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EARLY ORDOVICIAN (LATE FLOIAN) CONODONTS FROM THE ZENTA RANGE, CORDILLERA ORIENTAL, NW ARGENTINA

VOLDMAN, G. G.[1, 2], ALBANESI, G. L. [1, 2], ZEBALLO, F. J. [1] AND MONALDI, C. R.[3]

[1] Museo de Paleontología, CIGEA, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, X5000JJC, Córdoba, Argentina. *gvoldman@efn.uncor.edu, galbanes@com.uncor.edu, fzeballo@hotmail.com*
[2] CICTERRA-CONICET, Córdoba, Argentina
[3] CONICET, Facultad de Ciencias Naturales, Universidad Nacional de Salta, A4449XBN, Salta, Argentina. *crmonaldi@arnet.com.ar*

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LOWER Ordovician strata from the Central Andean Basin are superbly exposed in the Zenta Range of the Cordillera Oriental, NW Argentina. At the Laguna Verde section (23°18'S, 65° 1W, 4500 MASL) the sedimentary succession is mostly siliciclastic with subordinate coquinas and calcarenites (Fig. 1). It is unconformably overlain by glacial diamictites and quartzites from the Zapla Formation (Hirnantian). Previous conodont work by Albanesi *et al.* (2011) recognized the *Acodus deltatus* – *Paroistodus proteus* Zone in the nearby Abra de Santa Ana. Aráoz *et al.* (2008) suggested a Darriwilian to Sandbian age for the strata exposed in the Laguna Verde section, based on the presence of *Erismodus* and *Trapezognathus*. In a recent revision of the section, Carlorossi and Heredia (2013) documented from one sample *Trapezognathus diprion* Lindström(1954) and mentioned the occurrence of *Baltoniodus triangularis* Lindström (1954) and *B.* cf. *triangularis* Lindström (1954) in the same sample (p. 311 and table 2), suggesting a Dapingian age for the upper exposed levels of the Acoite Formation. In order to define the age of aforementioned strata, we took 18 rock samples from the Laguna Verde section plus 2 isolated samples (ZEN17 and ZEN17.2) located 2.5 km to the SW (23°19'S, 65° 0'W), stratigraphically below, which produced a significant conodont fauna, although the diversity is low. The rock samples (24 kg in total), which were digested in 10% acetic acid following the conventional procedures, produced 608 conodont elements. The studied specimens are relatively well preserved (CAI 2, Epstein *et al.*, 1977), with no chemical alteration but abundant fractures that truncate cusps and denticles. The faunal association includes *Acodus* n. sp. (see Zeballo *et al.*, this volume), *Baltoniodus* cf. *triangularis*, *Trapezognathus*? *argentinensis* Rao *et al.*(1994), *Trapezognathus diprion*, *Trapezognathus? primitivus* n. sp., *Scolopodus houlianzhaiensis An and* Xu in An *et al.* (1983), *Drepanodus arcuatus* Pander (1856), *Drepanoistodus chucaleznensis* Albanesi and Aceñolaza (2005), *D. costatus* (Abaimova, 1971), *D. basiovalis* (Sergeeva, 1963) and *Erraticodon patu* Cooper (1981). The record of the taxon *Baltoniodus* cf. *triangularis* confirms the presence of the homonymous biozone in the host strata, which indicates the uppermost zone of the Early Ordovician (Floian). According to its age, these strata correlate with the upper part of the Acoite Formation and equivalent units such as the Capillas/Zanjón Formation from the Subandean Ranges. The conodonts are stored in the Museo de Paleontología, Universidad Nacional de Córdoba, with repository code CORD-MP.

SYSTEMATIC PALEONTOLOGY

We provide comments on new or poorly documented species; other mentioned or illustrated species have been fully described elsewhere or are currently under study. We have followed the Bagnoli' and Stouge (1997) taxonomic criteria for morphotypes designations in platform-equipped apparatuses, i.e., Pa ambalodiforms and Pb amorphognathiforms.

Genus Baltoniodus Lindström, 1971

Type species. *Prioniodus navis* Lindström, 1954

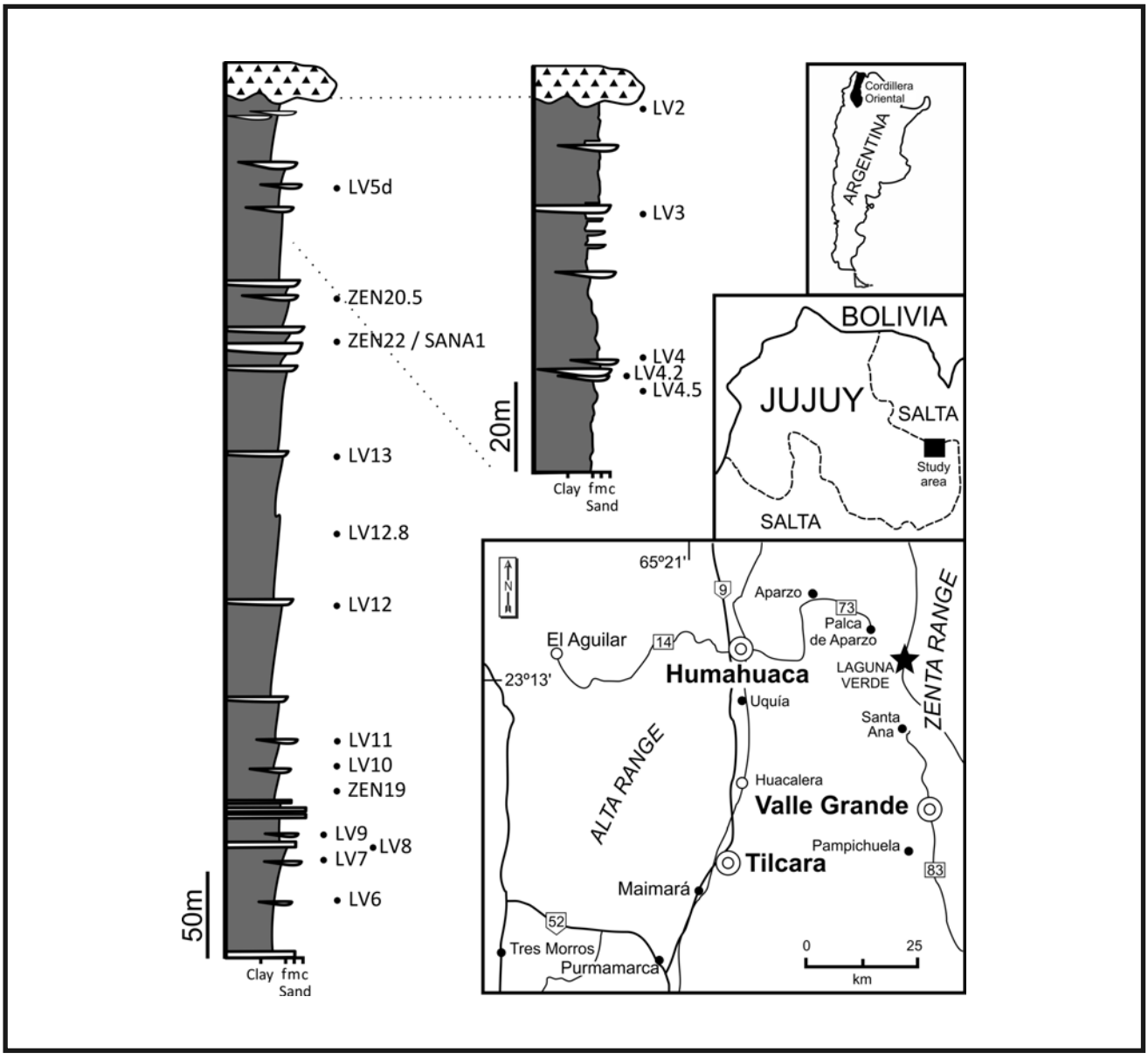
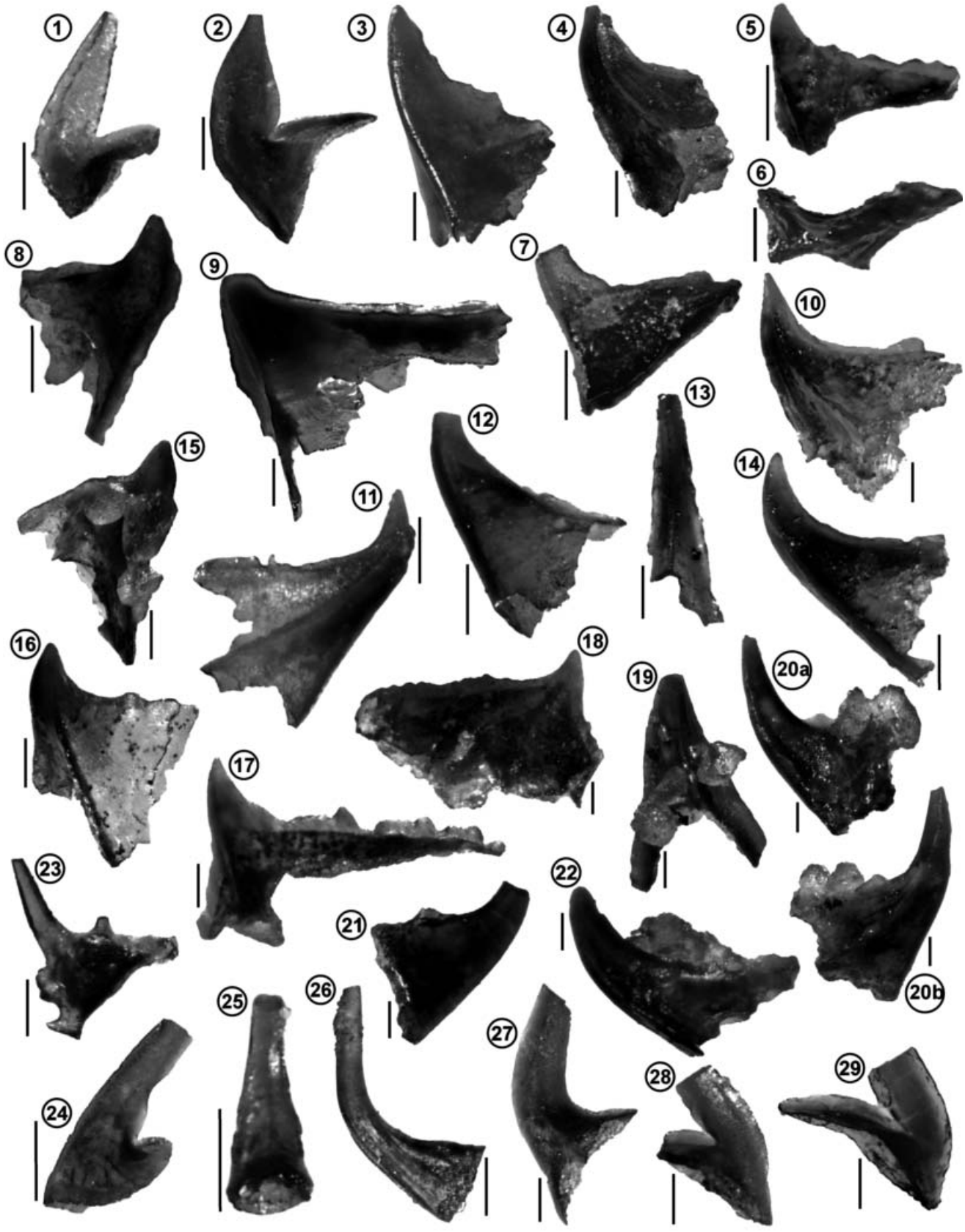


Figure 1. Location map and stratigraphic column with sampled levels for the Laguna Verde section, Cordillera Oriental, Jujuy Province, Northwestern Argentina.

Figure 2. Late Early Ordovician conodonts from the Zenta Range, Eastern Cordillera, Argentina.**1, 5–6,** ***Baltoniodus*** cf.***triangularis*** Lindström. **1**, M element, CORD-MP 28038/1, sample ZEN22; **5**,Pb element, CORD-MP 28019/1, sample LV4.5; **6**, Pb element, CORD-MP 28023/10, sample LV7; **2–4,** ***Trapezognathus diprion*** Lindström. **2**, M element, CORD-MP 28005/1, sample ZEN17; **3**,Pb element, CORD-MP 28013/1, sample ZEN17.2; **4**, Pa element, CORD-MP 28024/1, sample LV7; **7, 29,** ***Gothodus andinus*** Rao *et al.* **7**,Pb element, CORD-MP 28022/1, sample LV7; **29**, M element, CORD-MP 28028/1, sample SANA1; **8–14,** ***Trapezognathus? primitivus*** n. sp. **8**, M element, CORD-MP 28004/1, sample ZEN17; **9**, Pb element, CORD-MP 28004/3, sample ZEN17; **10**, Pa element (holotype), CORD-MP 28012/1, sample ZEN17.2; **11**, Sb element, CORD-MP 28012/5, sample ZEN17.2; **12**, Sc element, CORD-MP 28004/6, sample ZEN17; **13**, Sa element, CORD-MP 28012/4, sample ZEN17.2; **14**, Sd element, CORD-MP 28001/8, sample ZEN17; **15–21**, ***Trapezognathus?argentinensis*** Rao *et al.* **15,** M element, CORD-MP28029/1, sample SANA1; **16,** Pa element, CORD-MP 28029/1, sample SANA1; **17**, Pb element, CORD-MP 28034/1, sample ZEN22; **18,** Pb element, CORD-MP 1031/5, sample LC9 (Rao´s collection, paratype); **19,** Sa element, CORD-MP 28034/4, sample ZEN22; **20,** Sb element, CORD-MP 28034/7, sample ZEN22; **21,** Sc element, CORD-MP 28034/12, sample ZEN22; **22,** Sd element, CORD-MP 28034/20, sample ZEN22; **23**, ***Erraticodonpatu*** Cooper, Pa element, CORD-MP28032/1, sample ZEN22; **24, Drepanoistodus basiovalis** (Sergeeva), M element, CORD-MP 28036/1, sample ZEN22; **25–26,** ***Scolopodushoulianzhaiensis*** An and Xu. **24,** Sa element, CORD-MP 28026/6, sample LV7; **25,** Sb element, CORD-MP 28026/15, sample LV7; **27–28,** ***Acodus*** n.sp. **27,** Pa element, CORD-MP28003/12, sample ZEN17; **28,** M element, CORD-MP 28003/3, sample ZEN17. All outer-lateral views except 6, upper view; 13, 25.posterior views; 17, 20a, 23, 28, 29 inner-lateral views. Scale bar: 0.1 mm.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Baltoniodus cf. triangularis Lindström, 1954
Figure 2.1, 2.5–2.6

2010. *Baltoniodus* cf. *triangularis* (Lindström); Li *et al.*, p. 118–119, pl. 3, figs. 1–23. (*cum. syn.*).

Material examined and occurrence. 5 M, 2 Pa, 8 Pb, 1 Sa, 3 Sb, 4 Sd elements (CORD-MP 28019/1-3, 28021/1-2, 28023/1-17, 28038/1). Samples LV4.5, LV7, LV12.8, ZEN22.

Remarks. A few elements referable to Baltoniodus cf. triangularis sp. were recorded in the Laguna Verde section. The denticulation is rudimentary, with wide and short denticles composed of white matter confluent at their bases. Diagnostic Pb elements have three costae extending towards the base and forming an anterior process, a lateral process and a posterior process. The latter diverges distally by a second node of growth.

Genus Gothodus Lindström, 1954

Type species. *Gothodus costulatus* Lindström, 1954; original designation.

Gothodus andinus Rao *et al*., 1994
Figures 2.7, 2.29

v. 1994. *Baltoniodus crassulus andinus*Rao *et al.*, p. 64–65, pl. 3, figs. 1–6, 13, 15; pl. 4, figs. 1–4, 6–8; pl. 7, fig. 9 (cum. syn.).

Material examined and occurrence. 43 M, 69 Pa, 40 Pb, 41 Sa, 44 Sb, 42 Sc, 98 Sd elements (CORD-MP 28001/1-5, 28005/1-2, 28013/1-3, 28024/1-2, 28033/1-2). Samples LV2, LV7, ZEN 17, ZEN17.2, ZEN22.

Remarks. This species occurs in the upper part of the *Oepikodus* evae-Zone in the Acoite and Cieneguillas formations at the Cordillera Oriental of Jujuy (Rao *et al.,* 1994) and the Suri Formation in the Famatina System, northwestern Argentina (Albanesi and Astini, 2000). *Gothodus andinus* differs from *G. costulatus* (Lindström) in having the basal sheath less developed, taller denticles, and Pb elements with a lateral external expansion.

Genus Trapezognathus Lindström, 1954

Type species. *Trapezognathus quadrangulum* Lindström, 1954, original designation

Remarks. Stouge and Bagnoli(1990) emended the diagnosis of the genus *Trapezognathus* and provided a detailed description of the seven morphotypes that compose the oral apparatus. *Trapezognathus? primitivus* n. sp. appears as the direct ancestor of *T. argentinensis* Rao *et al.* (1994), being differentiated mainly in the development of denticulation. Both species share M elements characterized by short and proclined cusps with a bulge on the inner side of the base, with a similar aspect to *Lenodus antivariabilis*; thus supporting the phylogenetic relationship of these genera (Löfgren and Zhang, 2003). Our species of *Trapezognathus?* seems to conform an independent Andean lineage, with the intrusion of Baltic/Chinese rooted species (*i.e., T. diprion*) at the upper range of *T. primitivus.* Elements of *Trapezognathus* may be difficult to distinguish from *Baltoniodus triangularis* when the preservation is not good, as observed by Bagnoli and Stouge (1997).

Trapezognathus? argentinensis Rao *et al.,* 1994
Figure 2.15–2.21

v. 1994. *Trapezognathus argentinensis* Rao *et al.,* p. 73, 75, pl. 3, figs. 7–12, 14, pl. 7, figs. 1–8.

2003. *Lenodus* sp. Bultynck and Sarmiento, p. 266, pl.2, figs. 12–13 (only).

Material examined and occurrence.1 M, 3 Pa, 1 Pb, 3 Sa, 13 Sb, 7 Sc, 10 Sd elements (CORD-MP 28025/1-12, 28029/1-5, 28034/1-21). Samples LV7, SANA1, ZEN22.

Emended diagnosis. Septimembrate apparatus of robust elements with long cusps and large basal sheath. M element presents a proclined short cusp with an inner flare on the base. P elements are robust, with short cusps and anterior, lateral and posterior processes partly denticulated. The S-series morphotypes exhibit long cusps, the anterior margin is folded towards the inner side of the elements and the posterior margin is weakly denticulated.

Type material.Holotype:Pb element, CORD-MP 1031/3, pl. 3, fig. 11, pl. 7, fig. 7; paratypes:Pb element, CORD-MP 1031/1, pl. 7, fig. 5 (illustrated in Rao *et al.,* 1994); All type specimens proceed from Rao's original collection, sample LC9, Acoite Formation, La Ciénaga, Cordillera Oriental, Northwestern Argentina.

Description. Pa element has a wide, proclined short cusp, with an anteriorly extended base, and lateral and posterior processes. The latter presents undulating ridges or rudimentary denticles confluent at their bases, which increase in size distally. The basal cavity is deep and covered by a large basal sheath that connects the distal part of the

processes and the posterior margin of the base. The anterior edge continues straight downwards and, from the junction of the cusp with the lateral process, forms a characteristic concavity to the posterior process on the base. Pb element has a proclined and relatively short cusp with three well developed processes, and a shorter postero-lateral one, connected by the basal sheath. The posterior process is the longest, and is covered by irregular to hindeodelliform, slightly convergent denticles, confluent at their bases. Juvenile specimens may exhibit sharper denticles than geronts. Denticles on the lateral process are incipient to rudimentary. The anterior edge extends beyond the aboral margin as a short adenticulate process. M element is characterized by having a short, proclined cusp and a base with an inner flare and keeled margins. Anterior margin longer than posterior margin; both edges may present small crenulations. The outline of the leading edge of the M element is convex to the anterior. Sa element is wide and may have incipient denticles on the lateral processes. The basal sheath is well developed between the lateral and posterior process; free processes are short. Sb element tends to form a trapezoid, with a denticulate posterior process whose upper margin is displaced to the outer side of the element (not medial). It presents a long cusp sculpted on the external side by a half keel that runs from the tip through the base of the element. The anterior margin is folded posteriorly, delineating an inner sulcus. Sc element is similar to the Sb element, but lacks the outer costa. Sd element is asymmetrical, recurved, with incipient denticles on the antero-lateral and postero-lateral edges.

Remarks. Weassign here the type material for *Trapezognathus argentinensisafter* revising the original collection of Rao *et al.* (1994). This species differs from other species of the genus (*e.g., T. diprion, T. quadrangulum*) by the more proclined and adenticulate M element and the less developed denticulation in the P and S-series elements.

Trapezognathus diprion Lindström, 1954

Figures 2.2–2.4

2010. *Trapezognathus diprion* (Lindström); Li *et al.*, p. 119–120, pl. 1, figs. 4–13 (*cum syn.*).

2013. *Trapezognathus diprion* (Lindström); Carlorossi and Heredia, p. 315, 317, fig. 3 (non C, D, E, I, J –basal fillings).

Material examined and occurrence. 4 M, 2 Pa, 1 Pb, 2 P, 2 Sa, 3 Sd elements (CORD-MP28001/1-5, 28005/1-2, 28013/1-3, 28024/1-2, 28033/1-2). Samples LV2, LV7, ZEN 17, ZEN17.2, ZEN22.

Remarks. P elements with the general appearance of *Trapezognathus diprion* Lindström were collected in the Laguna Verde site. M elements present chubby and erect cusps. A Pb element exhibits an anterior margin that is sub-rounded instead of keeled (Fig. 2.3).

Trapezognathus? primitivus n. sp. Voldman, Albanesi and Zeballo

Figure 2.8–2.14

Material examined and occurrence. 3M, 2 Pa, 1 Pb, 2 Sa, 3 Sb, 3 Sc, 3 Sd (CORD-MP28004/1-8, 28012/1-8). Samples ZEN 17, ZEN17.2.

Derivation of name. From Latin *primitivus*: primitive, indicating its appearance before the other species of *Trapezognathus*.

Diagnosis. Septimembrate apparatus with robust elements of short cusps.M element with proclined, short cusp and a bulging inner base. P elements have three processes and are robust, with wide cusps and keeled margins. The S-series morphotypes exhibit incipient denticulation mainly on the posterior margin, whereas the anterior margin is slightly folded towards the inner side of the elements.

Type material. Holotype: Pa element, CORD-MP 28012/1, fig. 2.10, sample ZEN17.2. Paratype: Pa element, CORD-MP28004/1, sample ZEN17. Acoite Formation, Cordillera Oriental (23°19'S, 65° 0'W), Northwestern Argentina.

Description. Pa element has a proclined, robust keeled cusp, which continues straight into a keeled oral margin with incipient denticles distally. The cusp is bisected by a lateral costa that extends across the base to form a sharp lateral process. Pb element has a proclined and sturdy cusp with three well developed sharp edges. The posterior process is long and adenticulated, but shows undulating sharp edges instead. The anterior edge continues nearly straight downwards but with a slight concavity to the posterior on the base, when seen in lateral view. The basal cavity is deep and covered by a large basal sheath that connects the three processes. The M element is characterized by a proclined short cusp, a planar-convex outer base and a strongly convex inner base. Anterior margin longer than posterior margin, both edges may have small crenulations. The symmetrical Sa element has a proclined cusp, two lateral sharp edges that constitute a convex anterior surface and a posterior sharp edge. Sb element has a short cusp and a long posterior process that may carry incipient denticles distally. A prominent costa runs medially from the tip of the cusp to the basal margin on the outer side of the element. The anterior margin is folded posteriorly, delineating an inner sulcus. The basal sheath is large,

whereas the basal cavity is deep. Sc element is similar to the Sb element except that it lacks the external costa. Sd element is asymmetrical and possesses a rhomboid-shaped cross-section, with incipient denticles on the antero-lateral and postero-lateral edges. It has a short and recurved cusp with deep basal cavity.

Remarks. Conodont elements of *Trapezognathus? primitivus* n. sp. are intimately related to *T.? argentinensis* Rao *et al.* in morphotype characteristics, but occur earlier in the time, showing a close relationship in the evolutionary lineage. It is distinguished by comparatively shorter cups and minor denticulation, and differs from other species of *Trapezognathus* because of its proclined M element. On the other hand, this new species differs from *Baltoniodus* early species by the particular morphology of the P elements and the general lack of denticulation.

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REFERENCES

Abaimova, G.P. 1971. New Early Ordovician conodonts from the southeastern part of the Siberian Platform.*Paleontological Journal* 5: 486–493.

Albanesi, G.L. and Astini, R. 2000. Nueva fauna de conodontes de la Formación Suri (Ordovícico Inferior-Medio), Sistema de Famatina, Argentina. *Resúmenes de la Reunión anual de comunicaciones de la Asociación Paleontológica Argentina*, Mar del Plata. *Ameghiniana* 37: 68R.

Albanesi, G.L. and Aceñolaza, G.F. 2005. Conodontes de la FormacionRupasca (Ordovicico Inferior) en el Angosto de Chucalezna, Cordillera Oriental de Jujuy: Nuevos elementos bioestratigraficos para una localidad clasica del noroeste Argentina. *Ameghiniana* 42: 295–310.

Albanesi, G.L., Ortega, G., Monaldi, C.R. and Zeballo, F.J. 2011. Conodontes y graptolitos del Tremadociano tardío (Ordovícico) de la sierra de Zenta, Cordillera Oriental de Jujuy, Argentina. *Ameghiniana* 48: 242–263.

An, T.X., Zhang, F., Xiang, W.D., Zhang, Y.Q., Xu, W.H., ZHang, H.J., Jiang, D.B., Yang, C.S., Lin, L.D., Cui, Z.T. and Yang, X.C. 1983. The Conodonts of North China and the Adjacent Regions.*Science Press, Beijing*, 223 p. (in Chinese with English abstract).

Aráoz, L., Aceñolaza, G.F., Vergel, M.M., Heredia, S., Tortello, F.M. and Milana, J.P. 2008. El Ordovícico del sector central de la sierra de Zenta (Sistema Interandino de las provincias de Jujuy y Salta): cronoestratigrafía y correlación. *XVII CongresoGeologicoArgentino* (Jujuy, 2008), Actas 1: 339–340.

Bagnoli, G. and Stouge, S. 1997. Lower Ordovician (Billingenian - Kunda) conodont zonation and provinces based on sections from Horns Udde, north Öland, Sweden. *Bollettino della Societa Paleontologica Italiana* 35: 109–163.

Bultynck, P. and Sarmiento, G.N. 2003.Reworked Ordovician and authocthonousSiluro-Devonian conodonts from Khemis-n'Ga (Moroccan Meseta) – Depositional, environmental, and paleogeographic implications.*Courier Forschunginstitut Senckenberg* 242: 257–283.

Carlorosi, J.M.T. and Heredia, S.E. 2013. The Ordovician conodont *Trapezognathus* Lindström, 1955 in the Andean Basin, Argentina. *NeuesJahrbuchfür Geologie und Paläontologie Abhandlungen* 267: 309–321.

Cooper, B.J. 1981. Early Ordovician conodonts from the Horn Valley Siltstone, Central *Australia Palaentology* 24: 147–183.

Epstein, A.G., Epstein, J.B. and Harris, L.D. 1977. Conodont color alteration - An index to organic metamorphism. *Geological Survey Professional Paper* 995: 1–27.

Li, Z., Stouge, S., Chen, X., Wang, C., Wang, X. and Zeng, Q. 2010. Precisely compartmentalized and correlated Lower Ordovician *Oepikodus Evae* Zone of the Fuluoian in the Huanghuachang Section, Yichang, Hubei Province. *Acta Palaeontologica Sinica* 49: 108–124.

Lindström, M. 1954. Conodonts from the Lowermost Ordovician Strata of South-Central Sweden.*Geologiska Föreningensi Stockholm Förhandlingar* 76: 517–604.

Lindström, M. 1971. Lower Ordovician conodonts of Europe. In: W.C. Sweet and S.M. Bergström (Eds.), Symposium on Conodont Biostratigraphy. *Memoirs of the Geological Society of America* 127: 21–61.

Löfgren, A. and Zhang, J. 2003. Element association and morphology in some Middle Ordovician platform-equipped conodonts.*Journal of Paleontology* 77: 721–737.

Pander, C.H. 1856. *Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements*. Buchdruckerei der Kaiserlichen Akademie der Wissenschaften, St. Petersburg, 91 p.

Rao, R.I., Hünicken, M.A. and Ortega, G. 1994. Conodontes y Graptolitos del Ordovícico Inferior (Tremadociano-Arenigiano) en el Área de Purmamarca, Provincia de Jujuy, Argentina. *Anais da Academia Brasileira de Ciencias* 66: 59–83.

Sergeeva, S.P. 1963. Conodonts from theLowerOrdovician of the Leningrad region. *Paleontologicheskiy Zhurnal*, Akademiya Nauk SSSR, 2: 93–108.

Stouge, S. and Bagnoli, G. 1990. Lower Ordovician (Volkhovian-Kundan) conodonts from Hagudden, northern Öland, Sweden. *Palaentographia Italica* 77: 1–54.