5 m above section base) lies within the *Scolopodus subrex* Zone established by Pyle and Barnes (2002), who included elements assigned to *Scolopodus* cf. *S. rex* by Ji and Barnes (1996) in the synonymy of *S. subrex*. The assignment of the upper Carbonate Member of the Survey Peak Formation to the *S. lanceolatus-S. striatus* Zone was based on the occurrence of 53 elements of *S. lanceolatus* from only 5 samples, whereas *S.* cf. *S. rex* ranges through the member and was reported in 8 samples from the member. The present authors consider that the uppermost Survey Peak Formation should be assigned to the *S. subrex* Zone (Fig. 1).

The Outram Formation ranges through the *A. kechikaensis* Zone (from 331.5 m to 421.5 m above section base) of the Midcontinent Realm, defined by Pyle and Barnes (2002) as an interval zone extending from the first appearance of *A. kechikaensis* Pyle and Barnes to the first appearance of *Oepikodus communis* (Ethington and Clark). Two Atlantic Realm zones coeval with the *A. kechikaensis* Zone (uppermost Tremadocian) in the base of the Outram are the *Paroistodus proteus* Zone (Lindström, 1971) and *Paracordylodus gracilis* Zone (Johnston and Barnes, 1999). These species first occur at 316.2 m and 380 m above the section base, respectively. *Oelandodus elongatus* van Wamel (Fig. 2) appears just above the first appearance of *P. gracilis* and was used to define a subzone of the uppermost Tremadocian by Pyle and Barnes (2002). Representatives of the overlying *Prioniodus elegans* Zone are not present, and the Atlantic Realm zone that spans the upper part of the Outram Formation is the *Oepikodus evae* Zone proposed by Lindström (1971). The nominate species occurs in a pulse at 409 to 411.5 m above the section base and persists in fewer numbers until 462 m above section base (Fig. 2). The species is succeeded by *Oepikodus communis* which first occurs at 421.5 m above section base and ranges to 550 m above section base (Figs. 2, 3).

The *O. communis* Zone, established by Repetski and Ethington (1983), spans the Outram Formation (from 421.5 m to 550 m). Three subzones, above an unnamed subzone interval, were proposed by Pyle and Barnes (2002) and are recognized based on the first appearance of the nominate species: *Tropodus sweeti* (Serpagli), *Bergstroemognathus extensus* (Graves and Ellison), and *Juanognathus variabilis* Serpagli (at 427.5 m, 445 m, and 516.5 m above section base, respectively; Fig. 2).

The uppermost part of the Outram Formation lies within the *Jumudontus gananda* Zone (of Pyle and Barnes, 2002) at 550 m above the section base (Fig. 3). The overlying Sikanni Chief Member of the Skoki Formation ranges from the *J. gananda* Zone into the *Tripodus laevis* Zone, the latter defined by Ross et al. (1997), and which begins at 662.5 m above the section base (Fig. 3). The Atlantic Realm zonal species that occur in the upper part of the Skoki Formation, coeval with the upper part of the *T. laevis* Zone are *Paroistodus originalis* (Sergeeva) and *Microzarkodina parva* Lindström at 689.5 and 715.5 m above section base, respectively. The Keily Member of the Skoki Formation ranges from the *T. laevis* Zone to the base of the *Histiodella altifrons* Zone (Ethington and Clark, 1982), which almost coincides with the formational boundary between the Skoki and Owen Creek Formations (Fig. 4).

No specimens of *H. altifrons* Harris were recovered but the occurrence of *Pteracontiodus cryptodens* (Mound) within the uppermost beds of the Skoki Formation (832.5 m above section base; Fig. 4) and in the lower part of the Owen Creek Formation is consistent with correlation to the *H. altifrons* Zone (Ethington and Clark, 1982).

Within the Owen Creek Formation, the zonal species *H. sinuosa* (Graves and Ellison) appears at 888 m above the section base (Fig. 4) and is associated with species of Fauna 4 (of Sweet et al., 1971) such as *Neomultioistodus compressus* Harris and Harris. The boundaries of the overlying *H. holodentata* Zone cannot be firmly established, but *Paraprioniodus costatus* (Mound) and *Chosonodina rigbyi* Ethington and Clark are consistent associates

TABLE 1—Distribution of conodont species from the Outram Formation (see Tables 1–6).

Distance above base (m) / Species/Sample no. (WP-90-)	316.2 85	318.7 85A	321.5 86	324.5 87	327.5 88	331.5 89	334.5 89A	337 90	342.0 91	345 92	349.2 93	353.5 94	357 95	361.5 96	Total
Acodus deltatus		8	20	16	230	65									339
Acodus kechikaensis						5			4	307	184	34	86	31	651
Acodus neodeltatus								296	808	184	28	40	42	22	1,420
Colaptoconus multiplicatus											1	1			2
Colaptoconus quadraplicatus				51	187	60	90	24	28	97	6	203	45	21	812
Drepanoistodus angulensis	11	106	65	11	138	27	20	8	69	185	56	31	22	30	779
Drepanoistodus concavus	2						54								56
Oistodus lanceolatus											5	5	1	2	13
Paroistodus proteus	3	7	55	13	70	85	195	4	168	131	58	53	41	42	925
Paroistodus parallelus					2						44			8	54
Scandodus flexuosus	15	256	294	242	305	92	138	5	47	13	44	5	21		1,477
Scolopodus subrex		8			18	30	64	14	121	113	57	71	108	35	639
Stultodontus costatus							21					4			25
Tropodus comptus					32				5	18	21	2	5	5	88
Total	31	385	434	333	982	364	582	351	1,250	1,048	504	449	371	196	7,280

of *H. holodentata* Ethington and Clark in Utah and Nevada. Species that support assignment to the *Phragmodus* ''*pre-flexuosus*'' Zone or Fauna 5 (of Sweet et al., 1971) include *Curtognathus* spp. and *Erismodus asymmetricus* which first appear at 1,022.5 m above section base.

SELECTED TAXONOMIC AND BIOSTRATIGRAPHIC REMARKS

Most of the figured specimens have been described adequately in previous publications and require only selective taxonomic and biostratigraphic comments. These remarks are arranged sequentially to correspond to the illustrations of the fauna (Figs. 5–9), arranged stratigraphically from oldest to youngest. The specimens illustrated are housed in the National Type Collection of the Geological Survey of Canada (GSC), Ottawa, Ontario, Canada. The distribution and abundance of conodont species for all sections are listed in Tables 1–9. It should be noted that the total number of elements in some large and extremely productive samples was determined based on a split of the residue. Figures 2–4 illustrate the sample locations and stratigraphic distribution of the species. 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).

Fauna of the Outram Formation.—The fauna of the Outram Formation is diverse and abundant, totaling 48,087 elements (Tables 1–6). The base of the Outram Formation lies in the *Scolopodus subrex* Zone. Several species range from the underlying Survey Peak Formation, including the nominate species of the zone (Fig. 7.13–7.15), *Acodus deltatus* Lindström (Fig. 5.1–5.3), and the long ranging species *Drepanoistodus angulensis* (Harris) (Fig. 5.20, 5.21), and *D. concavus* (Branson and Mehl) (Fig. 5.22–5.24). Species that first occur within the zone include *Colaptoconus quadraplicatus* (Branson and Mehl) (Fig. 5.16–5.18), *Paroistodus parallelus* (Pander) (Fig. 6.16, 6.17), *Scandodus flexuosus* Barnes and Poplawski (Fig. 7.7–7.9), *Tropodus comptus* (Branson and Mehl) (Fig. 7.24, 7.25), and the zonal species of Atlantic Realm affinity, *Paroistodus proteus* (Lindström) (Fig. 6.18, 6.19).

The lower part of the Outram Formation lies within the *A. kechikaensis* Zone and yields many specimens of the nominate species of the zone (Fig. 5.4–5.7) and the descendent of *A. deltatus*, *A. neodeltatus* Pyle and Barnes (Fig. 5.8–5.10). Species that first appear in this zone include *Colaptoconus multiplicatus* Ji and

TABLE 2—Distribution of conodont species from the Outram Formation (see Tables 1–6).

Distance above base (m) / Species/Sample no. (WP-90-)	366 97	372 98	376 99	380 100	382 100A	386 101	388 101A	392 102	396.5 103	398 104	402 105	406.5 106	409 107	411.5 108	Total
Acodus kechikaensis	160	3							43					4	210
Acodus neodeltatus	325	616	54	180	19	383	278	49	918	949	129	155	30	93	4,178
Colaptoconus multiplicatus		4			5		143	79	6						237
Colaptoconus quadraplicatus	89		8	18					85	12	8			2	222
Drepanoistodus angulensis	22	13	20	83	20	47	59	27	173	49	10	61	17	111	712
Drepanoistodus concavus											14				14
Filodontus filosus									21						21
Kallidontus spp.														3	3
Oelandodus elongatus							10		43	8		25	9		95
Oepikodus evae													38	253	291
Oistodus lanceolatus	8	8	1	4			3	4	9		1			10	48
Paracordylodus gracilis				2			2	1			4	1	3	36	49
Parapanderodus striatus		8	2	6	2	4			65	26	30	100	10	52	305
Paroistodus parallelus	32	24	12	6			6							6	86
Paroistodus proteus	281	112	17	47	4	7	44	20	240	76	62	24	28	183	1,145
Protoprioniodus simplicissimus											5			22	27
Scolopodus subrex	416	94	49	97	22	19	25	125	98	12	65	21	20	183	1,246
Stiptognathus borealis										58		44	1	16	119
Stolodus stola										64					64
Stultodontus costatus			1						1					8	10
Tropodus comptus			16			4									20
Tropodus australis				2	2		29		65	40	10	13	8	5	174
Total	1,333	882	180	445	74	464	599	305	1,767	1,294	338	444	164	987	9,276

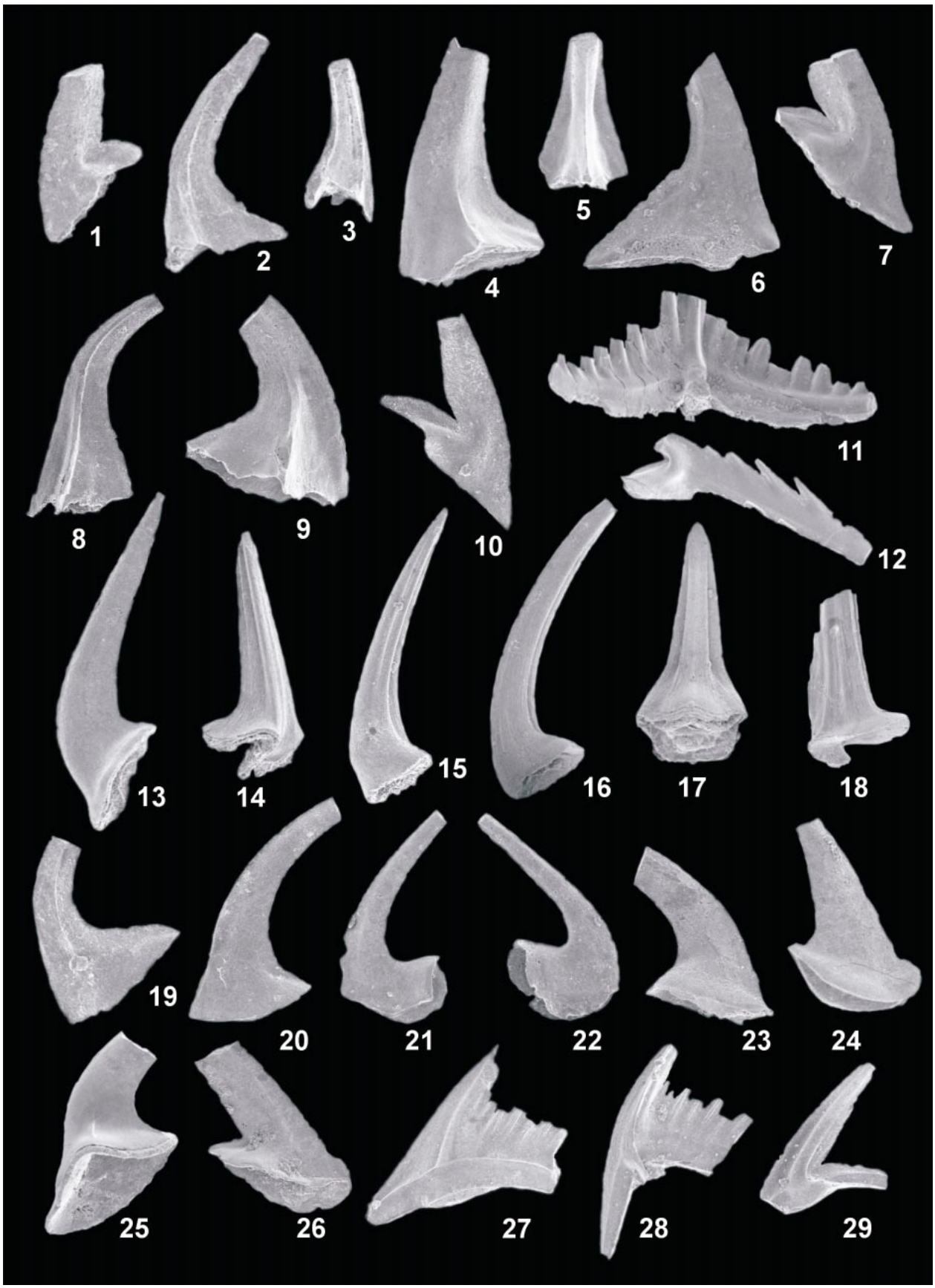
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TABLE 3—Distribution of conodont species from the Outram Formation (see Tables 1–6).

Distance above base (m) / Species/Sample no. (WP-90-)	414.5 109	417.5 110	421.5 111	424.5 112	427.5 113	430.5 113A	435 114	439 115	441.3 115A	445 115B	448.0 116	451 117	455 118	458 119	Total
Acodus kechikaensis	22	56	55	4	4	3									144
Acodus neodeltatus	13	1,025	7												1,045
Bergstroemognathus extensus										1					1
Colaptoconus quadraplicatus	4	2	6	6	1				1	2		28	5		55
Drepanodus arcuatus												2			2
Drepanoistodus angulensis	46	234	48	194	73	16		3	5			3	7		629
Drepanoistodus latus							7				1		8		16
Fahraeusodus marathonensis									1	2	2	28	54	5	92
Kallidontus spp.	1	18				3									22
Kallidontus nodosus										1					1
Oelandodus elongatus	3	7		43	1		5		3	5	1	10	2		80
Oepikodus communis			47	688	417	135	249	33	29	10	92	1,251	168	40	3,159
Oepikodus evae				16				2							18
Oistodus lanceolatus	7		1		6	2	2	2	4			2	8		34
Paracordylodus gracilis	2	5	1												8
Parapanderodus striatus	13	151	7	11	12	13	1	3	2	1		51	18	3	286
Paroistodus parallelus		64		4							1			5	74
Paroistodus proteus	17	248	55	251	56	27	2	3	3	7		67	38		774
Protopanderodus gradatus													2		2
Protopanderodus rectus												42	3	3	48
Protopanderodus leonardii		32	6			2									40
Protoprioniodus simplicissimus	3	64	4	9	1										81
Scolopodus krummi													44	4	48
Scolopodus subrex	16	14	7		22		1	1	7						68
Stiptognathus borealis													2	1	3
Stolodus stola								1				16	3		20
Tropodus australis	16	9		10	12	13	59		6	1	17	50	78	4	275
Tropodus sweeti					2	2	3								7
Total	163	1,929	244	1,236	607	216	329	48	61	30	114	1,550	440	65	7,032

Barnes (Fig. 5.13–5.15), *Oistodus lanceolatus* Pander (Fig. 6.12), *Protopanderodus leonardii* Serpagli (Fig. 6.24), *Protoprioniodus simplicissimus* McTavish (Fig. 6.26–6.28), and long-ranging species that range into the Skoki Formation such as *Tropodus australis* (Serpagli) (Fig. 7.21–7.23), *Stultodontus costatus* (Ethington and Brand) (Fig. 7.20), and *Parapanderodus striatus* (Graves and Ellison) (Fig. 8.9, 8.10).

Filodontus filosus (Ethington and Clark) (Fig. 6.1–6.3), a newly named genus described below, was recovered from a level 1.5 m below the first appearance of *Stiptognathus borealis* (Repetski) (Fig. 7.16–7.19). The stratigraphic distribution of *S. borealis* is restricted to an interval high in the North American Ibexian Series (Ethington et al., 2000) and has a similar range in this present study in which it first occurs high in the *A. kechikaensis* Zone and ranges into the *O. communis* Zone. Ethington et al. (2000) summarize the four geographic areas from which the species has been reported to date, all of which represent an open-marine, shallow-shelf environment.

An influx of species of the Atlantic Realm occurs in the lower Outram Formation and is pronounced with the first appearance of the zonal species *Paracordylodus gracilis* Lindström (Fig. 6.15) and *Oelandodus elongatus* van Wamel (Fig. 6.5) that are associated with the occurrence of *Stolodus stola* (Lindström) (not figured) and the overlying pulse of *Oepikodus evae* (Lindström) (Fig. 6.9–6.11).

Oepikodus communis (Fig. 6.6–6.8) dominates the fauna in abundance (23,409 elements total) and is the direct descendent of *A. neodeltatus* (Pyle and Barnes, 2002, fig. 15). *Fahraeusodus marathonensis* (Bradshaw) (Fig. 5.27–5.29) has a stratigraphic range similar to that of *O. communis*. Other species that first appear in the *O. communis* Zone include *Bergstroemognathus extensus* (Graves and Ellison) (Fig. 5.11, 5.12), *Dapsilodus mutatus*? (Branson and Mehl) (Fig. 5.19), *Drepanoistodus latus* Pyle and Barnes (Fig. 5.25, 5.26), *Kallidontus nodosus* Pyle and Barnes (Fig. 6.4), *Oistodus multicorrugatus* Harris (Fig. 6.13, 6.14), *Polonodus corbatoi* (Serpagli) (Fig. 6.20–6.22), *Protopanderodus gradatus* Serpagli (Fig. 6.23), *Protopanderodus rectus* (Lindström) (Fig. 6.25), *Scolopodus krummi* (Lehnert) (Fig. 7.10–7.12) and *Tropodus sweeti* (Serpagli) (Fig. 7.26–7.29). A new species questionably assigned to the genus *Rossodus* (Fig. 7.1–

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FIGURE 5—Scanning electron microscope photomicrographs of conodonts from the Outram Formation. All specimens in lateral view unless otherwise noted. *1–3, Acodus deltatus*. ×82, from sample WP-90-88; *1,* M element, GSC 124240; *2,* P element, GSC 124241; *3,* Sb element, GSC 124242. *4–7, Acodus kechikaensis*. ×55, from sample WP-90-95; *4,* P element, GSC 124243; *5,* Sa element, posterior view, GSC 124244; *6,* Sc element, GSC 124245; *7,* M element, GSC 124246. *8–10, Acodus neodeltatus*. ×80; *8,* Sb element, GSC 124247, from sample WP-90-110; *9,* P element, GSC 124248, from sample WP-90-105; *10,* M element, GSC 124249, from sample WP-90-110. *11–12, Bergstroemognathus extensus*. ×40, from sample WP-90-127; *11,* Sa element, posterior view, GSC 124250; *12,* M element, GSC 124251. *13–15, Colaptoconus multiplicatus*. ×68, from sample WP-90-88; *13,* e element, GSC 124252; *14,* f element, antero-lateral view, GSC 124253; *15,* b element, GSC 124254. *16–18, Colaptoconus quadraplicatus*. ×45; *16,* a element, GSC 124255, from sample WP-90-101A; *17,* c element, posterior view, GSC 124256, from sample WP-90-101A; *18,* f element, antero-lateral view, GSC 124257, from sample WP-90-93. *19, Dapsilodus mutatus*? S element, GSC 124258, ×78, from sample WP-90-128D. *20–21, Drepanoistodus angulensis*. ×60, from sample WP-90-110; *20,* a element, GSC 124259; *21,* e element, GSC 124260. *22–24, Drepanoistodus concavus*. From sample WP-90-105; *22,* e element, GSC 124261, ×64; *23,* a element, GSC 124262, ×64; *24,* c element, GSC 124263, ×40. *25–26, Drepanoistodus latus*. ×42, from sample WP-90-118; *25,* a element, GSC 124264; *26,* e element, GSC 124265. *27–29, Fahraeusodus marathonensis*. ×50, from sample WP-90-125; *27,* P element, GSC 124266; *28,* S element, GSC 124267; *29,* M element, GSC 124268.

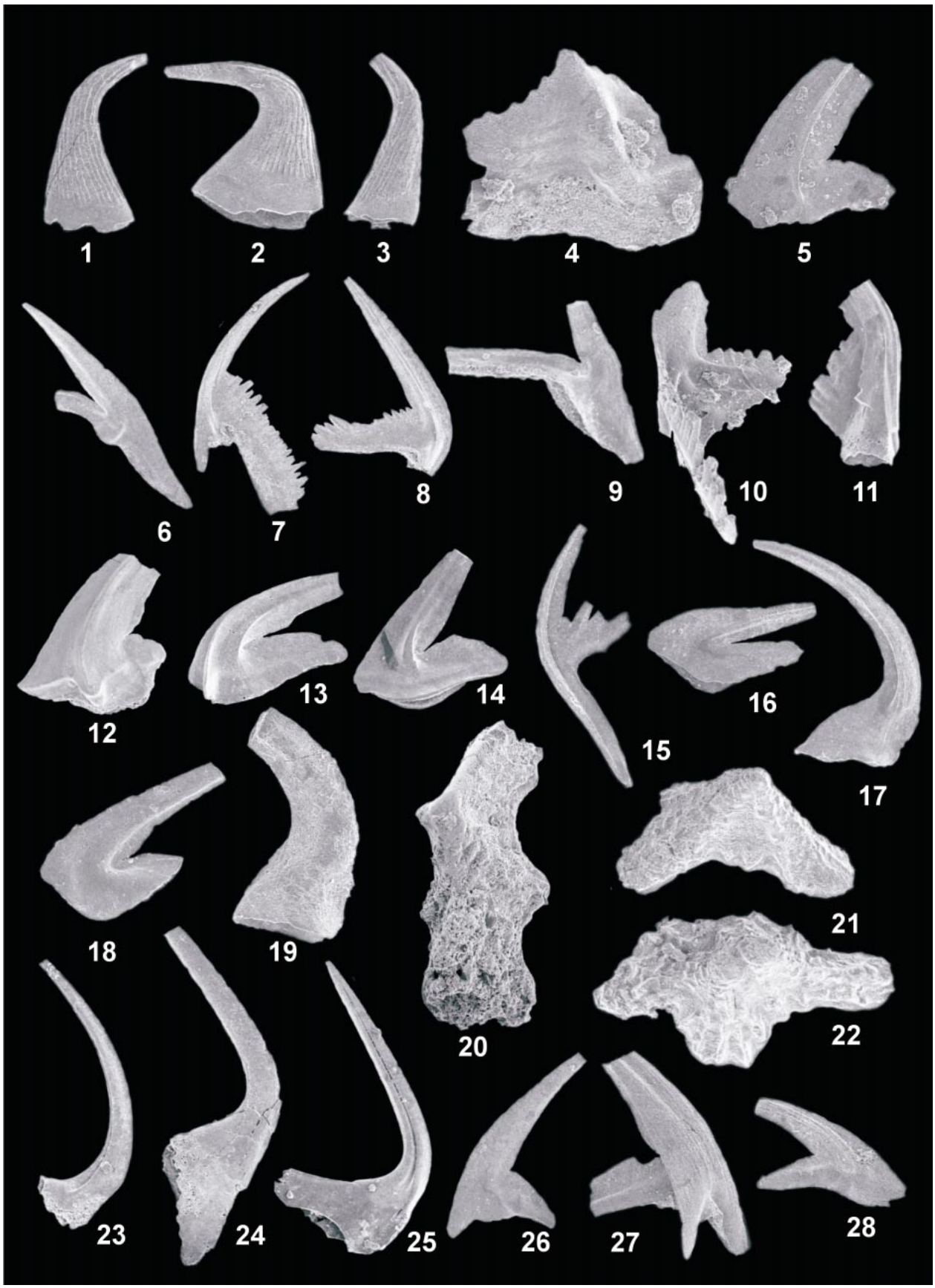
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TABLE 4—Distribution of conodont species from the Outram Formation (see Tables 1–6).

Distance above base (m)	462	465	468	471	474	476.7	480	481.5	483	486	489.0	492	494	497	
Species/Sample no. (WP-90-)	120	121	121A	121B	121C	121D	121E	121F	122	123	123A	124	125	125A	Total
Bergstroemognathus extensus						2				2		1	3		8
Colaptoconus quadraplicatus	3					9									12
Cornuodus longibasis						2									2
Drepanoistodus angulensis	12					6			2		5		4		29
Drepanoistodus latus													8		8
Fahraeusodus marathonensis	22		25	10	6	127	89		60	126	25	11	454		955
Kallidontus nodosus	1		2			3				3	3	2			14
Oepikodus communis	67	12	79	540	27	899	142	36	7	59	243	61	3,611	333	6,116
Oepikodus evae	3														3
Oistodus lanceolatus	24														24
Oistodus multicorrugatus											15	1			16
Paltodus subequalis			4			3									7
Parapanderodus striatus	14		2			50	15		7	7	5	5	18		123
Paroistodus parallelus	52		18	385	4	59	35	2	7	31	26	17	64	8	708
Periodon flabellum											1				1
Prioniodus elegans?											5				5
Protopanderodus gradatus									7	3	5	9	6		30
Protopanderodus rectus	24		8		1	41	2	2		11	21	31	97	4	242
Protopanderodus leonardii												12			12
Scolopodus krummi	51	1	7						31	13	15	8			126
Tropodus australis	97	1	2	4		155	18	17	42	49	2	34	10	8	439
Tropodus sweeti											36	3			39
Total	370	14	147	939	38	1,356	301	57	163	304	407	195	4,275	353	8,919

7.6) is described below and occurs in the uppermost part of the Outram Formation, within the *J. variabilis* Subzone and the *J. gananda* Zone. *J. variabilis* (Fig. 8.3, 8.4) ranges through to the upper Skoki Formation (Figs. 2–4) as does the nominate species (Fig. 8.5) of the overlying *J. gananda* Zone which extends almost to the top of the Skoki Formation (Figs. 3, 4).

Fauna of the Skoki Formation.—The Skoki Formation, which spans the *J. gananda* Zone and ranges into the *Histiodella altifrons* Zone, yielded a total of 12,799 elements (Tables 6–8). Many species range into the Skoki Formation from the Outram Formation (Fig. 3) and have been illustrated with the Outram Formation fauna (Figs. 5–7). Specimens that occur in both the Outram and Skoki Formations that are figured on the plate containing species of the Skoki Formation include *J. variabilis* (Fig. 8.3, 8.4), *K. nodosus* (Fig. 8.6), *Parapanderodus striatus* (Fig. 8.9, 8.10), and *Periodon flabellum* Lindström (Fig. 8.12, 8.13).

Species that first occur in the *J. gananda* Zone of the Skoki Formation include *Ansella longicuspica* Zhang (Fig. 8.1, 8.2), *Drepanoistodus basiovalis* (Sergeeva), and *Eucharodus parallelus* (Branson and Mehl) (both unfigured). Two species of *Protoprioniodus*, *P. aranda* Cooper (Fig. 8.18, 8.19) and *P. nyinti* Cooper (Fig. 8.20–8.23) also first occur in this zone, with the latter ranging into the overlying *Tripodus laevis* Zone.

Tripodus laevis Bradshaw (Fig. 8.24–8.28) occurs with *Prioniodus crassulus* (Lindström, 1955) emended by van Wamel 1974 (Fig. 8.14–8.17), which has been reported from the *Baltoniodus navis* Zone (van Wamel, 1974; Tipnis et al., 1978), correlative to the lower *T. laevis* Zone. Two zonal species also of Atlantic Realm affinity that occur in the upper part of the Skoki Formation are *Paroistodus originalis* (Sergeeva) (Fig. 8.11) and *Microzarkodina parva* Lindström (Fig. 8.7, 8.8).

Conodonts from the Owen Creek Formation.—The fauna of the Owen Creek Formation is not as abundant as that of the underlying formations and yielded only 331 elements (Table 9). The base of the *Histiodella altifrons* Zone lies just below the formational contact between the Skoki and Owen Creek Formations (Fig. 4). The species that is indicative of this zone is *Pteracontiodus cryptodens* (Mound) (Fig. 9.17–9.20). Both *Scandodus sinuosus* Mound (Fig. 9.21) and a new species of *Leptochirognathus* (Fig. 9.6–9.9), described in the next section, first occur in this zone and range into the *Histiodella sinuosa* Zone (Fig. 4). A single specimen of *Histiodella sinuosa* (Fig. 9.5) occurs with *Neomultioistodus compressus* Harris and Harris (Fig. 9.11, 9.12). Ethington and Clark (1982) described ?New Genus 4 as containing elements with broad, stubby denticles of albid material and strongly inflated basal regions. One element was recovered (Fig. 9.10) that is similar to the trichonodelliform element they describe and differs from the largely hyaline genera such as *Multioistodus* and *Pteracontiodus*. Two species indicative of the *H. holodentata*

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FIGURE 6—Scanning electron microscope photomicrographs of conodonts from the Outram Formation (13, 14, and 25 from Skoki Formation, but species first occur in Outram Formation). All specimens in lateral view unless otherwise noted. *1–3, Filodontus filosus*. ×75, from sample WP-90-103; *1,* a element, GSC 124269; *2,* e element, GSC 124270; *3,* a element, GSC 124271. *4, Kallidontus nodosus*; P element, anterior view, GSC 124272, ×76, from sample WP-90-123A. *5, Oelandodus elongatus*; S element, GSC 124273, ×65, from sample WP-90-112. *6–8, Oepikodus communis*. ×45, from sample WP-90-125; *6,* M element, GSC 124274; *7,* S element, GSC 124275; *8,* P element, GSC 124276. *9–11, Oepikodus evae*. ×65; *9,* M element, GSC 124277, from sample WP-90-108; *10,* P element, GSC 124278, from sample WP-90-112; *11,* S element, GSC 124279, from sample WP-90-108. *12, Oistodus lanceolatus*; S element, GSC 124280, ×32, from sample WP-90-109. *13–14, Oistodus multicorrugatus*. ×60, from sample WP-90-161; *13,* P element, GSC 124281; *14,* M element GSC 124282. *15, Paracordylodus gracilis*; S element, ×75, GSC 124283, from sample WP-90-110. *16–17, Paroistodus parallelus*. ×70, from sample WP-90-128F; *16,* M element, GSC 124284; *17,* P element, GSC 124285. *18–19, Paroistodus proteus*. ×80, from sample WP-90-88; *18,* M element, GSC 124286; *19,* S element, GSC 124287. *20–22, Polonodus corbatoi*. From sample WP-90-127A; *20,* P element, upper view, GSC 124288, ×50; *21–22,* P elements, upper views, GSC 124289, 124290, ×60. *23, Protopanderodus gradatus*; a element, GSC 124291, ×45, from sample WP-90-124. *24, Protopanderodus leonardii*; a element, GSC 124292, ×45, from sample WP-90-124. *25, Protopanderodus rectus*; a element, GSC 124293, ×40, from sample WP-90-161. *26–28, Protoprioniodus simplicissimus*. ×65, from sample WP-90-110; *26–27,* S elements, GSC 124294, 124295; *28,* M element, GSC 124296.

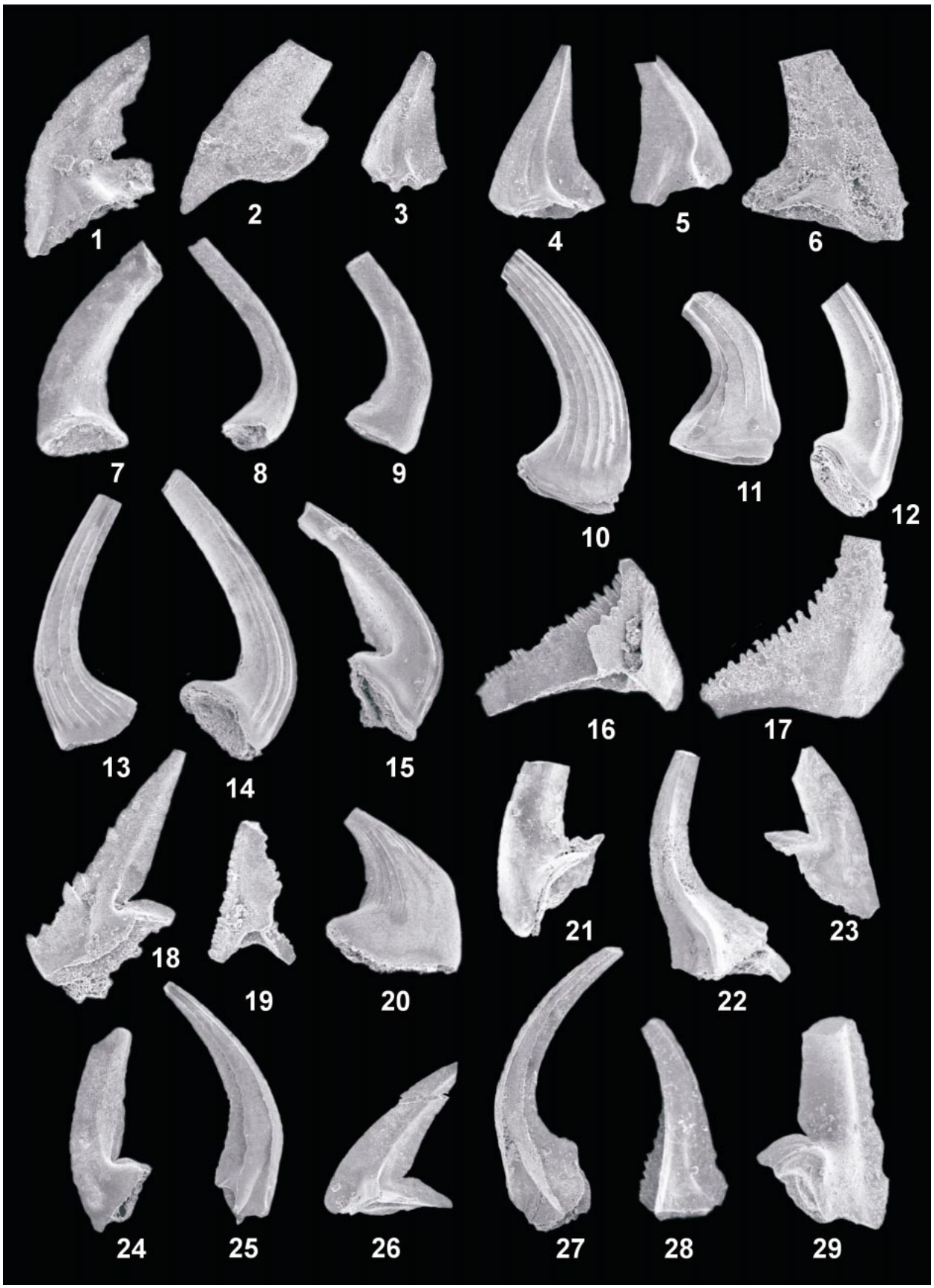
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TABLE 5—Distribution of conodont species from the Outram Formation (see Tables 1–6).

Distance above base (m) Species/Sample no. (WP-90-)	501 125B	504.5 126	506.5 127	514 127A	516.5 127B	521.5 128	525.5 128A	529 128B	532 128C	537 128D	541.0 128E	546 128F	550 129	556 130	Total
Bergstroemognathus extensus			19			1		1	1	7	2	2		2	35
Coelocerodontus sp.	4		1					1	1						7
Dapsilodus mutatus?										3					3
Diaphorodus sp.										2					2
Drepanodus arcuatus									4	6	3		2		15
Drepanoistodus sp.									2		2				4
Fahraeusodus marathonensis	18		15	4	193		1	17	133	10		6	1	5	403
Juanognathus variabilis					4					4		1		16	25
Jumudontus gananda													1	1	2
Oepikodus communis	826	80	28	4,246	962	1	897	836	847	80	3	22	2	547	9,377
Oistodus multicorrugatus				11	11	1		25	54	28	1	7		11	149
Paltodus subequalis									6				6	4	16
Parapanderodus striatus		1	2	64	88	2		50	103	23	2	15		22	372
Paroistodus parallelus	12	2	14	67	166			1	35	11	1	21	2	35	367
Periodon flabellum												5		4	9
Polonodus corbatoi			3	10				1							14
Protopanderodus rectus	78	1	5	64	195	2	65	48	140	13	1	30	1	48	691
Protopanderodus leonardii			13												13
Protopanderodus elongatus											1		1		2
Scolopodus krummi			11	1	7	2	4	17	50						92
Tropodus australis	22		54	4	265	3	18	13	172	9	2				562
Tropodus sweeti			17	9	241	2	7	17	151	4	4	45	7	23	527
Rossodus? n. sp. A												10	4		14
Total	960	84	182	4,480	2,132	14	992	1,027	1,699	200	22	164	27	718	12,701

Zone are *Chosonodina rigbyi* Ethington and Clark (Fig. 9.1) and *Paraprioniodus costatus* (Mound) (Fig. 9.14–9.16).

The fauna from the uppermost part of the Owen Creek Formation is characteristic of the *Phragmodus* ''*pre-flexuosus*'' interval and includes the first appearance of *Curtognathus* spp. (Fig. 9.2) and *Erismodus asymmetricus* (Branson and Mehl) (Fig. 9.3, 9.4). Three specimens of *Panderodus gracilis* (Branson and Mehl) (Fig. 9.13) were recovered and one finely striated coniform element is assigned to *Walliserodus declivis*? Bauer (Fig. 9.22).

SYSTEMATIC PALEONTOLOGY

The type specimens are housed in the National Type Collection of the Geological Survey of Canada (GSC), Ottawa, Ontario.

Genus FILODONTUS new genus

Type species.—*Scolopodus filosus* Ethington and Clark, 1964.

Diagnosis.—Apparatus of two coniform elements (a and e) that bear many extremely fine longitudinal costae from the tip of the recurved cusp, almost to the base. Tip of cusp is albid.

Etymology.—''Fil'' refers to thread-like costae.

Discussion.—*Filodontus* is known only from a single species, *F. filosus*, which is described below.

FILODONTUS FILOSUS (Ethington and Clark, 1964)
Figure 6.1–6.3

Scolopodus filosus ETHINGTON AND CLARK, 1964, p. 699, pl. 114, figs. 12, 17, 18, 19, text-fig. 2E; ETHINGTON AND CLARK, 1965, p. 200; FÅHRÆUS AND NOWLAN, 1978, p. 468, pl. 1, figs. 16, 17.

''*Scolopodus*'' *filosus* ETHINGTON AND CLARK, 1982, p. 100, pl. 11, fig. 22.

''*Scolopodus filosus*'' Ethington and Clark. SMITH, 1991, p. 63, fig. 36d.

Scolopodus gracilis Ethington and Clark. JONES, 1971, p. 63, pl. 5, figs. 9a–c, 11a–c, pl. 6, fig. 1a–c; LEE, 1976, p. 172–173, pl. 2, figs. 9, 10, text-fig. 3K; REPETSKI, 1982, p. 47, pl. 22, fig. 2; SEO, LEE AND ETHINGTON, 1993, fig. 11-1.

? ''*Scolopodus*'' aff. ''*S.*'' *filosus* Ethington and Clark. ETHINGTON AND CLARK, 1982, p. 100, pl. 11, figs. 23, 25, 29; STOUGE AND BAGNOLI, 1988, p. 138–139, pl. 15, figs. 1–2.

? *Scolopodus filosus* Ethington and Clark. MOUND, 1968, p. 418, pl. 5, figs. 16, 20, 25, 28, 33, 39, 45–46, 59 (figs. 45, 46 = *F. gracilis*); DUAN, 1990, pl. 1, fig. 14.

? *Scolopodus* cf. *filosus* Ethington and Clark. PEI AND CAI, 1987, p. 92–93, figs. 2–3.

? *Scolopodus* sp. aff. *S. filosus* Ethington and Clark. STAIT AND DRUCE, 1993, figs. 13G, 19A–E, K.

? ''*Scolopodus*'' aff. ''*S.*'' *filosus* Ethington and Clark. STOUGE AND BAGNOLI, 1988, p. 138, pl. 15, figs. 1–2.

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FIGURE 7—Scanning electron microscope photomicrographs of conodonts from the Outram Formation. All specimens in lateral view unless otherwise noted. *1–6, Rossodus*? n. sp. A. ×60; *1*, P element, GSC 124297, from sample WP-90-128F; *2*, M element, GSC 124298, from sample WP-90-129; *3*, Sa element, posterior view, GSC 124299, from sample WP-90-128F; *4–5*, Sb elements, posterior and anterior views, GSC 124300, 124301, from sample WP-90-128F; *6*, ?Sc element, GSC 124302, from sample WP-90-129. *7–9, Scandodus flexuosus*. ×60, from sample WP-90-85A; *7*, e element, GSC 124303; *8*, b element, GSC 124304; *9*, a element, GSC 124305. *10–12, Scolopodus krummi*. From sample WP-90-120; *10*, a element, GSC 124306, ×38; *11*, b element, GSC 124307, ×56; *12*, e element, GSC 124308, ×56. *13–15, Scolopodus subrex*. ×40; *13*, a element, GSC 124309, from sample WP-90-89A; *14*, e element, GSC 124310, from sample WP-90-89A; *15*, e element, GSC 124311, from sample WP-90-93. *16–19, Stiptognathus borealis; 16*, Sb element, postero-lateral view, GSC 124312, ×100, from sample WP-90-108; *17*, Sa element, anterior view, GSC 124313, ×100, from sample WP-90-118; *18*, M element, GSC 124314, ×75, from sample WP-90-108; *19*, Sa element, postero-lateral view, GSC 124315, ×80, from sample WP-90-108. *20, Stultodontus costatus*; a element, GSC 124316, ×50, from sample WP-90-89A. *21–23, Tropodus australis*. ×40, from sample WP-90-121D; *21*, P element, GSC 124317; *22*, Sb element, GSC 124318; *23*, M element, GSC 124319. *24–25, Tropodus comptus*. ×45, from sample WP-90-91; *24*, M element, GSC 124320; *25*, Sa element, GSC 124321. *26–29, Tropodus sweeti*. From sample WP-90-128F; *26*, P element, GSC 124322, ×40; *27*, Sa element, GSC 124323, ×40; *28*, Sb element, GSC 124324, ×80; *29*, M element, GSC 124325, ×40.

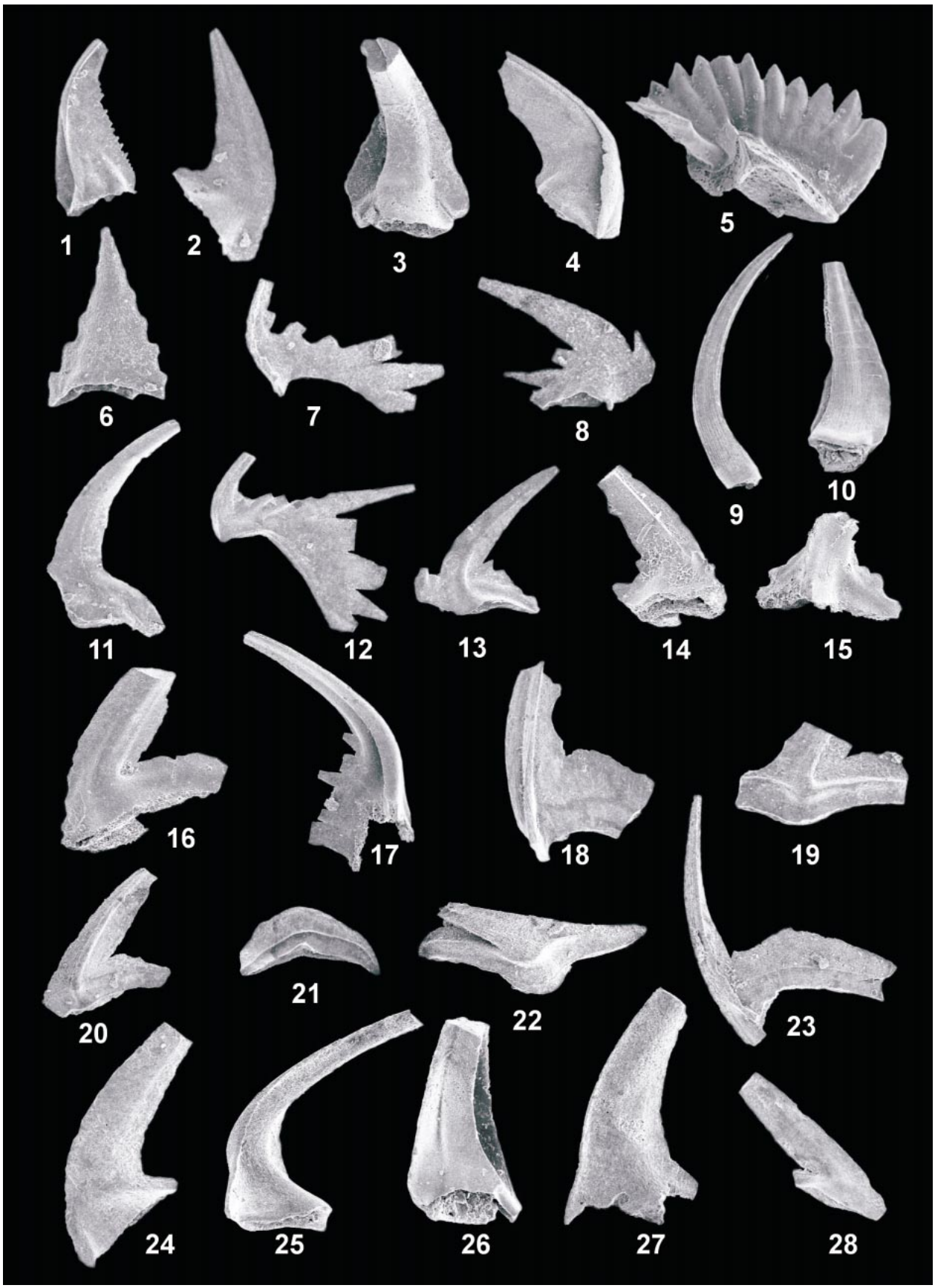
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TABLE 6—Distribution of conodont species from the Outram and Skoki formations (see Tables 1–6).

Distance above base (m) Species/Sample no. (WP-90-)	559.5 130A	563.5 131	566.5 131A	569 132	573.5 132A	577.5 132B	584 133	588.5 134	592 135	595 136	599.5 137	603.5 138	608.5 139	Total
Bergstroemognathus extensus		2		17			1	9	4	1	3			37
Coelocerodontus sp.	1													1
Drepanodus arcuatus							1							1
Drepanoistodus basiovalis		8		13				12	6	7		5		51
Drepanoistodus latus		4												4
Eucharodus parallellus			1	17										18
Fahraeusodus marathonensis		11	1				3	36	23	23	8			105
Juanognathus variabilis	1	19	3					15	8	16	22		38	122
Jumudontus gananda											1			1
Oepikodus communis		14		1,615		1	61	372	629	162	549	1,265	36	4,704
Oistodus multicorrugatus	1	8	1	23	2	2	3	12	6	2	11	20	3	94
Paltodus subequalis				2								1	2	5
Parapanderodus striatus	1	7		55			8	29	31	19	64	8	73	295
Paroistodus parallelus	4	9	2	162		2	3	25	49	23	126	192	30	627
Periodon flabellum	1	8					1							10
Protopanderodus elongatus		2	1											3
Protopanderodus gradatus					1		1							2
Protopanderodus rectus	3	6	1	51	1		5	49	56	16	218	131	172	709
Protoprioniodus aranda											1		18	19
Protoprioniodus nyinti												55		55
Scolopodus krummi	1	1												2
Tropodus australis		2		296	1							274	46	619
Tropodus sweeti	11	2	4	473	2	1	11	80	13	15	21	2		635
Rossodus? n. sp. A		1												1
Total	24	104	14	2,724	7	6	98	639	825	284	1,024	1,953	418	8,120

non *Scolopodus filosus xyron* REPETSKI, 1982, p. 47, pl. 22, fig. 2a–c.

Description.—Apparatus consists of two elemental morphotypes: one slender, elongate and other stout or squat. Elements are hyaline up to the tip of the recurved cusp which is albid. Base is unexpanded and elements have circular cross-section throughout their length. Both morphotypes bear surface ornamentation of many fine, longitudinal costae that extend from tip of cusp almost to base and occur on all sides of the cusp. Basal margin of element has smooth border. Basal cavity in both morphotypes deep, greater than half length of element; its tip lies near the posterior cusp margin. Recurved cusp about one-fifth length of element in elongate morphotype. Squat element has more strongly recurved cusp tip that occupies about one-third length of element.

Material examined.—21 elements; GSC 124269–124271.

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

Discussion.—Ethington and Clark (1982) reported and described the species yet it has not been assigned to a genus beyond its original form designation. The new genus differs from *Scolopodus* in the apparatus plan and the nature of the fine, numerous costae on the elements. The species appears to have a wide distribution and narrow stratigraphic range. Among the 21 elements in our present collection, only two morphotypes have been recognized. The forms listed above that are questionably assigned to the species may represent different morphotypes of a more complex apparatus, or perhaps another species of *Filodontus*.

Genus LEPTOCHIROGNATHUS Branson and Mehl, 1943

LEPTOCHIROGNATHUS WILCOXI new species

Figure 9.6–9.9

Leptochirognathus n. sp. HARRIS ET AL., 1979, p. 35, pl. 1, figs. 16–18.

Diagnosis.—Apparatus of *Leptochirognathus* that includes three morphotypes, each bearing three posteriorly directed, broad, compressed, sharp-edged denticles.

Description.—Apparatus of three morphotypes (P, M, S) characterized by nature of denticles which are largest in P elements. Basal cavity shallow in all elements.

P element asymmetrical with three posteriorly reclined, broad denticles. Posterior denticle tapers posteriorly, broader than medial denticle, compressed with thin, sharp edges. Upper edge rounded in profile and posterior edge almost straight, joining base of the element at almost a 90 degree angle. Inner denticle face rounded just above the flattened basal margin. Outer denticle face flat. Medial denticle laterally compressed with sharp-edged, anterior and posterior margins that taper to tip. Inner face concave but inflated where it joins base; outer face convex and bears medial costa. Anterior denticle flexed posteriorly, same width and

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FIGURE 8—Scanning electron microscope photomicrographs of conodonts from the Skoki Formation. All specimens in lateral view unless otherwise noted. *1–2, Ansella longicuspica*. ×75, from sample WP-90-161; *1,* S element, GSC 124326; *2,* P element, GSC 124327. *3–4, Juanognathus variabilis*. ×56, from sample WP-90-141; *3,* a element, posterior view, GSC 124328; *4,* e element, GSC 124329. *5, Jumudontus gananda*; P element, GSC 124330, ×48, from sample WP-90-161. *6, Kallidontus nodosus*; P element, GSC 124331, ×94, from sample WP-90-157. *7–8, Microzarkodina parva*. ×90, from sample WP-90-163; *7,* Sc element, GSC 124332; *8,* ?P element, GSC 124333. *9–10, Parapanderodus striatus*. ×50, from sample WP-90-154; *9,* a element, GSC 124334; *10,* e element, GSC 124335. *11, Paroistodus originalis*; Sb element, GSC 124336, ×40, from sample WP-90-161. *12–13, Periodon flabellum*. ×50, from sample WP-90-161; *12,* Sc element, GSC 124337; *13,* Pa element, GSC 124338. *14–17, Prioniodus crassulus*. From sample WP-90-151; *14–15,* P elements, lateral and anterior views, GSC 124339, 124340, ×73; *16,* M element, GSC 124341, ×73; *17,* S element, GSC 124342, ×63. *18–19, Protoprioniodus aranda*. ×58, from sample WP-90-139; *18,* S element, GSC 124343; *19,* P element, GSC 124344. *20–23, Protoprioniodus nyinti*. ×68; *20,* M element, GSC 124345, from sample WP-90-162; *21,* P element, GSC 124346, from sample WP-90-160; *22,* P element, GSC 124347, from sample WP-90-162; *23,* S element, GSC 124348, from sample WP-90-162. *24–28, Tripodus laevis*. ×68, from sample WP-90-154; *24,* P element, GSC 124349; *25,* Sb element, GSC 124350; *26,* Sa element, posterior view, GSC 124351; *27,* Sc element, GSC 124352; *28,* M element, GSC 124353.

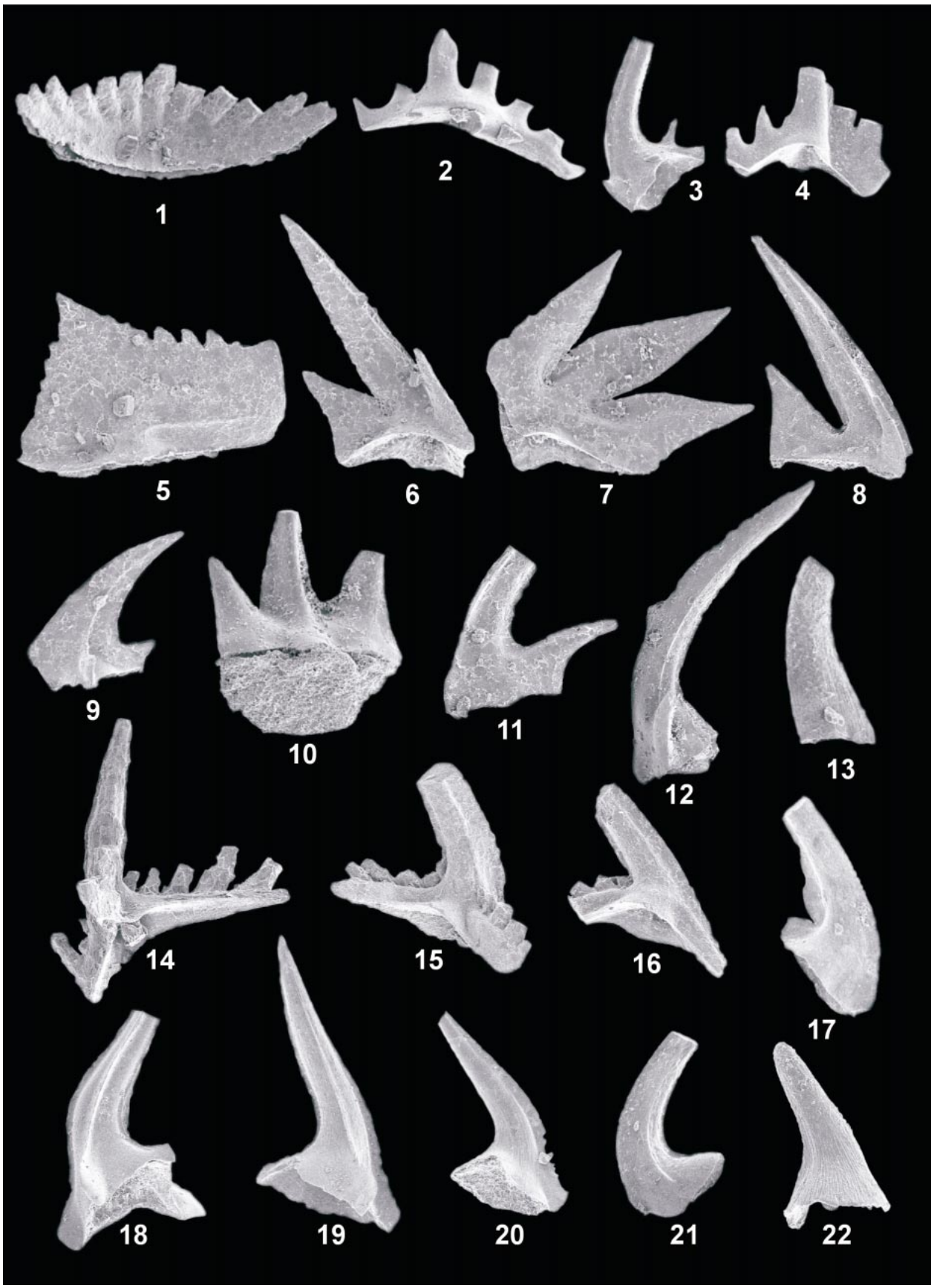
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TABLE 7—Distribution of conodont species from the Skoki Formation (see Tables 6–8).

Distance above base (m) / Species/Sample no. (WP-90-)	612.5 140	615 141	618.5 142	621.5 143	624.5 144	627.5 145	631 146	639.5 147	645.5 148	662.5 149	666.5 150	672.5 151	684.5 152	689.5 153	Total
Coelocerodontus sp.	1														1
Drepanoistodus basiovalis				1		11		5	4	9	6	72	14	46	168
Drepanoistodus lucidus										12	8				20
Juanognathus variabilis	80	62	3	28	5	14	12		1				2		207
Jumudontus gananda		1									1	1			3
Oepikodus communis	18	22	2	1	1			9							53
Oistodus multicorrugatus	5	10	6	3	3	2		1		11	2	10	1	8	62
Paltodus jemtlandicus			1												1
Parapanderodus striatus	52	4	13	2	11	34	8	2		19	12	76	8	8	249
Paroistodus originalis														4	4
Paroistodus parallelus	30	20	15			2	7		1	4		1			80
Periodon flabellum										12	11		1	4	28
Prioniodus crassulus										114	118	153	8		393
Protopanderodus rectus	137	34	23	14	3	41	31	3		3	40	21		6	356
Protoprioniodus nyinti	1			2		2	1			27		95	1	8	137
Stultodontus costatus	2	4	5	3	1	16	2								33
Tripodus laevis										380	56	19	98	8	561
Tropodus australis	94	8	21		1	13		9	1						147
Total	420	165	89	54	25	135	61	29	7	591	254	448	133	92	2,503

shape as medial denticle and almost as high. Anterior denticle margin joins base at almost 90 degree angle. Base extends under denticles and has a straight margin along the inner unit face. Base opens downward and toward the outer lateral face of the unit.

S element bears slender, erect, laterally compressed cusp. Anterior and posterior cusp margins sharp. Inner antero-lateral cusp face bears strong costa that extends from point where antero-lateral denticle arises almost to cusp tip. Both denticles are broad, compressed, with sharp edges and triangular profile and are one-third height of cusp. Antero-lateral denticle smaller than posterior denticle and has straight outer margin that meets the base at 90 degree angle. Posterior denticle erect to reclined posteriorly. Base of unit has rounded margin on inner surface and opens antero-laterally.

Non-geniculate ?M element has laterally compressed, reclined cusp. Base bears two broad denticles, much smaller than in P and S elements, in medial lateral and posterior positions. Costa extends from medial lateral denticle almost to cusp tip.

Etymology.—Named after Wilcox Pass.

Material examined.—21 elements; GSC 124359–124362.

Occurrence.—*Histiodella altifrons* Zone to *H. sinuosa* Zone, uppermost Skoki and lower Owen Creek Formations.

Discussion.—This new species differs from *L. quadratus* Branson and Mehl in which the P elements have 4 denticles. It has been reported from the Antelope Formation in central Nevada in strata containing *H. holodentata* and its associated fauna (Harris et al., 1979).

Genus ROSSODUS?
ROSSODUS? new species A
Figure 7.1–7.6

Description.—Apparatus consists of at least four morphotypes. Elements are laterally compressed with broad, blade-like cusp and broad base with a small, rounded, restricted basal cavity.

S elements have compressed cusp with sharp anterior and posterior cusp margins. Cusp bears weak rounded, medial costa on each lateral face that extend from cusp tip to basal margin. Cusp is proclined and gradually tapered. Base width is half cusp height. Antero-and postero-basal margins sharply rounded. Basal cavity restricted to midline of element, occupies central one-third of base width. Base flares slightly on inner lateral surface. Sa element symmetrical, Sb element asymmetrical.

P element geniculate with compressed, reclined cusp. Inner and outer lateral cusp faces each bear faint rounded costa. Basal cavity opens downward and base has prominent inner lateral flare.

M element is geniculate and laterally compressed. Basal cavity restricted under posterior portion of base. Antero-basal corner drawn down into keel that extends below basal margin. Basal outline sinuous.

Material examined.—15 elements; GSC 124297–124302.

Occurrence.—*Oepikodus communis* to *Jumudontus gananda* Zones, Outram Formation.

Discussion.—The generic assignment of the Wilcox Pass specimens is held in question because although the characteristics of

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FIGURE 9—Scanning electron microscope photomicrographs of conodonts from the Owen Creek Formation. All specimens in lateral view unless otherwise noted. *1, Chosonodina rigbyi*. GSC 124354, ×60, from sample WP-90-188. *2, Curtognathus* sp., cardiodelliform element, posterior view, GSC 124355, ×70, from sample WP-90-194. *3–4, Erismodus asymmetricus*. ×90; *3*, Sb element, GSC 124356, from sample WP-90-193; *4*, Sc element, GSC 124357, from sample WP-90-194. *5, Histiodella sinuosa*, Pa element, GSC 124358, from sample WP-90-181. *6–9, Leptochirognathus wilcoxi* n. sp.; *6*, S element, GSC 124359, ×55, from sample WP-90-182; *7*, P element, GSC 124360, ×53, from sample WP-90-182; *8*, S element, GSC 124361, ×75, from sample WP-90-181; *9*, ?M element, GSC 124362, ×88, from sample WP-90-181. *10*, ?New Genus 4 (of Ethington and Clark), trichonodelliform element, GSC 124363, ×67, from sample WP-90-184. *11–12, Neomultioistodus compressus*. ×50. *11*, Sc element, GSC 124364, from sample WP-90-182; *12*, Sb element, GSC 124365, from sample WP-90-184. *13, Panderodus gracilis*, GSC 124366, ×100, from sample WP-90-194. *14–16, Paraprioniodus costatus*. ×80, from sample WP-90-188. *14*, Pa element, GSC 124367; *15*, S element, GSC 124368; *16*, M element, GSC 124369. *17–20, Pteracontiodus cryptodens*. ×60, from sample WP-90-178; *17*, M element, GSC 124370; *18*, Sd element, GSC 124371; *19*, Sb element, GSC 124372; *20*, Sc element, GSC 124373. *21, Scandodus sinuosus*, acodiform element, GSC 124374, ×50, from sample WP-90-189. *22, Walliserodus declivis*?, GSC 124375, ×110, from sample WP-90-193.

TABLE 8—Distribution of conodont species from the Skoki Formation (see Tables 1–6).

Distance above base (m) / Species/Sample no. (WP-90-)	692.5 154	699.5 155	705.5 156	709.5 157	715.5 158	719.5 159	725.5 160	727 161	729.5 162	733.5 163	742.5 164	750.5 165	762.5 166	776 167	810 170	832.5 175	Total
Ansella longicuspica		6	1	57			11	41									116
Coelocerodontus sp.		7				3	6				3						19
Cornuodus longibasis								1									1
Drepanoistodus basiovalis	82		7	62	1		4	52	15	22							245
Drepanodus suberectus															1		1
Juanognathus variabilis		2	2	3	2	2	9	33	6	6	6	3	2				76
Jumudontus gananda	1			1	1	1		8	2	3				1			18
Kallidontus sp.				13	1				3								17
Leptochirognathus wilcoxi n. sp.																2	2
Microzarkodina parva					1		22		5	11							39
Multioistodus subdentatus?																1	1
Oepikodus communis		1				11	6										18
Oistodus multicorrugatus		16	13	1	4	20	10	121	6	14	6	2					213
Parapanderodus striatus	165	53	23	60	8	15	68	231	171	48	10	6	4	5			867
Paroistodus originalis	6	20		187	2	1	12	49	30	13	6						326
Periodon flabellum	13	68	7	117	7	13	21	324	8	10	2						590
Prioniodus crassulus	19	1		2													22
Protopanderodus rectus	62	28	4	84	3	21	78	322	44	10	4						660
Protoprioniodus nyinti	172	1	1	172		4	51	246	404	31	30	5					1,117
Pteracontiodus cryptodens																3	3
Tripodus laevis	102	10	4	22	6	12	11	101	54	36	11	2	1				372
Walliserodus ethingtoni		1															1
Total	622	214	62	781	36	103	309	1,529	748	204	78	18	7	6	1	6	4,724

TABLE 9—Distribution of conodont species from the Owen Creek Formation.

Distance above base (m) / Species/Sample no. (WP-90-)	845 176	857.5 178	865.5 179	873.5 180	888 181	901.5 182	912 183	918 184	930.5 185	971.5 188	982.5 189	995.5 190	1015.5 192	1022.5 193	1034.5 194	1037.5 195	Total
Chosonodina rigbyi										2							2
Curtognathus spp.														2	4	5	11
Drepanodus suberectus						3				5							8
Erismodus asymmetricus														24	7		31
Erismodus spp.													2			30	32
Histiodella sinuosa					1												1
Leptochirognathus wilcoxi n. sp.					8	8	3										19
Neomultioistodus compressus					5	20		58	1	3							87
Panderodus gracilis															3		3
Paraprioniodus costatus										11	2	6					19
Pteracontiodus cryptodens	13	50	20	5													88
Scandodus sinuosus		16							2	5	5						28
Walliserodus declivis?														1			1
?New Genus 4 (of Ethington and Clark, 1981)								1									1
Total	13	66	20	5	14	31	3	59	3	26	7	6	2	27	14	35	331

the elements and apparatus plan interpreted from the limited material at hand indicate affinities with the genus *Rossodus*, the genus is known previously only from the Tremadocian. Albanesi (1998, pl. 4, figs. 25–34) assigned specimens to *Rossodus* from the San Juan and Gualcamayo Formations (Arenigian) of the Precordillera Argentina.

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