CONODONTS FROM THE LADINIAN-CARNIAN BOUNDARY BEDS OF SOUTH CANYON, NEW PASS RANGE, NEVADA, USA

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Abstract—Conodonts from the Augusta Mountain Formation in the New Pass Range area of Nevada are documented and compared with those recently described from Ladinian-Carnian boundary strata in British Columbia. Budurovignathus mungoensis dominated faunas from the Lower Member of the formation correlate with conodont faunas known from the lower Sutherlandi Zone in B.C. Conodont faunas from around the lithological boundary of the Lower and Middle members comprise a diverse association of several new species that are assigned to the new intermedius Zone and suggest a position within the higher part of the Sutherlandi Zone at about the appearance of Daxatina. Similarly, the occurrence of Metapolygnathus tadpole with Mosherella newpassensis at ~6 m above the base of the Middle Member denotes the base of the tadpole Zone, which equates with the highest occurrence of Frankites in B.C. The implication is that the Sutherlandi and Desatoyense zones are in part equivalent. The youngest faunas recovered from New Pass yield Mosherella n. sp. A and correlate with strata as young as the Nanseni Zone.

INTRODUCTION

This report presents details of the conodont succession at South Canyon in the New Pass Range of central Nevada (Fig. 1). A history of study, details of the succession, and a summary of the biostratigraphy have been given previously in Balini et al. (2007), for which this provides a supplementary record. South Canyon is notable as the type locality for the Lower Carnian Desatoyense Zone, and its superposition above a Sutherlandi Zone ammonoid fauna (Silberling and Tozer, 1968). As such, it is crucial for discussions of the Ladinian-Carnian boundary (Fig. 2).

Mosher (1968) was the first to study conodonts from South Canyon, from both the Favret and Augusta Mountain formations. He found abundant collections of “Epipondolella” = Budurovignathus mungoensis starting at ~140 m below the Lower-Middle Member contact of the Augusta Mountain Formation, and ranging up to ~1.5 m above that contact. Mosher (1968, p. 911) also recorded “Neopathodus” = Mosherella newpassensis from ~6.7 m above the base of the Middle Member through ~136 m, and “Paragondolella” = Metapolygnathus polygnathiformis sensu lato from ~12 m and questionably to ~113 m above the base. Records of “P. excelsa” and “P. navicula” at the base of the Middle Member are probably assignable to P. inclinata and perhaps N. liardensis of this report. The occurrence of “Neopathodus” lanceolatus from near the top of the Middle Member (Mosher, 1968) is now attributed to Mosherella n. sp. A (see below). Mosher (1968) also reported many ramiform or “compound” elements from South Canyon, including three new species: Cypridodella scolosculptura, Hindeodella torta, and Parachirognathus jungi. These are now reconstructed as part of the multielement apparatuses of Budurovignathus and Mosherella (see below).

In 1989, Leopold Krystyn (U. Vienna) collected several conodont samples from South Canyon and shared them with the senior author; these essentially replicated the earlier data of Mosher (1968). A sample from the base of the Middle Member (sample 155) contained abundant Budurovignathus mungoensis, and a sample from the Desatoyense Zone (sample 105) yielded abundant Mosherella newpassensis, Paragondolella inclinata, and Metapolygnathus polygnathiformis sensu lato. Several samples from higher in the section yielded Mosherella n. sp. A (samples 131, 137). Subsequently, the present authors visited South Canyon in 2002 and made detailed collections through sections A and B. In 2005, these were supplemented by collections from section D (Balini et al., 2007).

THE CONODONT SUCCESSION

Conodont samples were taken from four sections reported in Balini et al. (2007): sections D(1), A, B, and D(2). The first of these covered the Lower-Middle Member boundary, the next two an additional 9.18 m of the Middle Member, and section D(2) the interval from about 35.45 m within the Middle Member.

A few meters below the top of the Lower Member, a conodont collection (D31) taken from gray bioclastic packstones with brachiopods yielded the conodonts Budurovignathus mungoensis, Neogondolella liardensis, and Paragondolella inclinata.

In so much as this fauna lacks Metapolygnathus, the association is typical of the lower parts of the Sutherlandi Zone in British Columbia. However, within the highest meter of the Lower Member in Sections A and B (Figs. 3-4), they are joined by metapolygnathids that suggest, by comparison with those in B.C., a position within the higher, Daxatina-bearing beds of the Sutherlandi Zone.

In general, conodont collections from both sections A and B at South Canyon show a tripartite division spanning the upper Lower and lower Middle members of the Augusta Mountain Formation. Samples from below 1 m from the top of the Lower Member are virtually monospecific Budurovignathus mungoensis faunas and, although this species continues into the Middle Member, it becomes subordinate to species of Metapolygnathus, Neogondolella, and Paragondolella (M-N-P) around the lithological boundary. Higher still, from ~6 m above the base of the Middle Member in section A, M-N-P in turn suddenly become subordinate to Mosherella newpassensis, which also forms virtually monospe-
neogondolella liardensis consists of that species plus can be assigned to the faunas from LCB strata in British Columbia (Orchard, this volume), they Budurovignathus None of these species are common compared with those of M. lobatus be correlated with the Lower Carnian Nanseni Zone in B.C. strata of the Augusta Mountain Formation with known to embrace the Desatoyense Zone in British Columbia. Higher metapolygnathids, these levels can be correlated with the in the Ladinian-Carnian boundary (LCB) interval at South Canyon. Above shown in Balini et al. (2007).

Section A (Fig. 3) contains the most complete conodont record for the Ladinian-Carnian boundary (LCB) interval at South Canyon. Above monospecific B. mungoensis collections (#SCAN8bis, #B2), the fauna consists of that species plus Paragondolella inclinata, P. ? sulcata, Neogondolella liardensis, Metapolygnathus acuminatus, M. intermedius, M. lobatus, and M. polygonathiformis sensu stricto (#SCAN8 and up). None of these species are common compared with those of Budurovignathus and Mosherella, but by comparison with conodont faunas from LCB strata in British Columbia (Orchard, this volume), they can be assigned to the intermedium Zone, equivalent to the upper Sutherlandi Zone. In section A, many of the species range up through the lower ~5 m of the Middle Member where Misikella longidentata also occurs sporadically (#SCAN6 thru #SCAN4). Budurovignathus mungoensis is very rare at these levels, too. Faunas above the level of the incoming of Mosherella newpassensis (#A19, #B5E) are rather poor in other species and appear less diverse, although Mosherella itself is extremely abundant. The taxon overlaps with the range of Frankites in B.C., as is the case in section B (#SCAN14, 15).

Higher strata in both sections A and B are dominated by M. newpassensis but also contain Metapolygnathus tadpole in section A (SCAN3) and in section B (SCAN15): this association is typical of the younger Daxatina faunas in British Columbia, which are newly referred to the tadpole Zone (sensu Orchard, this volume). Rare Budurovignathus sp. A also occurs in these higher strata (SCAN3, B11), above the range of B. mungoensis.

Higher parts of the Middle Member exposed in section D(2), yield conodont faunas dominated by Mosherella newpassensis. This species forms monospecific faunas in samples D1, D2, and D4, whereas in D9 and D10 it is far more abundant than associated Paragondolella inclinata, the only other taxon recovered. In spite of the absence of metapolygnathids, these levels can be correlated with the tadpole Zone, known to embrace the Desatoyense Zone in British Columbia. Higher strata of the Augusta Mountain Formation with Mosherella n. sp. A can be correlated with the Lower Carnian Nanseni Zone in B.C.

### TAXONOMIC NOTES

**Budurovignathus mungoensis** (Diebel)

(Figure 5. 1-10)

1956, *Polynomialia mungoensis* n. sp. – Diebel, p. 431, pl. 1, figs. 1-20; pl. 2, figs. 1-4; pl. 3, fig. 1; pl. 4, fig. 1.
1968, *Hindeodella torta* n. sp. – Mosher, p. 929, pl. 114, figs. 11, 12 (=P2 element).

**Remarks:** This is an extremely abundant species in the Lower Member of the Augusta Mountain Formation. It displays some variation in platform shape, often terminating in a point in small specimens and in many larger ‘typical’ sinuous representatives. Some other large specimens have broadened posterior platforms resulting from outgrowth of one postero-lateral margin. In those forms, a weak secondary keel may be developed (Fig. 5. 6). These are judged to be intraspecific variants of *B. mungoensis* although similar forms have been assigned to *B. diebelli*, which appears to be a Tethyan endemic.

The paratype of *Hindeodella torta*, the P2 element of the multielement *Budurovignathus* (Orchard, 2005), came from sample NL-1 of Mosher (1968), that is from ~6 m below the Lower-Middle Member boundary, and not from the Middle Member as was stated in the plate description (op. cit., p. 926).

**Budurovignathus sp. A**

(Figure 5. 15, 16, 25, 26)

**Remarks:** Two incomplete specimens from the Desatoyense Zone at South Canyon are characterized by rounded anterior nodes, which are only poorly defined in one specimen. The pit is located close to the anterior end of the platform. These specimens are broader than *B. mungoensis* and lack the sharp, well defined platform nodes of that species.

**Metapolygnathus polygonathiformis** (Budurov and Stefanov)

(Figure 6. 14, 19, 46-51)

1965, *Gondolella polygonathiformis* sp. nov. - Budurov & Stefanov, p.

### SUMMARY

Many of the conodonts identified in South Canyon (New Pass Range area) have recently been described from LCB strata in British Columbia (Orchard, this volume). This facilitates more refined correlation of the Nevanad successions.

*Budurovignathus mungoensis* dominated faunas of the Lower Member of the Augusta Mountain Formation correlate with conodont faunas known from the lower Sutherlandi Zone in B.C., broadly equivalent to the Paragondolella inclinata Zone differentiated by Orchard (this volume). Those associations known from around the lithological boundary of the Lower and Middle members are assigned to the intermedium Zone and suggest, in comparison with B.C., a position within the higher part of the Sutherlandi Zone at about the appearance of *Daxatina*. Similarly, the appearance of Mosherella newpassensis and *M. tadpole* at ~6 m above the base of the Middle Member argues for a position, in relation to B.C. faunas, at and above the highest occurrence of Frankites, assignable to the *tadpole* Zone of Orchard (this volume). This implies that the Sutherlandi and Desatoyense zones are in part equivalent, as was tentatively suggested by Tozer and Silberling (1968, p. 45). The youngest faunas recovered from South Canyon with Mosherella n. sp. A correlate with strata as young as the Nanseni Zone.

### FIGURE 2

The North American Upper Ladinian–Carnian ammonoid Standard Scale (Tozer, 1994) showing the position of the *Trachyceras desatoyense* Zone (shaded area). BC=British Columbia; CA=California.

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<tr>
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FIGURE 3. Conodont distribution in Section A in South Canyon. Solid circles are occurrences, open circles are questionable. Column on right shows total numbers of elements recovered and variation in the ratio of the principal conodont groups.
FIGURE 4. Conodont distribution in Section B in South Canyon. Solid circles are occurrences, open circles are questionable. Column on right shows total numbers of elements recovered and variation in the ratio of the principal conodont groups.
Remarks: This species was originally described from a collection taken at the south end of the village of Snezha in the Burgas District of Bulgaria, in strata close to the Ladinian-Carnian boundary. According to H. Kozur (pers. comm., 2007), it occurred with abundant specimens of Paragondolella inclinata and is probably of “latest Ladinian” age. The original illustration of the holotype is poor and so, apparently, is its preservation. However, an essential feature of its morphology is the geniculation of the lateral anterior platform margins and it is this character that has been used as diagnostic in all subsequent reports of the species. As such, the species has been broadly interpreted and used as a guide for both Lower and Upper Carnian strata. Hence, the polygnathiformis Assemblage Zone of Mosher (1968, p. 911) and Sweet et al. (1971, p. 458) was based on Upper Carnian Tropites beds in Europe and North America with the Hallstatt Limestone at Someraukogel designated as the type locality for zone. The breadth of interpretation subsequently given to Metapolygnathus polygnathiformis is demonstrated by the records of Mosher (1973, p. 164), who recorded it from as low as the upper Ladinian Maclearni Zone as well as from the Lower Carnian Nanseni Zone, and Upper Carnian Welleri Zone. In Europe, Krystyn (1980, p. 78) also showed polygnathiformis as ranging from near top of late Ladinian Sutherlandi Zone through the Upper Carnian Subbullatus Zone and Anatropites Beds; his more restricted polygnathiformis Assemblage Zone was largely Tuvalian in age.

Elements from the Upper Carnian show significant differences when compared with specimens from the Ladinian-Carnian boundary interval. In this report, the species polygnathiformis is restricted to elements that have the following features:

1) A platform that is posteriorly rounded to more commonly subquadrate in outline.

2) A platform that extends the entire length of the element and, when viewed from above, has gradually tapered anterior margins without inward deflection.

3) When viewed from the side, at least one anterior lateral margin has a geniculation point or anterior ‘step’.

4) The carina is moderately high and fused but may be more or less submerged by the upturned platform margins when viewed in profile.

5) The fixed blade is generally well differentiated and partially fused and projects above the downturned platform margins.

6) The cusp is large, prominent, well differentiated from the fused carinal nodes, subterminal in position, and surrounded by a narrow posterior platform brim.

Metapolygnathus polygnathiformis is close to M. acuminatus but differs particularly in platform shape. Metapolygnathus intermedius is the next evolutionary step within the group, which involves further
reduction of the anterior platform, which becomes evident in upper view as well as in lateral view, and which involves the appearance of a ‘free blade’. This trend continues to produce Metapolygnathus tadpole, in which the free blade is at least half the total element length. Derivatives of *M. polygonathiformis* sensu stricto with a reduced anterior platform have been referred to *Metapolygnathus noah* Hayashi by Kozur (pers. comm., 2007). However, that species has more discrete nodes, a wide brim, and seemingly a more anterior pit than LCB species. *Metapolygnathus noah* corresponds to elements from the Upper Carnian, for which this species name is now restricted.

*Misikella longidentata* Kozur & Mock (Figure 5. 13, 14, 23, 24)

1974, *Misikella longidentata* n. sp. – Kozur & Mock, p. 136-37, pl. 1, figs. 4, 5.

Remarks: Four specimens of this species were recovered in Section A and one from sample 110 of Krystyn (collected ~4 m above the base of the Middle Member). They show the characteristic large terminal cusp and few short anterior denticles. Cited records of this species are mostly late Carnian and Norian in age, so these early Carnian occurrences may be the oldest known.

*Mosherella newpassensis* (Mosher) (Figure 5. 17-20)

1968, *Neospathodus newpassensis* n. sp. – Mosher, p. 931, pl. 115, figs. 5, 6, 9 (= P1 element).
1968, *Cypridodella scolosculptura* n. sp. – Mosher, p. 921, pl. 113, figs. 13, 22 (=S2 element).
1968, *Parachiropgnathus jungi* n. sp. – Mosher, p. 933, pl. 115, figs. 18, 19 (= S3/4 element).
2005, *Mosherella newpassensis* (Mosher) – Orchard, p. 92, text-fig. 18H-I.
2006, *Mosherella newpassensis* (Mosher) – Orchard, p. 247, pl. 6, fig. 19.

Remarks: This species is abundant in the Desatyonyene Zone at South Canyon, and in B.C. it is also known from *Frankites*-bearing beds in North Besa River, with both *Frankites* and *Daxatina* at South Besa River, and with *Daxatina* alone on Liard River (Orchard, this volume). The species also occurs in the Pelly Mountains, Yukon Territory (Orchard, 2006).

Multi-element *Mosherella* was reconstructed by Orchard (2005) based largely on New Pass material. Mosher (1968) formerly described the S2 and S3/4 elements as new species.

*Mosherella n. sp. A* (Figure 5. 11, 12, 21, 22)

1968, *Neospathodus lanceolatus* n. sp. – Mosher, p. 930-31, pl. 115, fig. 10 (only).
1973, *Neospathodus* sp. E – Mosher, p. 173, pl. 18, fig. 36.

Remarks: This new species apparently developed from *Mosherella newpassensis* through the loss of denticles posterior of the cusp. This reduction of the posterior process appears to be progressive because in a collection from the Desatyonyene Zone in the Clearwater area in British Columbia (GSC loc. 83825), some elements retain a slight posterior denticle.

Mosher (1968) referred five specimens from South Canyon (sample NP-116) to a new species for which he selected a holotype from the Upper Norian Hallstatter Kalk at Steinbergkogel, Austria. The holotype is an example of *Misikella* whereas that from South Canyon is not. The South Canyon specimens came from near the top of the Middle Member of the Augusta Mountain formation, and were replicated in several collections made by L. Krystyn. The specimen reported by Mosher (1973) came from a Nanseni Zone collection from the Ludington Formation (“Grey Beds”) at Ewe Mountain in B.C. (GSC loc. 42308).

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**REFERENCES**


