Conodont biostratigraphy and T-R cycles of the Middle Devonian Hume Formation at Hume River (type locality), northern Mackenzie Mountains, Northwest Territories, Canada

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ABSTRACT: The type section of the Hume Formation (114.6 m), located along the Hume River in western Northwest Territories, is examined in detail for its conodonts and benthic fossils. For the most part it consists of a late Eifelian (early Middle Devonian) *kockelianus* Zone age, with short intervals of *australis* and *ensensis* zones at its base and top, respectively. Three benthic assemblage zones are recognized, in ascending order, *Eoschuchertella adoceta, Carinatrypa dysmorphostrota,* and *Eliorhynchus castanea*. The ranges of selected benthic fossils suggest transgression and regression, which are in agreement with three T-R cycles of Johnson, Klapper and Sandberg (1985) and Johnson and Klapper (1992), namely Id, Ie, and If. Cycle Id occurs at the base of the Hume Formation, at contact with the underlying Gossage Formation, and is within the *australis* Zone. Cycle Ie is about midway in the Hume Formation, within the *kockelianus* Zone. Cycle If, at the top of the Hume Formation, signals the entry of the *ensensis* Zone and the Kačák Episode, with the deposition of the overlying Hare Indian Formation.

INTRODUCTION AND BRIEF STRATIGRAPHY

The type locality of the Hume Formation is located at Hume River in central Mackenzie Valley, western Northwest Territories (65°20' N, 129°W), where the river exits the mountain front of the northern Mackenzie Mountains (text-fig. 1A, B). The name Hume Formation was proposed by Bassett (1961) for a series of limestones and interbedded shales that on the east bank of Hume River overlies the Gossage Formation and is overlain by the Hare Indian Formation (text-fig. 2). Except for a short interval near the top of the Hume Formation, the strata are completely exposed and easily accessible. Bassett (1961) assigned the strata underlying the Hume Formation to the Bear Rock Formation. These limestones, however, are part of an unbrecciated sequence of carbonate rocks, the Gossage Formation, that crop out eastward along the mountain front and change facies between East Gayna River and Powell Creek to mainly breccias of the Bear Rock Formation.

Only the Hume Formation (114.6 m) was completely measured. The lower contact of the formation is abrupt, noted by a downward change in color from dark grey to dark brown and by an almost complete disappearance of the abundant broken fossil fragments characteristic of the Hume. The upper contact is easily recognizable with the black, recessive-weathering shales of the Hare Indian Formation overlying light grey-weathering resistant carbonates of the Hume Formation (text-fig. 2).

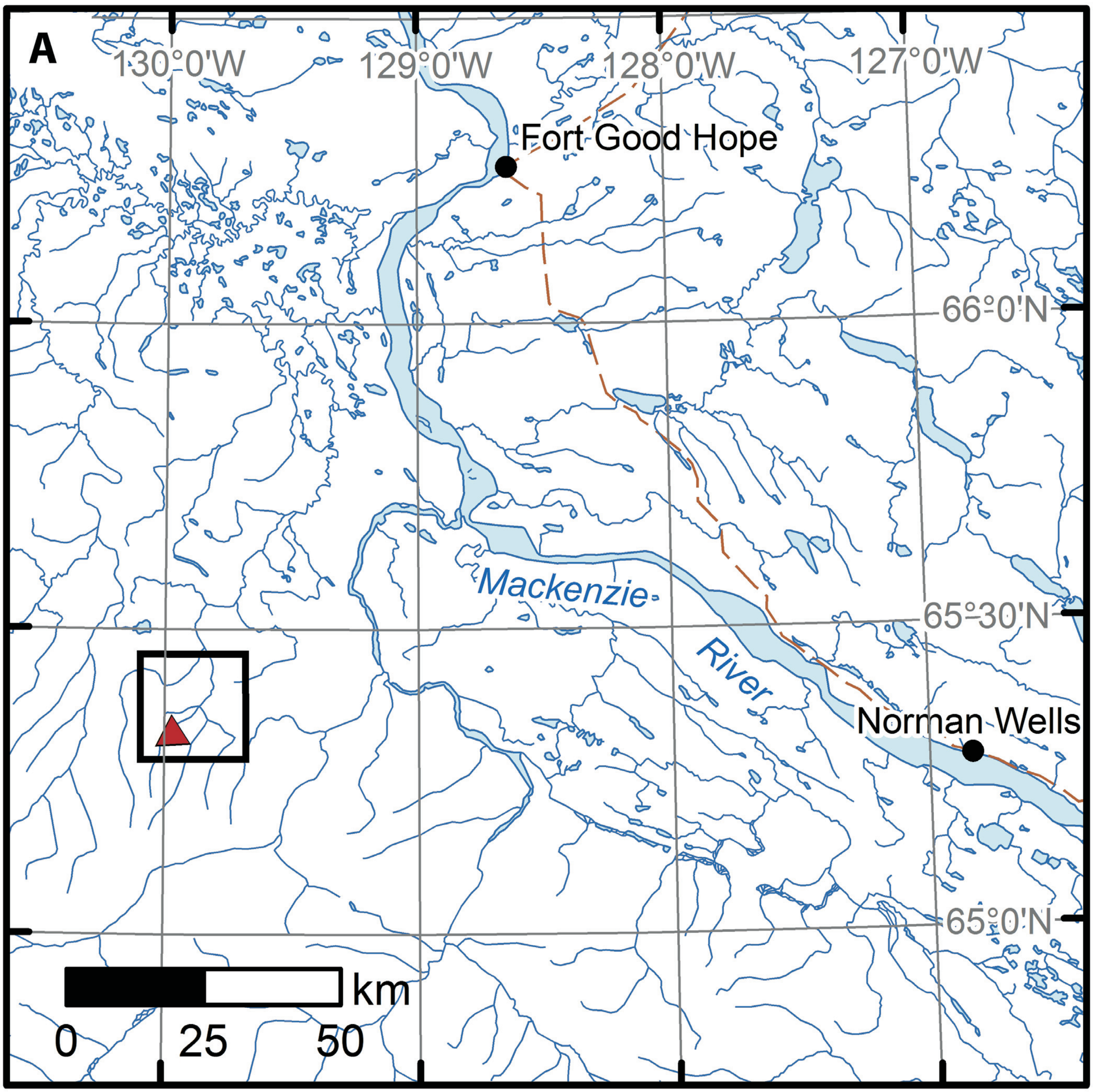
The Hume Formation is divisible into lower thin-bedded, recessive-weathering, argillaceous limestones with interbedded shales, and upper thicker-bedded carbonates that are less argillaceous and lack shale interbeds (text-fig. 3). This transition may coincide with the transgression that is depicted by T-R Cycle Ie of Johnson, Klapper and Sandberg (1985, fig. 2). The formation is mainly dark grey, fine and microcrystalline, argillaceous limestone with abundant broken skeletal remains. Other microfacies with different amounts of fossil debris and different degrees of granularity occur intermittently throughout the sequence. Detailed examination of rock types by the late Warren S. MacKenzie suggested that most of the constituent sediment was laid down in relatively quiet water, near the wave base where organisms flourished and where lime mud settled out of suspension. Regional facies changes support the concept of a semi-restricted environment on a wide, gently sloping shelf. Braun (2001) studied ostracodes from the type Hume Formation and correlated their evolutionary cycles with T-R cycles. He concluded that the major change in his T-R cycle occurred at 64 m below the top of the formation. In this study we conclude that T-R Cycle Ie occurs about 52 m below the top.

Present study

Fieldwork was carried out by W. S. MacKenzie, AEHP, and TTU in August 1972. TTU is responsible for conodont study, AEHP for the study of benthic fossils and discussion on the Kačák Episode, and TAU for providing SEM images of conodonts and preparations of the conodont plates and text-figure 3. Detailed discussion of the benthic faunas and regional stratigraphic relationships can be found in the paper by AEHP also published in this memorial volume. The study of Walliser and Bultynck (2011) of Moroccan sections provided critical guidance for this study.

Biostratigraphy and Devonian T-R cycles

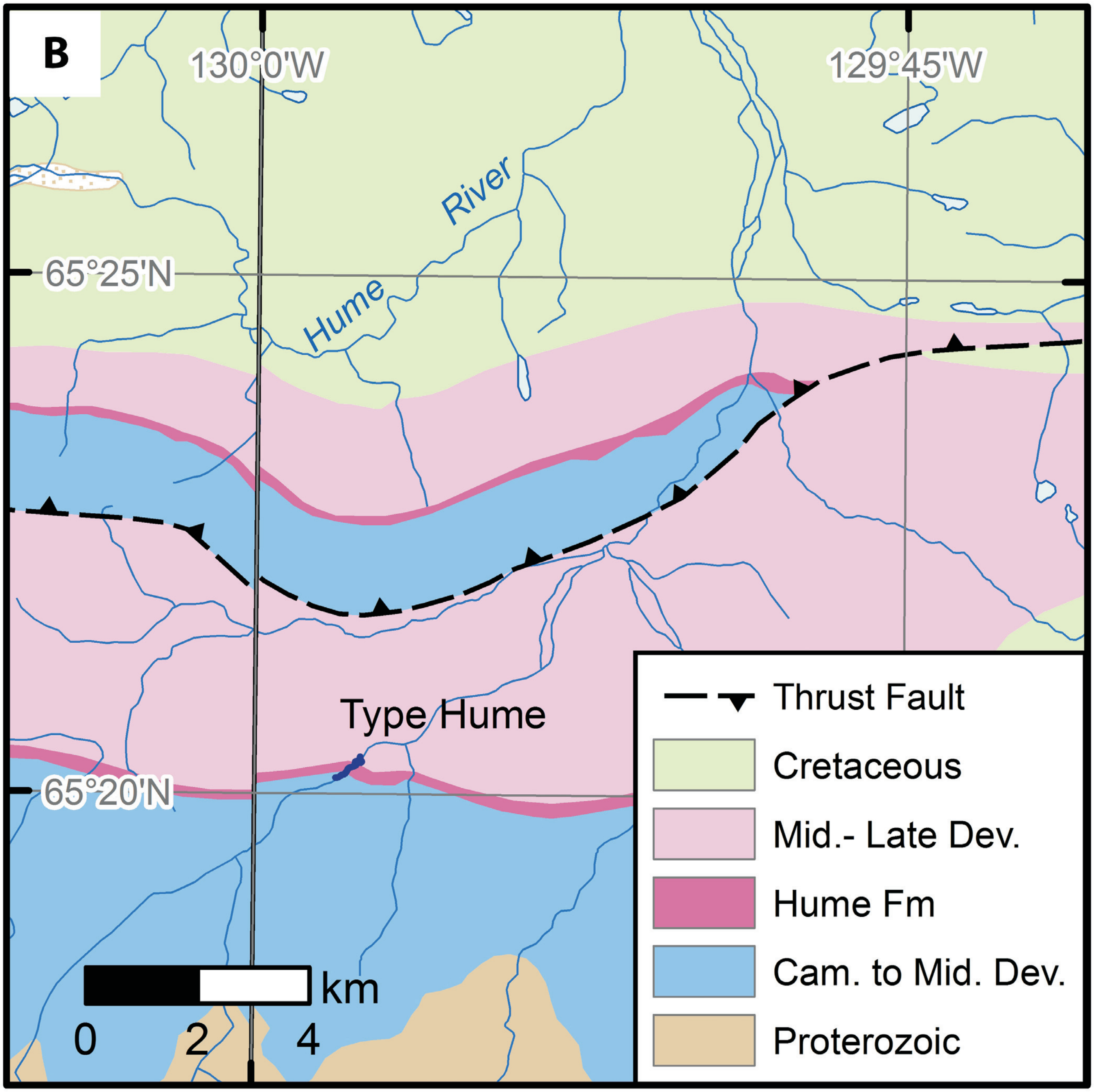
The relatively shallow-water conodonts of the type Hume section lack zonal-defining species. Proxy species that are characteristic



TEXT-FIGURE 1A
Map of western Northwest Territories with enclosure of text-figure 1B.

of the *australis* and *kockelianus* zones are used, and as such, zonal boundaries as depicted on text-figure 3 are approximate only. These zonal assignments are based partly on previous reports and their assignments (Chatterton 1978; Uyeno 1978; Klapper and Johnson 1980; Klapper and Barrick 1983). Three of the Euramerican Devonian T-R cycles outlined by Johnson, Klapper and Sandberg (1985) and Johnson and Klapper (1992) are recognized in the Hume section: Id, Ie, and If (text-fig. 3). Day et al. (1996) discussed the relative sea-level histories, including Cycles Ie and If in western and central North American interior basins. Some modifications/revisions of these cycles were made by Ver Straeten, Brett and Sageman (2011) based on mudrock sequence stratigraphy of the Appalachian Basin.

The interval with the two *Steptotaxis* species, ranging from the highest beds of the Gossage Formation to the lower Hume Formation (Samples 25 to 20), is assigned to the *australis* Zone. The transgression of T-R Cycle Id occurs within the *australis* Zone at the transition from dolomitic Gossage Formation to fossiliferous, dark brown limestones of the Hume Formation. The deepening is also suggested by the *Eoschuchertella adoceta* benthic assemblage in the lowest part of the Hume For-



TEXT-FIGURE 1B
Geological map of the locality of the type Hume section.

mation. The deeper phase of the transgression is marked by a 3.5-m interval of calcareous, silty shale (between Samples 19 and 20).

The greater part of the Hume Formation is assigned to the *kockelianus* Zone, starting with the first appearances of *Polygnathus curtigladius* Uyeno 1978*, Ozarkodina brevis* (Bischoff and Ziegler 1957) and *O. raaschi* Klapper and Barrick 1983. Klapper and Barrick (1983) reported this combination in the lower part of the Spillville Formation, in northern Iowa and southern Minnesota, which they interpreted to be a near-shore conodont biofacies and approximately correlatable with the *kockelianus* Zone. The striking similarity of the Hume *P. curtigladius* and that of the Spillville is noted in the Systematics. At the type Hume section, this zone encompasses the *Carinatrypa dysmorphostrota* benthic assemblage zone. Within this interval there is initially a shallowing as suggested by species of *Utaratuia* and stromatoporoids, followed by deepening (see Pedder 2017, this volume). The transition is assigned to T-R Cycle Ie. Whether this coincides with the lower and upper parts of the Hume Formation is difficult to assess since the change is very subtle. The deepening continues for the remainder of the formation. Conodont species that are restricted to Cycle Ie deposition include *Polygnathus robusticostatus* Bischoff and Ziegler 1957, *P. angusticostatus* Wittekindt 1966, *P. intermedius* Bultynck 1970, *P. schwartzi* Chatterton 1978, and *Icriodus* '*expansus*' of Chatterton 1978.

The uppermost 2.1 m of the Hume Formation with the *Eliorhynchus castanea* benthic assemblage zone contain specimens of *Polygnathus pseudofoliatus* Wittekindt 1966 that are transitional to *P. hemiansatus* Bultynck 1987 and to *P. ensensis* Ziegler and Klapper 1976. The interval is placed in the *ensensis* Zone. It marks the beginning of Cycle If and the start of the *ensensis* Zone and the Kačák Episode. The zone continues upwards into the basal beds of the Hare Indian Formation with the index species *P. ensensis, P. pseudoeiflius* Walliser and Bultynck 2011, and *P.* sp. M of Klapper (in Johnson, Klapper and Trojan 1980). This suggests that there is little, if any, hiatus between the Hume and the Hare Indian formations.

Kačák Episode

House (1985) introduced the term Kačák event, taking its name from the Kačák Member of the Srbsko Formation, Barrandian Terrane. Primarily this was to recognize profound changes in goniatite faunas at the base of the *Maenioceras* Stufe, which had been the base of the Givetian Stage for goniatite specialists. House (1996) emphasized that the widespread introduction of anoxic conditions that caused the Kačák event was polyphased over considerable time. The other principal paleontological definition proposed for the base of the Givetian is the incoming of the dacrioconarid *Nowakia otomari* Bouček 1964, which became the base of the *otomari* Zone (Bouček 1968). As Walliser et al. (1995) and Walliser (2000) have noted, the basal Givetian boundary as now defined by Walliser and Bultynck (2011), the incoming of *Polygnathus hemiansatus* at Jebel Mech Irdane, Morocco, is probably above the old basal *Maenioceras* Stufe and certainly above the base of the *N. otomari* Zone. Walliser (2000) proposed that, since the Kačák event embraces more than one level, it should be named the otomari Event/Kačák Episode.

Polygnathus hemiansatus has not been found in the type Hume Formation outcrop, although the sharp transition between the Hume and Hare Indian formations is clearly exposed (text-fig. 2). *Cabrieroceras* has been identified at two localities in the Mackenzie Mountains (House and Pedder 1963; Pedder 1969) in the lower 3 m of the Hare Indian Formation. We assume that this is further confirmation that the uppermost Hume Formation is Eifelian.

Walliser and Bultynck (2011) summarized the conodont distribution in three key sections in SE Morocco, including Jebel Mech Irdane and its Global Stratotype Section and Point (GSSP) for the base of the Givetian. They demonstrated the precise positions of the Kačák Episode at the Eifelian-Givetian boundary. In the present study only the lower limit of the episode is defined in the *ensensis* Zone in the highest part of the Hume Formation (text-fig. 3).

CONODONT SYSTEMATIC PALEONTOLOGY

Based on their P_1 elements, the species are described in the same stratigraphic order as in the range chart. The number of specimens listed on text-figure 3 are based on the P_1 elements, although all available elements of species of *Ozarkodina* are illustrated. Since the emphasis of this paper is primarily biostratigraphic, synonymy lists are purposely brief. The stratigraphic ranges of these species are based solely on their occurrences in the type Hume section. The anatomical notation is after Purnell, Donoghue and Aldridge (2000). All figured and unfigured specimens are stored at the GSC (Geological Survey of Canada), 601 Booth St., Ottawa, Ontario.

Genus *Steptotaxis* Uyeno and Klapper 1980

Steptotaxis uyenoi (Chatterton 1978)
Plate 1, figures 22–24

Pelekysgnathus uyenoi CHATTERTON 1978, p. 204–205, pl. 7, figs. 1–11, 26, 27.
Sannemannia uyenoi (Chatterton) KLAPPER and JOHNSON 1980, p. 455.

Remarks: The specimens in this section are from the upper Gossage and lowest part of the Hume formations. They are similar to those reported from the more southerly locations by Chatterton (1978, sections 6, 17, 18). Although Chatterton (1978) stated that this species often occurs with *Steptotaxis pedderi*, they were reported together from only one locality (section 6, sample 390). This finding is similar to the type Hume section where the two species are mutually exclusive, with *S. uyenoi* preceding *S. pedderi*. Klapper and Johnson (1980) recorded the occurrence of this species in the *australis* Zone.

Steptotaxis pedderi (Uyeno and Mason 1975)
Plate 1, figure 21

Pelekysgnathus pedderi UYENO and MASON 1975, p. 720–721, pl. 1, figs. 20–44. – CHATTERTON 1978, p. 203, pl. 7, figs. 12–23. – UYENO 1978, p. 249, pl. 1, figs. 8–10.
Sannemannia pedderi (Uyeno and Mason) KLAPPER and JOHNSON 1980, p. 455.
Steptotaxis pedderi (Uyeno and Mason) UYENO 1991, pl. 2, fig. 25 [reillustration of holotype].

Remarks: This species was found in the basal Hume Formation at its type section. It was originally reported from the Hume and Ogilvie formations in the Mackenzie Corridor (Uyeno and Mason 1975). Farther south, Chatterton (1978, sections 8 and 9) recorded it from the upper Bear Rock and lower Nahanni formations. Klapper and Johnson (1980) recorded its range as *australis* Zone.

Genus *Icriodus* Branson and Mehl 1938

***Icriodus* sp. D**
Plate 2, figures 27–31

Icriodus aff. *I. angustus* Stewart and Sweet of Bultynck (1972) UYENO 1978, p. 248, pl. 1, figs. 2–4.

Description: P_1 element: The spindle has parallel sides to slightly biconvex sides. All denticles on the spindle are discrete, of circular cross-section, with only a slight tendency of the lateral row denticles to lateral elongation towards the middle row. The anterior [ventral] end has a single denticle in the middle row, followed by two fused denticles. The posterior [dorsal] extension of the middle row has 2 or 3 large denticles that are slightly inclined posteriorly [dorsally]. Lateral and middle row denticles on the spindle number 4–6. The basal cavity is narrowly rounded at the posterior [dorsal] end. The lower margin is straight and slopes downward posteriorly [dorsally] beneath the extension.

TEXT-FIGURE 2
The *castanea*-bearing limestone of the Hume Formation overlain by the shales of the Hare Indian Formation. 5-ft (~1.5-m) measuring stick shows scale. The 427-ft mark is the level of 130.1-m mark on text-figure 3. The boundary transition is the result of the Kačák Episode.

Remarks: In contrast to *Icriodus* n. sp. A of Chatterton (1978), the denticles on the middle row extension are laterally compressed, larger, and posteriorly [dorsally] inclined. Uyeno (1978) previously reported this species from the lower Hume Formation in the Powell Creek section, located 57 km almost due east of the type Hume section. There, a single specimen was reported from 45.6–46.6 m above base of the formation.

Occurrence: In the lower Hume Formation in the interval assigned to the *australis* Zone.

***Icriodus* n. sp. A** of Chatterton (1978)
Plate 2, figures 25, 26

Icriodus n. sp. A CHATTERTON 1978, p. 203, pl. 6, figs. 19–25.

Remarks: In lower view the basal cavity of *Icriodus* n. sp. A is narrower posteriorly [ventrally] than that of *I.* '*expansus*' Branson and Mehl of Chatterton (1978). The latter exhibits a distinct spur in the posterior inner [caudal] margin. The posterior [dorsal] extension of the middle row of *I.* n. sp. A is longer than in *I.* '*expansus*', and consists of 3–4 denticles that are only slightly higher than those on the spindle. Chatterton (1978) reported it from the lower and middle parts of the Headless Formation, lower Hume Formation, and the upper Funeral Formation in the more southerly locations.

Occurrence: In the lower Hume Formation in intervals assigned to *australis* and *kockelianus* zones.

***Icriodus* n. sp.** of Narkiewicz, Bultynck and Narkiewicz (2013)
Plate 2, figures 22, 23

Icriodus orri KLAPPER and BARRICK 1983, p. 1230–1231, figs. 9X, 9Y, 9AA [only].
Icriodus n. sp. NARKIEWICZ, BULTYNCK and NARKIEWICZ, 2013 [figs. not numbered.]

Remarks: Icriodus orri Klapper and Barrick (1983) was subdivided into three species by Narkiewicz, Bultynck and Narkiewicz (2013): *I. orri* s.s., *I.* n. sp., and *I. retrodepressus* Bultynck (1970). The Hume specimens are assigned to their *I.* n. sp., which was earlier reported by Klapper and Barrick (1983) from the U.S. Midwest (Iowa, Michigan, Wisconsin, and Ohio) and southern Ontario. The reported range is from the mid-*costatus* to mid-*ensensis* zones.

Occurrence:. In the type Hume section, *I.* n. sp. is in the lower part of the Hume Formation (*kockelianus* Zone).

***Icriodus* '*expansus*'** Branson and Mehl of Chatterton (1978)
Plate 2, figures 20, 21

Icriodus expansus Branson and Mehl CHATTERTON 1978, p. 201–202, pl. 6, figs. 13–18.
Icriodus '*expansus*' Branson and Mehl KLAPPER and JOHNSON 1980, p. 448.

Remarks: P_1 element: *See* under *Icriodus* sp. A for comparison with that species.

Occurrence: In the upper Hume Formation in the *kockelianus* and *ensensis* zones. In areas to the south of the type Hume section, Chatterton (1978) previously reported it from the lower Funeral, Nahanni, lower Hare Indian and Headless formations. Klapper and Johnson (1980, p. 448) summarized its occurrence as ranging from the *australis* to *ensensis* zones.

Genus *Polygnathus* Hinde 1879

Polygnathus parawebbi Chatterton 1974
Plate 1, figures 6, 7

Polygnathus parawebbi CHATTERTON 1974, p. 1473–1478, pl. 1, figs. 12, 15–19, 25–27; pl. 2, figs. 1–9. – KONONOVA and KIM 2005, p. 129–130, pl. 11, figs. 1–15; pl. 12, figs. 1–19; pl. 13, figs. 1, 2 [review]. – NARKIEWICZ 2011, p. 170–171, pl. 1, fig. 11 [summary].

Remarks: Polygnathus parawebbi morphotypes α and β (of Chatterton 1978) are present. They range throughout the Hume Formation and lower Hare Indian Formation.

Polygnathus linguiformis linguiformis Hinde 1879
Plate 1, figures 1–3

Polygnathus linguiformis HINDE 1879, p. 367, pl. 17, fig. 15.
Polygnathus linguiformis linguiformis Hinde UYENO 1998, p. 162, pl. 12, figs. 2, 3, 20; pl. 14, figs. 12, 13. – WALLISER and BULTYNCK 2011, p. 14–15, pl. 3, figs. 1–6.

Remarks: The Hume collection has two morphotypes of *Polygnathus linguiformis linguiformis* distinguished by Walliser and Bultynck (2011), γ1a and γ1b. A single specimen assigned to *P. linguiformis alveolus* Weddige 1977 (GSC 136573; pl. 1, fig. 12) was recovered from Sample 1 (associated with *castanea* benthic assemblage Zone). A fragmentary specimen with a long posterior tongue is present in the lower Hare Indian Formation (Sample 3). It may perhaps be assignable to *P. linguiformis klapperi* Clausen, Leuteritz and Ziegler 1979.

Polygnathus curtigladius Uyeno 1978
Plate 1, figures 19, 20

Polygnathus curtigladius UYENO 1978, p. 241, 244, pl. 1, figs. 20–25, 29–31. – CHATTERTON 1978, p. 193, pl. 8, figs. 8–24, pl. 9, figs. 12, 13. – KLAPPER and BARRICK 1983, p. 1237, figs. 12K, AB, AC. – UYENO 1991, pl. 2, fig. 23.

Remarks: The small specimen on plate 1, fig. 20 is strikingly similar to the lower Spillville specimen illustrated by Klapper and Barrick (1983, fig. 12K, loc. 1). It was found in mid-part of the Hume Formation (Sample 15). In the type Hume section, *P. curtigladius* occurs sporadically throughout the Hume Formation, in the interval assigned to the *kockelianus* Zone. Previous findings were summarized by Klapper and Barrick (1983). It also occurs in the upper part of the Dundee Formation in a mine shaft in Lambton County, southwestern Ontario (Devran Sarnia 1-3-3-VI; Tract 1-3, Lot 3, Concession VI, Sarnia Township, unpublished collection).

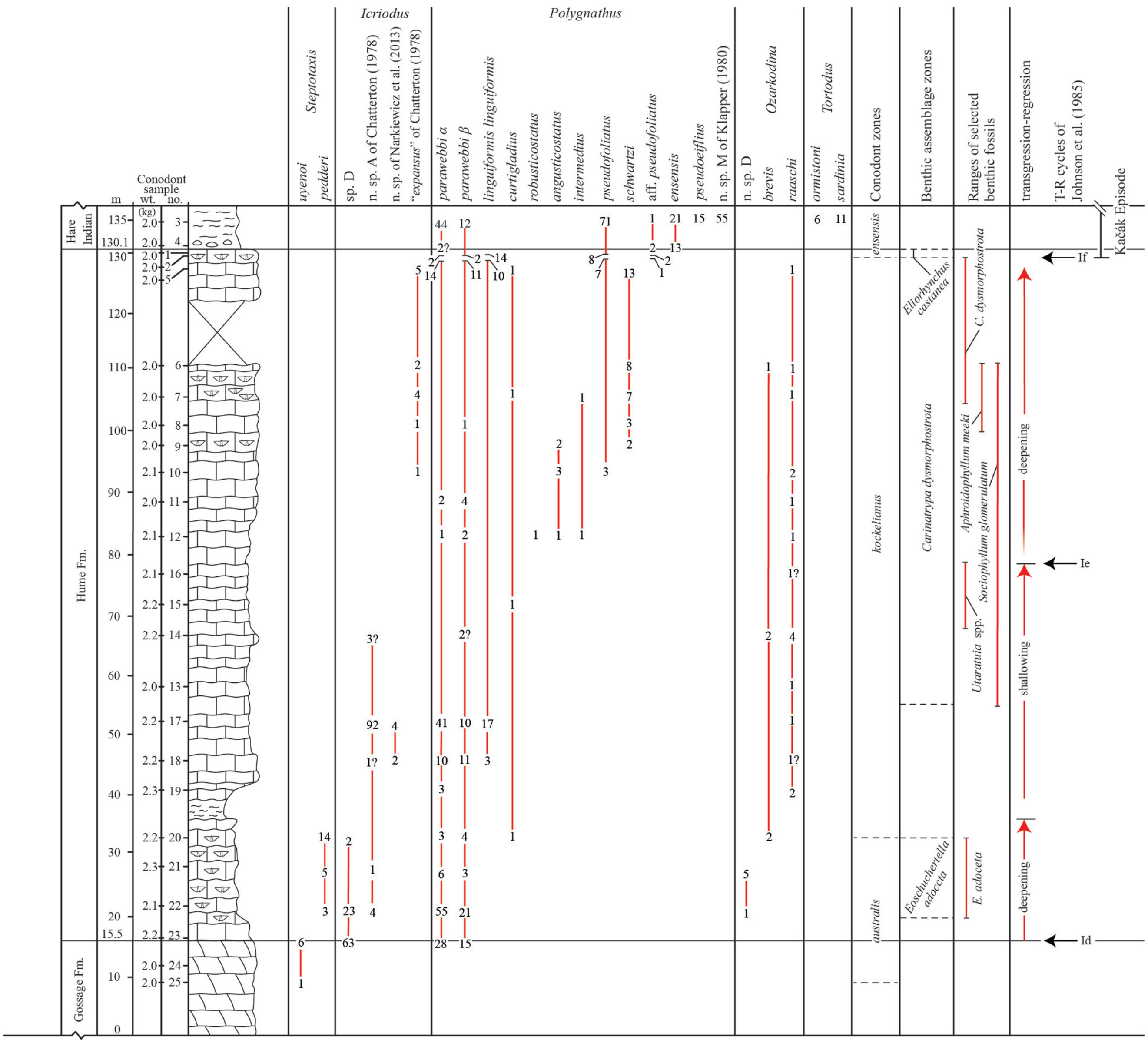
Polygnathus robusticostatus Bischoff and Ziegler 1957

Polygnathus robusticostatus BISCHOFF and ZIEGLER 1957, p. 95–96, pl. 3, figs. 4–9. – WALLISER and BULTYNCK 2011, p. 13, pl. 2, figs. 1, 2.

Remarks: The single Hume specimen from Sample 12 (82.9–83.2m above base of section) was lost during the imaging process.

Polygnathus angusticostatus Wittekindt 1966
Plate 1, figure 18

Polygnathus angusticostatus WITTEKINDT 1966, p. 631, pl. 1, figs. 15–18. – SAVAGE 1977, p. 1348, pl. 3, figs. 25–28. – SAVAGE 1995, p. 545, figs. 5.1–5.3, 8.14. – VODRÁŽKOVÁ, KLAPPER and MURPHY 2011, p. 760, fig. 13J. – GOUWY, LIAO and VALENZUELA-RÍOS 2013, p. 326, fig. 4N.



TEXT-FIGURE 3
Columnar section of the type Hume section, showing the distribution of conodont species and zones; the benthic assemblage zones; the ranges of selected benthic fossils and their inference of transgression and regression; and the Euramerican Devonian T-R cycles of Johnson, Klapper and Sandberg (1985) and Johnson and Klapper (1992). Figures on the distribution lines indicate the number of specimens. *Polygnathus* aff. *P. pseudofoliatus* includes specimens transitional to *P. hemiansatus* and to *P. ensensis* (see plate explanation). The 'cricoconarid bed' is Sample 3 in the basal Hare Indian Formation.

Remarks: The Hume specimen is close to those illustrated by Savage (1977, 1995) from the Wadleigh Limestone in southeastern Alaska. Gouwy, Liao and Valenzuela-Ríos (2013) noted this species ranges from the base of the *costatus* to lower *hemiansatus* zones. In the type Hume section, it occurs in an interval assigned to the *kockelianus* Zone.

Polygnathus intermedius (Bultynck 1970)
Plate 1, figures 9, 10

Spathognathodus intermedius BULTYNCK 1970, p. 133–134, pl. 18, figs. 2–6
Polygnathus intermedius (Bultynck) UYENO 1982, p. 74, pl. 31, figs. 23–25. – KLAPPER and BARRICK 1983, p. 1239, figs. 12A–F [synonymy]. – SPARLING 1983, p. 854, fig. 12AJ. – BULTYNCK 1985, pl. 7, fig. 20.
Tortodus intermedius (Bultynck) BULTYNCK 1987, pl. 9, fig. 16.
Tortodus? *intermedius* (Bultynck) WALLISER and BULTYNCK 2011, p. 13, pl. 2, figs. 11, 12.

Remarks: Polygnathus intermedius was found in the upper part of the Hume Formation in an interval assigned to the *kockelianus* Zone. The free blade of the specimen on plate 1, figure 9 is missing. The posterior [dorsal] end of the carina is slightly incurved, suggesting a possible assignment to *Tortodus* as suggested by Walliser and Bultynck (2011).

Polygnathus pseudofoliatus Wittekindt 1966
Plate 1, figure 8

Polygnathus pseudofoliatus WITTEKINDT 1966, p. 637–638, pl. 2, figs. 20–23. – WALLISER and BULTYNCK 2011, p. 11, pl. 1, figs. 1, 2.

Remarks: Walliser and Bultynck (2011) distinguished two morphotypes, α and β. They overlap in the upper Hume Formation with the α morphotype extending into the lower Hare Indian Formation.

Polygnathus pseudofoliatus Wittekindt 1966 → ***P. ensensis*** Ziegler and Klapper 1976
Plate 1, figure 4

Polygnathus pseudofoliatus Wittekindt 1966 → *P. xylus ensensis* Ziegler and Klapper 1976 JOHNSON, KLAPPER and TROJAN 1980, p. 103, pl. 4, fig. 4.

Remarks: Johnson, Klapper and Trojan (1980) reported the transitional form from the *ensensis* Zone. In the type Hume section it was found in the basal Hare Indian Formation.

Polygnathus pseudofoliatus Wittekindt 1966 → ***P. hemiansatus*** Bultynck 1987
Plate 1, figures 16, 17

Polygnathus aff. *P. pseudofoliatus* Wittekindt, 1966 WALLISER and BULTYNCK 2011, p. 12, pl. 1, figs. 7–10.

Remarks: In Moroccan sections, the transitional form ranges from the *ensensis* through *hemiansatus* zones (Walliser and Bultynck 2011, figs. 2–4). At the type Hume section, it was found in the highest Hume and basal Hare Indian formations.

Polygnathus schwartzi Chatterton 1978
Plate 1, figure 11

Polygnathus schwartzi CHATTERTON 1978, p. 198–199, pl. 4, figs. 17–22, 24–26. – KLAPPER and JOHNSON 1980, p. 454. – PYLE et al. 2003, pl. 2, figs. 16, 17.

Remarks: In the type Hume section, the species was found in the upper Hume in an interval assigned to upper part of the *kockelianus* Zone.

Polygnathus ensensis Ziegler and Klapper 1976
Plate 1, figure 15

Polygnathus xylus ensensis ZIEGLER and KLAPPER in ZIEGLER, KLAPPER AND JOHNSON 1976, p. 125–127, pl. 3, figs. 4–9.
Polygnathus ensensis Ziegler and Klapper WALLISER and BULTYNCK 2011, p. 12, pl. 1, figs. 21, 22.

Remarks: Walliser and Bultynck (2011) noted the range of the species in Morocco from the base of the *ensensis* Zone to the *timorensis* Zone. It ranges as high as the *ansatus* Zone in the Pine Point area of the District of Mackenzie (Uyeno 1998). In the type Hume section it occurs in the lowest part of the Hare Indian.

Polygnathus pseudoeiflius Walliser and Bultynck 2011
Plate 1, figures 13, 14

Polygnathus pseudoeiflius WALLISER and BULTYNCK, 2011, p. 11, pl. 1, figs. 3–5. – GOUWY, LIAO and VALENZUELA-RÍOS 2013, p. 330, fig. 4H.

Remarks: As noted by Walliser and Bultynck (2011), the characteristic features of this species include a short rostrum with parallel margins, the semi-circular protrusion of the outer [rostral] margin, and the outer rostral margin that is slightly diagonal. These authors noted its range as within the *kockelianus* zone to within the *timorensis* Zone. At the type Hume section it was found only in the cricoconarid bed (Sample 3) in the lower Hare Indian Formation (*ensensis* Zone).

Polygnathus **n. sp. M** of Klapper 1980
Plate 1, figure 5

Polygnathus n. sp. M KLAPPER in JOHNSON, KLAPPER AND TROJAN 1980, p. 103, pl. 4, figs. 9, 10. – KLAPPER and JOHNSON 1980, p. 454, pl. 4, figs. 11, 12, 16. – MORGAN 2003, p. 288, pl. 3, figs. 1–4 [only].

Remarks: The figured specimen was lost after imaging; an unfigured specimen (GSC no. 136617) is included in the GSC collection. Klapper (1980) reported this species from the *ensensis* Zone (*sensu lato*) from the Antelope Range, Nevada. An early *ensensis* Zone age was suggested by Morgan (2003, p. 291) for material from the Moore Creek Limestone in N.S.W., Australia. In the type Hume section, it was found in the basal Hare Indian Formation in Sample 3, 4.3–4.4 m above the base of the formation.

Genus *Ozarkodina* Branson and Mehl 1933

Ozarkodina **n. sp. D**
Plate 2, figures 1–11

Diagnosis: P_1 element with two prominent posterior [dorsal] cusps separated by a deep V-shaped gap. Basal cavity may be oval and situated at extreme posterior [dorsal] end, or sagittate occurring at or near the posterior [dorsal] end.

Description: P_1 element: Two prominent cusps are present at the posterior [dorsal] end, the posteriormost [dorsalmost] one being slightly larger of the two. They are separated by a deep V-shaped gap. The second cusp may be followed anteriorly [ventrally] by up to five small denticles. The basal cavity may be oval shape, situated at the posterior [dorsal] end of the blade (pl. 2, fig. 7) or sagittate and located at or near the posterior [dorsal] end (pl. 2, figs. 1, 10).

P_2 element: The large centrally-located cusp is flanked on both sides by much smaller denticles. Its basal cavity is beneath the cusp and may taper posteriorly [dorsally].

M element: The strongly recurved cusp has a ridge extending along its anterior [ventral] margin. Although the figured specimen (pl. 2, fig. 11) is only partly preserved, its lower outer [rostral] lateral side appears to be smooth.

S_1, S_2 and S_3? elements: All have thin, compressed denticles. No S_0 element was recognized.

Remarks: The P_1 element of the species is similar to that of *Ozarkodina brevis* but differs in its two prominent cusps. *Ozarkodina brevis* has a prominent cusp at the posterior [dorsal] end, and is followed anteriorly [ventrally] by a smaller denticle (see Klapper and Barrick 1983, fig. 10P). Where the basal cavity of the P_1 element is located at the extreme posterior [dorsal] end, it is similar to that of *O. brevis*, but where it is situated slightly more anteriorly [ventrally], it is similar to *O. raaschi* (see Klapper and Barrick 1983, figs. 10N, 10P).

Occurrence: Ozarkodina n. sp. D was found only in Samples 21 and 22 in the basal part of the Hume Formation. It is associated with the brachiopod *Eoschuchertella adoceta* and dated as *australis* Zone.

Ozarkodina brevis (Bischoff and Ziegler 1957)
Plate 2, figures 16–18

Spathognathodus brevis BISCHOFF and ZIEGLER 1957, p. 116–117, pl. 19, figs. 24, 27–29.
Ozarkodina brevis (Bischoff and Ziegler) KLAPPER and BARRICK 1983, p. 1234, figs. 10L, 10O, 10P [synonymy]. – NICOLL 1985, p. 139–144, figs. 6–9. – UYENO 1998, p. 159, pl. 12, figs. 8, 9; pl. 17, figs. 1–26; pl. 18, figs. 1–20, 27. – ABOUSSALAM 2003, p. 171, pl. 28, fig. 18.
'*Ozarkodina brevis*' (Bischoff and Ziegler) GOUWY, LIAO and VALENZUELA-RÍOS 2013, p. 325, fig. 4P.

Remarks: The species has a long range, from the *kockelianus* Zone (herein) to the *norrisi* Zone (Klapper in Ziegler 1977).

Ozarkodina raaschi Klapper and Barrick 1983
Plate 2, figures 12–15

Ozarkodina raaschi KLAPPER and BARRICK 1983, p. 1234–1235, 1237, figs. 10K, 10N, 11A–11W.

Remarks: The M element (pl. 2, fig. 13) has an outer (ventral?) [rostral?] lateral process. A similar element was found associated with *Ozarkodina brevis* in the Pine Point Formation in the Great Slave Lake area of the Northwest Territories (Uyeno 1998, pl. 17, fig. 24) and in the Winnipegosis Formation of southern Manitoba (Uyeno 1982, pl. 32, figs. 33, 34). As noted by Klapper and Barrick (1983) and Nicoll (1985) the main difference between *O. raaschi* and *O. brevis* is in the morphology of the P_1 element, namely in the shape and position of the basal cavity. Although *Ozarkodina* n. sp. D displays a basal cavity in the P_1 element that is similar to both of these other species, its morphology significantly differs in other ways.

Genus *Tortodus* Weddige 1977

Tortodus ormistoni (Chatterton 1978)
Plate 2, figure 24

'*Spathognathodus*' *ormistoni* CHATTERTON 1978, p. 200–201, pl. 5, figs. 10, 11. – KLAPPER and JOHNSON 1980, p. 455.

Remarks: In areas south of this study, Chatterton (1978) reported *T. ormistoni* from the top of the Nahanni just below the Hare Indian and from the lower Horn Plateau. In the type Hume section, it was found in Sample 3, 4.3–4.4 m above the base of the Hare Indian Formation. Klapper and Johnson (1980) assigned it to the *ensensis* Zone (*sensu lato*) in an interval assigned to the *ensensis* Zone. Aboussalam (2003) noted its range from the *ensensis* to *disparilis* zones. Walliser and Bultynck (2011) recorded it from the lower *hemiansatus* Zone in the Bou Tchrafine section, Morocco.

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PLATE 1

Conodonts from the type Hume section

All specimens are P_1 elements from the Hume Formation unless otherwise noted. All views are oblique upper unless otherwise noted. All figures are ~ ×51, unless otherwise noted. Sample number is that indicated on text-figure 3.

All figured specimens are in the collection of the GSC (Geological Survey of Canada), 601 Booth St., Ottawa, Ontario.

1 *Polygnathus linguiformis linguiformis* Hinde 1879, γ1a morphotype Walliser and Bultynck 2011, GSC 136563, Sample 2.

2 *Polygnathus linguiformis linguiformis* Hinde 1879, γ1b morphotype Walliser and Bultynck 2011, GSC 136564, Sample 1.

3 *Polygnathus linguiformis linguiformis* Hinde 1879, GSC 136565, Sample 18 (×44).

4 *Polygnathus pseudofoliatus* Wittekindt 1966 → *P. ensensis* Ziegler and Klapper 1976, GSC 136566, Hare Indian Formation, Sample 3.

5 *Polygnathus* n. sp. M of Klapper 1980, specimen lost, Hare Indian Formation, Sample 3.

6 *Polygnathus parawebbi* α morphotype Chatterton 1974, GSC 136567, Hare Indian Formation, Sample 3.

7 *Polygnathus parawebbi* β morphotype Chatterton 1974, GSC 136568, Sample 2.

8 *Polygnathus pseudofoliatus* Wittekindt 1966, GSC 136569, Sample 1.

9 *Polygnathus intermedius* (Bultynck 1970), GSC 136570, Sample 12.

10 *Polygnathus intermedius* (Bultynck 1970), lateral view, GSC 136571, Sample 7.

11 *Polygnathus schwartzi* Chatterton 1978, GSC 136572, Sample 7.

12 *Polygnathus linguiformis alveolus* Weddige 1977, GSC 136573, Sample 1.

13 *Polygnathus pseudoeiflius* Walliser and Bultynck 2011, GSC 136574, Hare Indian Formation, Sample 3 (x92).

14 *Polygnathus pseudoeiflius* Walliser and Bultynck 2011, GSC 136575, Hare Indian Formation, Sample 3 (×92).

15 *Polygnathus ensensis* Ziegler and Klapper 1976, GSC 136576, Hare Indian Formation, Sample 3.

16 *Polygnathus pseudofoliatus* Wittekindt 1966 → *P. hemiansatus* Bultynck 1987, GSC 136577, Hare Indian Formation, Sample 1 (×77).

17 *Polygnathus pseudofoliatus* Wittekindt 1966 → *P. hemiansatus* Bultynck 1987, GSC 136578, Hare Indian Formation, Sample 3 (×77).

18 *Polygnathus angusticostatus* Wittekindt 1966, upper view, GSC 136579, Sample 9.

19 *Polygnathus curtigladius* Uyeno 1978, GSC 136580, Sample 7.

20 *Polygnathus curtigladius* Uyeno 1978, upper view, GSC 136581, Sample 15.

21 *Steptotaxis pedderi* (Uyeno and Mason 1975), upper view, GSC 136582, Sample 20.

22 *Steptotaxis uyenoi* (Chatterton 1978), upper view, GSC 136583, Gossage Formation, Sample 23.

23 *Steptotaxis uyenoi* (Chatterton 1978), upper view, GSC 136584, Gossage Formation, Sample. 23.

24 *Steptotaxis uyenoi* (Chatterton 1978), upper view, GSC 136585, Gossage Formation, Sample 25.


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PLATE 2

Conodonts from the type Hume section. All specimens are from the Hume Formation unless otherwise noted. All views are lateral views unless otherwise noted. Magnifications as noted. Sample number is that indicated on text-figure 3.
All figured specimens are in the collection of the GSC (Geological Survey of Canada), 601 Booth St., Ottawa, Ontario.

1 *Ozarkodina* n. sp. D, P_1 element, GSC 136586, Sample 21 (×122).

2 *Ozarkodina* n. sp. D, P_1 element, GSC 136587, Sample 21 (×122).

3 *Ozarkodina* n. sp. D, S_1 element, GSC 136588, Sample 21 (×122).

4 *Ozarkodina* n. sp. D, S_{3-4} element, GSC 136589, Sample 21 (×122).

5 *Ozarkodina* n. sp. D, S_{3-4} element, GSC 136590, Sample 21 (×122).

6 *Ozarkodina* n. sp. D, S_4 element, GSC 136591, Sample 21 (×122).

7 *Ozarkodina* n. sp. D, P_1 element, GSC 136593, Sample 21 (×122).

8 *Ozarkodina* n. sp. D, P_2 element, GSC 136592, Sample 21 (×122).

9 *Ozarkodina* n. sp. D, P_2 element, GSC 136594, Sample 21 (×122).

10 *Ozarkodina* n. sp. D, P_1 element, GSC 136595, Sample 22 (×122).

11 *Ozarkodina* n. sp. D, M element, GSC 136596, Sample 22 (×122).

12 *Ozarkodina raaschi* Klapper and Barrick 1983, P_1 element, GSC 136597, Sample 7 (×122).

13 *Ozarkodina raaschi* Klapper and Barrick 1983, M element, GSC 136598, Sample 7 (×122).

14 *Ozarkodina raaschi* Klapper and Barrick 1983, P_1 element, GSC 136599, Sample 5 (×122).

15 *Ozarkodina raaschi* Klapper and Barrick 1983, P_2 element, 136600, Sample 5 (×122).

16 *Ozarkodina brevis* (Bischoff and Ziegler 1957), P_1 element, GSC 136601, Sample 20 (×122).

17 *Ozarkodina brevis* (Bischoff and Ziegler 1957), P_1 element, GSC 136602, Sample 20 (×122).

18 *Ozarkodina brevis* (Bischoff and Ziegler 1957), M element, GSC 136603, Sample 6 (×122).

19 *Tortodus sardinia* (Mawson and Talent 1989), P_1 element, GSC 136604, Hare Indian Formation, Sample 3 (×51).

20 *Icriodus 'expansus'* Branson and Mehl of Chatterton (1978), P_1 element, upper view, GSC 136605, Sample 7 (×68).

21 *Icriodus* '*expansus*' Branson and Mehl of Chatterton (1978), P_1 element, upper view, GSC 136606, Sample 7 (×68).

22 *Icriodus* n. sp. of Narkiewicz, Bultynck and Narkiewicz (2013), P_1 element, lower view, GSC 136607, Sample 17 (×68).

23 *Icriodus* n. sp. of Narkiewicz, Bultynck and Narkiewicz (2013), P_1 element, upper view, GSC 136608, Sample 18 (×68).

24 *Tortodus ormistoni* (Chatterton 1978), P_1 element, GSC 136609, Hare Indian Formation, Sample 3 (×51).

25 *Icriodus* n. sp. A of Chatterton (1978), P_1 element, upper view, GSC 136610, Sample 22 (×68).

26 *Icriodus* n. sp. A of Chatterton (1978), P_1 element, upper view, GSC 136611, Sample 22 (×68).

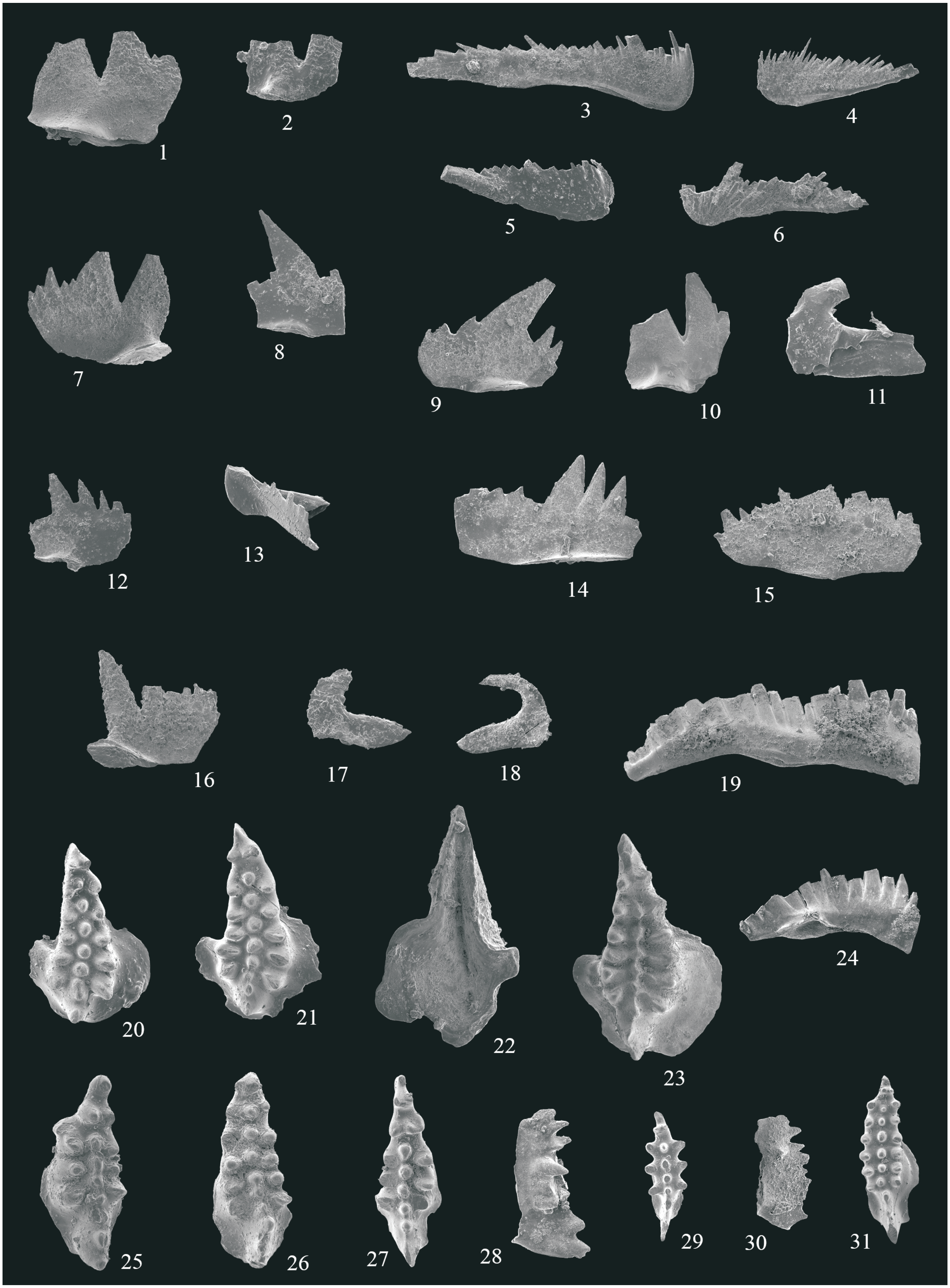
27 *Icriodus* sp. D, GSC 136612, P_1 element, upper view, Sample 22 (×68).

28 *Icriodus* sp. D, P_1 element, GSC 136613, Sample 23 (×68).

29 *Icriodus* sp. D, P_1 element, upper view, GSC 136614, Sample 23 (×68).

30 *Icriodus* sp. D, P_1 element, GSC 136615, Sample 23 (×68).

31 *Icriodus* sp. D, P_1 element, upper view, GSC 136616, Sample 23 (×68).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