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Early Silurian Conodonts from the Quinton Formation of the Broken River Region (North-Eastern Australia)

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4 Text-Figures and 2 Plates

Australia
Queensland
Silurian
Conodonts
Stratigraphy

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Untersilurische Conodonten aus der Quinton-Formation des Broken-River-Gebietes (nordöstliches Australien)

Zusammenfassung

Die früh-silurische Quinton-Formation der Umgebung des Broken Rivers in Nord-Queensland ist eine mächtige, weitgehend turbiditische Abfolge mit mehreren kleinen allochthonen Kalken. Diese Kalke enthalten eine frühsilurische Conodontenfauna der *celloni* Zone (spätes Llandovery) bis zur *amorphognathoides* Zone (spätes Llandovery bis frühes Wenlock). Nach Süden zu ist das laterale Equivalent der Quinton-Formation, früher als Poley-Cow-Formation bezeichnet, dünner und weniger turbiditisch. Es enthält eine isolierte, vermutlich allochthone Karbonatscholle bei Broken River Crossing, die ebenso früh-silurische Conodonten ähnlichen Alters geliefert hat. Diese allochthonen Einheiten reihen sich demnach zeitlich nebeneinander, ein Indiz für eine vermutliche Herkunft aus generell demselben Ursprungsgebiet. Das Fehlen jeglicher größerer chronologischer Diskrepanzen zwischen den Conodonten der allochthonen Kalke und den Graptoliten des späten Llandovery aus den eingeschlossenen Klastika weist auf etwa zeitgleiche Erosion und Wiederabsatz dieser Karbonate hin.

Abstract

The Early Silurian Quinton Formation in the Broken River region of north Queensland is a thick, largely turbiditic sequence with several small allochthonous carbonates. These limestones yield an Early Silurian conodont fauna of late Llandovery *celloni* Zone to late Llandovery/early Wenlock *amorphognathoides* Zone. To the south the lateral equivalent of the Quinton Formation (previously referred to as the Poley Cow Formation), is thinner and less turbiditic; it includes one isolated, presumably allochthonous, carbonate at the Broken River Crossing which has also yielded Early Silurian conodonts of similar age. These allochthonous units therefore align chronologically, indicating probable derivation from the same general source. The lack of any major chronological disparity between conodonts from the allochthonous limestones and late Llandovery graptolites of the enclosing clastics indicates the penecontemporaneous nature of erosion and redeposition of these carbonates.

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1. Introduction

The Graveyard Creek Group crops out in the Graveyard Creek Subprovince of the Broken River region of northern Queensland (Text-Fig. 1). The group consists of a combination of Middle Palaeozoic clastic and carbonate lithologies – basal Crooked Creek Conglomerate, the predominantly petitic Quinton and Poley Cow formations, and the carbonates and clastics of the uppermost Jack Formation – unconformably overlying the tectonised turbiditic Judea Formation, and underlying the shallow marine to possibly fluviatile Shield Creek Formation (WITHNALL et al., 1993). The tectonic and geological setting of the Broken River region has been outlined by WITHNALL & LANG (1988, 1990, 1993).

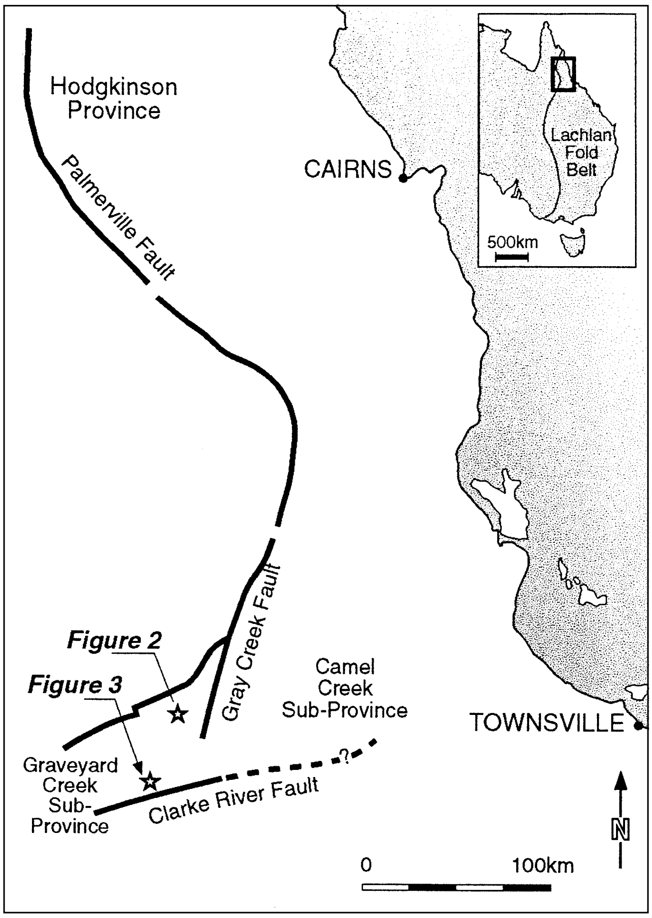
This report presents conodont data from rare and scattered carbonate units within the Early Silurian Quinton and Poley Cow Formations as presently defined. It builds on information previously presented in summary form (SLOAN et al., 1995) from two localities in the northern part of the Broken River region (Top Hut and Tomcat Creek localities) and includes data from an Early Silurian southern locality (Broken River Crossing). Silurian to basal Devonian conodont data from the overlying carbonates of the Jack Formation were discussed by SIMPSON (1983, 1994, 1995a, 1995b, and in press).

2. Geology

The Quinton Formation, as currently construed, is primarily a turbiditic unit cropping out around the south-west plunging Black Wattle Anticline. It is not less than 5000 m thick on the western limb where it consists of arenite with minor mudstone, shale and conglomerate (WITHNALL et al., 1993). Allochthonous limestone blocks up to 200 m long occur from 100 m to 500 m above the base of the formation on both sides of the anticline. Thin bedded limestones are known from some areas with internal architecture suggesting they are calcareous turbidites.

Outcrop on the eastern limb of the Black Wattle Anticline is considered to consist of more distal facies (see WITHNALL & LANG, 1992); arenites from this area are graded and show well developed Bouma sequences. The formation is thinner in this area and the upper half of the sequence near Turtle Creek consists of calcareous turbidites or debris flows that have been interpreted as derived from an inferred basement high just to the south of a laterite plateau (WITHNALL et al., 1993). Towards the base of the sequence, on the eastern side of the Black Wattle Anticline near Top Hut, minor limestones crop out and have been interpreted as possibly in situ (WITHNALL et al., 1993). To the south-east of this, a steeply dipping limestone approximately 60 m thick crops out in the Tomcat Creek region. This carbonate is associated with conglomerates and is enclosed by a shallow-dipping turbiditic sequence. The limestone has been interpreted as an allochthonous channel deposit (SLOAN et al., 1995). These two carbonate units, previously unnamed, are here informally designated the Top Hut and Tomcat Creek limestones.

A large limestone unit crops out to the west of the Black Wattle Anticline, in the headwaters of Turtle and Magpie creeks near the top of the Quinton Formation. This unit, variously referred to as the Turtle Creek Limestone (MUNSON, 1987), the Turtle Creek Member (JELL & TALENT, 1989) and the Magpie Creek Member (WITHNALL et al., 1993) is 5 km long and 300 m to 500 m thick. It consists of massive calcilutite, fine calcarenite and discontinuous mudstone. The limestone occurs within turbiditic sequences and is



Text-Fig. 1.
Location of Broken River region in north Queensland consisting of the Graveyard Creek Subprovince and the Camel Creek Subprovince and location of major structural units.
Location of Figures 2 and 3 within the Graveyard Creek Subprovince.

locally brecciated with angular clasts. MUNSON (1987) interpreted the unit as a large olistolith and documented its coral fauna. WITHNALL et al. (1993) interpreted the brecciated limestone as stylobreccias, noted the lack of an associated thick, chaotic debris flow, and suggested the unit may be in situ, but noted that, without further investigation, the issue remained essentially unresolved. Reconnaissance sampling for conodonts was undertaken by SIMPSON (1995a) and results were equivocal; a more intense sampling strategy is required. These early results are not included in this report.

Quartz-poor volcaniclastic rocks were recorded in an interval approximately 100 m thick from about 100 m above the base of the Quinton Formation and interpreted by ARNOLD & HENDERSON (1976) as pyroclastic turbidites. WITHNALL et al. (1993) considered them indicative of minor, short-lived contemporaneous volcanism restricted to the north-east area of the Graveyard Creek Subprovince. The Quinton Formation has been interpreted as a submarine fan system adjacent to an actively subsiding fault system along the margin of the Georgetown Block, the major source of the clastic material (WITHNALL et al., 1993).

The Poley Cow Formation, as defined by WITHNALL (1989), crops out south of the laterite plateau in an area where the Graveyard Creek Group extends in a folded belt of outcrop north and south of the Broken River. The formation consists of arenite and mudstone with large lenses of polymictic conglomerate. Thickness varies greatly. In the type section exposed in the Broken River just downstream from the Jack Hills Gorge, the formation is 680 m thick; to the north on the eastern limb of the Wade Anticline in the region of the inferred basement high, only 100 m of arenites are exposed beneath the carbonates of the overlying Jack Formation. WITHNALL et al. (1993) interpreted this as indicating that the sequence is greatly thinned or possibly absent if the arenites are interpreted as part of the Jack Formation. WITHNALL et al. (1993, p. 62) stated that this may indicate uplift and erosion of the Poley Cow Formation prior to deposition of the Jack Formation. The Poley Cow Formation is also greatly thinned around the hinge of the Broken River Anticline to the south. Here it is represented only by a basal conglomerate overlain by clastics equated with the Jack Formation. WITHNALL et al. (1993, p. 62) drew no inferences as to whether this also represents possible uplift and erosion or is simply indicative of lateral facies variation.

The Poley Cow Formation has been interpreted as flysch by ARNOLD & HENDERSON (1976). FIELDING (in WITHNALL et al., 1993), however, recognised seven lithofacies in the area about the type section and cited evidence indicative of a shallow water aspect to the sequence including occurrence of the trace fossil *Zoophycus* and the brachiopod *Lingula* (MUNSON, 1979), the existence of wave-formed structures and hummocky cross stratification, lack of well developed Bouma sequences, and the lensoid nature of arenite beds. Although some of this evidence, such as the occurrence of *Zoophycus* and *Lingula*, is not diagnostic of shallow water environments (CHERNS, 1979), FIELDING (in WITHNALL et al., 1993) interpreted the formation as indicative of storm and fair weather deposits on a shallow offshore marine shelf. Conglomerates in the Poley Cow Formation had previously been interpreted as submarine slope debris flows (ARNOLD & HENDERSON, 1976; SAVORY, 1987; WITHNALL et al., 1988). FIELDING (in WITHNALL et al., 1993) reinterpreted them as the subaqueous portion of fan deltas derived from a tectonically uplifted area of Judea Formation to the west.

3. Biostratigraphic Summary

Most of the age data for the Quinton Formation derives from a small number of highly scattered localities, giving a general late Llandovery to early Wenlock age. WHITE (1965) recorded a fauna of trilobites and brachiopods from Gray Creek, incorrectly interpreting it as from the Wairuna Formation and, therefore, in current stratigraphic terminology, below the major unconformity at the top of the Judea Formation. This locality is now known to be near the base of the Quinton Formation just above the unconformity. LANE & THOMAS (1978) described a small trilobite fauna also from Gray Creek (Top Hut limestone). This locality, 600 m above the base of the Quinton Formation was ascribed a similar age to that of WHITE's (1965) locality. They noted the occurrence of *celloni* Zone conodonts and reported the recovery of palynomorphs of a similar age. Brachiopods, corals and bivalves from the same locality (ARNOLD & HENDERSON, 1976) remain undescribed. A Llandovery graptolite fauna from Gray Creek consists predominantly of *Monograptus exiguus* (WITHNALL et al., 1993). Corals have been documented from the Top Hut and Tomcat Creek limestones (MUNSON, 1987) and a general late Llandovery to early Wenlock age is indicated.

The coral faunas of the Magpie Creek Member, high in the Quinton Formation, remain undescribed; it is considered a possible correlative of the Jack Formation of Ludlow to Pridoli age, primarily on the basis of the coral faunas (MUNSON, 1987) and stratigraphic criteria. As noted above, reconnaissance sampling of the Magpie Creek member for conodonts has yielded poorly, with equivocal results.

FIELDING (in WITHNALL et al., 1993, p. 62) stated that the Poley Cow Formation is equivalent in age to the Quinton Formation, whereas WITHNALL (in WITHNALL et al., 1993, p. 62) noted that graptolites in the Quinton Formation suggest a slightly younger age. Despite the fact that they are stratigraphic equivalents (SLOAN et al., 1995), there is no age control on the upper parts of the Quinton Formation, so the precise chronological relationship between the two is unknown.

Most of the age data from the Poley Cow Formation are derived from scattered graptolite localities from the pelitic lithologies of the formation. FIELDING (in WITHNALL et al., 1993, p. 63) noted that, in general, the graptolite occurrences are inconsistent with a shallow water environment. Their presence, however, is not diagnostic of deep water environments as their occurrence in shallow water may result from storm activity. WHITE & STEWART (1959) and THOMAS (1960) gave the first reports of Silurian graptolites from the vicinity of the Broken River Crossing and Jessey Springs. Several new localities have since been discovered and species were listed by JELL et al. (1988). One locality 30 m from the base of the Poley Cow Formation includes *Monograptus proteus*, *M. rickardsi*, *M.* cf. *halli*, *M.* ?*turriculatus*, *M.* cf. *marri*, *Pristiograptus regularis*, *Monoclimacis* ?*galaensis*, *Petalograptus* ?*kirki*, and *Glyptograptus* sp. Another locality 200 m above the base of the formation includes ?*Monograptus proteus*, *M. rickardsi*, *M. marri*, *Pristiograptus regularis*, ?*Monoclimacis galaensis* and *Petalograptus palmeus*. These and other Poley Cow localities indicate late Llandovery (Telychian) ages low in the interval spanning the *turriculatus* to *greistoniensis* zones. This is slightly older than the Quinton Formation graptolite locality with *Monograptus exiguus* reported by JELL et al. (1988).

A fauna of disarticulated trilobites, including a new encrinurid genus, was reported from the Poley Cow Formation in the vicinity of the Broken River Crossing by HOLLOWAY (1994). HOLLOWAY (1994, p. 224) considered the fauna had been transported, reworked and possibly sorted, but that it was not inconsistent with the interpretation (FIELDING in WITHNALL et al., 1993) of deposition on a shallow off-shore marine shelf.

Other fossils in the Poley Cow Formation have been noted by SAVORY (1987), in particular trace fossils which include ?*Scalaratuba missouriensis*, ?*Chondrites* sp., ?*Helminthopsis* sp. and ?*Zoophycus* sp. A small number of poorly preserved trilobites and brachiopods are also known from the formation (JELL et al., 1988).

4. Revision of Stratigraphic Nomenclature

The Quinton Formation and the Poley Cow Formation were defined by WITHNALL (1989). These two names are currently applied to much of the Silurian sequence in the Broken River to Gray Creek areas (WITHNALL & LANG, 1992). They are considered stratigraphic equivalents; the Quinton Formation exposed in an extensive area in the north of the region, and the thinner Poley Cow Formation interfolded between the basal Judea Formation and the overlying Jack Formation in the south of the region. The two areas are geographically separated by a laterite plateau. A basement high is inferred to have existed during the Silurian just to the south of the laterite plateau (WITHNALL et al., 1993). SLOAN et al. (1995) argued that the two stratigraphic units (Quinton and Poley Cow formations) represent the same Silurian sedimentary tract – thinner and less turbiditic in the south, thicker and more turbiditic in the north – and suggested that only one name be retained.

As the existence of a basement high between the two outcrop tracts has not been demonstrated, the suggestion of SLOAN et al. (1995) is supported here. The Quinton Formation is far more areally extensive than is the outcrop of the Poley Cow Formation. It is therefore proposed that the name Quinton Formation be retained and applied to both outcrop tracts and the use of the name Poley Cow Formation be discontinued. This amended definition of the Quinton Formation retains the type section as defined by WITHNALL (1989, p. 217) in Chinaman Creek.

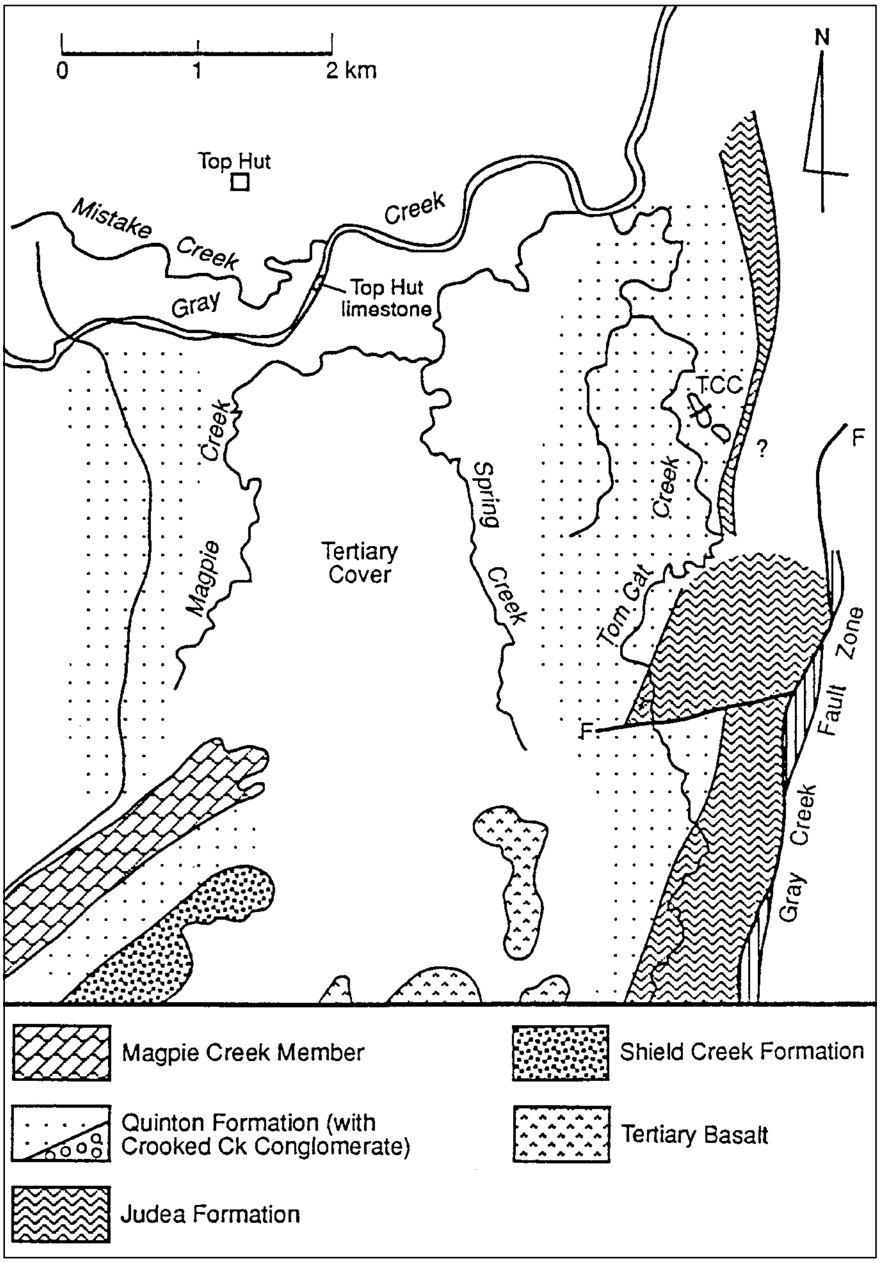
5. Age of Quinton Formation Carbonates

Age data in this report are derived from sampling two of the carbonates, the Top Hut limestone and Tomcat Creek limestone, in the northern area (Text-Fig. 2) and at Broken River Crossing, in the south (Text-Fig. 3). Age data derived from the two northern localities, in particular, indicate clast ages; this may also be the case with the southern locality. These data show no major chronological disparity with the enclosing pelitic sediments, indicating the transport of carbonates, soon after lithification, from an unpreserved source, for incorporation in the deeper water sediments.

Spot samples were taken from the Top Hut limestone and the Broken River Crossing; these represent further sampling of lithologies tested in an earlier study (SIMPSON, 1983). Samples were collected from a short section through the Tomcat Creek limestone (Text-Fig. 4). Although the faunas recovered in each case were poor, they are adequate for providing accurate chronological data.

5.1. Top Hut Limestone

A small conodont fauna was recovered from an isolated limestone in the Quinton Formation near Top Hut (Text-Fig. 2). Species include *Pseudolonchodina expansa*, *Distomodus staurognathoides*, *Aulacognathus bullatus* and *Panderodus* n. sp.

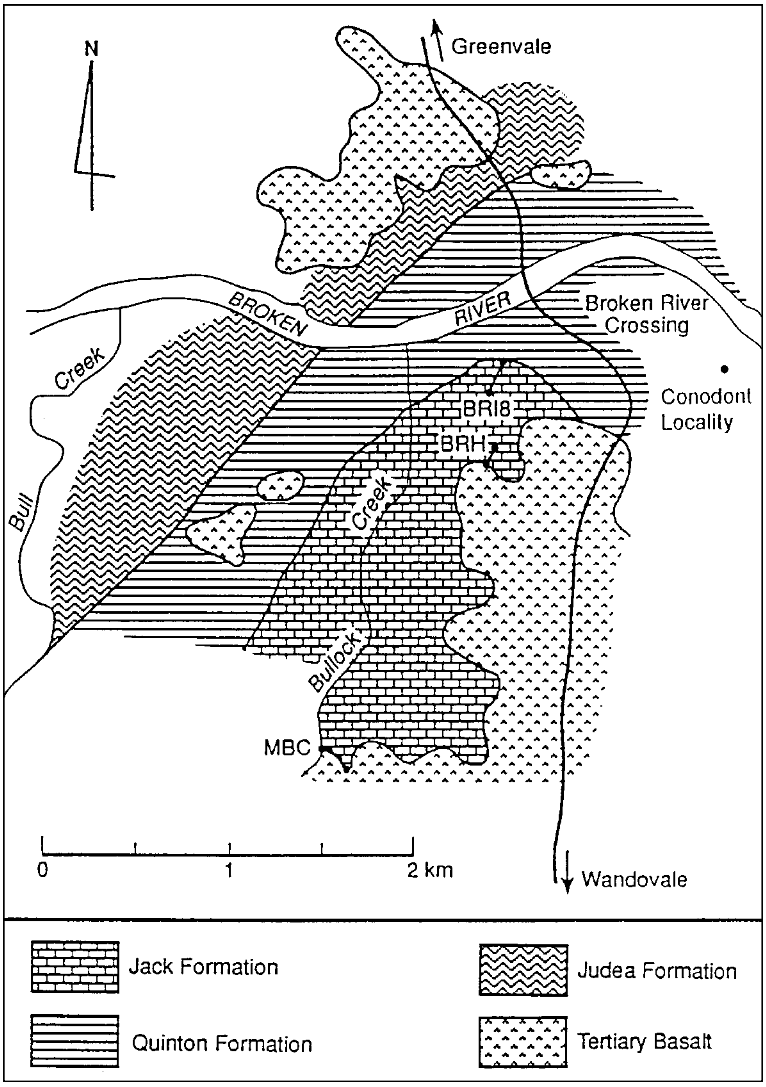


Text-Fig. 2.
Sketch map of Top Hut – Tomcat Creek area showing location of the Top Hut limestone in the bed of Gray Creek and the location of section TCC through the Tomcat Creek limestone.

Pseudolonchodina expansa is the nominate species of an outer shelf Llandovery Zone from Greenland (ARMSTRONG, 1990). The first occurrence in Greenland was noted as close to the Ordovician-Silurian boundary (ARMSTRONG, 1990, p. 30), and the species is most common in middle Llandovery strata. In all the Greenland sequences *P. expansa* occurs with taxa typical of a "pre-*celloni*" interval. *P. expansa* can be recognised in the collections from central New South Wales, where they have been referred to as *Oulodus planus planus* (BISCHOFF, 1986). These elements were documented from the *cyphus* to *griestonensis* graptolite zones; an extension of the upper range of this species into the *celloni* Zone is thus possible.

Distomodus staurognathoides is a cosmopolitan species which first appears in the Aeronian *gregarius* Graptolite Zone. It is the nominate species of the "pre-*celloni*" *D. staurognathoides* Zone (ALDRIDGE & SCHÖNLAUB, 1989); the species extends through into the early Wenlock and is recorded throughout the *amorphognathoides* Zone.

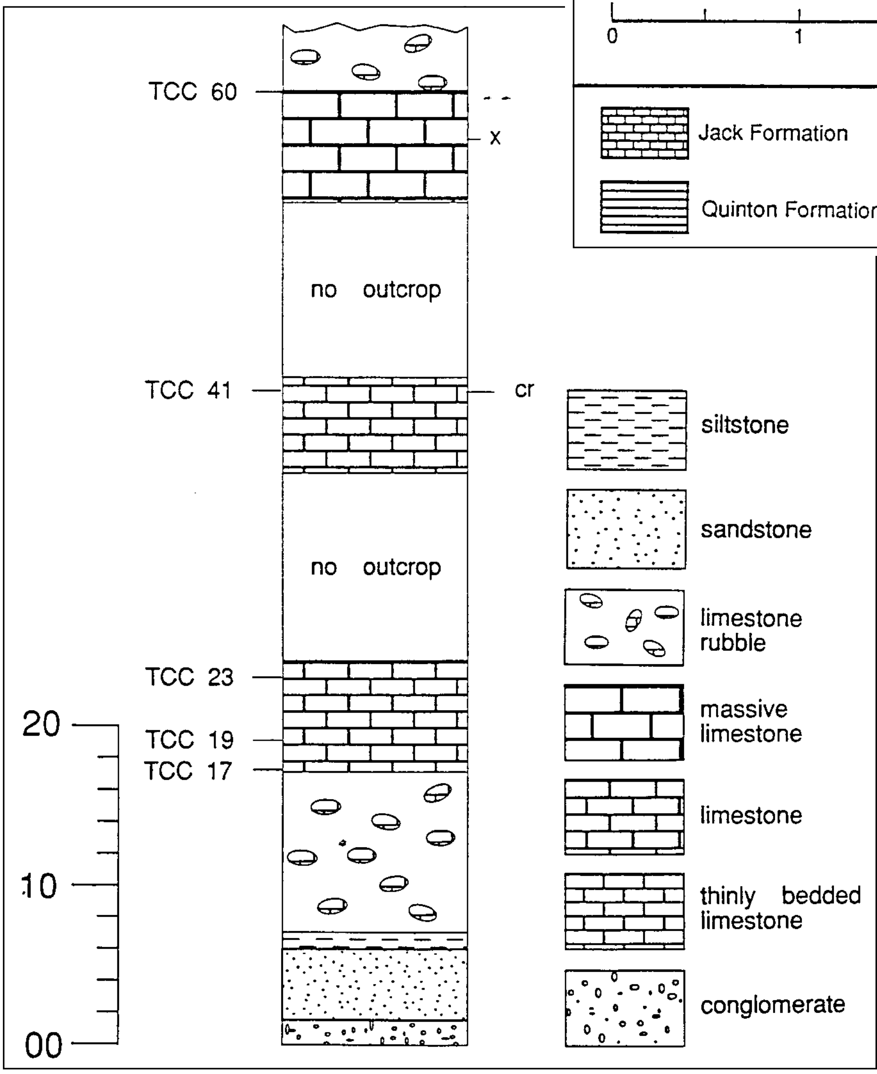
Aulacognathus bullatus was first recorded from the Lee Creek Member of the Brassfield Limestone in North America (NICOLL & REXROAD, 1968). KLAPPER (in ZIEGLER, 1977, p. 57) noted that this species is restricted to the late Llandovery *celloni* Zone. The species concept employed herein includes Pa elements with bifurcate



Text-Fig. 3.
Sketch map of the Broken River Crossing area showing the location of the Quinton Formation (Poley Cow Formation sensu WITHNALL et al., 1993) conodont locality.

and unbifurcate posterior processes. Whilst the latter is known from "pre-*celloni*" strata equated with the *turriculatus* Graptolite Zone (BISCHOFF, 1986; UYENO & BARNES, 1983), the former is not recorded prior to the *celloni* Zone.

From the available data, this limestone unit is considered late Llandovery (*celloni* Zone) in age, and can be equated with the *griestonensis* Graptolite Zone. JELL et al. (1993, p. 240) reported the existence of a late Llandovery graptolite fauna from Top Hut dominated by *Monograptus exiguus*, noting this suggested a slightly younger age than graptolite faunas from the southern exposures of the Quinton Formation. Correlation of these faunas (JELL et al., 1993, Text-Fig. 85) shows the Top Hut graptolite fauna as younger than some southern Quinton Formation graptolite faunas (e.g. Broken River Crossing) but older than others (e.g. south-east of Jessey Springs). The Top Hut graptolite fauna is shown as equivalent to the *celloni* Zone in age.



5.2. Tomcat Creek Limestone

The Tomcat Creek limestone is an isolated carbonate unit 60 m thick cropping out near Tomcat Creek, approximately 4 km south of Top Hut (Text-Fig. 2), in the middle of a series of pelitic lithologies of the Quinton Formation. The limestone strikes differently from the enclosing strata and is associated with a number of conglomerates. The highest conglomerate in the measured section is separated from the lowest limestones by an upward-fining lithic arenite. The unit is probably allochthonous. Limestones range from thin bedded, richly bioclastic carbonate to thick bedded to massive, finely recrystallised carbonate. Six samples were taken from a section through the unit (Text-Fig. 4), concentrating on thin bedded, bioclastic carbonates.

Text-Fig. 4.
Details of section TCC through the Tomcat Creek limestone.
x = unproductive conodont sample, cr = crinoids. Scale in metres.

A small conodont fauna was recovered including *Pseudolonchodina fluegeli*, *Distomodus staurognathoides*, *Walliserodus curvatus*, *Ozarkodina* cf. *O. hadra* and *Panderodus* n. sp. Most of these species are known from the *celloni* and *amorphognathoides* zones, but are known to extend into older strata. *Ozarkodina* cf. *O. hadra* is a species only reported from Greenland where it is restricted to the *celloni* Zone (ARMSTRONG, 1990, p. 92). It was recovered as a single specimen from the Tomcat Creek limestone from low in the section. The fauna from high in the section was very poor. A single specimen of *Walliserodus curvatus* was recovered from the highest sample. This species is known to range from the early Llandovery to the top of the *amorphognathoides* Zone. For these reasons the entire sequence is broadly equated with the *celloni* and *amorphognathoides* zones. Despite the poor nature of the fauna, it is possible to tentatively correlate basal samples with the *celloni* Zone. The subsequent *amorphognathoides* Zone may be present higher in the section; this would require testing by further sampling of the unit.

5.3. Broken River Crossing

A small conodont fauna was recovered from an isolated block of marlstone in the Quinton Formation downstream from the Broken River Crossing (Text-Fig. 3). The microfauna is dominated by molds of crinoid oscicles in iron-rich mud. Conodonts recovered include *Oulodus jeannae*, *Pseudolonchodina expansa* and *Distomodus staurognathoides.* An earlier study (SIMPSON, 1983) recovered fragments tentatively identified as ?*Astropentagnathus irregularis*.

Oulodus jeannae is known from the western Karawanken Alps; the range of the species is given as the *celloni* Zone (SWEET & SCHÖNLAUB, 1975). In mid-western New South Wales, BISCHOFF (1986) recorded this species from the Cobbler's Creek Limestone, the Glendalough Formation and the Liscombe Pools Limestone. These units span the late *sedgwickii* to *greistonensis* graptolite zones. This suggests an extension of the range of the species down into "pre-*celloni*" strata. Some earlier examples are also documented from the Bridge Creek Limestone. The ranges of *Pseudolonchodina expansa* and *Distomodus staurognathoides* are discussed above. These three species indicate a general late Aeronian to Telychian age.

The occurrence of *Astropentagnathus irregularis*, if correctly identified from fragments, allows a more precise age diagnosis. In England, *A. irregularis* occurs only in the lower part of the *celloni* Zone (ALDRIDGE, 1985). In Greenland, a single specimen was recovered with *Pterospathodus celloni* (ARMSTRONG, 1990). On Anticosti Island in Canada it was recorded from a single sample just below the range base of *Pterospathodus celloni* (UYENO & BARNES, 1983). In mid-western New South Wales, this species is known from the Burly Jack Limestone Member and the Liscombe Pools Limestone. The first appearance of this species defines the lower boundary of the *Astropentagnathus irregularis–Pterospathodus pennatus* Assemblage Zone of BISCHOFF (1986). Much of this zone is equated with the *celloni* Zone (SIMPSON, 1995b). *A. irregularis* first appears at the base of the Burly Jack Member, one sample lower than the first appearance of forms referable to *Pterospathodus celloni*. BISCHOFF (1986) interpreted the range of *A. irregularis* as aligning with the *crispus* and *griestonensis* graptolite zones.

A *celloni* Zone or slightly older age is inferred for this unit. This is in general accord with graptolite data from pelitic lithologies at the Broken River Crossing. JELL et al. (1993) summarised the graptolite faunas in this area, and considered them to indicate a span from low in the *turriculatus* Zone to the *griestonensis* Zone.

6. Systematic Palaeontology

The taxonomic classification of SWEET (1988) is employed unless indicated otherwise. Conodonts are housed in the micropalaeontological collections of the University of Queensland (UQY prefix). Photographs were taken on a Joel 6400 at the Centre for Microscopy and Microanalysis at the University of Queensland.

Class: Cavidonti SWEET 1988
Order: Belodellida SWEET 1988
Family: Belodellidae KHODALEVICH & TCHERNICH 1973

Remarks: For discussion of this family and the interpretations of BERGSTRÖM & KLAPPER (in CLARK et al., 1981), SWEET (1988) and FORDHAM (1991), see SIMPSON & TALENT (1995, p. 123–124).

Genus: *Walliserodus* SERPAGLI 1967

Type species: *Acodus curvatus* BRANSON & BRANSON, 1947.

Walliserodus curvatus **(BRANSON & BRANSON, 1947)**
(Pl. 1, Fig. 1)

For synonymy see SIMPSON & TALENT (1995, p. 127–128) and add the following:

1994 *Walliserodus curvatus* (BRANSON & BRANSON) – WATKINS et al., p. 18–19, Pl. 8, Fig. 4, Pl. 9, Fig. 5.

Remarks: A single, partially preserved, broad-based cone was recovered. The element has a single costa on the inner lateral face running parallel to the anterior margin. This feature is typical of the Sc element of *Walliserodus curvatus* and is not seen in *W. sancticlairi*. A more detailed discussion of this species was given by SIMPSON & TALENT (1995).

Material: 1 Sc element.

Occurrence: Quinton Formation, Tomcat Creek limestone.

Class: Conodonti BRANSON 1938
Order: Panderodontida SWEET 1988
Family: Panderodontidae LINDSTRÖM 1970
Genus: *Panderodus* ETHINGTON 1959

Type species: *Paltodus unicostatus* BRANSON & MEHL

Remarks: SANSOM et al. (1994) reconstructed this genus as nonimembrate from a bedding plane assemblage. They also produced a new locational scheme and expanded the descriptive terminology of *Panderodus* elements. Their recognition of a greater range of element morphologies than previously identified within a single apparatus will lead to a substantial taxonomic reinterpretation of previously illustrated and described discrete collections of *Panderodus* elements.

In this study, only a small number of *Panderodus* elements were recovered. Most of these have not been identified beyond genus level. A small number of distinctive cones are grouped together and considered to represent a partial suite of a new species of *Panderodus*. This interpretation is based on general morphology, consistent micro-ornament and stratigraphic criteria. Because of the incomplete reconstruction, descriptive terminology is used and the new species is recorded in open nomenclature. Where possible the descriptive terminology (SANSOM et al., 1994) is tentatively related to earlier attempts to apply SWEET & SCHÖNLAUB's (1975) locational scheme to the genus (such as SMITH et al., 1987), a morphologically based methodology of some utility when working with small discrete coniform collections.

Panderodus n. sp.
(Pl. 1, Figs. 2–6)

Description: Falciform (M) element. Broad-based strongly recurved cone with rapidly tapering cusp. Cone furrowed on one side and bowed slightly towards furrowed face. Unfurrowed face gently convex; furrowed face has a prominent rounded costa along medial region posterior of and close to furrow. Large keel developed along entire anterior margin, most prominent in region of greatest recurvature. Posterior margin sharp with a small keel developed in basal region (Pl. 1, Fig. 2). Fine wrinkle zone around entire basal region of cone extending to basal margin. Furrow smoothly curved, located in posterior half of cone with profuse ornament of very fine striations close to furrow.

Graciliform (Sa) element. Not recovered in this study.

Graciliform (?Sb) element. Gently recurved cone with a subrounded to subtriangular cross section, narrow base and sharply rounded unkeeled anterior and posterior margins. Prominent furrow located in posterior half of cone which is gently bowed towards furrowed face. Unfurrowed face slightly convex, furrowed face strongly convex. Area adjacent to furrow covered with numerous fine striations which emanate from within furrow in basal region and run subparallel with furrow. Striations merge with fine wrinkle zone which extends to basal margin around basal circumference of cone. The specimen (Pl. 1, Fig. 3) has a basal body preserved.

Arcuatiform (Sc) element. Broad-based, recurved cone bowed slightly towards furrowed face with small tapering cusp. Prominent furrow located close to posterior margin with a prominent basal notch (Pl. 1, Fig. 6). Unfurrowed face flat to gently convex, furrowed face strongly convex with large gently rounded costa anterior of furrow. Large sharp anterior keel most prominent in basal half of cone and extending upwards onto cusp. Posterior margin sharply rounded. Numerous fine striations emanating from furrow and running subparallel to furrow. High on cone, on both sides of furrow, the entire region between the posterior margin and the anterolateral costa is finely striated (Pl. 1, Fig. 5). Unfurrowed face strongly striated high on cone (Pl. 1, Fig. 4). Anterior keel strongly striated only on furrowed face (Pl. 1, Fig. 5) with striae emanating from anterior margin and merging anterior to the anterolateral costa.

Remarks: This species is readily separated from others by the abundant striate ornament, particularly on the arcuatiform element. No other species of *Panderodus* has a striate ornament on the unfurrowed face of the cone. The general shape of elements, in particular the falciform element, is close to *Panderodus gibber*, but the species is distinct by virtue of the prominent anterior keel on some elements and the micro-ornament. The identification of the graciliform (Sb) element is considered tentative as it is based on a single incomplete specimen.

Material: 3 falciform elements, 1 graciliform (?Sb) element, 5 arcuatiform elements.

Occurrence: Quinton Formation, Top Hut limestone and Tomcat Creek limestone. The falciform elements of this taxon were recovered only from the overlying Jack Formation, one example (Pl. 1, Fig. 2) is included for illustrative purposes. Other arcuatiform elements were also recovered from the overlying Jack Formation, lower limestone unit, Jack Hills Gorge. The later are not documented in this paper.

Panderodus sp.
(Pl. 1, Figs. 7–12)

Remarks: A variety of *Panderodus* elements were recovered; many of these are incomplete or poorly preserved. Some are illustrated here to indicate the variety of element morphology.

Material: 12 undifferentiated elements.

Occurrence: Quinton Formation, Top Hut Limestone and Tomcat Creek Limestone.

Order: Prioniodinida SWEET 1988
Family: Prioniodinidae BASSLER 1925
Genus: *Oulodus* BRANSON & MEHL 1933

1933 *Oulodus* BRANSON & MEHL, p. 116.
1935a *Gyrognathus* STAUFFER, p. 114.
1935b *Barbarodina* STAUFFER, p. 602–603.
1969 *Ligonodina* BASSLER – JEPPSSON, p. 20–21.
1971 *Delotaxis* KLAPPER & PHILIP, p. 446.
1975 *Oulodus* BRANSON & MEHL – SWEET & SCHÖNLAUB, p. 45–46.

Type species: *Cordylodus serratus* STAUFFER 1930.

Remarks: MAWSON (1986, p. 45–46) summarised the arguments for the above synonymy. *Delotaxis* was originally reconstructed as a quinquimembrate apparatus (KLAPPER & PHILIP, 1971). Synonymy of *Delotaxis* and *Oulodus* was argued for and against by various authors (KLAPPER & PHILIP, 1971; SWEET & SCHÖNLAUB, 1975; BARRICK & KLAPPER, 1976; PICKETT, 1980). It has since been shown that species separated as *Delotaxis* have seximembrate apparatuses as with *Oulodus* (SWEET & SCHÖNLAUB, 1975).

MAWSON (1986) discussed differences between Sb elements of Late Silurian and Ordovician forms, previously cited as grounds for generic separation, and concluded the term digyrate could be applied to both. She observed that the primary difference between the older and the younger forms was the size of the basal cavity, which is best interpreted as a general evolutionary trend and provides insufficient grounds for generic separation. MAWSON (1986) indicated that variation in the Pa elements between older and younger species should be interpreted in the same way.

As currently construed, the genus ranges from the Middle Ordovician to the Early Devonian (KLAPPER & BERGSTRÖM in CLARK et al., 1981). JEPPSSON (1969) used the generic name *Ligonodina* BASSLER for the reconstruction of the Late Silurian to Early Devonian "*Ligonodina elegans*". *Ligonodina*, as originally defined (BASSLER, 1925), referred to the Sc element of an unreconstructed Late Devonian species. As noted by MAWSON (1986), if it can be conclusively demonstrated that this element is part of an *Oulodus* assemblage, then *Oulodus* would become a junior subjective synonym of *Ligonodina*. Until this is achieved the taxonomy of KLAPPER & BERGSTRÖM (in CLARK et al., 1981) is followed.

Oulodus jeannae SCHÖNLAUB, 1975

(Pl. 1, Figs. 13–14)

1975 *Oulodus jeannae* SCHÖNLAUB in SWEET & SCHÖNLAUB, p. 49–51, Pl. 1, Figs. 13–24.
?1980 ?*Oulodus jeannae* SCHÖNLAUB – MAYR et al., Pl. 32.1, Fig. 14.
1986 *Oulodus australis* BISCHOFF, p. 72–75, Pl. 16, Figs. 31–36; Pl. 17, Figs. 1–27.

Remarks: The Sc elements recovered have large processes that are oval in cross section. Denticles on the gently bowed posterior process are large and robust with circular cross sections; they are separated by broad "U"-shaped spaces. The smaller antero-lateral process diverges from beneath the anterior region of the cusp and is directed downwards and twisted slightly in an anterior direction. This process is incomplete but bears a number of smaller, anteriorly oriented denticles. The angle formed between the two processes is 90 degrees. The cusp is large and oriented in a different plane from the denticles on both processes (Pl. 1, Fig. 13). The different orientation of the cusp is not as pronounced in the other Sc element (Pl. 1, Fig. 14); this feature is thus interpreted as variable. The basal cavity is shallow and extends beneath the preserved portions of both processes. A furrow runs along the basal portion of both processes in one example (Pl. 1, Fig. 14) possibly representing a region of inverted basal cavity.

SWEET & SCHÖNLAUB (1975, p. 50) noted that the Sc element differs from all other Silurian examples of *Oulodus* in the configuration of the processes. The illustrations (SWEET & SCHÖNLAUB, 1975, Pl. 1, Figs. 17 and 23) show minor differences in the angle between the processes, best interpreted as intraspecific variation. BISCHOFF (1986, p. 74) indicated that the Sc elements of *Oulodus australis* are morphologically similar to those of *O. jeannae*. There is also minor variation in the configuration of the antero-lateral processes of Sc elements illustrated (compare BISCHOFF, 1986, Pl. 17, Fig. 19 with Fig. 22) from Australian localities. BISCHOFF (1986, p. 74) did not consider all the illustrated elements of SWEET & SCHÖNLAUB's (1975) reconstruction of *O. jeannae* as equivalents of his taxon, *O. australis*. BISCHOFF (1986) compared the Llandovery examples of SWEET & SCHÖNLAUB (1975, Pl. 1, Figs. 14 = Sb element, 16 = Sa element and 17 = Sc element) with his younger Australian taxa that either span the Llandovery-Wenlock boundary or are Wenlock in age, namely *O. rectangulus angustatus* and *O. sinuosus*. *O. jeannae* was based on 220 Llandovery elements (SWEET & SCHÖNLAUB, 1975), of which only 12 were illustrated. An alternative interpretation to that of BISCHOFF (1986) is that the forms illustrated by SWEET & SCHÖNLAUB (1975) show some intraspecific variation.

BISCHOFF (1986, p. 74) also noted that Pa and Sa elements of *Oulodus jeannae* are similar to those of *O. australis*. Pb elements of *O. jeannae* (SWEET & SCHÖNLAUB, 1975, Pl. 1, Figs. 14, 20) are equivalent to those identified as Pa elements of *O. australis* (BISCHOFF, 1986, Pl. 16, Fig. 31 = holotype). Similarly the Pa element of *O. jeannae* (SWEET & SCHÖNLAUB, 1975, Pl. 1, Figs. 13 = an incomplete specimen, 19) shows no significant differences to those identified as Pb elements of *O. australis* (BISCHOFF, 1986, Pl. 17, Fig. 13). BISCHOFF (1986, p. 74) considered the two forms had different Pb, M and Sb elements, but did not document the differences. A comparison of the M elements, e.g. SWEET & SCHÖNLAUB (1975, Pl. 1, Fig. 18) and BISCHOFF (1986, Pl. 17, Fig. 17), and Sb elements, e.g. SWEET & SCHÖNLAUB (1975, Pl. 1, Fig. 21) and BISCHOFF (1986, Pl. 16, Fig. 35), also show no appreciable difference, apart from a slightly different orientation of the illustration of the Sb element. The two forms have a comparable stratigraphic range in the late, but not latest Llandovery. As all six elements of both apparatuses are broadly similar, with only minor variation interpreted as intraspecific, the two are placed in synonymy.

Only two Sc elements were recovered in this study. SWEET & SCHÖNLAUB (1975) indicated these were the most abundant in their collections, possibly because of their robust nature. BISCHOFF (1986, p. 73) suggested the Sc element was vicarious with the older taxon *Oulodus angullongensis*. Unlike *O. jeannae*, however, some of the illustrated examples (BISCHOFF, 1986, Pl. 16, Figs. 8, 11–12) have denticles on the posterior process that are as large as, or larger than, the cusp.

FORDHAM (1991, p. 71–72) incorporated the elements of *O. jeannae* within a taxonomically broader concept of *Ligonodina petila*. Some of the elements grouped therein belong to the genus *Pseudolonchodina*, whereas other *Oulodus* species, such as *Oulodus petila* and *O. kentuckyensis* were also included. All elements of *O. petila* have a more slender denticulation than *O. jeannae*. In both *O. petila* and *O. kentuckyensis*, the antero-lateral process of the Sc element diverges from a point anterior to the cusp, whereas in *O. jeannae* the process diverges from the anterior half of the cusp. These are considered separate species here.

Material: 2 Sc elements.

Occurrence: Quinton Formation, Broken River Crossing.

Genus: *Pseudolonchodina* ZHOU, ZHAI & XIAN 1981

Type species: *Pseudolonchodina irregularis* ZHOU, ZHAI & XIAN.

Remarks: For synonymy and discussion of this genus see SIMPSON & TALENT (1995, p. 109–111).

Pseudolonchodina expansa (ARMSTRONG, 1990)

(Pl. 1, Figs. 15–16)

Remarks: For synonymy and discussion of this species see SIMPSON & TALENT (1995, p. 111–112).

The Pb element is digyrate with two denticulate processes and a cusp only slightly larger than the denticles on both processes and with a flattened lenticular cross section. As with other elements of the apparatus, denticles are discrete and the basal cavity is broadly expanded. The angle between the two processes is approximately 90 degrees.

The M element of this species has a broad basal cavity extending along the entire preserved portion of the posterior process (Pl. 1, Fig. 16). It lacks an anterior process, unlike the example from McCarty's limestone in south-eastern Australia (SIMPSON & TALENT, 1995, Pl. 1, Fig. 3) and is therefore equivalent to the e-1 element of MCCRACKEN (1991a), who noted this form to be the more common of the two e elements. The cusp is large, laterally compressed and broad. All denticles are discrete with a large gap between the cusp and the most proximal denticle. The basal margin below the cusp is gently curved downwards on both sides of the element.

Apart from the Pb and M elements, fragments of other elements were recovered from the same samples.

Material: 2 Pb elements, 1 M element.

Occurrence: Quinton Formation, Broken River Crossing and Top Hut limestone.

Pseudolonchodina fluegeli (WALLISER, 1964)

(Pl. 2, Figs. 1–2)

For synonymy and discussion of this species see SIMPSON & TALENT (1995, p. 112–113) and add the following:

1996 *Aspelundia fluegeli* (WALLISER) – GIRARD & WEYANT, p. 56–57, Pl. 2, Figs. 6–8.
1996 *Pseudolonchodina fluegeli* (WALLISER) – WANG & ALDRIDGE, Pl. 3, Fig. 6.

Remarks: The alate Sa element (Pl. 2, Fig. 1) has a long compressed cusp and a narrow basal cavity. There is a large angle between the two processes unlike the examples from Greenland illustrated by ARMSTRONG (1990, Pl. 3, Fig. 4) where they form an angle of 90 degrees. The narrow basal cavity is closely comparable with other Australian examples (e.g. BISCHOFF, 1986, Pl. 20, Fig. 7) and examples elsewhere (e.g. UYENO, 1990, Pl. 2, Fig. 30).

The bipennate Sc element (Pl. 2, Fig. 2) is only partially preserved. The anterolateral process is not as sharply bowed as in other examples (e.g. ARMSTRONG, 1990, Pl. 3, Fig. 12; BISCHOFF, 1986, Pl. 20, Fig. 39), but this feature is variable and the example from this study is very small. The basal cavity is narrow and extends along the preserved portion of both processes. The cusp is broad, laterally compressed and large; proximal denticles on both processes are small. The narrow basal cavity is typical of all elements of this species.

Apart from the Sa and Sc elements, other fragments were recovered.

Material: 1 Sa element, 1 Sc element.

Occurrence: Quinton Formation, Tomcat Creek limestone.

Order: Prioniodontida DZIK 1976
Family: Distomodontidae KLAPPER 1981
Genus: *Distomodus* BRANSON & BRANSON 1947

Type species: *Distomodus kentuckyensis* BRANSON & BRANSON.

Remarks: For synonymy and discussion of this genus see SIMPSON & TALENT (1995, p. 165–166).

Distomodus staurognathoides (WALLISER, 1964)

(Pl. 2, Figs. 3–9)

1964 *Hadrognathus staurognathoides* – WALLISER, p. 35, Pl. 5, Fig. 2, Pl. 13, Figs. 6–15.
1964 *Ligonodina egregia* n. sp. – WALLISER, p. 40–41, Pl. 6, Fig. 5, Pl. 32, Figs. 3–4.
1964 *Roundya caudata* n. sp. – WALLISER, p. 70, Pl. 5, Fig. 9.
1964 *Roundya detorta* n. sp. – WALLISER, p. 70, Pl. 5, Fig. 8.
1965 *Hadrognathus staurognathoides* WALLISER – BROOKS & DRUCE, p. 376, Pl. 12, Figs. 5–6.
1968 *Distomodus? egregia* (WALLISER) – NICOLL & REXROAD, p. 33–34, Pl. 5, Figs. 26–27.
1968 *Roundya detorta* BRANSON & BRANSON – NICOLL & REXROAD, p. 58, Pl. 6, Figs. 16–18.
1968 *Trichonodella? expansa* n. sp. – NICOLL & REXROAD, p. 64, Pl. 4, Figs. 19–22.
1968 *Hadrognathus staurognathoides* WALLISER – NICOLL & REXROAD, p. 36–37, Pl. 3, Figs. 12–14.
1968 *Distomodus kentuckyensis* BRANSON & BRANSON – NICOLL & REXROAD, p. 34–35, Pl. 5, Figs. 24–25.
1968 *Distomodus? extrorsus* (REXROAD) – NICOLL & REXROAD, p. 34, Pl. 5, Fig. 23.
1970 *Hadrognathus staurognathoides* WALLISER – MOSKALENKO, Pl. 1, Fig. 8.
1971 *Ambalodus carnicus* n. sp. – SCHÖNLAUB, p. 45–46, Pl. 2, Figs. 18–20.
1971 *Distomodus kentuckyensis* BRANSON & BRANSON – SCHÖNLAUB, p. 47, Pl. 3, Fig. 9.
1971 *Hadrognathus staurognathoides* WALLISER – SCHÖNLAUB, p. 44, Pl. 1, Figs. 17–18.
1971 *Hibbardella brevialata* (WALLISER) – SCHÖNLAUB, p. 47–48, Pl. 3, Figs. 10–11.
1971 *Hibbardella caudata* (WALLISER) – SCHÖNLAUB, p. 48, Pl. 3, Figs. 12–13.
1972 *Distomodus? egregius* (WALLISER) – ALDRIDGE, p. 172, Pl. 6, Figs. 4, 9 (only).
1972 *Distomodus kentuckyensis* BRANSON & BRANSON – ALDRIDGE, p. 173, Pl. 6, Figs. 7, 11 (only).
1972 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – ALDRIDGE, p. 176–177, Pl. 7, Fig. 4.
1972 *Exochognathus caudatus* (WALLISER) – ALDRIDGE, p. 177–178, Pl. 7, Fig. 13.
1972 *Exochognathus detortus* (WALLISER) – ALDRIDGE, p. 178, Pl. 7, Figs. 7, 12.
1972 *Hadrognathus staurognathoides* WALLISER – ALDRIDGE, p. 180–181, Pl. 2, Figs. 8, 10–11.
1972 *Trichonodella? expansa* NICOLL & REXROAD – ALDRIDGE, p. 218–219, Pl. 7, Fig. 14.
1972 *Distomodus egregia* (WALLISER) – REXROAD & NICOLL, Pl. 2, Figs. 47–48.
1972 *Distomodus extrorsus* REXROAD – REXROAD & NICOLL, Pl. 2, Figs. 49–50.
1972 *Distomodus kentuckyensis* BRANSON & BRANSON – REXROAD & NICOLL, Pl. 2, Fig. 46.
1972 *Exochognathus caudatus* (WALLISER) – REXROAD & NICOLL, Pl. 1, Fig. 14.
1972 *Exochognathus expansus* (NICOLL & REXROAD) – REXROAD & NICOLL, p. 67, Pl. 2, Figs. 24–25.
1972 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – REXROAD & NICOLL, Pl. 2, Fig. 23.
1975 *Hadrognathus staurognathoides* WALLISER – KLAPPER & MURPHY, p. 27, Pl. 2, Figs. 21–25.
1975 *Hadrognathus staurognathoides* WALLISER – SCHÖNLAUB, p. 53–56, Pl. 1, Figs. 1–4, 17, 20, 23–25, Pl. 2, Figs. 1–10, 12–21.
1976 *Distomodus staurognathoides* (WALLISER) – BARRICK & KLAPPER, p. 71–72, Pl. 1, Figs. 20–28.
1977 *Exochognathus expansus* (NICOLL & REXROAD) – LIEBE & REXROAD, Pl. 1, Fig. 28.
1977 *Distomodus kentuckyensis* BRANSON & BRANSON – LIEBE & REXROAD, Pl. 1, Fig. 30.
1977 *Exochognathus caudatus* (WALLISER) – LIEBE & REXROAD, Pl. 1, Fig. 32–33.
1977 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – LIEBE & REXROAD, Pl. 1, Fig. 34.
1977 *Exochognathus detortus* (WALLISER) – LIEBE & REXROAD, Pl. 1, Fig. 39.
1977 *Distomodus egregia* (WALLISER) – LIEBE & REXROAD, Pl. 1, Figs. 37–38.
1977 *Distomodus extrorsus* REXROAD – LIEBE & REXROAD, Pl. 1, Fig. 31.
1977 *Hadrognathus staurognathoides* WALLISER – LIEBE & REXROAD, Pl. 1, Fig. 36.
1977 *Hadrognathus staurognathoides* WALLISER – COOPER, p. 1066–1067, Pl. 1, Figs. 1, 5–7, 12.
1977 *Johnognathus huddlei* n. sp. – MASHKOVA, p. 129–131, Figs. 2a-g.
1978 *Hadrognathus staurognathoides* WALLISER – MILLER, Pl. 4, Fig. 26.
1979 *Distomodus staurognathoides* (WALLISER) – ALDRIDGE, Pl. 1, Figs. 16–17.

1979 *Hadrognathus staurognathoides* WALLISER – BUCHROITHNER, Pl. 1, Fig. 4.
1981 *Distomodus staurognathoides* (WALLISER) – UYENO & BARNES, Pl. 1, Fig. 3.
1981 *Distomodus staurognathoides* (WALLISER) – NOWLAN, Pl. 5, Figs. 21, 27, Pl. 6, Fig. 21.
1981 "*Johnognathus*" *huddlei* MASHKOVA – UYENO & BARNES, Pl. 1, Fig. 25.
1982 *Distomodus staurognathoides* (WALLISER) – ALDRIDGE & MOHAMED, Pl. 2, Figs. 1–6.
1982 *Johnognathus huddlei* MASHKOVA – ALDRIDGE & MOHAMED, Pl. 2, Fig. 25.
1983 *Distomodus staurognathoides* (WALLISER) – MABILLARD & ALDRIDGE, Pl. 1, Figs. 15–20.
1983 *Distomodus staurognathoides* (WALLISER) – NOWLAN, Figs. 3, F-H.
1983 *Distomodus staurognathoides* (WALLISER) – UYENO & BARNES, p. 17, Pl. 3, Figs. 1–15.
1983 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – ZHOU & ZHAI, p. 275, Pl. 65, Fig. 27.
1983 *Exochognathus caudatus* (WALLISER) – ZHOU & ZHAI, p. 275, Pl. 65, Fig. 29.
1983 *Hadrognathus staurognathoides* WALLISER – ZHOU & ZHAI, p. 277, Pl. 66, Fig. 4.
1983 *Johnognathus huddlei* MASHKOVA – MABILLARD & ALDRIDGE, Pl. 2, Figs. 11–12.
1983 *Microcoelodus egregius* (WALLISER) – ZHOU & ZHAI, p. 281, Pl. 66, Figs. 2–3.
1983 *Microcoelodus extrorsus* (REXROAD) – ZHOU & ZHAI, p. 281, Pl. 66, Figs. 2–3.
1984 *Distomodus egregius* (WALLISER) – DRYGANT, p. 80–81, Pl. 2, Figs. 34–35.
1984 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – DRYGANT, p. 81, Pl. 2, Figs. 36–38.
1984 *Exochognathus caudatus* (WALLISER) – DRYGANT, p. 82, Pl. 3, Fig. 7.
1984 *Exochognathus detortus* (WALLISER) – DRYGANT, p. 81–82, Pl. 3, Figs. 3–6.
1984 *Hadrognathus staurognathoides dentatus* ssp. n. – DRYGANT, p. 131–132, Pl. 15, Figs. 13–14.
1984 *Hadrognathus staurognathoides staurognathoides* WALLISER – DRYGANT, p. 131–132, Pl. 15, Figs. 13–14.
1984 *Johnognathus huddlei* MASHKOVA – DRYGANT, p. 133, Pl. 15, Figs. 19–20.
1985 *Distomodus staurognathoides* (WALLISER) – ALDRIDGE, Pl. 3.1, Figs. 12–17.
1985 *Distomodus staurognathoides* (WALLISER) – KLEFFNER, Pl. 2, Figs. 40–44.
1985 *Distomodus staurognathoides* (WALLISER) – MABILLARD & ALDRIDGE, Text-Fig. 7d.
1985 *Distomodus staurognathoides* (WALLISER) – SAVAGE, p. 718, Figs. 9, A-L.
1985 ?*Distomodus* sp. – NEHRING-LEFELD, Pl. 6, Fig. 13.
1985 *Distomodus*? sp. – NORFORD & ORCHARD, p. 11, Pl. 1, Fig. 4, Pl. 2, Fig. 7.
1985 *Exochognathus* cf. *brassfieldensis* (BRANSON & BRANSON) – YU, Pl. 1, Fig. 16.
1985 *Hadrognathus staurognathoides* WALLISER – NEHRING-LEFELD, Pl. 3, Figs. 9–10.
1985 *Hadrognathus staurognathoides* WALLISER – YU, Pl. 1, Fig. 17.
1985 *Johnognathus huddlei* MASHKOVA – ALDRIDGE, p. 86, Pl. 3.3, Fig. 12.
1985 *Johnognathus huddlei* MASHKOVA – SAVAGE, p. 716, Figs. 6A-K.
1985 *Ligonodina egregia* WALLISER – NEHRING-LEFELD, Pl. 3, Fig. 11.
1986 *Distomodus staurognathoides* (WALLISER) – BISCHOFF, p. 106–118, Pl. 10, Figs. 13–36, Pl. 11, Figs. 1–33, Pl. 12, Figs. 1–28.
1986 *Distomodus staurognathoides* (WALLISER) – CRAIG, Pl. 2, Fig. 8.
1986 *Distomodus staurognathoides* (WALLISER) – NAKREM, Fig. 8b.
1986 *Exochognathus brassfieldensis* (BRANSON & BRANSON) – JIANG et al., Pl. IV-1, Fig. 19.
1986 *Hadrognathus staurognathoides* WALLISER – JIANG et al., Pl. IV-1, Fig. 24.
1986 *Johnognathus huddlei* MASHKOVA – BISCHOFF, p. 227–230, Pl. 12, Figs. 29–40, Pl. 13, Figs. 1–7.
1986 *Johnognathus huddlei* MASHKOVA – NAKREM, Fig. 6k.
1986 *Roundya caudatus* WALLISER – JIANG et al., Pl. IV-4, Fig. 4.
1987 *Distomodus staurognathoides* (WALLISER) – KLEFFNER, Fig. 5.23–28.
1987 *Distomodus staurognathoides* (WALLISER) – OVER & CHATTERTON, Pl. 2, Figs. 10–25.
?1987 ?*Hadrognathus* sp. – AN, Pl. 34, Fig. 16.
1987 *Johnognathus huddlei* MASHKOVA – KLEFFNER, Fig. 5.13.
1990 *Dentacodina multidentata* WANG – AN & ZHENG, Pl. 15, Figs. 15–16.
1990 *Dentacodina trilinearis* WANG – AN & ZHENG, Pl. 15, Fig. 17.
1990 *Distomodus kentuckyensis* BRANSON & BRANSON – AN & ZHENG, Pl. 15, Fig. 11.
1990 *Distomodus staurognathoides* (WALLISER) – ARMSTRONG, p. 73–76, Pl. 8, Figs. 6–10, Pl. 9, Figs. 2–3.
1990 *Distomodus staurognathoides* (WALLISER) – UYENO, p. 68–69, Pl. 3, Figs. 21, 26–29, Pl. 12, Fig. 8.
1990 *Exochognathus caudatus* (WALLISER) – AN & ZHENG, Pl. 15, Figs. 14, 18.
1990 *Roundya detorta* WALLISER – AN & ZHENG, Pl. 15, Fig. 13.
1990 *Trichonodella expansa* NICOLL & REXROAD – AN & ZHENG, Pl. 15, Fig. 12.
1991 *Distomodus staurognathoides* (WALLISER) – KLEFFNER, Fig. 6.18–19, 23.
1991b *Distomodus staurognathoides* (WALLISER) – MCCRACKEN, p. 108, Pl. 3, Fig. 17.
1992 *Johnognathus huddlei* MASHKOVA – VOROZBITOV, Pl. 3, Figs. 1–2.
?1993 *Distomodus* sp. indet. – XIA, Pl. 3, Fig. 8.
1994 *Distomodus staurognathoides* (WALLISER) – KLEFFNER, Fig. 10.30.
1994 *Distomodus staurognathoides* (WALLISER) – WATKINS et al., p. 21, Pl. 7, Fig. 6, Pl. 10, Fig. 5, Pl. 11, Figs. 1–5, Pl. 12, Fig. 1.
?1995 ?*Johnognathus huddlei* MASHKOVA – SIMPSON & TALENT, p. 169–170, Pl. 12, Fig. 4.
1996 *Distomodus staurognathoides* (WALLISER) – GIRARD & WEYANT, Pl. 2, Figs. 11–12.
1996 *Distomodus staurognathoides* (WALLISER) – WANG & ALDRIDGE, Pl. 3, Fig. 5.

Remarks: This widespread Early Silurian species is known for the highly variable nature of the diagnostic Pa element. ALDRIDGE & SCHÖNLAUB (1989) suggested this variation may ultimately be chronologically useful. BISCHOFF (1986) recognised four "morphotypes" based on Pa element morphology, some of which have different stratigraphic ranges suggesting this may form a basis for subdividing the species into a number of chronological subspecies.

A single fragmentary Pa element tentatively referred to this species was recovered (Pl. 2, Fig. 3). It consists of two processes and has an ornament consisting of variably located nodes and sinuous ridges. The upper surface of the Pa element of this species shows a marked variety of ornament and can consist entirely of nodes, or ridges, or a combination of the two. The longer of the two processes has a median row of large nodes thus conforming to the description of the alpha morphotype of BISCHOFF (1986, p. 111). The anterolateral process has a sharp medial ridge on the upper surface (Pl. 2, Fig. 3).

Other elements have been described in detail in the literature. No Pb element was recovered in this study. M elements are mostly fragmentary and are closely comparable with those of the older *Distomodus kentuckyensis*. All have smooth surfaces, sharp posterior and anterior edges and very small "denticulate" extensions in the posterobasal region.

The symmetry transition series is well documented consisting of previously described form-species "*Exochognathus brassfieldensis*" (Sa element), "*Exochognathus caudatus*" (Sb element) and "*Distomodus egregius*" (Sc element) which are found to co-occur in many Early Silurian strata (e.g.

ALDRIDGE, 1972). The Sa element (Pl. 2, Fig. 5) is preserved with a basal funnel; it is closely similar to specimens illustrated by BISCHOFF (1986, Pl. 12, Figs. 24–28) as beta to delta morphotypes of *D. staurognathoides*. Any distinction with the Sa elements of the older alpha morphotype is presumably purely stratigraphic. BISCHOFF (1986, p. 111–118) indicated this element was not diagnostic for individual morphotypes, or for discrimination from other *Distomodus* species. He listed 35 Sa elements of the alpha morph (BISCHOFF, 1986, p. 112), but did not illustrate any. The nature of the denticulation on the lateral processes in the Sa element (Pl. 2, Fig. 5) is slightly asymmetrical. Sb and Sc elements recovered in this study conform closely to previously published descriptions (see synonymy).

"*Johnognathus*" type elements were first considered part of this species by OVER & CHATTERTON (1987, Table 2). ARMSTRONG (1990, p. 73–74) first incorporated these elements into a comprehensive synonymy. It is generally accepted that these elements represent large fragmentary Pa elements and some Sa elements with platform development along the posterior process. OVER & CHATTERTON (1987, Tables 2–3) indicated a restricted range for these elements. The presence of "*Johnognathus*" type elements only in the upper range of *D. staurognathoides* (*amorphognathoides* Zone) may prove a valid criterion for future chronological subspecific separation.

Forms that appear closely related to *Distomodus staurognathoides* are known from China. "*Exochognathus luomianensis*" ZHOU, ZHAI & XIAN, and "*Exochognathus orbicudentatus*" ZHOU, ZHAI & XIAN, differ from the characteristic ?Sb element in the nature of the denticulation and the slender cusps. They probably represent elements of a closely related species of which "*Hibbardella luomianensis*" ZHOU, ZHAI & XIAN may be the Sc element.

Material: 1 Pa element (fragment), 3 M elements, 1 Sa element, 2 Sb elements, 2 Sc elements, 1 undesignated cone.

Occurrence: Quinton Formation, Top Hut limestone, Tomcat Creek limestone, Broken River Crossing. This taxon was also recovered from the overlying Jack Formation, lower limestone unit, Jack Hills Gorge. These later examples are not documented in this paper.

Order: Ozarkodinida DZIK 1976
Family: Spathognathodontidae HASS 1959
Genus: *Ozarkodina* BRANSON & MEHL 1933

Type species: *Ozarkodina typica* BRANSON & MEHL.

?*Ozarkodina* cf. *O. hadra* ARMSTRONG, 1990
(Pl. 2, Fig. 10)

1990 *Ozarkodina* cf. *O. hadra* (NICOLL & REXROAD) – ARMSTRONG, p. 90–91, Pl. 13, Figs. 4–9.

Remarks: The single element recovered closely fits the descriptions of the Sb element of this taxon (ARMSTRONG, 1990, p. 92). The basal cavity is incomplete, but rounded on the posterior face, extending posteriorly from beneath the erect cusp. ARMSTRONG (1990, p. 92) interpreted this as a modified tertiopedate element. Preserved portions of the denticles are basally fused and laterally compressed. ARMSTRONG (1990, p. 92) discussed the differences between the Pa elements of this and closely related taxa; and noted that the Sa and Sb elements of some *Ozarkodina* species lack the posterior extension beneath the basal cavity as is seen in this species. He (ARMSTRONG, 1990) concluded that there was a close affinity between this taxon and *O. confluens* based on the similarity of S elements.

This identification is considered tentative as it is based on a single element.

Material: One Sb element.

Occurrence: Quinton Formation, Tomcat Creek Limestone.

Family: Pterospathodontidae COOPER 1977
Genus: *Astropentagnathus* MOSTLER 1967

Type species: *Astropentagnathus irregularis* MOSTLER 1967.

Remarks: For comments on this genus and discussion of relationships to the genera *Apsidognathus* and *Aulacognathus* see ARMSTRONG (1990, p. 58).

?*Astropentagnathus irregularis* (MOSTLER, 1967)
(Pl. 2, Figs. 11–12)

1967 *Astropentagnathus irregularis* n. sp. – MOSTLER, p. 298–300, Pl. 1, Figs. 1–11.
1967 *Spathognathodus tyrolensis* n. sp. – MOSTLER, p. 302, Pl. 1, Figs. 17, 19, 20, 23.
1971 *Falcodus*? n. sp. – SCHÖNLAUB, p. 47, Pl. 3, Figs. 1–3.
1971 *Hadrognathus irregularis* (MOSTLER) – SCHÖNLAUB, p. 42–43, Pl. 1, Figs. 1–11.
1971 *Hadrognathus ceratoides* (NICOLL & REXROAD) – SCHÖNLAUB, p. 43, Pl. 1, Figs. 12–13, 16, 19.
1971 "*Rhynchognathodus*" n. sp. – SCHÖNLAUB, p. 48–49, Pl. 3, Figs. 15–19.
1971 *Synprioniodina typica* n. sp. – SCHÖNLAUB, p. 49, Pl. 3, Figs. 4–5.
1972 *Astropentagnathus irregularis* MOSTLER – ALDRIDGE, p. 166–167, Pl. 2, Fig. 5.
1975 *Astropentagnathus irregularis* MOSTLER – KLAPPER & MURPHY, p. 24–25, Pl. 1, Figs. 1, 15–18.
1976 *Hadrognathus irregularis* (MOSTLER) – MILLER, Fig. 8.38.
1978 *Pterospathodus tyrolensis* (MOSTLER) – MILLER, p. 341, Pl. 4, Figs. 5–6.
1978 *Astropentagnathus irregularis* MOSTLER – MILLER, Pl. 4, Fig. 7.
1981 *Astropentagnathus irregularis* MOSTLER – UYENO & BARNES, Pl. 1, Fig. 13.
1983 *Astropentagnathus irregularis* MOSTLER – NOWLAN, Fig. 4D.
1983 *Synprioniodina typica* SCHÖNLAUB – ZHOU & ZHAI, p. 299, Pl. 68, Fig. 16.
1985 *Astropentagnathus irregularis* MOSTLER – ALDRIDGE, Pl. 3.2, Figs. 1–2.
1985 *Astropentagnathus irregularis* MOSTLER – NORFORD & ORCHARD, p. 10, Pl. 2, Figs. 2–3, 6.
1990 *Astropentagnathus irregularis irregularis* MOSTLER – ARMSTRONG, p. 59–60, Pl. 5, Figs. 1–10.
1990 *Astropentagnathus irregularis* n. ssp. – MOSTLER – ARMSTRONG, p. 59–60, Pl. 5, Figs. 11–15.
1996 *Astropentagnathus irregularis irregularis* MOSTLER – GIRARD & WEYANT, p. 57, Pl. 1, Figs. 1–10.

Remarks: ALDRIDGE (1985, p. 82) first suggested the possibility of a septimembrate apparatus. ARMSTRONG (1990, p. 58) emended the generic diagnosis to a septimembrate apparatus and discussed the history of earlier ideas concerning this species (ARMSTRONG, 1990, p. 60).

In this study, only fragmentary material was recovered and the identification is therefore tentative.

Material: Two fragments interpreted as processes of the Pa elements.

Occurrence: Quinton Formation, Broken River Crossing.

Genus: *Aulacognathus* MOSTLER 1967

1967 *Aulacognathus* MOSTLER, p. 300.
1968 *Neospathognathodus* NICOLL & REXROAD, p. 42.
1990 *Aulacognathus* MOSTLER – ARMSTRONG, p. 62.

Type species: *Aulacognathus kuehni* MOSTLER 1967.

Remarks: KLAPPER & MURPHY (1975, p. 25) undertook synonymy of the generic names *Aulacognathus* and *Neospathognathodus* based on gross similarities of Pa elements. Only Pa and Pb elements of species of this genus are generally recorded, with the latter vicarious in a number of species (ALDRIDGE, 1979). BISCHOFF (1986) concluded the apparatus of the genus was bimembrate based on the absence of recurrent M and symmetry transition elements in low diversity samples yielding the Pa and Pb elements. ARMSTRONG (1990) reconstructed a seximembrate apparatus with a variable stelliscaphate Pa element, anguliscaphate Pb element, tertiopedate M element, alate Sa and Sb element and bipennate Sc element. The apparatus as reconstructed by ARMSTRONG (1990) is c mparable in architecture to closely related genera such as *Pterospathodus* and *Astropentagnathus*.

The three most commonly recorded species, *Aulacognathus kuehni*, *A. bullatus* and *A. latus*, are not known from strata older than the *celloni* Zone (KLAPPER in ZIEGLER, 1977). BISCHOFF (1986) recognised five new species, based in part on differences between Pa elements, and proposed two lineages. Three of the new species occurred in strata predating the *celloni* Zone.

Aulacognathus bullatus (NICOLL & REXROAD, 1968)

(Pl. 2, Figs. 13–15)

1964 *Ozarkodina* sp. ex. aff. *O. adiutricis* WALLISER – WALLISER, p. 54, Pl. 27, Fig. 11, Text-Fig. 7n.
1964 *Spathognathodus* sp. ex. aff. S. *celloni* WALLISER – WALLISER, p. 74, Pl. 14, Figs. 17–18, Text-Fig. 7a.
1968 *Neospathognathodus bullatus* n. sp. – NICOLL & REXROAD, p. 44–45, Pl. 1, Figs. 5–7.
1972 *Neospathognathodus bullatus* NICOLL & REXROAD – ALDRIDGE, p. 196, Pl. 3, Fig. 15.
1975 *Aulacognathus bullatus* (NICOLL & REXROAD) – KLAPPER & MURPHY, p. 26, Pl. 2, Figs. 15–20.
1978 *Neospathognathodus latus* NICOLL & REXROAD – PICKETT, Pl. 1, Fig. 31.
1979 *Aulacognathus bullatus* (NICOLL & REXROAD) – MURPHY et al., Fig. 19.3.
1981 *Aulacognathus bullatus* (NICOLL & REXROAD) – NOWLAN, Pl. 5, Figs. 20, 23–24.
1983 *Aulacognathus bullatus* (NICOLL & REXROAD) – UYENO & BARNES, p. 15, Pl. 4, Figs. 18, 20–22.
1983 *Aulacognathus bullatus* (NICOLL & REXROAD) – NOWLAN, Figs. 4E, 4O, 4P.
1983 *Aulacognathus bullatus* (NICOLL & REXROAD) – ZHOU & ZHAI, p. 269, Pl. 65, Fig. 8.
1985 Gen. et sp. indet. *A.* – STOUGE & BAGNOLI STOUGE, p. 110, Pl. 2, Fig. 21.
1986 *Aulacognathus bifurcatus* n. sp. – BISCHOFF, p. 168–170, Pl. 4, Figs. 1–5, ?6–9.
1986 *Aulacognathus bullatus* (NICOLL & REXROAD) – CRAIG, Pl. 2, Figs. 20–21.
1986 *Aulacognathus bullatus* (NICOLL & REXROAD) – JIANG et al., Pl. IV-1, Fig. 6.
1986 *Aulacognathus bullatus* (NICOLL & REXROAD) – NAKREM, Figs. 8g, 8i, ?8j.
1986 *Aulacognathus liscombensis* n. sp. – BISCHOFF, p. 174–176, Pl. 4, Figs. 10–17, ?6–9.
1987 *Aulacognathus bullatus* (NICOLL & REXROAD) – OVER & CHATTERTON, p. 20, Pl. 3, Figs. 1–3, 6–7.
1990 *Aulacognathus bullatus* (NICOLL & REXROAD) – UYENO, p. 67–68, Pl. 2, Figs. 26–28, 34–36.
1990 *Aulacognathus bullatus* (NICOLL & REXROAD) – ARMSTRONG, p. 62–65, Pl. 6, Figs. 1–2, 4–7.
1991b *Aulacognathus bullatus* (NICOLL & REXROAD) – MCCRACKEN, p. 108, Pl. 3, Figs. 1–2.
1994 *Aulacognathus bullatus* (NICOLL & REXROAD) – WATKINS et al., p. 24, Pl. 6, Figs. 4–5.

Remarks: This species is well known for the highly variable nature of the Pa element. Only two complete Pa elements were recovered and these have markedly different characteristics, but both lie within the broad species concept. This includes forms with a single posterior process and those with a variably developed bifurcating posterior process. Both are included in the above listing. Of the examples recovered from the same sample in this study, one (Pl. 2, Fig. 15) has a bifurcating posterior process with ornament consisting of sharp-crested ridges. Another (Pl. 2, Fig. 13) has nodose ornament and a single, unsplit posterior process. From the available collection it is not possible to interpret this as either an ontogenic or a taxonomic difference.

BISCHOFF (1986) did not recognise *Aulacognathus bullatus* from any of the *celloni* Zone strata of mid-western New South Wales, but did record a closely similar form, *A. liscombensis* from the Liscombe Pools Limestone, a sequence of comparable age. BISCHOFF (1986, p. 176) in part differentiated between *A. bullatus* and *A. liscombensis* by the nature of the ornament on the anterior part of the anterolateral lobe; nodose in the former and consisting predominantly of thin sharp-crested ridges in the latter. Sharp-crested ridges, however, do occur on the posterior part of the anterolateral lobe on the paratype of *A. bullatus* figured by NICOLL & REXROAD (1968, Pl. 1, Fig. 6). Furthermore, the ornament of some elements of *A. liscombensis* figured by BISCHOFF (1986, Pl. 4, Figs. 13, 16) is, in part, nodose. The variable ornament is here interpreted as intraspecific variation. *A. liscombensis* therefore is placed in synonymy.

BISCHOFF (1986, p. 176) differentiated between *Aulacognathus bifurcatus* and *A. liscombensis* by the lack of an inner posterolateral lobe in the latter (resulting from fusion with the anterolateral lobe) but noted the existence of transitional forms. In an apparatus with a highly variable Pa element, this could be regarded as intraspecific variability. BISCHOFF (1986, text-Fig. 10a) recorded *A. bifurcatus* from strata preceding the *celloni* Zone, with a range base near the top of the *turriculatus* Graptolite Zone. *A. bifurcatus* and *A. liscombensis* were recovered from the *celloni* Zone of the Liscombe Pools Limestone. If a stratigraphic discrimination of older forms with bifurcating posterior processes can be demonstrated in other sections, then the differences between the two may be more appropriately interpreted as a morphological gradient of subspecific rank. *A. bifurcatus* is therefore interpreted as synonymous with *A. bullatus*.

An example of a specimen with a bifurcating posterior process from Member 4 of the Jupiter Formation was illustrated by UYENO & BARNES (1983, Pl. 4, Fig. 20). In this sequence *Aulacognathus bullatus* predates the first occurrence of *Pterospathodus celloni*.

Material: 2 Pa elements, one Pa fragment.

Occurrence: Top Hut limestone, Quinton Formation.

Genus and sp. indet.

(Pl. 2, Figs. 16–17)

Description: ?M element. Short stelliplanate element with a short anterior process, longer posterior process and remnant of lateral process on outer side of element. Anterior process consisting of remnant of single large cusp with a prominent, downwardly directed adenticulate anticusp which is distally deflected outwards. Anterior margin of cusp smoothly and gently concave in lateral view; anterior and posterior margins sharply rounded. Posterior process straight, decreasing in height posteriorly and bearing five discrete low denticles with gently rounded terminations. Remnant of lateral process on outer side of element, obscured by sediment, but basal cavity can be seen to extend high beneath this process.

?Sa/Sb element. Modified tertiopedate element with a short anterior process and two short posterolateral processes twisted in opposite directions. Anterior process with three large, erect denticles, two of them fused for most of their height. Anterior margin of element in lateral view has a gently sinuous outline. All denticles have rounded peaks, inclined anterior margins and erect posterior margins. Two posterolateral processes; one short with three small denticles fused only at their bases and with sharp anterior and posterior margins and sharply pointed terminations. The other posterolateral process is longer with six similar denticles. Basal cavity asymmetrically triangular in outline.

Remarks: These elements are grouped together because of their relatively short processes and large anterior denticles. Element homologies are tentative but it is possible that the entire apparatus consists of tertiopedate elements. These elements are unlike most reported Silurian conodonts. The ?M element is similar to the M element of some Late Ordovician species of *Plectodina* except for the presence of a small lateral process. Similar elements have been illustrated as *Guizhouprioniodus guizhouensis* from the Jiguling Formation in China (ZHOU, ZHAI & XIAN, 1981, Pl. 1, Figs. 13–14; ZHOU & ZHAI, 1983, Pl. 65, Fig. 30); these are from a comparable stratigraphic level to the Queensland specimens. The Chinese examples lack a lateral process and have a comparatively longer posterior process.

Material: 1 ?M element, 1 ?Sa/Sb element.

Occurrence: Quinton Formation, Broken River Crossing.

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Plate 1

Fig. 1: ***Walliserodus curvatus* (BRANSON & BRANSON).**
Sc element.
Quinton Formation, Tomcat Creek limestone (TCC 60).
UQY7614 lateral view, × 90.

Figs. 2–6: ***Panderodus* n. sp.**
Fig. 2: M element.
Jack Formation, Jack Hills Gorge
(BR8 20, see SIMPSON, 1995a).
UQY7199 lateral view, × 60.
Fig. 3: ?Sb element.
Quinton Formation, Top Hut limestone.
UQY7200 lateral view, × 120.
Fig. 4: Sc element.
Quinton Formation, Tomcat Creek limestone (TCC 60).
UQY7611 lateral view, × 120.
Fig. 5: Sc element.
Quinton Formation, Top Hut limestone.
UQY7201 lateral view, × 120.
Fig. 6: Sc element.
Quinton Formation, Top Hut limestone.
UQY7202 lateral view, × 120.

Figs. 7–12: ***Panderodus* sp.**
Fig. 7: Graciliform (?Sa) element.
Quinton Formation, Tomcat Creek limestone (TCC 13).
UQY7645 lateral view, × 90.
Fig. 8: Graciliform element.
Quinton Formation, Top Hut limestone.
UQY7612 lateral view, × 90.
Fig. 9: Graciliform element.
Quinton Formation, Top Hut limestone.
UQY8668 lateral view, × 90.
Fig. 10: Graciliform element.
Quinton Formation, Tomcat Creek limestone.
UQY8669 lateral view, × 90.
Fig. 11: Arcuartiform element.
Quinton Formation, Top Hut limestone.
UQY8670 lateral view, × 90.
Fig. 12: Arcuartiform element.
Quinton Formation, Top Hut limestone.
UQY8671 lateral view, × 90.

Figs. 13–14: ***Oulodus jeannae* SCHÖNLAUB**
Fig. 13: Sc element.
Quinton Formation, Broken River Crossing.
UQY7143 inner lateral view, × 45.
Fig. 14: Sc element.
Quinton Formation, Broken River Crossing.
UQY7144 outer lateral view, × 60.

Figs. 15–16: ***Pseudolonchodina expansa* (ARMSTRONG)**
Fig. 15: Pb element.
Quinton Formation, Top Hut limestone.
UQY7147 inner lateral view, × 90.
Fig. 16: M element.
Quinton Formation, Broken River Crossing.
UQY7148, lateral view, × 90.

Figs. 1, 4, 7, 8 previously illustrated in SLOAN et al. (1995, pl. 12, Figs. 5, 3, 4, 24) respectively.

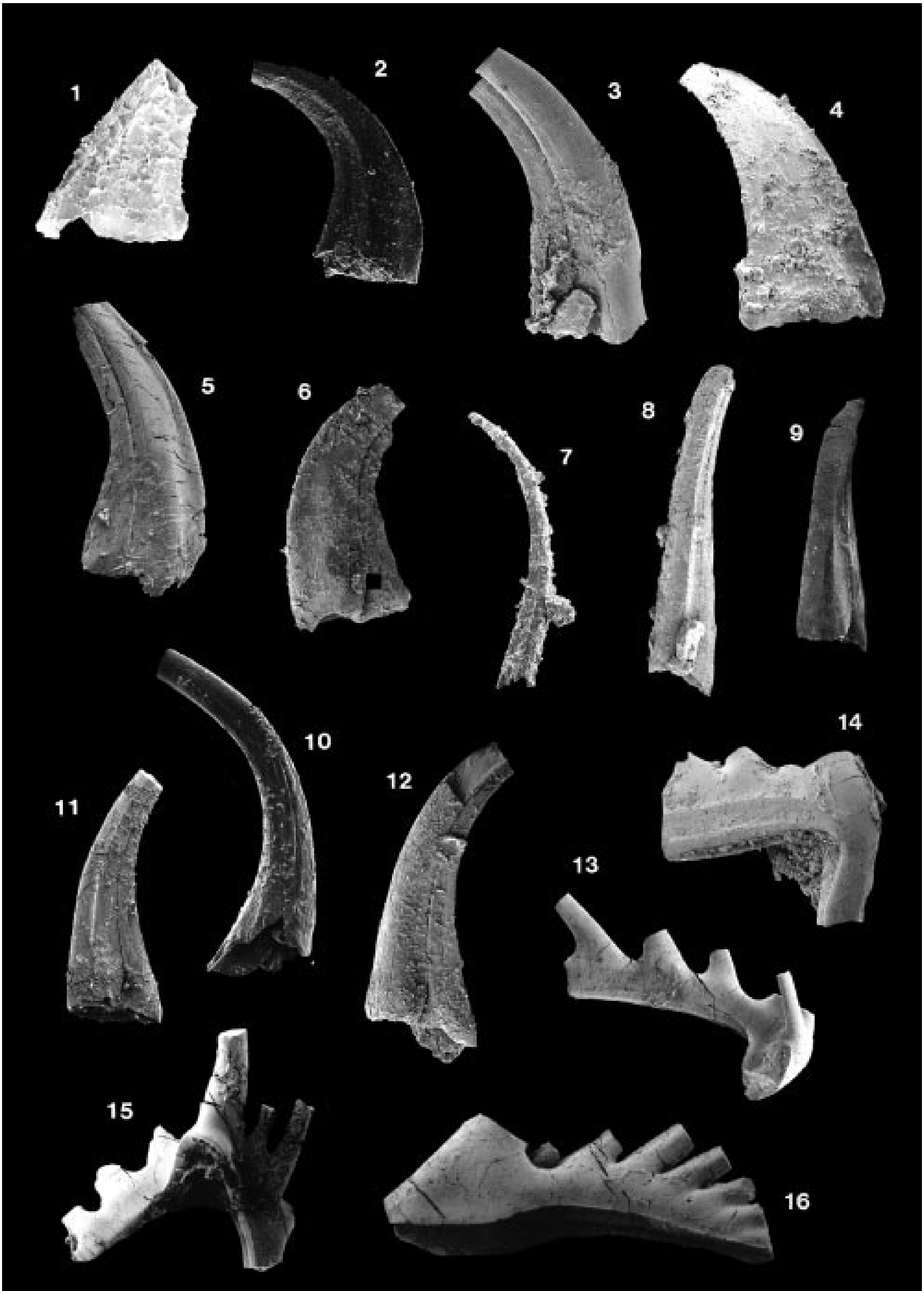
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Plate 2

Figs. 1–2: ***Pseudolonchodina fluegeli* (WALLISER).**
Fig. 1: Sa element.
Quinton Formation, Tomcat Creek limestone (TCC 17).
UQY7606, inner lateral view, × 90.
Fig. 2: Sc element.
Quinton Formation, Tomcat Creek limestone (TCC 19).
Outer lateral view, × 120.

Figs. 3–9: ***Distomodus staurognathoides* (WALLISER).**
Fig. 3: Pa element (fragmentary).
Quinton Formation, Top Hut limestone.
UQY7609, upper view, × 90.
Fig. 4: M element.
Quinton Formation, Broken River Crossing.
UQY7442, lateral view, × 90.
Fig. 5: Sa element.
Quinton Formation, Top Hut limestone.
UQY7608, oblique lateral view, × 60.
Fig. 6: Sb element.
Quinton Formation, Broken River Crossing.
UQY7443, lateral view, × 90.
Fig. 7: Sb element.
Quinton Formation, Tomcat Creek limestone (TCC 17).
UQY7607, lateral view, × 90.
Fig. 8: Sc element.
Quinton Formation, Broken River Crossing.
UQY 7444, outer lateral view, × 60.
Fig. 9: Sc element.
Quinton Formation, Top Hut limestone.
UQY7610, inner lateral view, × 90.

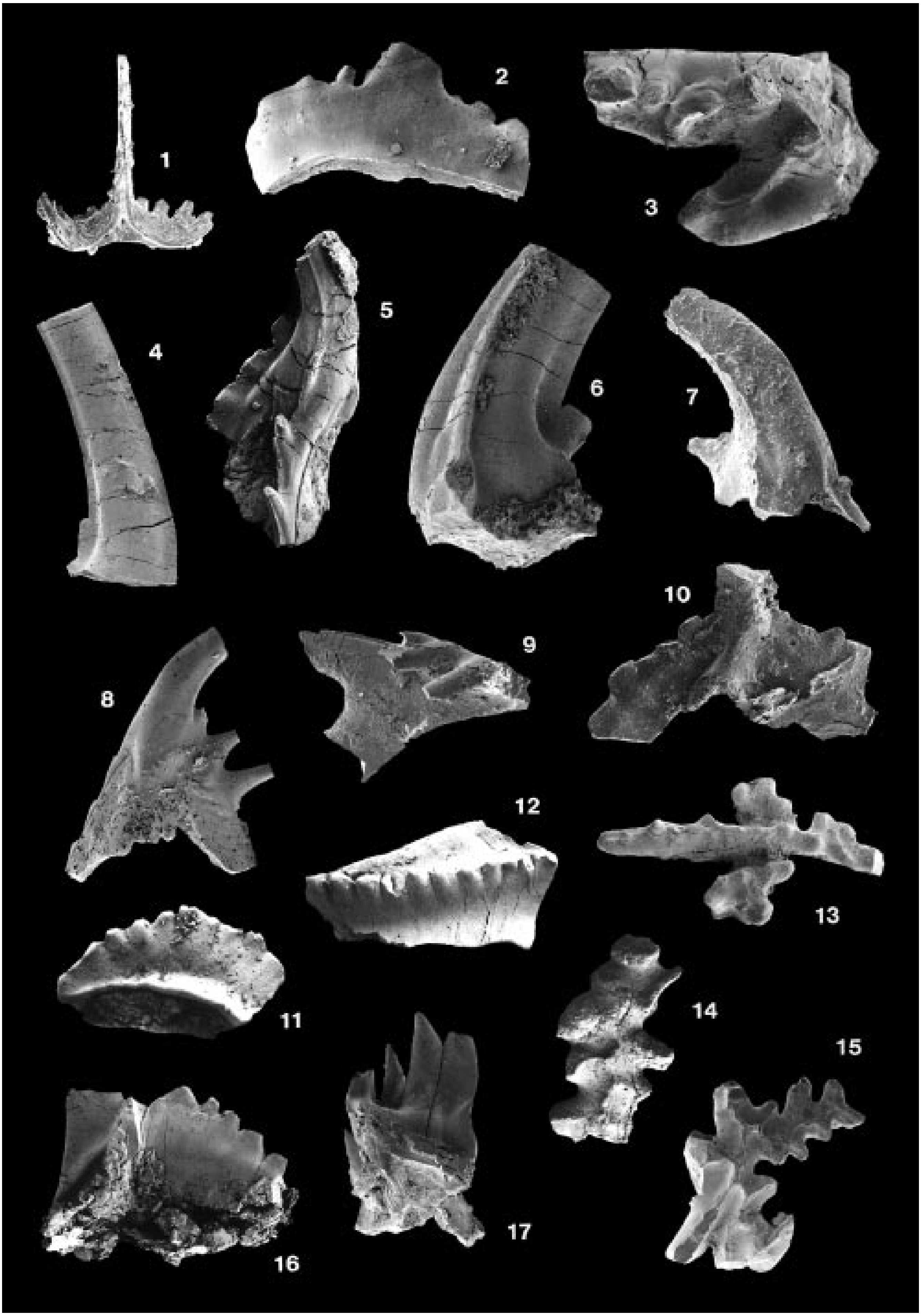
Fig. 10: ***Ozarkodina* cf. *O. hadra* (NICOLL & REXROAD).**
Sb element.
Quinton Formation, Tomcat Creek limestone (TCC 23).
UQY7351, inner lateral view, × 120.

Figs. 11–12: ?***Astropentagnathus irregularis* MOSTLER**
Fig. 11: ?Pa element fragment.
Quinton Formation, Broken River Crossing.
UQY5326, × 50.
Fig. 12: ?Pa element fragment.
Quinton Formation, Broken River Crossing.
UQY5327, × 50.

Figs. 13–15: ***Aulacognathus bullatus* (NICOLL & REXROAD)**
Fig. 13: Pa element.
Quinton Formation, Top Hut limestone.
UQY7627, upper view, × 45.
Fig. 14: Pa element (fragment).
Quinton Formation, Top Hut limestone.
UQY8672, upper view, × 50.
Fig. 15: Pa element.
Quinton Formation, Top Hut limestone.
UQY7628, upper view, × 30.

Figs. 16–17: **Genus and sp. indet.**
Fig. 16: ?M element.
Quinton Formation, Broken River Crossing.
UQY7461, lateral view, × 45.
Fig. 17: ?Sa/Sb element.
Quinton Formation, Broken River Crossing.
UQY7461, lateral view, × 60.

Figs. 1–3, 5, 7, 9, 13, 15 previously illustrated in SLOAN et al. (1995, Pl. 12, Figs. 6, 1, 22, 21, 2, 13, 18, 20) respectively.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