An Early Ordovician conodont fauna from the Santa Rosita Formation at its type area in the Santa Victoria Range, Cordillera Oriental, Northwestern Argentina

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ABSTRACT: The Cambrian - Lower Ordovician stratigraphic units from the Cordillera Oriental were originally defined in the Santa Victoria Range, Salta Province, northwestern Argentina, however, the extensive outcrops of this region lack detailed biostratigraphic studies. We describe and analyse the first reported conodont fauna from the Santa Rosita Formation at its type area, which produced significant biostratigraphic information. Over 4,500 well-preserved conodont elements were recovered from outcrops of the Santa Rosita Formation at the southern margin of the Santa Victoria River, near the homonymous locality. Collected specimens exhibit a CAI 3 and correspond to the *Paltodus deltifer deltifer* Subzone of the *P. deltifer* Zone (middle Tremadocian, Tr2). A number of species are described for the genera *Acanthodus, Acodus, Decoriconus, Drepanodus, Drepanoistodus, Filodontus, Granatodontus, Hammannodus, Iapetonudus, Kallidontus, Paltodus, Paroistodus, Teridontus*, *Tilcarodus*, *Utahconus*, *Variabiloconus*, Gen. and sp. indet., the protoconodont *Phakelodus* and the paraconodont *Coelocerodontus.* Two new conodont species, *Drepanoistodus andinus* Voldman, Zeballo and Albanesi and *Filodontus carolinae* Voldman, Albanesi and Zeballo, are diagnosed herein. The studied assemblages include conodont species of wide intercontinental distribution as well as endemic forms from the Central Andean Basin, which characterize a faunal province with a particular signature from the Shallow Water Realm.

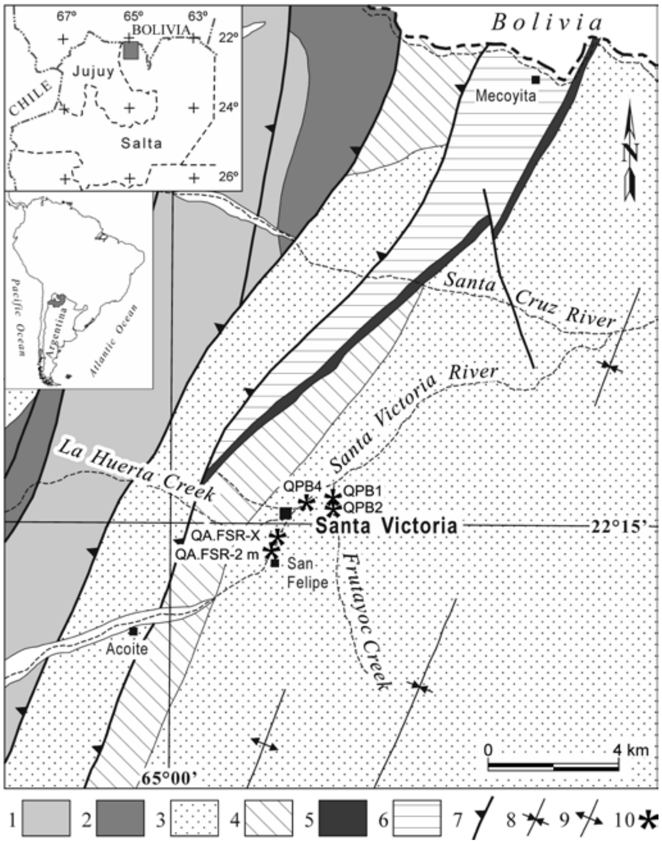
INTRODUCTION

Thick sedimentary sequences accumulated in the Central Andean Basin, which was a retroarc foreland basin established along the western margin of Gondwana during the lower Paleozoic (Benedetto et al. 1992). In the Cordillera Oriental of northwestern Argentina, sedimentary deposition took place along ramp platforms arranged over a large forebulge area (Astini 2003). The Cambrian - Lower Ordovician stratigraphic units from the Cordillera Oriental were traditionally assigned to the Santa Victoria Group (Turner 1964), one of the classical lower Paleozoic units of northwestern Argentina. This group encompasses the Santa Rosita Formation (Turner 1960) and the Acoite Formation (Harrington and Leanza 1957), originally defined in the Santa Victoria Range, Salta Province, NW Argentina.

The Santa Rosita Formation reaches up to a maximum thickness of 2,300 min its type area (Turner 1960), yet detailed stratigraphic studies of the succession in the Santa Victoria Range are lacking. It presents a complex depositional history, characterized by a wide range of sedimentary environments, which are represented by fluvial, tide-dominated, estuarine, and wave dominated shallow-marine lithofacies. Buatois et al. (2006) provided a detailed stratigraphic and paleoenvironmental analysis of the Santa Rosita Formation and equivalent units in the Tilcara Range and Alfarcito Hills, on the eastern flank of the Quebrada de Humahuaca at the Alfarcito area. For this region, Buatois et al. (2006) divided the Santa Rosita Formation into six members: Tilcara, Casa Colorada, Pico de Halcón, Alfarcito, Rupasca and Humacha. Each member represents transgressive-regressive cycles of different magnitude. The Tilcara and Pico de Halcón members were deposited in fluvio-estuarine environments and the remaining units were deposited under open sea conditions, in a shallow-water platform setting.

The Santa Rosita Formation contains a rich fossil fauna including conodonts, graptolites, trilobites, brachiopods, gastropods, bivalves, cephalopods, echinoderms, ostracods, and acritarchs (e.g., Harrington and Leanza 1957; Manca et al. 1995; Brussa et al. 2003; Rubinstein et al. 2003; Waisfeld and Vaccari 2003, 2008; Zeballo et al. 2005a, b; Albanesi et al. 2008; Zeballo and Albanesi 2013a). Currently, a Furongian to middle Tremadocian (TR2) age of the Santa Rosita Formation is well constrained. However, the Cambrian-Ordovician boundary establishment remains elusive due to unfavorable facies or tectonic suppression affecting the stratigraphic successions. Despite the fact that the Santa Rosita Formation was defined in the Santa Victoria Range, the extensive outcrops of this region lack detailed stratigraphic studies and the members of the Santa Rosita Formation were not yet recognized. The purpose of this contribution is to introduce and describe the first conodont records from the Santa Rosita Formation at its type area, in a preliminary approach to reconstruct the complex stratigraphy of the Santa Victoria Range.

A series of 15 conodont samples (34 kg), each weighting 2-3 kg, from the Santa Rosita Formation were processed in 10% acetic acid solution following the standard techniques described by Stone (1987). The samples were collected from sections at the southern margin of the Santa Victoria River, near the homonymous locality, as well as from the Peña Blanca Creek, on the path that connects Santa Victoria with Mesón, and from



TEXT-FIGURE 1
Geological map of the Santa Victoria area (after Rubiolo et al. 2001). 1: Puncoviscana Formation, 2: Mesón Group, 3: Santa Rosita Formation; 4: Acoite Formation; 5: Mecoyita Formation; 6: Lipeón Formation; 7: reverse fault; 8: sinclinal fold; 9: anticlinal fold; 10: fossiliferous point.

the San Felipe Creek, near the Acoite locality (Figure 1). Only five of the 15 digested samples were productive, yielding over 4,500 conodont elements. The specimens are well preserved and exhibit a conodont Color Alteration Index (CAI) of 3, which accounts for burial paleotemperatures ranging from 110°-200°C (Esptein et al. 1977). The studied specimens are housed under the repository code CORD-MP 21727 up to 21940 in the Museo de Paleontología, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba, Argentina.

GEOLOGICAL FRAMEWORK

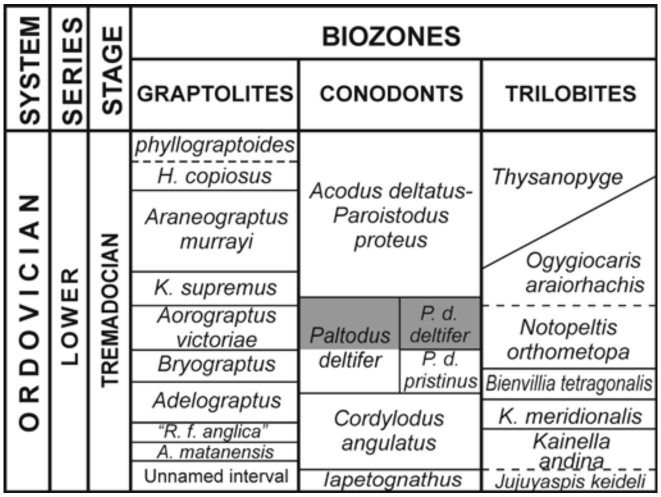
The analyzed area is located in northernmost Salta Province, Argentina, close to the border with Bolivia, on the eastern flank of the Santa Victoria Range. This orographic unit represents the northeasternmost part of the Cordillera Oriental in northwestern Argentina. The geology of this range was described in diverse articles from the late 19th Century until recently (e.g. Brackebusch 1883; Hausen 1925, 1930; Nesossi 1953; Turner 1960, 1964; and Rubiolo et al. 2001). The stratigraphic succession initiates with Neoproterozoic – lower Cambrian basement, which consists of greenish-gray to purple slates, greenschists, quartzites, and metagraywackes, folded and low grade metamorphic rocks that are assigned to the Puncoviscana Formation. This unit is unconformably overlain by quartzites and sandstones which are alternatively gray, green, and purple in colour, with cross stratification and trace fossils (dominantly *Skolithos* sp.), belonging to the late Cambrian Mesón Group. This succession is followed by gray to greenish-gray sandstones, siltstones and shales that correspond to the Santa Victoria Group (Furongian – Lower Ordovician). The stratigraphic succession ends up with dark gray diamictites of the Mecoyita Formation (Upper Ordovician), which are covered by grayish micaceous siltstones of the lower Silurian Lipeón Formation.

The fossil fauna described herein was collected in neighbouring localities of Santa Victoria town, where one of the classical profiles of the Lower Ordovician of northwestern Argentina is located. After the original designation by Turner (1960), the Santa Victoria Group consists of the Santa Rosita (Turner 1960) and Acoite formations (Harrington; in Harrington and Leanza 1957, page 8), of late Cambrian-Tremadocian and Floian age, respectively. The Santa Rosita Formation is made up of dark shales and interbedded sandstones, wackestones and siltstones of greenish gray colour. Calcareous coquina lenses are sparsely interestratified through the siliciclastic succession. A thorough analysis and interpretation of the mostly shelfal environments of the six members that comprise the formation was carried out by Buatois et al. (2006) in different sections that are exposed along the Quebrada de Huamahuaca area in the central part of the Cordillera Oriental. The overlying Acoite Formation is composed of greenish gray and yellowish shales and siltstones that intercalate with fine sandstones and isolated levels of coquinas. The lighter colours of these rocks and the less resistant morphological expression in the topographic profile allow for identifying the Acoite Formation from the adjacent units.

CONODONT BIOSTRATIGRAPHY

The *Paltodus deltifer* Zone was originally defined by Lindström (1971) in the Baltoscandian region and subsequently refined by Löfgren (1996, 1997a) into two subzones: *Paltodus deltifer pristinus* (lower) and *Paltodus deltifer deltifer* (upper), which correspond to the whole Tremadocian TR2 stage slice (Bergström et al. 2009). Both subzones are distinguished exclusively by the presence of the eponymous subspecies, as well as the absence of the genera *Paroistodus* in the lower subzone and *Cordylodus* in the upper subzone. In the Central Andean Basin, the *Paltodus deltifer* Zone is mostly correlative with the *Bienvillia tetragonalis* and *Notopeltis orthometopa* trilobite zones, and the *Adelograptus, Bryograptus kjerulfi, Aorograptus victoriae*, and *Kiaerograptus supremus* graptolite zones (Ortega and Albanesi 2005; Albanesi et al. 2008; Zeballo et al. 2008, 2009).

Complete apparatuses and diagnostic elements of *Paltodus deltifer deltifer* (Lindström 1955) were recovered from the Peña Blanca and San Felipe sections in Santa Victoria, along with *Acanthodus humachensis* Zeballo and Albanesi (2013a), *Acodus primitivus* Zeballo and Albanesi (2013a), *Decoriconus peselephantis* (Lindström 1955), *Drepanodus arcuatus* Pander (1856), *Drepanoistodus chucaleznensis* Albanesi and Aceñolaza (2005), *D. andinus* n. sp. Voldman, Zeballo and Albanesi, *Filodontus carolinae* n. sp. Voldman, Albanesi and Zeballo, *Kallidontus gondwanicus* Zeballo and Albanesi (2013a), *Paltodus deltifer peracutus* (Lindström 1955), *Paroistodus numarcuatus* (Lindström 1955), *Utahconus purmamarcensis* Zeballo and Albanesi (2013a), *U. scandodiformis* Zeballo and Albanesi (2013a), *Variabiloconus variabilis* (Lindström 1955) and the long-ranging protoconodonts *Phakelodus elongatus* (Zhang in An et al. 1983) and *Ph. tenuis* (Müller 1959). The studied conodont assemblage corresponds to the *Paltodus*



TEXT-FIGURE 2
Biostratigraphic chart of the Tremadocian from northwestern Argentina. The gray interval corresponds to the analyzed conodont zone (modified from Zeballo and Albanesi 2013a).

d. deltifer Subzone and is considered, following the recent chronostratigraphic chart of Bergström et al. (2009), to be of late early Tremadocian age (TR2) (Figure 2). The assemblages include elements of wide intercontinental distribution as well as endemic forms from the Central Andean Basin, characteristics of the Southwestern Gondwana Province from the Cold Domain in the Shallow-Sea Realm (Zeballo and Albanesi 2013b).

A conodont fauna belonging to the *Paltodus deltifer pristinus* Subzone was previously recorded by Albanesi and Aceñolaza (2005) in the lower Ruspasca Member of the Santa Rosita Formation at Angosto de Chucalezna Creek. The strata include abundant trace fossils, trilobites, brachiopods, and fragments of the echinoderm *Macrocystella* sp. Tortello and Rao (2000) reported a conodont fauna that consists of *Semiacontiodus nogami* (Miller 1969) and *Acanthodus lineatus* (Furnish 1938) from the base of the Saladillo Formation at the Angosto de Lampazar Creek. However, those elements actually correspond to *Utahconus purmamarcensis* and *Acanthodus raqueli* Zeballo and Albanesi (2013a), a typical association from the *Paltodus deltifer pristinus* Subzone from the Cordillera Oriental (Zeballo and Albanesi 2013a, b). Conodonts from this subzone have also been retrieved from the Bordo Atravesado Formation in the Famatinian Volcanic Arc System, La Rioja Province (Albanesi et al. 2005). The fauna consists of *Paltodus deltifer pristinus* (Viira 1970), *Cornuodus longibasis* (Lindström 1955), *Drepanodus arcuatus*, *Paltodus subaequalis* Pander (1856), *Paroistodus numarcuatus* and *Rossodus manitouensis* Repetski and Ethington (1983). In the southern outcrops of the Cuyania (Precordillera) composite terrane at La Pampa Province, Albanesi et al. (2003) inferred the occurrence of the *Paltodus deltifer pristinus* Subzone in the middle part of the San Jorge Formation by means of the coexistence of *Acanthodus lineatus*, *Cordylodus angulatus* Pander (1856), *Diaphorodus delicatus* (Branson and Mehl 1933), *Loxodus bransoni* Furnish 1938, *Ventricodus spurius* (Ethington and Clark 1981), *Semiacontiodus iowensis* (Furnish 1938), *Toxotodus carlae* (Repetski 1982), *Colaptoconus quadraplicatus* (Branson and Mehl 1933) and *Variabiloconus bassleri* (Furnish 1938).

In the Cordillera Oriental, the *Paltodus d. deltifer* Subzone has been recorded through the top of the Rupasca Member and the Humacha Member of the Santa Rosita Formation at the Casa Colorada, Chucalezna, El Arenal and San Gregorio creeks as well as from the Coquena Formation, around Purmamarca city (Zeballo et al. 2008; Zeballo 2011). The conodont fauna comprises specimens documented in the Santa Victoria area. Bultynck and Martin (1982) reported the presence of *Acodus deltatus* Lindström (1955) at the Coquena Creek but those elements actually correspond to *A. primitivus* Zeballo and Albanesi (2013a), an ancestral form of the same genus probably restricted to the *Paltodus d. deltifer* Subzone. Manca et al. (1995) identified the *Paltodus deltifer* Zone in the Santa Rosita Formation at Nazareno, 40 km to the southeast of Santa Victoria. A recent revision of the latter collection allowed for identifying the *Paltodus deltifer deltifer* Subzone, with the eponymous taxon along with *Phakelodus elongatus* and *Utahconus scandodiformis* as the main constituents of the fauna. New conodont collections from the Alfarcito and Rupasca members at Nazareno reveal the presence of the lower and upper subunits of the *Paltodus deltifer* Zone in the area (Giuliano et al. 2013). Rao and Flores (1998) sampled calcareous strata from the siliciclastic mineralized succession exposed at Río Blanco, in the Aguilar Range, and yielded conodonts from the upper *Paltodus deltifer* Zone, including *Paltodus d. deltifer*, *P.* cf. *inaequalis* (Pander 1856), *Drepanodus* sp., *Drepanoistodus* sp., *Paroistodus numarcuatus*, *Teridontus* cf. *gracillimus* Nowlan (1985), *Teridontus* cf. *nakamurai* (Nogami 1967), and *Utahconus* sp.

In the Argentine Precordillera, transported conodont assemblages referable to the *P. deltifer* Zone were recovered from slope sedimentary sequences that crop out in the western domain (Voldman et al. 2009). These assemblages include the typical species from the shallow, warm-water domain (*Scolopodus floweri* Repetski (1982), *S. krummi* (Lehnert 1995), and *Colaptoconus quadraplicatus*) and the open, cold-water domain (*P. deltifer, Drepanodus arcuatus,* and *Paroistodus numarcuatus*). Coeval autochthonous platform carbonates, which crop out in the Central Precordillera (La Silla Formation), represent a shallow platform covered by extensive peloidal sand flats and low-relief banks mostly barren of fossils (Pratt et al. 2012). The conodont association from this facies is characterized by Laurentian species, such as *Parapanderodus striatus* (Graves and Ellison 1941), *Scolopodus floweri*, and *Colaptoconus quadraplicatus* (Lehnert 1995; Albanesi et al. 1998).

The *P. deltifer* Zone has an extensive world geographic distribution, with well-documented records in the cold-water successions of Baltica and Gondwana, as recognized in Sweden (Lindström 1971; Wamel 1974; Bagnoli et al. 1988; Löfgren 1997a), Estonia (Viira 1970; Viira et al. 2001), Poland (Szaniawski 1980), Latvia (Dubinina 1983), Spain (Álvaro et al. 2007; Serpagli et al. 2007, 2008), Russia (Tolmacheva 2001) and China (Zhen et al. 2007, and references therein). In North America, it correlates with the "Low Diversity Interval", defined by Ethington and Clark (1981) and discussed by Ethington et al. (1987), and the overlying *Macerodus dianae* Zone established by Ross et al. (1997), which straddles the *Ceratopyge* regressive event and integrates the Stairsinian of the Ibexian Series. Landing et al. (2007) recovered specimens of *Paroistodus numarcuatus, Variabiloconus variabilis, Filodontus filosus* (Ethington and Clark 1964), and early representatives of *Drepanodus arcuatus*, together with the eponymous form of the *Paltodus deltifer deltifer* Subzone in the Mexican Tiñú Formation, although the authors correlated the faunal association with the *Rossodus manitouensis* Zone, upper Skullrockian, of the Ibexian Series.

Other reports of coeval conodont faunas from North America were documented by Ji and Barnes (1994) from the Saint George Group, western Newfoundland, and Pyle and Barnes (2002) from the Canadian Rocky Mountains in northeastern British Columbia.

SYSTEMATIC PALEONTOLOGY

The terminology used for the location of elements within apparatuses of conodonts follows the morphotype designations after Sweet (in Clark et al. 1981) that include P, M, and S elements and their subdivisions. Conodont elements that require no revision are not discussed further in this report.

Euconodonts

Genus ***Acanthodus*** Furnish 1938
Type species: Acanthodus uncinatus Furnish 1938, original designation.

Discussion: An emended diagnosis for *Acanthodus* was recently provided by Zeballo and Albanesi (2013a), who proposed a seximembrate apparatus for the genus that consists of acanthodiform (Sb-Sc-Sd), drepanodiform (M), scandodiform (P), and suberectiform elements (Sa). Each morphotype may exhibit a wide variability in the inclination of the cusp, yet retaining the outline of the base.

Acanthodus humachensis Zeballo and Albanesi 2013a
Plate 1, figures 15-20

Acanthodus humachensis n. sp. ZEBALLO AND ALBANESI 2013a, p. 9, fig. 7: H-N, fig. 9: P-AB.

Material examined: 1,978 elements (CORD-MP 21733, 21737, 21743, 21754-21759, 21814-21817, 21820-21822, 21876-21882, 21905, 21908, 21912-21917): 384 M, 284 P, 159 Sa, 166 Sb, 342 Sc, 183 Sd, 19 S, 441 unassigned elements.

Occurrence: Samples QA.FSR-2m (8 elements), QA.FSR X (19 elements), QPB1 (1 element), QPB2 (1757 elements), QPB4 (193 elements).

Discussion: This species was described by Zeballo and Albanesi (2013a) from beds of the Santa Rosita Formation (*P. deltifer* Zone), which crop out at the Humacha Creek, 15 km to the north of Tilcara. Statistics morphotype relationships indicate a multielement apparatus composed of 2 M : 2 P : 1 Sa : 1 Sb : 2 Sc : 1 Sd.

***Acanthodus* sp.**
Plate 1, figure 11

Material examined: 1 element (CORD-MP 21770): 1 S.

Occurrence: Sample QPB2 (1 element).

Discussion: The single specimen recovered is an acanthodiform element, symmetrical, hyaline, bilaterally compressed, with long base and deep basal cavity. The angle between the posterior margin of the cusp and the upper margin of the base is ~90°. The cusp section is rhomboidal, with acute anterior and posterior margins, whereas the outline of the basal margin is circular. The antero-basal region and the oral surface are rounded, but surmounted by very low sharp keels that project from the anterior and posterior margins of the cusp, respectively.

Genus ***Acodus*** Pander 1856
Type species: Acodus erectus Pander 1856, original designation.

Discussion: Despite the fact that the original specimens of the type material are lost, the multielement genus *Acodus* is deeply rooted in the Ordovician conodont literature. Albanesi et al. (2011) emended the diagnosis of the genus with material from the Zenta Range and the Incamayo area, Cordillera Oriental of Argentina. The apparatus is composed of seven morphotypes: Pa (acodiform/prioniodiform), Pb (gothodiform), M (oistodiform, non-geniculate) and the S series (coniform/branching, with up to four processes).

Acodus primitivus Zeballo and Albanesi 2013a
Plate 2, figures 12, 15

Acodus primitivus n. sp. ZEBALLO AND ALBANESI 2013a, p. 20-21, fig. 6: J-P, fig. 10: A-G.

Material examined: 30 elements (CORD-MP 21763, 21857-21860, 21933): 11 Pa, 4 Pb, 2 Sa, 13 Sb.

Occurrence: Samples QPB2 (27 elements), QPB4 (3 elements).

Discussion: The current specimens are in agreement with the description and illustration of the type material from Huacalera (Tilcara Department), located 50 km to the south of the Santa Victoria area. These include small acodiform (Pa) and gothodiform (Pb) elements with suberect to proclined cusps and lateral costae on the external side and symmetrical–asymmetrical specimens from the S-series.

Genus DECORICONUS Cooper 1975
Type species: *Paltodus costulatus* Rexroad 1967.

Decoriconus peselephantis (Lindström 1955)
Plate 2, figure 16

Scolopodus? *peselephantis* n. sp. LINDSTRÖM 1955, p. 595, pl. 2, figs. 19-20, text-fig. 3: q. – VIIRA 1974, p. 124, fig. 162: a-g. – SZANIAWSKI 1980, p. 116- 117, pl. 18, figs. 3-4.– ETHINGTON and CLARK 1981, p. 102-103, pl. 11, fig. 26.
Scolopodus peselephantis Lindström – ALBANESI 1998, p. 132-133,pl. 12, figs. 31-33.
non *"Scolopodus" peselephantis Lindström* – NOWLAN 1981, p. 13, pl. 5, figs. 10, 11.
*Decoriconus peselephantis (*Lindström) – LÖFGREN 1998, p. 342-344, fig. 2: m-r, fig. 3: k, p, r, fig. 4: a-g, o, p (cum. sym.). – TOLMACHEVA, HOLMER, POPOV and GOGIN 2004, fig. 6: i.– LÖFGREN, VIIRA and MENS 2005, fig. 5: s.

Material examined: 13 elements (CORD-MP 21729, 21767, 21853, 21936, 21940).

Occurrence: Samples QA.FSR-2m (1 element), QPB2 (9 elements) and QPB4 (3 elements).

Discussion: Our specimens fit well with the description and revision of the species based on the material from the Tremadocian *Paltodus deltifer* Zone of Sweden (Löfgren 1998). The state of preservation of our conodont elements allows observing the transitional zone between the albid cusp and the hyaline material surrounding the basal cavity. This zone constitutes a straight line that reaches the anterior margin of the cusp at angle of about 90 degrees, as noted by Löfgren (1998) in the Lower Ordovician collections from Sweden. Szaniawski (1980) found Tremadocian specimens from the Holy Cross Mountains (Poland) completely devoid of striations, while Viira (1974) noted the absence of striations in some specimens of her collection. The illustrated specimens of Ethington and Clark (1981) and Albanesi (1998) also lack striations at microscope magnifications, in contrast with our specimens from Santa Victoria. This fact may be regarded as intraspecific variations. Specimens of "*Scolopodus" peselephantis* described by Nowlan (1981) are probably elements of *D. pesequus Löfgren*.

Genus ***Drepanodus*** Pander 1856
Type species: Drepanodus arcuatus Pander 1856.

Drepanodus arcuatus Pander 1856
Plate 3, figures 19-21

Drepanodus arcuatus n. sp. PANDER 1856, p. 20, pl. 1, figs. 2, 4, 5, 17. – DZIK 1994, p. 68–70, pl. 15, figs. 2-6, text-fig. 8: a-b. – LÖFGREN and TOLMACHEVA 2003, p. 211-215, fig. 2: a-q, fig. 3: a-c, e-h, fig. 5: k-v, fig. 6: m-u, fig. 7: h-n, fig. 8 a-g (cum syn.). – ZHEN, WANG, ZHANG, BERGSTRÖM, PERCIVAL and CHENG 2011, p. 222, fig. 10: A-N.

Material examined: 12 elements (CORD-MP 21781, 21883-21887, 21939): 2 M, 2 Pa, 2 Pb, 2 Sa, 2 Sb, 2 Sc.

Occurrence: Samples QPB2 (11 elements), QPB4 (1 element).

Discussion: Löfgren and Tolmacheva (2003) provided a thorough review and proposed a septimembrate apparatus for *Drepanodus arcuatus* and taxonomically related species. They incorporated all morphotypes previously noted by Dzik (1994) but with different locations in the apparatus. Our early forms of *D. arcuatus* include M, P and S elements, following the scheme given by Löfgren and Tolmacheva (2003).

Drepanodus reclinatus? (Lindström 1955)
Plate 3, figure 18

Acontiodus reclinatus n. sp. LINDSTRÖM 1955, p. 548, pl. 2, figs. 5-6, text-fig. 3: C.
Drepanodus reclinatus (Lindström) – LÖFGREN and TOLMACHEVA 2003, p. 216-217, fig. 5: A-J, fig. 7: A-G (cum. syn.). – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 11. – ZHEN, WANG, ZHANG, BERGSTRÖM, PERCIVAL and CHENG 2011, p. 222, fig. 11: A-P.

Material examined: 4 elements (CORD-MP 21732, 21894).
Occurrence: Samples QA.FSR-2m (1 element), QPB2 (3 elements).

Discussion: A few specimens probably referable to *Drepanodus reclinatus* were recovered from the Santa Rosita Formation. These include elements of large size that resemble *D. arcuatus* but are laterally costate. The small collection precludes a confident determination.

Genus ***Drepanoistodus*** Lindström 1971
Type species: *Oistodus forceps* Lindström 1955.

Discussion: Drepanoistodus was fairly common and widely distributed during the Ordovician, with nearly 30 species names proposed in the conodont literature. These simple coniform elements were often inadequately documented. Zhen et al. (2007) thoroughly revised drepanoistodontid conodonts from the Early Ordovician Honghuayuan Formation of Guizhou, South China, and suggested a seximembrate or septimembrate apparatus. Generally, the oistodiform element serves as diagnostic in the apparatus of *Drepanoistodus*, because elements from the symmetry transition series tend to exhibit homeomorphism.

Drepanoistodus chucaleznensis Albanesi and Aceñolaza 2005
Plate 4, figures 1-6

? *Drepanodus conulatus* n. sp. LINDSTRÖM 1955, p. 561, pl. 2: 34, pl. 4: 34 (Sd?).
? *Drepanoistodus conulatus* (Lindström) – WAMEL 1974, p. 63-64, pl. 3: fig. 4 (Sd?).
Drepanoistodus n. sp. A. ZEBALLO, ALBANESI and ORTEGA 2005a, p. 54, 56, figs. 4: G-K.
Drepanoistodus chucaleznensis n. sp. ALBANESI and ACEÑOLAZA 2005, p. 301-302, fig. 4: a-f. – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 21. – ZEBALLO, ALBANESI and ORTEGA 2011, fig. 3: 13.

Material examined: 120 elements (CORD-MP 21730, 21735, 21789-21794, 21888-21893, 21928-21932): 18 M, 14 P, 17 Sa, 29 Sb, 21 Sc, 21 Sd.

Occurrence: Samples QA.FSR-2m (1 element), QA.FSR-X (16 elements), QPB2 (97 elements), QPB4 (6 elements).

Description: The diagnostic element of *Drepanoistodus chucaleznensis* is a non-geniculate oistodiform (M element) with reclined cusp and triangular base in lateral view. It presents keeled anterior, posterior and oral margins. The inner flank is convex, bounded by two separated grooves towards the anterior and posterior margins. The scandodiform (P) element is characterized by an expanded bell-shaped base with the inner flank slightly depressed towards the anterior margin. The S-series includes conodonts with keeled anterior and posterior margins with biconvex to planar-convex lateral margins.

Discussion: Landing and Fortey (2011) emended the diagnosis of *Scandodus* to include longitudinally microstriated elements arranged in a gradational coniform shape transition consisting of drepanodiforms, suberectiforms, and primarily non-geniculate oistodiforms. These authors reassigned *Drepanoistodus chucaleznensis* to *Scandodus* mainly on the presence of a modified oistodiform element (see Albanesi and Aceñolaza 2005, fig. 4D). However, the generic assignment to *Drepanoistodus* is supported by the presence of a symmetrical suberectiform Sa element and by the presence of an oistodiform element that, although it is not typically geniculated, it is not morphologically transitional into the other elements of the apparatus as proposed for *Scandodus*. Previously, Wamel (1974) referred the oistodiform type-species of the form genus *Scandodus*, *Scandodus furnishi* Lindström, to *Drepanoistodus*, taking into account the shape of the base and its orientation with regard to the cusp. However, Wamel (1974) erroneously determined *Paltodus* Pander 1856 and *Scandodus* Lindström 1955 as synonyms of *Drepanoistodus*, since the former generic names have nomenclatural priority (Bergström in Clark et al. 1981). Alternatively, it has been proposed that ancient species of *Drepanoistodus* may lack a true oistodiform (e.g., *Drepanoistodus pervetus* Nowlan 1985). The form species *Drepanodus conulatus* Lindström 1955 probably constitutes the Sd element in the multielement *Drepanoistodus chucaleznensis*, as observed in our collections. On the other hand, *D. chucaleznensis* resembles *D. concavus* (Branson and Mehl), following the descriptions of Kennedy (1980) and Ji and Barnes (1994), but with slight differences in the symmetry transition series and, particularly, in the P scandodiform. *Drepanoistodus chucaleznensis* probably developed from *Drepanoistodus alfarcitensis*, given the stratigraphic records and the similar configuration of the oral apparatuses, being distinguished by its larger elements and higher amounts of albid material (Zeballo et al. 2005a; Zeballo 2011). Ultimately, no microstriae were observed on the surfaces of the elements, in contrast to *Scandodus avalonensis*.

Drepanoistodus andinus Voldman, Zeballo and Albanesi **n. sp.**
Plate 4, figures 7-14

Drepanoistodus concavus (Branson and Mehl) – JI and BARNES 1994, p. 34-35, pl. 7, figs. 1, 5-7 (only). – PYLE and BARNES 2002, p. 62, pl. 6, figs. 1, 3–4 (only, not 2). – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 20.
Drepanodus? cf. *concavus* (Branson and Mehl) – LÖFGREN 1997a, figs. 5: K-O (only, not J).
cf. *Drepanoistodus* cf. *nowlani* Ji and Barnes – ZHEN, PERCIVAL, LÖFGREN and LIU 2007, p. 132-134, pl. 2, figs. 1-21, pl. 3, figs. 1-9.

Etymology: From the Andes.

Types: Holotype: oistodiform element, CORD-MP 21797/1 from sample QPB2; paratypes: oistodiform elements CORD-MP 21797/2, 21797/3 from same sample, Peña Blanca Creek, Santa Victoria, Salta, Northwestern Argentina.

Stratotype: Sample QPB2, Santa Rosita Formation, Peña Blanca Creek (22º 14´ 38" S, 64º 57´ 11"W), Santa Victoria, Salta, Northwestern Argentina.

Material examined: 184 elements (CORD-MP 21797-21802, 21895-21900, 21928-21932): 37 M, 61 P, 2 Sa, 30 Sb, 23 Sc, 31 Sd.

Occurrence: Samples QPB2 (178 elements), QPB4 (6 elements).

Diagnosis: A seximembrate species of *Drepanoistodus* where the cusp of the oistodiform element is evenly reclined and strongly laterally compressed, with sharp edges and the inner flank planar-concave and the outer flank convex. The base is short, posteriorly extended with subquadrangular to subtriangular shape. The angle between the inner lateral margin of the cusp and oral margin ranges from 60-80°. Drepanodiform elements form a well-developed symmetry transition series from symmetrical Sa element with the base posteriorly expanded and asymmetrical Sd with a slightly twisted cusp. P elements are characterized by an extended, acute antero-basal corner. All these elements are commonly robust and hyaline.

Description: The oistodiform (M element) possesses a prominent keeled cusp evenly curved, strongly laterally compressed, with the anterior edge slightly bent towards the inner side of the element that results in a concave-planar inner margin and a convex outer margin. The anterior keel extends to the antero-basal corner, and the posterior keel meets the oral margin of the base at angle around 60-80°. The oral margin is short and sharp. It meets the aboral margin with an angle of around 60°. The base is subtriangular to occasionally subquadrangular. The Sa element is symmetrical, with laterally compressed cusp, sharp anterior and posterior edges, and smooth lateral faces. The base is posteriorly expanded. The Sb element is asymmetrical, keeled, with a much more convex outer lateral face and the cusp broadly curved posteriorly. The Sc element is subsymmetrical, with large recurved cusp and posteriorly extended base. Cusp more strongly compressed laterally among all elements of the apparatus, with the anterior part of the base laterally compressed forming a thin sheet. The Sd element is slightly asymmetrical with recurved cusp and anteriorly extended, compressed antero-basal corner inwardly curved. The oral margin is sharp, straight, and of medium length. P element asymmetrical, with the anterior flank inwardly deflected. Cusp suberect to slightly proclined, sharp keeled, slightly twisted inwards. Base oval and strongly flared laterally.

Discussion: The elements assigned by Zhen et al. (2007) to *Drepanoistodus* cf. *nowlani* from the Early Ordovician Honghuayuan Formation of Guizou, South China, are notably similar to *Drepanoistodus andinus* n. sp. They present an equivalent multielement structure despite being arranged in a different way (Pa-Pb elements of *Drepanoistodus* cf. *nowlani* would correspond to the Sd element of *D. andinus*). The main differences among these taxa arise from the shapes of the oistodiform elements. In particular, the angle located between the inner lateral margin of the cusp and oral margin ranges

PLATE 1

Conodonts from the Santa Victoria Formation. All scales represent 0.1mm. All specimens are from sample QPB2.

1-10, 14. *Filodontus carolinae* n. sp. Voldman, Zeballo and Albanesi

- 1-2 CORD-MP21744/1, Sa element, postero-lateral and lateral views.
- 3 CORD-MP21745/1, Sb element, upper view.
- 4 CORD-MP21745/2, Sb element, lateral view.
- 5 CORD-MP21746/1, Sc element, lateral view.
- 6 CORD-MP21747/1, Sd element, upper view.
- 7 CORD-MP21747/2, Sd element, lateral view.
- 8 CORD-MP21748/1, M element, lateral view.
- 9 CORD-MP21749/1, P element (paratype), upper view.
- 10 CORD-MP21749/2, P element (holotype), lateral view.
- 14 CORD-MP21749/3, P element (paratype), lateral view.

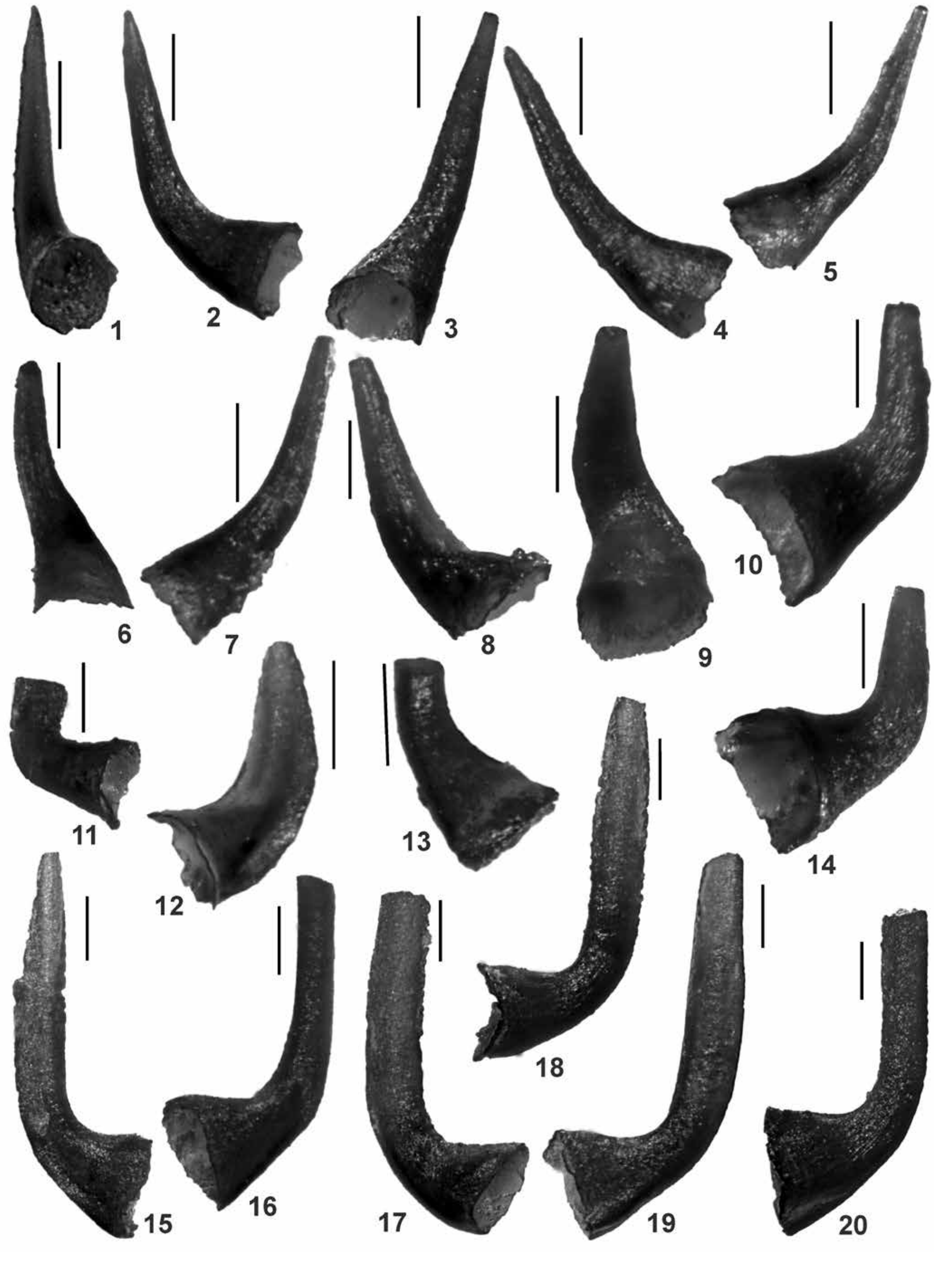
11 *Acanthodus* sp., CORD-MP21770/1, lateral view.

12 *Tilcarodus* sp., CORD-MP21774/1, Sb element, lateral view.

13 *Teridontus* cf. *gallicus* Serpagli et al. 2008, CORD-MP21771/1, lateral view.

15-20 *Acanthodus humachensis* Zeballo and Albanesi 2013a.

- 15 CORD-MP21758/1, M element, lateral view.
- 16 CORD-MP21755/1, Sb element, lateral view.
- 17 CORD-MP21756/1, Sc element, lateral view.
- 18 CORD-MP21754/1, Sa element, lateral view.
- 19 CORD-MP21757/1, Sd element, lateral view.
- 20 CORD-MP21759/1, P element, lateral view.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from 30-60º in *Drepanoistodus* cf. *nowlani*, whereas it ranges from 60-80º in *D. andinus*. The element morphotypes of *D. andinus* are also very similar to the corresponding elements of *D. chucaleznensis* Albanesi and Aceñolaza (2005), but the latter species is characterized by *non*-geniculate oistodiforms instead, as occurs in *D. pervetus*. The M element of *D. lucidus* Stouge and Bagnoli (1988) is distinguished from *D. andinus* by having a straight anterior margin, a subquadratic to rhombohedral base with an almost right antero-basal angle, and the posterior part of the aboral margin and the cusp parallel, among other differences.

On the other hand, the lectotype of *Oistodus concavus* Branson and Mehl (1933) from the Jefferson City Formation of Missouri presents a high resemblance to the Sd element of *D. andinus* (Branson and Mehl 1933, pl. 4, fig. 6; Kennedy 1980, pl. 1, fig. 26) with respect to the compressed and extended antero-basal corner and the basal cavity more expanded to the outer side. However, *O. concavus* (arcuatiform element in the multielement apparatus of *Drepanodus concavus sensu* Kennedy 1980) is distinguished by possessing a rounded oral margin, and mainly, a different oral apparatus structure (see Landing and Westrop 2006, and Zhen et al. 2007, for complementary discussions).

Drepanoistodus* cf. *expansus (Chen and Gong 1986)
Plate 4, figures 15-18

cf. *Drepanodus expansus* n. sp. CHEN and GONG 1986, p. 136-137, pl. 48, figs. 2, 6, 9, pl. 50, figs. 1, 7–8, 12–13, pl. 52, fig. 13, text-fig. 44.
cf. *Drepanoistodus expansus* (Chen and Gong) – PYLE and BARNES 2002, p. 62, pl. 6, figs. 5–8.

Material examined: 13 elements (CORD-MP 21795-21796, 21901-21904): 4 M, 5 P, 2 Sa, 2 S.

Occurrence: Sample QPB2 (13 elements).

Discussion: The specimens assigned to *Drepanoistodus* cf. *expansus* exhibit all of the characteristics of *Drepanodus expansus* Chen and Gong (1986) but are entirely composed of hyaline matter. Pyle and Barnes (2002) reassigned this latter species to *Drepanoistodus* considering a different apparatus plan. However, their M morphotype is rather paltodiform. Previously, Landing et al. (1996) synonymized the suberectiform element of *Drepanodus expansus* to *Laurentoscandodus triangularis*. *Drepanoistodus* cf. *expansus* includes hyaline asymmetrical and subsymmetrical elements with the base strongly flared as well as the typical geniculated oistodiforms of *Drepanoistodus*. The number of specimens recovered precludes a complete apparatus reconstruction.

***Drepanoistodus* sp.**
Plate 4, figures 19-22

PLATE 2

Conodonts from the Santa Victoria Formation. All scales represent 0.1mm.

1 *Iapetonodus* sp., CORD-MP21762/1, postero-lateral (1a) and lateral (1b) views, sample QPB2.

2-4 *Kallidontus gondwanicus* Zeballo and Albanesi 2013a.

2 CORD-MP21764/1, Pa element, postero-lateral view, sample QPB2.

3 CORD-MP21764/2, Pb element, postero-lateral view, sample QPB2.

4 CORD-MP21939/2, Sc? element, lateral view, sample QPB4.

5-6 *Variabiloconus variabilis* (Lindström 1955).

5 CORD-MP21764/1, Pb element, postero-lateral view, sample QPB2.

6 CORD-MP21739/1, Sb element, lateral view, sample QA.FSR-X.

7-9 *Utahconus scandodiformis* Zeballo and Albanesi, 2013a.

7 CORD-MP21772/1, P element, lateral view, sample QPB2.

8 CORD-MP21773/1, M element, lateral view, sample QPB2.

9 CORD-MP21772/4, S element, lateral view, sample QPB2.

10, 13 *Hammanodus* cf. *juliae* Serpagli et al. 2007

10 CORD-MP21765/1, P element, lateral view, sample QPB2.

13 CORD-MP21765/2, P element, lateral view, sample QPB2.

11 *Utahconus purmamarcensis* Zeballo and Albanesi, 2013a. CORD-MP21734/6, S element, lateral view, sample QA.FSR-X.

12, 15 *Acodus primitivus* Zeballo and Albanesi, 2013a.

12 CORD-MP21857/1, Pa element, lateral view, sample QPB2.

15 CORD-MP21763/1, Sa element, postero-lateral view, sample QPB2.

14 *Phakelodus* cf. *savitzkyi* (Abaimova 1978), CORD-MP21750/1, lateral view, sample QPB2.

16 *Decoriconus peselephantis* (Lindström 1955), CORD-MP21767/1, lateral view, sample QPB2.

17 *Granatodontus* sp., CORD-MP21769/1, lateral view, sample QPB2.

18 *Coelocerodontus* sp., CORD-MP21753/1, lateral view, sample QPB2.

19-20 Genus and sp. indet. 1, CORD-MP21849, lateral view, sample QPB2.

21 *Phakelodus elongatus* (An 1983), CORD-MP21751/1, lateral view, sample QPB2.

22 *Phakelodus tenuis* (Müller 1959), CORD-MP21752/1, lateral view, sample QPB2.

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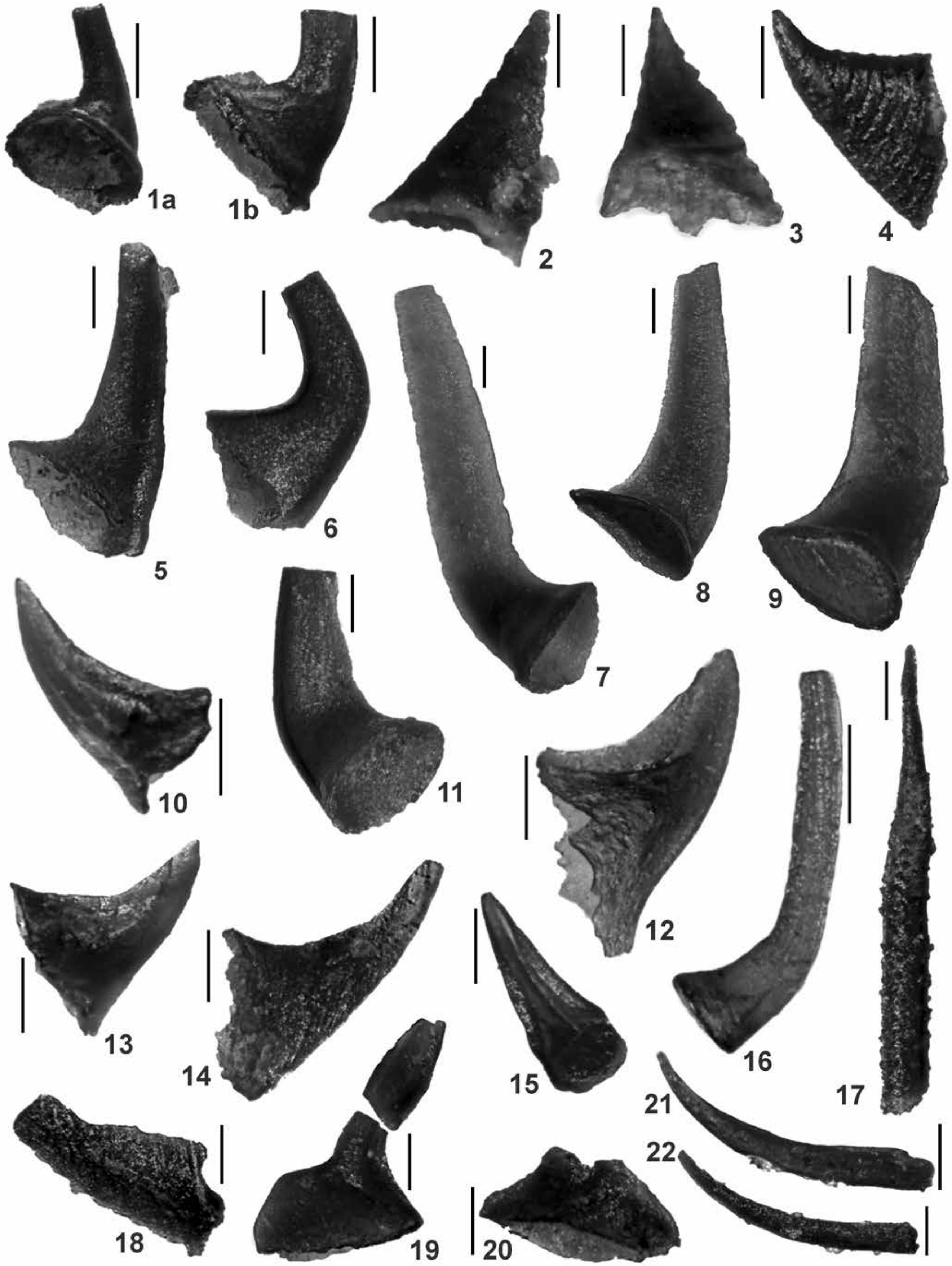
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Drepanoistodus nowlani n. sp. JI and BARNES 1994, p. 35, pl. 7, fig. 20 (only).

Material examined: 20 elements (CORD-MP 21766, 21856, 21930, 21940): 15 M, 2 P, 3 S.

Occurrence: Samples QPB2 (17 elements), QPB4 (3 elements).

Description: Hyaline coniform elements with diffusively albid cusps. Oistodiform elements laterally compressed with the inner flank slightly concave and the outer flank convex. Cusps reclined, bladelike, bicostate, somewhat bent inwards and broadly carinated. Angle between posterior edge of cusp and oral margin acute, below 45 degrees. Drepanodiform elements are keeled, laterally compressed, short based. Cusps proclined and commonly twisted, partially albid. Basal cavity apex situated near the anterior edge of the cusp.

Discussion: Ji and Barnes (1994) erected *Drepanoistodus nowlani* for partially albid, simple cones consisting of three element morphotypes: subrounded drepanodiforms with slender cusp, high base, and deep basal cavity; symmetrical suberectiforms having keeled straight cusps strongly laterally compressed with extremely expanded base; and compressed oistodiforms with bladelike reclined cusps and posteriorly expanded large base. However, there are some uncertainties about the definition and constituent elements of this species, as noted by Zhen et al. (2007). For instance, the illustrated paratypes of the oistodiform element of *Drepanoistodus nowlani* exhibit a wide morphological variability, including elements with a shorter base and more strongly posteriorly-curved cusp, and another (Ji and Barnes 1994, pl. 7, fig. 20) with a longer base and a straight basal margin that closely resembles the Santa Victoria species. However, the oistodiform elements of *Drepanoistodus* sp. show a curved anterior margin, a longer inner-lateral process and a more curved basal margin in comparison with other species of *Drepanoistodus* [e.g., *D. basiovalis* (Sergeeva 1963), *D. forceps* (Lindström 1955), *D. nowlani* Ji and Barnes 1994, *D. suberectus* (Branson and Mehl 1933)]. However, the number of specimens is limited and no symmetrical suberectiform elements have been recovered. Further studies may confirm its taxonomic designation.

Genus ***Filodontus*** Pyle, Barnes and Ji 2003.
Type species: Scolopodus filosus Ethington and Clark 1964.

Emended diagnosis: A multielement apparatus (M, P, S) bearing symmetrical and asymmetrical proclined simple coniform elements covered by conspicuous fine longitudinal costae (striations) from the tip of the cusp almost to the base. Elements are hyaline, usually with the tip of the cusp albid. Striations tend to run obliquely to the main axis of the cusp. The M element is laterally compressed and exhibits the oral margin expanded posteriorly. The P elements are stout and usually twisted. The S elements are slender and form a complete symmetry transition series, from symmetrical Sa elements, asymmetrical Sb elements, subsymmetrical Sc elements and strongly asymmetrical Sd elements.

Discussion: Pyle et al. (2003) erected the genus *Filodontus* and assigned *Scolopodus filosus s. f.* Ethington and Clark (1964) as the type species. They postulated the genus as bimembrate, consisting of one slender, elongante element (a = S) and other stout or squat (e = M). Despite their small

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PLATE 3

Conodonts from the Santa Victoria Formation. All scales represent 0.1mm.

1-9 *Paltodus deltifer deltifer* (Lindström 1955).

1-2 CORD-MP21775/1-2, M elements, lateral views, sample QPB2.

3 CORD-MP21741/1, Pa element, lateral view, sample QA-.FSR-X.

4 CORD-MP21776/1, Pa element, lateral view, sample QPB2.

5 CORD-MP21777/1, Pb element, lateral view, sample QPB2.

6 CORD-MP21778/1, Sa element, lateral view, sample QPB2.

7 CORD-MP21779/1, Sb element, lateral view, sample QPB2.

8 CORD-MP21780/1, Sc element, lateral view, sample QPB2.

9 CORD-MP21780/5, Sd element, lateral view, sample QPB2.

10-17 *Paltodus deltifer peracutus* (Lindström 1955).

10 CORD-MP21785/1, Sa element, lateral view, sample QPB2.

11-12 CORD-MP21782/1-2, M elements, lateral views, sample QPB2.

13 CORD-MP21784/1, Pb element, lateral view, sample QPB2.

14 CORD-MP21783/1, Pa element, lateral view, sample QPB2.

15 CORD-MP21786/1, Sb element, lateral view, sample QPB2.

16 CORD-MP21787/1, Sc element, lateral view, sample QPB2.

17 CORD-MP21788/1, Sd element, lateral view, sample QPB2.

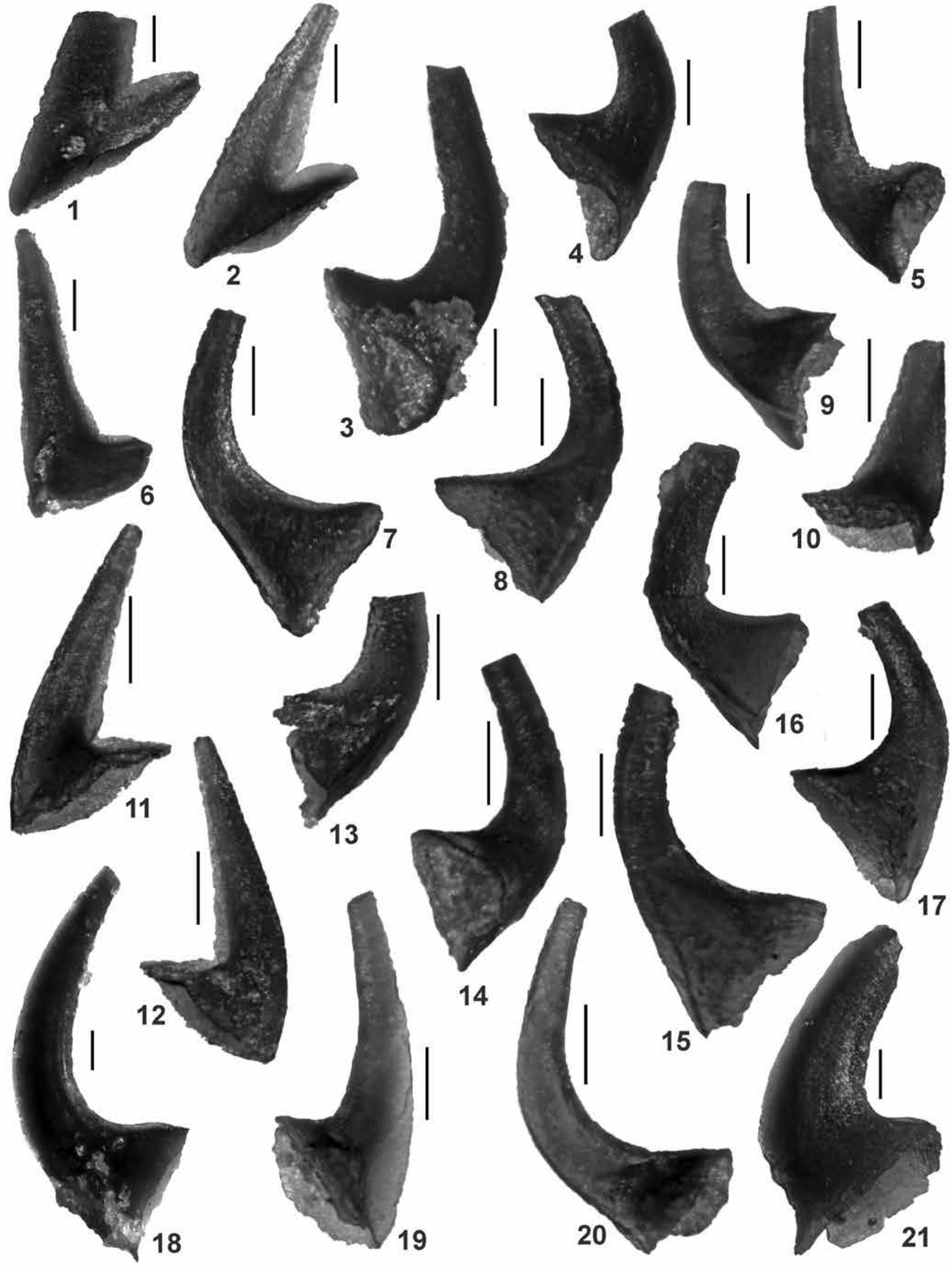
18 *Drepanodus reclinatus*? (Lindström 1955), CORD-MP21732/1, Sc element, lateral view, sample QA-.FSR-2m.

19-21 *Drepanodus arcuatus* Pander 1856.

19 CORD-MP21781/1, M element, lateral view, sample QPB2.

20 CORD-MP21781/2, Sa element, lateral view, sample QPB2.

21 CORD-MP21781/3, Pb element, lateral view, sample QPB2.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collection from the Outram Formation (Alberta, Canada), they suggested that *Filodontus* may exhibit a more complex apparatus after considering an extensive synonymy list. Subsequently, Agematsu et al. (2008) added to the genus *F. tenuis*, from the homonymous biozone of the Thung Song Formation on Tarutao Island, southern peninsular Thailand. Their specimens fit to a bimembrate apparatus of coniform S and M elements that are more slender, and have more proclined cusps and shorter bases than elements of *F. filosus* of Pyle et al. (2003). Additionally, M elements of *F. tenuis* possess the posterior margin keeled at the cusp in contrast to elements of *F. filosus*, which exhibit a circular cross section throughout their length. The *Filodontus tenuis* Zone correlates to the *Acodus deltatus—Oneotodus costatus* Zone of the standard zonation in the North American Midcontinent (TR3, see Bergström et al. 2009). On the other hand, *Filodontus* differs from *Scolopodus* in the apparatus plan and the fine numerous costae on the elements do not reach the aboral margin. *Filodontus* resembles *Parapanderodus* but lacks the diagnostic posterior groove. *Semiacontiodus* is striated and may look like *Filodontus* but the cusps are more erect, bases more expanded, and striations run parallel to the length of the cusp.

Filodontus carolinae Voldman**,** Albanesi and Zeballo **n. sp.**
Plate 1, figures 1-10, 14

Etymology: After Carolina Arroyo, wife of G.V.

Types: Holotype: oistodiform element, CORD-MP 21797/1 from sample QPB2; paratypes: oistodiform elements CORD-MP 21797/2, 21797/3 from same sample, Peña Blanca Creek, Santa Victoria, Salta, Northwestern Argentina.

Stratotype: Sample QPB2, Santa Rosita Formation, Peña Blanca Creek (22º 14´ 38" S, 64º 57´ 11"W), Santa Victoria, Salta, Northwestern Argentina.

Material examined: 17 elements (CORD-MP 21744-21749, 21934, 21938): 1 M, 3 P, 1 Sa, 7 Sb, 2 Sc, 2 Sd, 1 S.

Occurrence: Samples QPB2 (13 elements), QPB4 (4 elements).

Diagnosis: A seximembrate species of *Filodontus* consisting of M, P and S elements. Elements are hyaline, with the tip of cusp albid. Striations run along the entire length of the elements except for a smooth border against the aboral margin. P elements are stout and squat, with twisted cusps. M elements are laterally compressed, with the oral margin extended posteriorly. The S-series is composed of symmetrical Sa elements, asymmetrical Sb elements, subsymmetrical Sc elements and strongly asymmetrical Sd elements.

Description: All elements are covered by conspicuous striations and have proclined cusps. The basal margin of elements has a smooth border and tends to conserve the attachment cone. The cusp gradually tapers toward the tip. The dark color of the elements precluded observing the outline of the basal cavity with diascopic light. The multielemental apparatus of *Filodontus carolinae* n. sp. is composed of the three morphotype groups (M, P, and S elements). The M element is laterally compressed, subsymmetrical, with two weak costae running along the intersection of the posterior face and the lateral sides of the element. Cusp proclined and oral margin extended posteriorly. The P elements are proclined, stout, and strongly asymmetrical with the cusp laterally twisted occupying about one-third of the length of element. Posterior face of the cusp tends to be flat. A

PLATE 4

Conodonts from the Santa Victoria Formation. All scales represent 0.1mm. All specimens are from sample QPB2.

1-6 *Drepanoistodus chucaleznensis* Albanesi and Aceñolaza 2005.

1 CORD-MP21789/1, M element, lateral view.

2 CORD-MP21790/1, P element, lateral view.

3 CORD-MP21791/1, Sa element, lateral view.

4 CORD-MP21892/1, Sb element, lateral view.

5 CORD-MP21893/1, Sc element, lateral view.

6 CORD-MP21894/1, Sd element, lateral view.

7-14 *Drepanoistodus andinus* n. sp. Voldman, Zeballo and Albanesi.

7 CORD-MP21797/1 (holotype), M element, lateral view.

8 CORD-MP21797/2 (paratype), M element, lateral view.

9 CORD-MP21798/1, P element, lateral view.

10 CORD-MP21799/1, Sa element, lateral view.

11 CORD-MP21798/2, P element, lateral view.

12 CORD-MP21800/1, Sb element, lateral view.

13 CORD-MP21801/1, Sc element, lateral view.

14 CORD-MP21802/1, Sd element, lateral view.

15-18 *Drepanoistodus* cf. *expansus* (Chen and Gong 1986)

15 CORD-MP21796/2, M element, lateral view.

16 CORD-MP21796/3, Sa element, lateral view.

17 CORD-MP21796/4, Sb? element, lateral view.

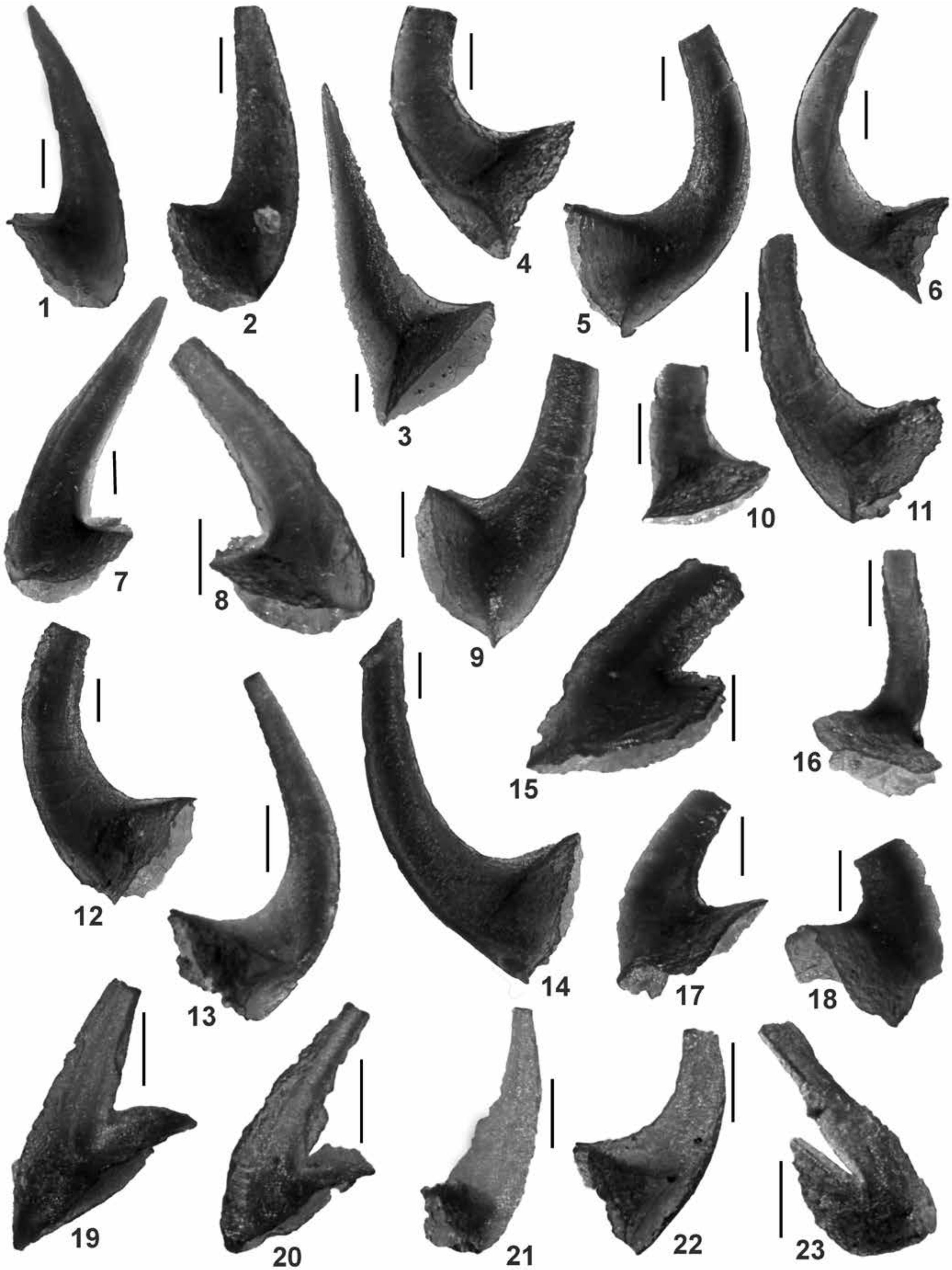
18 CORD-MP21795/1, P element, lateral view.

19-22 *Drepanoistodus* sp.

19-20 CORD-MP21766/1-2, M elements, lateral views.

21-22 CORD-MP21766/3-4, S elements, lateral views.

23 *Paroistodus numarcuatus* (Lindström 1955), CORD-MP21761/1, M element, lateral view.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weak costa runs in posterolateral position from the tip of the cusp up to the basal margin. The cross section of the cusp is oval whereas the outline of the basal cavity is subquadrangular. The S elements form a complete symmetry transition from symmetrical Sa elements to strongly asymmetrical Sd elements. The Sa is the most erect element from the symmetry transition series. It has a long base and circular cross-section along the entire length of the element. The Sb element is asymmetrical, slightly laterally compressed, possessing a weak bulge in the intersection of the inner lateral side and the posterior face. The cross section of the cusp and of the basal margin is oval. The upper part of the cusp of some specimens twists anteriorly and bends laterally. The cusp is the most proclined among all morphotypes. The Sc element is subsymmetrical and differs from the Sa element by the more proclined cusp and shorter base. The upper part of the cusp may twist anteriorly. The Sd elements are asymmetrical, laterally deflected, and have long bases and proclined cusps.

Discussion: Filodontus carolinae differs from *F. filosus* and *F. tenuis* by the characteristic twisting and proclined cusps of the P elements. *Filodontus tenuis* possesses a more simple apparatus plan, with slender elements of shorter and less expanded bases. *Filodontus carolinae* was also recorded in outcrops of the Santa Rosita Formation from the Humacha Creek, *ca*. 20 km to the north of Tilcara city.

Genus ***Granatodontus*** Chen and Gong 1986
Type species: *Hirsutodontus*? *ani* Wang 1985.

Discussion: Granatodontus is a distinctive genus with minute warts along the entire surface of the elements and a single skeletal apparatus. The conodont elements lack white matter and are primitive in not being differentiated into base and cusp (Lee 2008). In contrast, *Hirsutodontus* displays larger nodes confined to the basal region of the element, the cusp often contains white matter and the base and cusp are differentiated (Pyle and Barnes 2002). Originally, *Granatodontus* was thought to be a paraconodont (Chen and Gong 1986) but histological analysis demonstrated euconodont growth patterns (Dong et al. 2005). The euconodont genus *Rotundaconus* is closely related, sharing a fine granulose ornament, but has a rounded to bulbous tip, whereas *Granatodontus* has a pointed tip.

***Granatodontus* sp.**
Plate 2, figure 17

Material examined: 2 elements (CORD-MP 21769, 21851).

Occurrence: Sample QPB2.

Description: The specimens recovered herein are almost straight despite small flexures along the cusp, have a rounded cross section, deep basal cavity, and are sculptured with numerous tiny warts. Ornamentation reduces towards the tip of the cup, which gradually tapers, conferring a sub-cylindrical aspect to the elements.

Discussion: Our specimens differ from *Granatodontus ani* (Wang) and other *Granatodontus* specimens (*G. asymmetrica* Lee, *G. hwajeolensis* Lee and Lee, *G. multicorrugata* Lee) described by Lee (2008) and Lee et al. (2009) by the more straight cusp and the less expanded base. *Granatodontus* cf. *ani* Pyle and Barnes (2002) resembles our specimens but is thicker, with a larger base width / element height rate.

Genus ***Hammannodus*** Serpagli et al. 2007
Type species: *Hammannodus sarae* Serpagli et al. 2007.

Hammannodus* cf. *juliae Serpagli et al. 2007
Plate 2, figures 10, 13

cf. *Hammannodus juliae* n. sp. SERPAGLI et al. 2007, p. 1453-1454, pl. 2, figs. 1-20, text-fig. 5-6.

Material examined: 2 elements (CORD-MP 21765).

Occurrence: Sample QPB2.

Description: The specimens recovered are asymmetrical, with a triangular (isosceles) profile in lateral view. They exhibit a short proclined cusp with a long base and three sharp costae located in the anterior, lateral and posterior margins. The basal cavity extends to the tip and has a triangular opening.

Discussion: The P elements recovered resemble *Acodus primitivus* but have sharper costae, deeper basal cavity and a lower cusp length / base width ratio, typical of *Hammannodus*. The scarce number of specimens recovered precludes a more precise diagnosis.

Genus IAPETONUDUS Nicoll et al. 1999
Type species: *Iapetonudus ibexensis* Nicoll et al. 1999.

***Iapetodnudus* sp.**
Plate 2, figure 1

Material examined: 1 element (CORD-MP 21762).

Occurrence: Sample QPB2.

Discussion: The single specimen recovered is a symmetrical rounded simple cone with suberect, laterally compressed cusp. The anterior and posterior margins of the cusp are costate, but turn rounded approximately below the tip of the basal cavity; thus the oral margin and the anterobasal corner are rounded. It has a minor bump on the external wall of the cusp. The basal opening exhibits an egg-shaped contour. The material described herein resembles *Iapetonudus ibexensis* by the laterally compressed cusp and the lack of processes or denticulation. However, the absence of diagnostic elements precludes a specific determination.

Genus KALLIDONTUS Pyle and Barnes 2002
Type species: *Kallidontus serratus* Pyle and Barnes 2002.

Kallidontus gondwanicus Zeballo and Albanesi 2013a
Plate 2, figures 2-4

Furnishina furnishi Müller – LANDING, WESTROP and KEPPIE 2007, fig. 9: c.
Kallidontus gondwanicus n. sp. ZEBALLO and ALBANESI 2013a, p. 6, 8, fig. 7: V-Z, fig. 9: AC-AH.

Material examined: 59 elements (CORD-MP 21731, 21764, 21803-21807, 21937, 21939): 16 Pa, 8 Pb, 4 Sa, 18 Sb, 5 Sc, 6 Sd, 2 S.

Occurrence: Samples QA.FSR-2m (2 elements), QPB2 (46 elements), and QPB4 (11 elements).

Discussion: Elements assigned to the Pa, Pb and S positions of the apparatus of *Kallidontus gondwanicus* were recovered. These are distinguished by their small size and poor ornamentation consisting of soft rings of crests parallel to the base. All elements are proclined and exhibit wide bases, slender walls and deep basal cavities. The Pa element is symmetric, antero-posteriorly compressed, triangular in outline, with keeled lateral margins with small nodes and the posterior flank concave and the anterior flank convex. The basal cavity opening is oval-shaped. A Pb element type is incorporated to the apparatus of *K. gondwanicus*. It resembles the Pa element but has three lateral sharp keels which bound a sub-triangular oral margin of asymmetrical appearance. The Sa element is symmetrical, laterally compressed, posteriorly keeled with a tear-drop section. The Sb element is asymmetrical, with a flat inner side and an antero-lateral carinae or bulge on the outer-lateral side. The Sc element is subsymmetrical, laterally compressed with keeled margins. The cusp is less proclined than in the other morphotypes of the apparatus. The asymmetric Sd element is similar to the Sb but exhibits a costa in the outer lateral flank located in a medial position and has more rectilinear anterior and posterior margins. The specimen illustrated as *Furnishina furnishi* Müller (1959) by Landing et al. (2007, fig. 9c) from the Río Salinas Member of the Tiñú Formation (*Paltodus deltifer* Zone) is probably an S morphotype of *K. gondwanicus*, since it presents a soft ring of crests, proclined cup and flatter keeled margins. *Furnishina furnishi* Müller (1959) is distinguished instead by a round cross section at the tip of the cusp that turns subtriangular towards an expanded basal opening.

Remarks: K. gondwanicus was defined 140 km south of the present study area, within the *Cordylodus angulatus* Zone–*Paltodus deltifer* Zone (*Paltodus deltifer pristinus* Subzone) (Zeballo and Albanesi 2013a).

Genus ***Paltodus*** Pander 1856
Type species: *Paltodus subaequalis* Pander 1856, original designation.

Discussion: Wamel (1974) considered that the form species *Oistodus inequalis* Pander was part of the apparatus of *Drepanoistodus inaequalis*, making *inaequalis* a valid species name. However, there are distinct morphologic differences between the apparatus of *Paltodus* and *Drepanoistodus* (Lindström 1977; Szaniawksi 1980). Additionally, the geniculated specimen illustrated as *D. inaequalis* by Wamel (1974) is different from the original material illustrated by Pander. In a thorough revision of the genus, Löfgren (1997a) tentatively synonymized this latter form with *Paltodus subequalis*, as previously suggested by Lindström (1977). Bagnoli et al. (1988) distinguished *Paltodus peracutus* as a separate species with the nominate element as the Sa element and *Acodus tetrahedron* as the acodiform (P) element. These criteria were not followed by Löfgren (1997a), who tentatively synonymized *P. peracutus* with *P. d. deltifer* and relocated *Acodus tetrahedron* s.f. as the acodiform element in the *Paltodus d. deltifer* apparatus. The transitional morphologic character of *P. peracutus* is verified in our collection and is regarded here as a subspecies of *P. deltifer*.

Paltodus deltifer deltifer (Lindström 1955)
Plate 3, figures 1-9

Drepanodus deltifer n. sp. LINDSTRÖM 1955, p. 562, pl. 2, figs. 42-43 (Sc? element)
Paltodus deltifer deltifer (Lindström) – BRUTON, HARPER and REPETSKI 1989, fig. 5: X-AD. – LÖFGREN 1997a, p. 264-265, fig. 5: Z-AG, fig. 6: H-N (source includes synonymy). – LANDING, WESTROP and KEPPIE 2007, p. 929-930, fig. 8: a-e, j-q, *non* f-i. – ÁLVARO et al. 2007, fig. 7: M, N. – SERPAGLI, FERRETTI, VIZCAINO AND ÁLVARO 2007, text-fig. 3: b. – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 2. – VOLDMAN, ALBANESI and RAMOS 2009, fig. DR1: 10, 14, 28.
Paltodus deltifer (Lindström) – ZHEN, PERCIVAL, LÖFGREN and LIU 2007, p. 134-135, pl. IV, figs. 1-23. – VIIRA 2011, fig. 4: J.

Material examined: 64 elements (CORD-MP 21727, 21782-21788, 21869-21875, 21920): 20 M, 4 Pa, 5 Pb, 5 Sa, 14 Sb, 12 Sc, 4 Sd.

Occurrence: Samples QA.FSR-2m (3 elements), QPB2 (59 elements), QPB4 (2 elements).

Discussion: Complete apparatuses of *Paltodus deltifer deltifer* have been illustrated and discussed by Löfgren (1997a) from Baltic successions. The abundant *Paltodus* elements from the Santa Victoria area allow reconstructing an apparatus with typically geniculated oistodiforms (M element) with concave-convex reclined cusps slightly bent inwards and relatively elongate bases. The symmetrical suberectiforms (Sa element) possess fairly prominent antero-lateral costae symmetrically arranged and the aboral edge convex downwards and sinuous like in *P. subequalis*. The symmetry transition series (S) includes drepanodiform elements with the inner flank concave and the outer flank convex. The Pa element is characterized by a notch or indentation in the aboral margin whereas the Pb element is slightly concavo-convex with the basal cavity opening to the inner side. The observed characteristics are in agreement with those reported by Löfgren (1997a). Scandodiform elements reported by Landing et al. (2007) are absent in Löfgren's reconstructions of the apparatus of *P. deltifer*. Those elements are actually M and S morphotypes of *Utahconus*, probably *U. purmamarcensis* Zeballo and Albanesi, as is discussed in more detail below.

Paltodus deltifer peracutus (Lindström 1955)
Plate 3, figures 10-17

Distacodus peracutus n. sp. LINDSTRÖM 1955, p. 555-556, pl. 3, figs. 1-2 (*non* text-fig. 5: d).
? *Acodus tetrahedron* n. sp. LINDSTRÖM 1955, p. 546, pl. 4, figs. 1-2.
Drepanoistodus acuminatus (Pander) –WAMEL 1974, p. 62-63, pl. 2, fig. 3 (only).
Drepanoistodus inaequalis (Pander) –WAMEL 1974, p. 65-66, pl. 2, fig. 7 (only).
? *Paroistodus*? sp. REPETSKI and PERRY 1980, pl.2, fig. 9.
Paltodus peracutus (Lindström) – BAGNOLI, STOUGE and TONGIORGI 1988, p. 213-214, pl. 41, figs. 2, 4-7 (*non* 1, 3).
Paltodus deltifer (Lindström) – AN 1987, p. 161-162, pl. 10, figs. 16, 17.
Paltodus deltifer n. ssp. ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 3.

Material examined: 157 elements (CORD-MP 21736, 21741, 21775-21780, 21862-21868, 21920): 43 M, 3 Pa, 4 Pb, 7 Sa, 41 Sb, 31 Sc, 23 Sd, 5 S.

Occurrence: Samples QA.FSR-X (9 elements), QPB2 (143 elements), QPB4 (5 elements).

Description: This subspecies includes geniculated oistodiforms with reclined, laterally deflected cups, and narrow short bases more protracted posteriorly than anteriorly. The cusp is keeled and exhibits a low inner median carina that projects as a bulge to the base. The symmetrical suberectiform (*Distacodus peracutus* s.f. Lindström 1955) has a proclined cusp with sharp anterior and posterior edges and a low keel on the anterior part. The Pa element is comparable with the Pa of *P. d. pristinus*, with the typical notched aboral margin of the genus but with the anterior margin keeled. The Pb element of *P. d. peracutus* seems to be indistinguishable from the Pb elements of *P. deltifer deltifer*. Drepanodiforms elements from the symmetry transition series also resemble *P. deltifer deltifer*, but have a longer base. In particular, the Sd elements show the maximum grade of homeomorphism.

Discussion: This subspecies includes intermediate forms between *Paltodus deltifer pristinus* and *P. d. deltifer*, being distinguished mainly by the shape of the oistodiform element. The oistodiform element of *Paltodus deltifer pristinus* is not geniculated and has a less reclined cusp and a narrower shorter base in contrast to *P. d. peracutus*. The oistodiform element of *P. d. deltifer* is geniculated and has a similar basal cavity, but in *P. d. peracutus* the base is more extended posteriorly than anteriorly, yet the posterior process is shorter than in *P. d. deltifer*, and the cusp is more curved and laterally bent. Alternatively, the erectiform elements of *P. d. deltifer* are less proclined and carry more prominent costae. This way *Paltodus deltifer peracutus* constitutes an intermediate form between *P. d. pristinus* and *P. d. deltifer*. This fact is supported by the overlap of its biostratigraphic record, as was observed in other sections from Cordillera Oriental (Zeballo, Albanesi and Ortega 2008).

Genus PAROISTODUS Lindström 1971
Type species: *Oistodus parallelus* Pander 1856.

Paroistodus numarcuatus (Lindström 1955)
Plate 4, figure 23.

Drepanodus numarcuatus n. sp. LINDSTRÖM 1955, p. 564-565, pl. 2, figs. 48-49
Paroistodus numarcuatus (Lindström) – LINDSTRÖM 1971, p. 46, fig. 8. – STOUGE and BAGNOLI 1988, p. 127-128, pl. 8, figs. 8-11. – LÖFGREN 1994, fig. 6: 1-3. – LÖFGREN 1997a, fig. 4: b. – LÖFGREN 1997b, p. 921-922, text-fig. 2: o-u, 3:a-g, 4:a-k. – RAO and FLORES 1998, p. 16, pl. 1, figs. 4, 7, 8. – LANDING, WESTROP and KEPPIE 2007, fig. 8: r-t. – VIIRA, 2011, fig. 4: d.

Material examined: 1 element (CORD-MP 21761): 1 M.

Occurrence: Sample QPB2.

Discussion: This species has been fully described by previous authors.

Genus ***Teridontus*** Miller 1980
Type species: Oneotodus nakamurai Nogami 1967, original designation.

Teridontus cf. gallicus Serpagli et al. 2008
Plate 1, figure 13

Material examined: 1 element (CORD-MP 21771).

Occurrence: Sample QPB2.

Discussion: A single teridontiform element was recovered from the samples of Santa Victoria. It is a simple cone, symmetrical, with long, slightly expanded base, proclined cusp, and circular cross section along the entire length of the element. The specimen is hyaline, but the tip of the cusp is broken. It conserves the basal funnel attached. It is covered by numerous fine striae typical of *Teridontus,* which allow distinguishing it from the intimately related genus *Orminskya* Landing, Westrop and Keppie (2007). The scarce number of elements recovered precludes making further inferences.

Genus TILCARODUS Zeballo and Albanesi 2013a
Type species: *Utahconus humahuacensis* Albanesi and Aceñolaza 2005, original designation.

***Tilcarodus* sp.**
Plate 1, figure 12

Material examined: 2 elements (CORD-MP 21774): 2 Sb.

Occurrence: Sample QPB2.

Discussion: The apparatus of *Tilcarodus* was fully described by Zeballo and Albanesi (2013a). Two Sb elements, probably corresponding to *T. humahuacencis*, were recovered. They are characterized by bicostate, postero-laterally compressed and torsioned, proclined cusps. The absence of diagnostic elements precludes a specific determination.

Genus ***Utahconus*** Miller 1980
Type species: Paltodus utahensis Miller 1969.

Discussion: We adopt the emended diagnosis of the genus of Pyle and Barnes (2002), where the apparatus of *Utahconus* contains three to four morphotypes characterized by compression along the cusp and round to triangular basal outline. These include *a* (rounded and subsymmetrical), *c* (suberect symmetrical), *e* (compressed cusp), and *b* (laterally compressed) morphotypes. Early *Utahconus* species are bimembrate, composed of *a* (unicostate) and *e* (bicostate) elements, as originally observed by Miller (1980). Zeballo and Albanesi (2013a) homologized the bicostate element to the M morphotype and the unicostate forms to the S and P morphotypes. Landing et al. (1996), synonymized *Utahconus* with *Scalpellodus* Dzik, a genus ascribed to longitudinally microstriated, albid, short- to long-based coniform elements arranged in a weakly to strongly differentiated symmetry transition series. These criteria were followed by Landing et al. (2003), Landing et al. (2007) and Tolmacheva and Abaimova (2009). However, *Scalpellodus* has a later and unconnected range (Middle Ordovician), since the genus *Utahconus* is considered valid to designate the forms restricted to the Furongian to Early Ordovician (Zeballo and Albanesi 2013a).

Utahconus purmamarcensis Zeballo and Albanesi 2013a
Plate 2, figure 11

Paltodus deltifer deltifer (Lindström) – LANDING, WESTROP and KEPPIE 2007, only fig. 8: f-i.
Utahconus purmamarcensis n. sp. ZEBALLO and ALBANESI 2013a, p. 13, fig. 6: D-F, fig. 8: H-M.

Material examined: 17 elements (CORD-MP 27734, 21740): 5 M, 5 S, 7 P.

Occurrence: Sample QA.FSR-X.

Discussion: Zeballo and Albanesi (2013a) recognized asymmetrical to subsymmetrical coniform elements and proposed a trimembrate apparatus for this species. M element: asymmetric, suberect to slightly proclined cusp, twisted with respect to the base, with keeled posterior margin and acute rounded margin. S element: asymmetric, with righter antero-lateral margin and shorter base than the M element. P element: subsymmetric, short base, strongly proclined cusp and posteriorly keeled, bilaterally compressed. Landing, Westrop and Keppie (2007) documented in the Mexican Tiñú Formation scandodiform elements as *Paltodus deltifer deltifer* (fig. 8: f-i) and paltodiform elements as *Cornuodus? clarkei* (fig. 9: q), but these are actually M-S and P morphotypes, respectively, of *Utahconus purmamarcensis.*

Utahconus scandodiformis Zeballo and Albanesi 2013a
Plate 2, figures 7-9

Protopanderodus incontans (Branson and Mehl) – JI and BARNES 1994, p. 53-54, pl. 18, figs. 13-14 (only). – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 13.

Protopanderodus prolatus Ji and Barnes – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 14.
Utahconus scandodiformis n. sp. ZEBALLO and ALBANESI 2013a, p. 13, 16-17, fig. 6: G-I, fig. 8: N-R.

Material examined: 1404 elements (CORD-MP 21728, 21772-21773, 21824-21848, 21906, 21911, 21918-21919, 21926): 491 M, 785 P, 64 S, 64 unassigned elements.

Occurrence: Samples QA.FSR-2m (9 elements), QPB2 (1271 elements), QPB4 (124 elements).

Discussion: Utahconus scandodiformis comprises strongly bilaterally compressed elements, generally devoid of ornamentation, with constrained, short bases and keeled margins. Zeballo and Albanesi (2013a) proposed a trimembrate apparatus for this species, including M, P and S morphotypes. The M element is asymmetric, with proclined cusp, narrow ogival base and curved antero-lateral and postero-lateral margins. The S element distinguishes from the M element by possessing an oval basal cavity contour. The P morphotype is subsymmetrical, with the inner flank slightly concave and the outer flank convex. They exhibit a weak constraint at the base-cusp transition. Cusps suberect to weakly reclined, bicostate. The posterior keel curves over the oral margin to intercept the basal margin slightly displaced from the medial of the element.

Genus ***Variabiloconus*** Landing, Barnes and Stevens 1986
Type species: *Paltodus bassleri* Furnish 1938, original designation.

Discussion: The genus *Variabiloconus* Landing et al. (1986) is characterized by a septimembrate apparatus with intergradational symmetries and ribbed, sulcate and microstriated surfaces. Cusps are completely albid whereas bases are hyaline with different amount of white matter. It shows an increase in ornamentation and development of the cusp from older to younger taxa of the genus (Zeballo and Albanesi, 2013a).

Variabiloconus variabilis (Lindström 1955)
Plate 2, figures 5-6

Oneotodus variabilis n. sp. LINDSTRÖM 1955, p. 582, pl. 2, figs. 14-18, pl. 5, figs. 4, 5, text-fig. 6.
Variabiloconus variabilis (Lindström) – LÖFGREN, REPETSKI and ETHINGTON 1999, p. 162-166, pl. 1, figs. 1-20, pl. 2, figs. 1-17, text-fig. 2: A-S (cum. syn.). – ZEBALLO, ALBANESI and ORTEGA 2005a, p. 60, fig. 4: AF. – LANDING, WESTROP and KEPPIE 2007, p. 930, fig. 8: u–cc. – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 18. – VOLDMAN, ALBANESI and RAMOS 2009, fig. DR1: 13, 19, 25.

Material examined: 5 elements (CORD-MP 21739, 21760, 21854).

Occurrence: Samples QA.FSR-X (3 elements), QPB2 (2 elements).

Discussion: The few specimens recovered are in agreement with the material described and illustrated by Löfgren et al. (1999).

Genus and sp. indet. 1
Plate 2, figures 19-20

Genus and species 1 LANDING, WESTROP and KNOX 1996, p. 678, fig. 5: 26, 28-30.

Material examined: 3 elements (CORD-MP 21849).

Occurrence: Sample QPB2 (3 elements).

Description: Hyaline coniform elements with suberect, antero-posteriorly compressed cusp with sharp to rounded margins above laterally compressed, ogival base with irregular bumps and hollows. Oral margin sharp. One specimen shows a lateral sulcus.

Discussion: Sample QPB2 has yielded a few specimens similar to the Genus and species 1 of Landing, Westrop and Knox (1986, fig. 5: 28, 30). The form resembles *Iapetognathus* by the inwardly directed antero-lateral process but have a lateral sulcus on the cusp and irregular bumps and hollows. Microstriae are not discernible with optical microscopy as noticed by Landing, Westrop and Knox in their specimens from the Lower Ordovician Tribes Hill Formation, East-Central New York. The few specimens recovered here do not allow further inferences.

Protoconodonts

Genus ***Phakelodus*** Miller 1984
Type species: Oneotodus tenuis Müller 1959.

Discussion: Anatomical comparative studies have shown that the protoconodont spines of *Phakelodus* are strikingly similar in shape, morphology and internal structure to recent chaetognath grasping spines. They also share a similar architecture of the whole grasping apparatus as well as comparable longitudinal ridges on the surface (Szaniawski 2002, 2009).

Phakelodus elongatus (Zhang in An et al. 1983)
Plate 2, figure 21

Oneotodus tenuis n. sp. MÜLLER 1959, p. 457-458, pl. 13, fig. 11.
Proconodontus elongatus n. sp. ZHANG *in* AN et al. 1983, p. 125, pl. 5, figs. 4-5.
Phakelodus elongatus (An) – MÜLLER and HINZ 1991, p. 32-33, pl. 1, figs. 1-5, 7-9, 12-14, 22 (*cum syn*.). – ZEBALLO, ALBANESI and ORTEGA 2005a, p. 62, fig.4: AG. – LEE and SEO 2008, pl. 1, fig. 17. – TOLMACHEVA, DEGTYAREV, SAMUELSSON and HOLMER 2008, fig. 7: A. – ZEBALLO, ALBANESI and ORTEGA 2008, fig. 4: 31. – LEE, LEE, MILLER and JEONG 2009, fig. 6: 9–10.
Phakelodus elongatus (Zhang *in* An et al.) – MÜLLER and HINZ-SCHALLREUTER 1998, p. 99, fig. 6: 3-5.
'*Phakelodus elongatus*' (Zhang *in* An et al.) – LANDING, WESTROP and KEPPIE 2007, fig. 6: u.

Material examined: 169 elements (CORD-MP 21738, 21751, 21808, 21811-21812, 21907, 21909, 21935).

Occurrence: Samples QA.FSR-X (1 element), QPB2 (162 elements), QPB4 (6 elements).

Discussion: The long-ranging and widespread *Phakelodus elongatus* and *P. tenuis* are distinguished by their transverse cross sections: the former have a drop-shaped cross-section with a keeled posterior margin whereas *P. tenuis* elements have a rounded-oval cross-section. Landing et al. (2007) suggested that *P. elongatus* may be a junior synonym of *P. tenuis*, since both species co-occur regularly in samples and have comparable stratigraphic ranges. However, they are not regarded as morphotypes of a single species because clusters are generally composed of up to four very similar elements differing mainly in size (Müller and Hinz 1991; Szaniawski and Bengtson 1998).

Phakelodus tenuis (Müller 1959)
Plate 2, figure 22

Oneotodus tenuis n. sp. MÜLLER 1959, p. 457-458, pl. 13, fig. 13, 14, 20.
Phakelodus tenuis (Müller) – CHEN and GONG 1986, p. 157-158, pl. 22,

figs.7, 8, 12, 14, 19, 21. – MÜLLER and HINZ 1991, p. 33-34, pl. 1, figs. 6, 10, 11, 15-21, 23, pl. 2, figs. 1-24 (*cum syn.*). – SZANIAWSKI 2002, fig. 2: I, K. – LANDING, WESTROP and KEPPIE 2007, fig. 6: s. – LEE and SEO 2008, pl. 1, fig. 18. – TOLMACHEVA, DEGTYAREV, SAMUELSSON and HOLMER 2008, fig. 5: H, 6: D, 7: B. – LEE, LEE, MILLER and JEONG 2009, fig. 6: 12, 14.

Material examined: 64 elements (CORD-MP 21752, 21808-21813, 21910, 21935).

Occurrence: Samples QPB2 (63 elements), QPB4 (1 elements).

Discussion: This species is characterized by long, slender, simple cones with circular cross-section and deep basal cavity. These are slightly recurved and variably flattened on the flanks, with posterior and anterior margins convex.

Phakelodus cf. savitzkyi (Abaimova 1978)
Plate 2, figure 14

? *Phakelodus elongatus* (An) – MÜLLER and HINZ 1991, pl. 1, figs. 14, 22 (only)
Phakelodus savitzkyi (Abaimova) – SZANIAWKSI 2002, fig. 2: J.
Proconodontus? savitzkyi Abaimova – TOLMACHEVA, DEGTYAREV, SAMUELSSON and HOLMER 2008, fig. 5: I.

Material examined: 24 elements (CORD-MP 21750, 21818-21819, 21927).

Occurrence: Samples QPB2 (22 elements), QPB4 (2 elements).

Description: The specimens with the general character of *Phakelodus* are nearly symmetrical, with a slight deflection towards one of the flanks. The anterior surface is rounded while the posterior margin is keeled. The lateral flanks are convex but may display flattening. The basal cavity is deep, with a teardrop section, usually filled with some sort of hyaline tissue. The surface is characterized by obliquely outcropping lamellae forming more or less regular intervals. The general length-width ratio of the elements is 3:1.

Discussion: Müller and Hinz (1991) grouped in *P. elongatus* slender with comparatively broad sclerites (Pl 1: 14, 22). The latter possibly belong to *P. savitzkyi*. Swaniawski (2002) illustrated a cluster of *Phakelodus savitzkyi* (Abaimova) but did not argue on its reassignment to *Phakelodus*. This simple form resembles *Phakelodus elongatus* but with a much smaller length-thickness ratio and with a higher inclination of the cusp.

Protoconodonts

Genus *Coelocerondontus* Ethington 1959
Type species: Coelocerodontus trigonius Ethington 1959.

***Coelocerondontus* sp.**
Plate 2, figure 18

Material examined: 4 elements (CORD-MP 21753, 21823).

Occurrence: Sample QPB2 (4 elements).

Description: Specimens completely hollow, with thin unicostate compressed lateral margins. The anterior face is convex whereas the postero-lateral faces are either concave to planar. Surface of the walls transversed obliquely by strips of fibrils that protrude from the anterior keel as nodes, reminiscent of the mode of growth of paraconodonts.

Discussion: The fragmentary preservation and the number of specimens recovered is not sufficient for determination at species level.

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