TREMADOC CONODONTS AND TRILOBITES FROM THE CARDONAL FORMATION, INCAMAYO CREEK, SALTA PROVINCE, NORTHWESTERN ARGENTINA

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The conodont assemblages from the Lower Ordovician Cardonal Formation (NW Argentina) include *Cordylodus angulatus* Pander, *Cordylodus intermedius* Furnish, *Cordylodus* cf. *proavus* Müller, *Cristodus*? sp., *Drepanodus* sp. s.f., *Drepanoistodus* sp. n. A, *Monocostodus sevierensis* (Miller), *Phakelodus elongatus* (An), *Striatodontus* sp., *Teridontus obesus* Ji *et* Barnes, and *Utahconus* aff. *longipinnatus* Ji *et* Barnes. Material is well preserved with a Color Alteration Index (CAI) of 1.5 to 2. Most of the taxa (ca. 70%) are typical of the Midcontinent Realm. Trilobite species include *Micragnostus chiushuensis* (Kobayashi), *Leptoplastides marianus* (Hoek), *Brackebuschia acheila* Harrington *et* Leanza, and a ?Kainellidae indet. The trilobite *Kainella meridionalis* Zone is correlated with the conodont *Cordylodus angulatus* Zone (Middle Tremadoc).

K e y w o r d s : Conodonta, Trilobita, biostratigraphy, Tremadoc, Ordovician, Salta Province, Argentina.

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INTRODUCTION

The Lower Ordovician deposits are widely represented in the Cordillera Oriental of northwestern Argentina. Incamayo Creek, in Salta Province, is one of the areas where they are better exposed. In this area, KEIDEL (1937, 1943) described the Lampazar and Cardonal Formations (Lower Tremadoc), the Saladillo Formation (Upper Tremadoc), and the Parcha Formation (Lower Arenig). Later on, HARRINGTON and LEANZA (1957) provided important biostratigraphic information based mainly on the trilobite faunas (see also HARRINGTON 1937, 1938). In spite of the paleontological richness, subsequent stratigraphic studies have not been undertaken. Only VILELA (1956) presented a geological-economic chart, and SANDRUSS (1974) made a geological map of the middle part of the creek.

The objective of this paper is to describe Middle Tremadoc conodont-trilobite assemblage and to discuss its biostratigraphic significance. Conodonts are described for the first time from Incamayo Creek thus allowing for a more precise stratigraphic correlation with trilobite zonation.

The conodont collection includes 540 elements showing mostly excellent preservation, with a Color Alteration Index (CAI) of 1.5 to 2. Multielement taxonomy is considered for all described taxa. The element letter code proposed by JI and BARNES (1994) is used.

Conodonts are reposited in the Museo de Paleontologia, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba (abbr. CORD-MP), Córdoba city, Argentina. Trilobite material is in the Facultad de Ciencias Naturales e Instituto Miguel Lillo, Universidad Nacional de Tucumán (abbr. PIL), Tucumán city, Argentina.

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FOSSIL LOCALITY

The fossil localities are on the eastern flank of Cerro Gólgota, 4 km north of the Ingeniero Maury locality, Rosario de Lerma Department, Salta Province (Fig. 1). The studied section (about 140 m thick, Fig. 2) consists of quartz sandstones, sandy limestones, sandy shales, and siltstones assigned to the Cardonal Formation (KEIDEL 1937, 1943; HARRINGTON and LEANZA 1957). The base of the unit is in apparent conformity, alternatively, in different parts of the studied area, either over the Chalhualmayoc Formation (Upper Cambrian) or over the Campanario Formation (Upper Cambrian); and the top is in conformity with the overlying Saladillo Formation (Upper Tremadoc). Material was collected 82, 90, and 115 m above the base of the formation (levels 1, 2, and 3, respectively). Rock samples consisting of calcareous nodules (90–750 g in weight) were taken from sandstone layers and processed using standard analytic techniques.

BIOSTRATIGRAPHY

The studied trilobite fauna can be assigned to the trilobite *Kainella meridionalis* Zone (upper part of the lower Tremadoc). This is in agreement with traditional assignation of the Cardonal Formation (HARRINGTON and LEANZA 1957; ACEÑOLAZA 1968; SANDRUSS 1974).

Brackebuschia acheila HARRINGTON *et* LEANZA reported here was previously described from the Santa Rosita Formation at the Santa Victoria locality in northern Argentina, close to the border with Bolivia (HARRINGTON and LEANZA 1957). The species occurred in association with *Leptoplastides marianus*, an undetermined *Geragnostus–Micragnostus*, kainellids (*Kainella meridionalis* KOBAYASHI, *Pseudokainella*

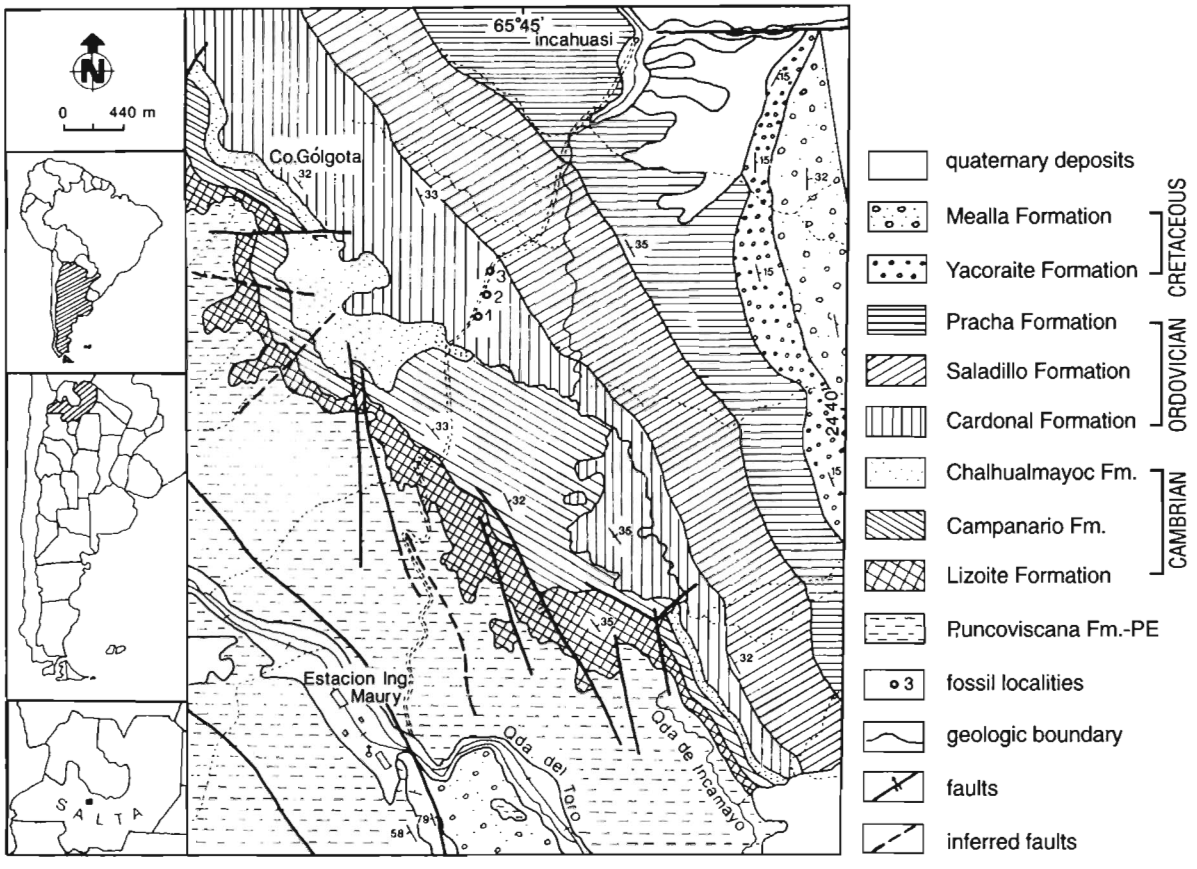

Fig. 1
Map of the study area (after SANDRUSS 1974).

lata (KOBAYASHI), *Apatokephalus tibicen* PRIBYL *et* VANEK), *Asaphellus catamarcensis* KOBAYASHI, and *Hapalopleura clavata* HARRINGTON *et* LEANZA. This trilobite assemblage was assigned to the *Kainella meridionalis* Zone (HARRINGTON and LEANZA 1957: p. 246).

Two other trilobite species have wide geographic and stratigraphic distribution and thus are biostratigraphically less significant. *Micragnostus chiushuensis* (KOBAYASHI, 1931) has been documented from the Upper Cambrian–lowest Ordovician of North America, Mexico and China (see WESTROP 1995). PRATT (1988) described *M. chiushuensis* (= *M. intermedius*) from northwestern Canada, in levels of the Rabbitkettle Formation that correlate with the *Kainella meridionalis* Zone of Argentina. *Leptoplastides marianus* (HOEK 1912) has been described from the lower and lower upper Tremadoc of Bolivia and from several localities in northwestern Argentina (*Parabolina frequens argentina* Zone, *Kainella meridionalis* Zone and *Bienvillia tetragonalis–Shumardia minutula* Zone (e.g., HARRINGTON and LEANZA 1957; HENNINGSMOEN 1957), including the Cardonal Formation type locality. As is the case for *Micragnostus chiushuensis, Leptoplastides marianus* has also been documented in the uppermost Cambrian–Tremadoc of Mexico (ROBISON and PANTOJA-ALOR 1968).

The conodont assemblage (Fig. 2) is composed of *Cordylodus angulatus* PANDER, 1856, *C. intermedius* FURNISH, 1938, *C.* cf. *proavus* MÜLLER, 1959, *Cristodus*? sp., *Drepanodus* sp. s.f., *Drepanoistodus* sp. n. A, *Monocostodus sevierensis* (MILLER, 1969), *Phakelodus elongatus* (AN, 1983), *Striatodontus* sp., *Teridontus obesus* JI *et* BARNES, 1994, *Utahconus* aff. *longipinnatus* JI *et* BARNES, 1994, and Gen. et sp. indet. The assemblage is dominated by *Monocostodus sevierensis* (53%), followed by *Utahconus* aff. *longipinnatus* (32%) and *Teridontus obesus* (6%). These species are characteristic of the Midcontinent paleobiogeographic Realm. The representatives of the genera *Cordylodus, Drepanoistodus,* and *Drepanodus* constitute the remaining 8%.

The occurrence of *Cordylodus angulatus* PANDER together with the associated conodont fauna indicates that the studied levels of the Cardonal Formation can be assigned to the *C. angulatus* Zone (Middle Tremadoc). This zone has a wide geographic distribution (see LÖFGREN 1996). In Argentina it was also

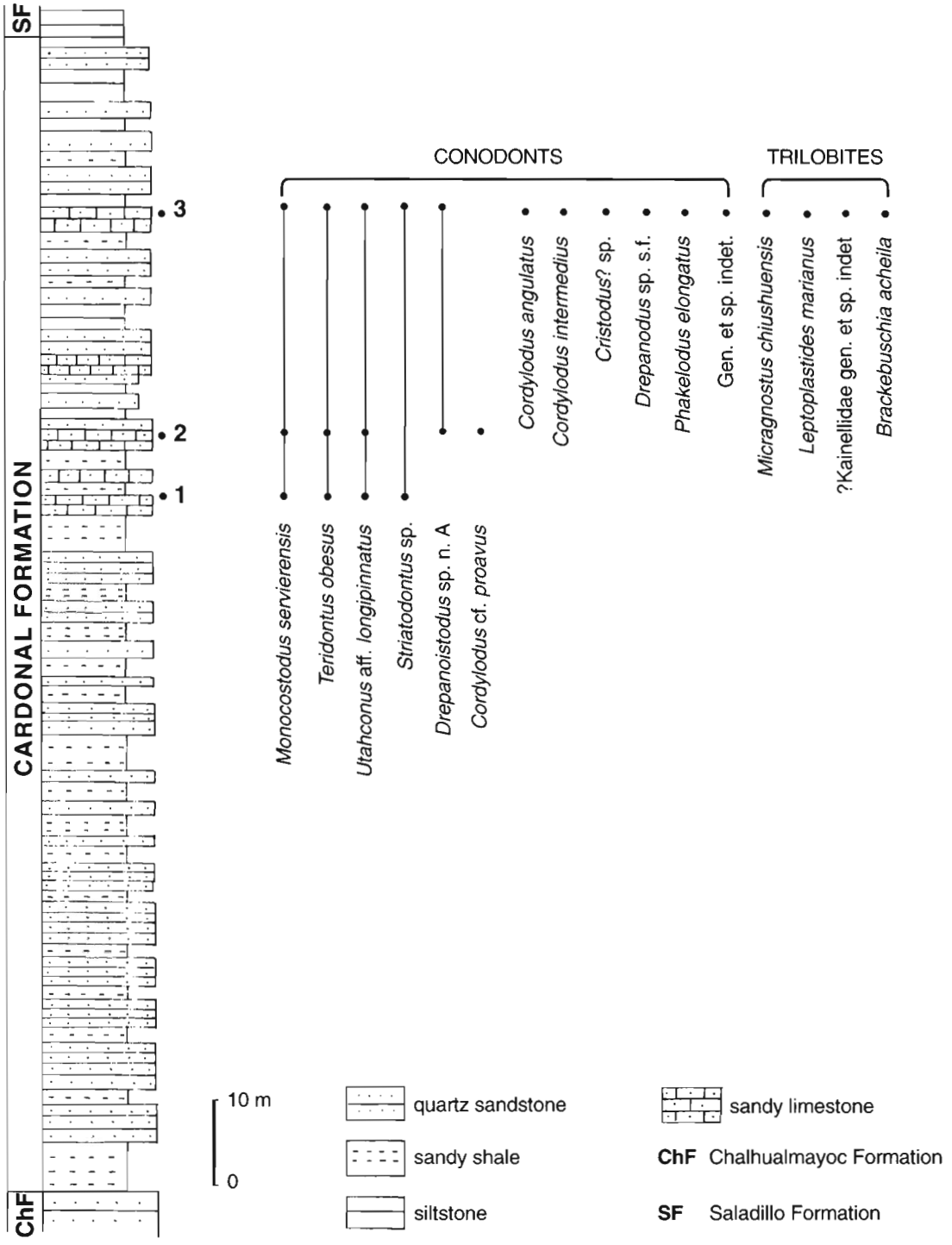

Fig. 2
Stratigraphic column of the studied unit, showing the location of the fossiliferous horizons and the position of the samples.

found in the Sierra de Cajas, Jujuy Province (SUAREZ RIGLOS *et al.* 1982; RAO 1994; RAO and HÜNICKEN 1995).

Monocostodus sevierensis (MILLER) was previously reported from the Santa Rosita Formation (Lower and Upper Tremadoc) in the Purmamarca area, in northwestern Argentina (RAO *et al.* 1994; RAO and HÜNICKEN 1995). MILLER (1980) described *M. sevierensis* as a multielement coniform apparatus from the Notch Peak Limestone in Utah and discussed its distribution.

Teridontus obesus JI and BARNES was mentioned from the Parcha Formation at its type locality, Cordillera Oriental, Salta Province (Argentina), in the *Paroistodus proteus* Zone (ALBANESI *et al.* 1997). *T. obesus* and *Utahconus longipinnatus* JI *et* BARNES were described from the Watts Bight and Boat Harbour formations, in western Newfoundland (JI and BARNES 1994) in the *Cordylodus angulatus* Zone (Middle and lower Upper Tremadoc).

Striatodontus sp. and *Utahconus* aff. *longipinnatus* are described for the first time from Argentina; they belong to genera that are well known in the Laurentian North America (JI and BARNES 1994).

SYSTEMATIC NOTES

The notes are limited to those taxa for which new observations can be presented.

CONODONTS

Genus *Cristodus* REPETSKI, 1982

Type species: *Cristodus loxoides* REPETSKI, 1982.

Cristodus? sp.
(Pl. 2: 18)

Material. — One element. CORD-MP 1371. Level 3.

Description. — Laterally compressed, albid bladelike element with seven small denticles laterally fused; they are posteriorly erect but progressively incline towards the anterior margin. Element with low base and narrow, shallow basal cavity. No conspicuous cusp is present. Smooth exterior surface.

Remarks. — General morphology of the only recovered specimen suggests that it should be assigned to the genus *Cristodus* REPETSKI, 1982. However, it roughly resembles also some forms of *Loxodus* FURNISH, 1938 and *Jumudontus* COOPER, 1981.

Genus *Drepanodus* PANDER, 1856

Type species: *Drepanodus arcuatus* PANDER, 1856.

Drepanodus sp. s.f.
(Pl. 1: 5)

Material. — One element. CORD-MP 1378. Level 3.

Description. — Drepanodiform, laterally compressed element. Cusp recurved. White matter present. Anterior and posterior edges sharp. Both sides rounded on the cusp and flat on the base. Basal cavity relatively deep.

Genus *Drepanoistodus* LINDSTRÖM, 1971

Type species: *Oistodus forceps* LINDSTRÖM, 1955.

Drepanoistodus sp. n. A
(Pl. 1: 8–12)

Material. — Twenty-two elements, 6 **a** elements and 16 **e** elements. CORD-MP 1379/1-18 and 1380/1-4. Levels 2 and 3.

Description. — A species of *Drepanoistodus* with two element morphotypes: **a** subrounded drepanodiform and **e** compressed oistodiform. White matter in all elements, beginning in the upper part of the base and continuing as a filament in the cusp.

a element: Drepanodiform morphology with a long recurved cusp and short base. Sharp anterior and posterior edges. Sides of the cusp slightly convex, base with flat face. Relatively deep basal cavity. Apex of the basal cavity of some elements pointed slightly anteriorly.

e element: Oistodiform, laterally compressed with a long, reclined cusp and short base, posteriorly extended. Cusp twisted inwardly with keeled anterior and posterior edges and an outer face slightly convex to flat. A weak carina on the inward side of the cusp (becomes prominent toward the base). A shallow groove adjacent posterior to the carina. Moderately deep basal cavity with the apex situated anteriorly.

Both elements show a wide range of variability mainly in the outline of the base and the basal cavity.

Remarks. — This species is similar to *Drepanoistodus concavus* (BRANSON *et* MEHL 1933) but differs from the latter by slightly recurved cusp in the **a** element and a more reclined cusp in the **e** element. *Drepanoistodus* sp. n. A is similar also to *D. nowlani* JI *et* BARNES (1994), but it can be distinguished from it by more rounded and asymmetrical drepanodiform elements.

Genus *Monocostodus* MILLER, 1980

Type species: *Acodus sevierensis* MILLER, 1969.

Emmended diagnosis. — *Monocostodus* apparatus includes three element morphotypes: **a** – rounded to subrounded, **b** – transitional, asymmetric, slightly laterally compressed, and **e** – asymmetric, laterally compressed. All elements have a sharp-posterior edge ("costa" *sensu* MILLER, 1980) that extends throughout the cusp. They are weakly covered by fine striations.

Remarks. — MILLER (1980) established the genus *Monocostodus* as "apparatus consisting of symmetry-transition series with slender, erect to reclined simple cones; dextral, sinistral, and rare bilaterally symmetrical symmetry-trasition variants produced by changes in position of narrow, sharp costa beginnig near of cusp and extending to tip; costa usually on right or left side, rarely posterior". However, the illustrations of MILLER (1980: fig. 4U and pl. 2: 8, 9) clearly show that this costa is a sharp-posterior edge. Specimens illustrated by MILLER (1980) do not show real costa on the right or left side. It is also not observed in the elements figured by AN *et al.* (1983: pl. 6: 19–23) and in those figured by NOWLAN (1985: pl. 5: 33–35) and AN (1987: pl. 5: 30, 32 and pl. 7: 17).

Monocostodus differs from the genus *Semiacontiodus* as defined by JI and BARNES (1994: p. 59) in having **a** and **b** elements with a sharp posterior edge without lateral costa.

Monocostodus is similar to *Teridontus*, but differs in having the **a** and **b** elements with a sharp posterior edge.

JI and BARNES (1994: pp. 65, 66) included tentatively *Monocostodus sevierensis* MILLER in the synonymy list of *Teridontus gracillimus* as the **e** element. However, this morphotype has posterior costa and a rounded anterior edge (MILLER 1980, see fig. 4U) whereas the same morphotype described by JI and BARNES (1994: p. 64) has an anterior knife-edge and a posterior sharp edge.

Considering the above discussion, the specimens of *M. sevierensis* (MILLER) illustrated by NOWLAN (1985) and AN *et al.* (1983) should not be in the synonymy of *Teridontus nakamurai*, as proposed by JI and BARNES (1994).

Monocostodus sevierensis (MILLER, 1980)
(Pl. 1: 13–18; Fig. 3)

1969. *Acodus sevierensis* sp. nov.; MILLER: p. 418; pl. 63: 25–28.
1980. *Monocostodus sevierensis* (MILLER); MILLER: p. 27; fig. 4 U; pl. 2: 8, 9 (see for synonymy).
1983. *Monocostodus sevierensis* (MILLER); AN *et al.*: p. 108; pl. 6: 19, 23.
1985. *Monocostodus sevierensis* (MILLER); NOWLAN: p. 113; figs 5.33–5.35.
1987. *Monocostodus sevierensis* (MILLER); AN: p. 158; pl. 5: 30, 32; pl. 7: 17.

Material. — 279 elements (205 **a** elements, 32 **b** elements and 42 **e** elements). CORD-MP 1382/1-256, 1383/1-18, and 1384/1-5. Levels 1, 2, and 3.

Description. — **a** element: The elements show a symmetry transition series of rounded to subrounded forms. The subrounded elements are slightly compressed laterally. Cusp long and slender, slightly reclined to proclined. The anterior edge rounded and the posterior one sharp, with costa that extends from the apex to the middle part of the element. Short base, 1/3 to 1/4 of the length of the cusp. The basal cavity relatively deep with its apex located at the level of the strongest curvature. The basal outline oval to circular with a drop-shaped cross-section.

b element: Laterally compressed and asymmetrical element with a long, suberect and slender cusp, slightly deflected laterally. The anterior edge rounded. The posterior edge has one costa that extends to the upper of the basal margin. The base short, 1/4 of the length of the cusp. The basal cavity shallower than in **a** element. Rounded basal outline.

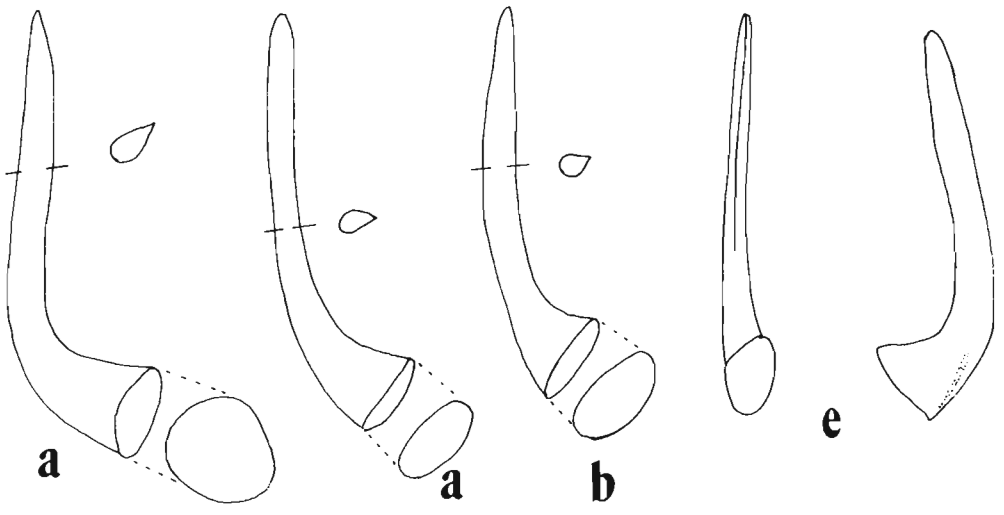

Fig. 3
Elements of *Monocostodus sevierensis* (MILLER); the base and cusp cross-sections of the **a**, **b** and **e** morphotypes.

e element: Asymmetrical and laterally compressed element. Long, suberect to proclined and slender cusp. Rounded anterior edge and sharp posterior one. The posterior costa extends from the apex to the middle part of the element. A smooth groove near the anterior margin of the base on the flat side. The other side convex. The basal cavity shallow and the basal outline asymmetrically rounded.

Remarks. — MILLER (1980) established the genus *Monocostodus* as an apparatus consisting of a symmetry transition series of slender, erect to reclined, simple cones. JI and BARNES (1994) considered *M. sevierensis* to be the **e** element of *Teridontus*. Specimens from Incamayo Creek show resemblance with those of *Teridontus gracillimus* JI *et* BARNES, but all morphotypes (not only the **e** element) have a sharp--posterior edge. Because of this feature they are reassigned to *Monocostodus sevierensis*.

Genus *Striatodontus* JI *et* BARNES, 1994

Type species: *Striatodontus prolificus* JI *et* BARNES, 1994.

Striatodontus sp.
(Pl. 2: 13)

Material. — Three elements. CORD-MP 1389/1, 2, and 1390. Levels 1 and 3.

Description. — Simple proclined cone with small, slightly twisted cusp, and a long base. Two prominent postero-lateral carinae extend from the middle part until the apex of the element. Each carina bounded by an anterior groove. Element with a convex anterior face and a triangular groove located in the middle upper part of the posterior side. The posterior side convex in the middle lower part. Deep and conical basal cavity.

Remarks. — As it was observed by JI and BARNES (1994: p. 57), the genus *Striatodontus* differs from *Scolopodus* by albid elements with fine striations and a posterior groove. JI and BARNES (1994) diagnosed this genus for the Lower Arenig of Newfoundland, Canada. Our specimens are similar to the species described by JI and BARNES but probably represent an older species.

Genus *Teridontus* MILLER, 1980

Type species: *Oneotodus nakamurai* NOGAMI, 1967.

Teridontus obesus JI *et* BARNES, 1994
(Pl. 2: 1–7)

1994. *Teridontus obesus* sp. nov.; JI and BARNES: pp. 65–66, pl. 24: 10–17, text-fig. 37B (see for synonymy).

Material. — Thirty two elements, 19 **a** elements, 2 **b** elements, 3 **c** elements, and 8 **e** elements. CORD-MP 1375/1-25, 1376, and 1377/1-8. Levels 1, 2, 3.

Remarks. — JI and BARNES (1994) defined *Teridontus obesus* as a multielement species with **a** (subrounded), **b** (transitional), **c** (suberect) and **e** (compressed) elements. The albid elements of our collections show a shorter cusp, and some **c** elements have smooth posterior costa. These features are attributed to intraspecific changes in *T. obesus.*

Genus *Utahconus* MILLER, 1980

Type species: *Paltodus utahensis* MILLER, 1969.

Utahconus aff. *longipinnatus* JI *et* BARNES, 1994
(Pl. 2: 8–12)

aff. 1994. *Utahconus longipinnatus* sp. nov.; JI and BARNES: pp. 66–67; pl. 25: 1–8, text-fig. 38A (see for synonymy).

Material. — 178 elements, 16 **a** elements (asymmetric), 54 **a** elements (subsymmetric) and 108 **e** elements. CORD-MP 1386/1-161, 1387/1-13, and 1388/1-4. Levels 1, 2, and 3.

Description. — **a** element: Laterally compressed, subsymmetrical, and postero-laterally compressed asymmetrical elements. All characterized by a long cusp and a short base. The cusp proclined to erect, filled with white matter. The asymmetrical elements with a sharp or keeled posterior side and smooth anterolateral carina on anterior face and edge. The cross-section tear-shaped. The subsymmetrical elements with rounded anterior and sharp posterior edges, slightly deflected. Flanks slightly convex. Basal cavity moderately deep, with a narrow anterior margin.

e element: Bicostate and posterolaterally compressed elements. The lateral costae reach near the basal margin. The anterior face smoothly rounded, the posterior one concave and with a weak central carina more prominent toward the point of major curvature. The carina bounded by a shallow groove at each side, is better developed near the base. Short, posterolaterally extended base with a basal cavity deeper than in the **a** elements; apex of the cavity situated at the anterior side. The basal profile tear-shaped.

The **c** morphotype has not been recovered.

Remarks. — This species is similar to *Utahconus longipinnatus* JI *et* BARNES, but in our specimens the **a** elements are both subsymmetric and symmetric, and the outline of the basal cavity is rounded. In the **e** element, the basal margin is narrower than in *U. longipinnatus. Utahconus* aff. *longipinnatus* differs from *U. utahensis* by having a long cusp and a short base.

Gen. et sp. indet.
(Pl. 2: 14, 15)

Material. — Two elements. CORD-MP 1393/1, 2. Level 3.

Description. — The elements with a short base, shallow basal cavity, and small cusp with the apex broken that forms a braid. One of the elements bears a prominent carina at the base.

TRILOBITES

Order **Agnostida** SALTER, 1864
Family **Agnostidae** M'COY, 1849
Genus *Micragnostus* HOWELL, 1935

Type species: *Agnostus calvus* LAKE, 1906.

Micragnostus chiushuensis (KOBAYASHI, 1931)
(Fig. 4A–F)

1931. *Agnostus chiushuensis* sp. nov.; KOBAYASHI: pp. 173–174; pl. 22: 1–5.

?1993. *Geragnostus* sp. aff. *G. intermedius* PALMER; MOYA *et al.*: pp. 24–25; pl. 1:1.

1995. *Micragnostus chiushuensis* (KOBAYASHI); WESTROP: pp. 15–16; pl. 1: 14–16 (see for synonymy).

Material. — Sixteen cephala and six pygidia, PIL 13930–13939, 13941–13946, 13948–13951. Level 3.

Remarks. — Recently, WESTROP (1995) discussed the synonymy of this widespread and variable species. A fragmentary cephalon from the Lower Ordovician of La Puna in northwestern Argentina, tentatively assigned by MOYA *et al.* (1993: pl. 1: 1) to *Geragnostus* sp. aff. *G. intermedius,* is probably conspecific.

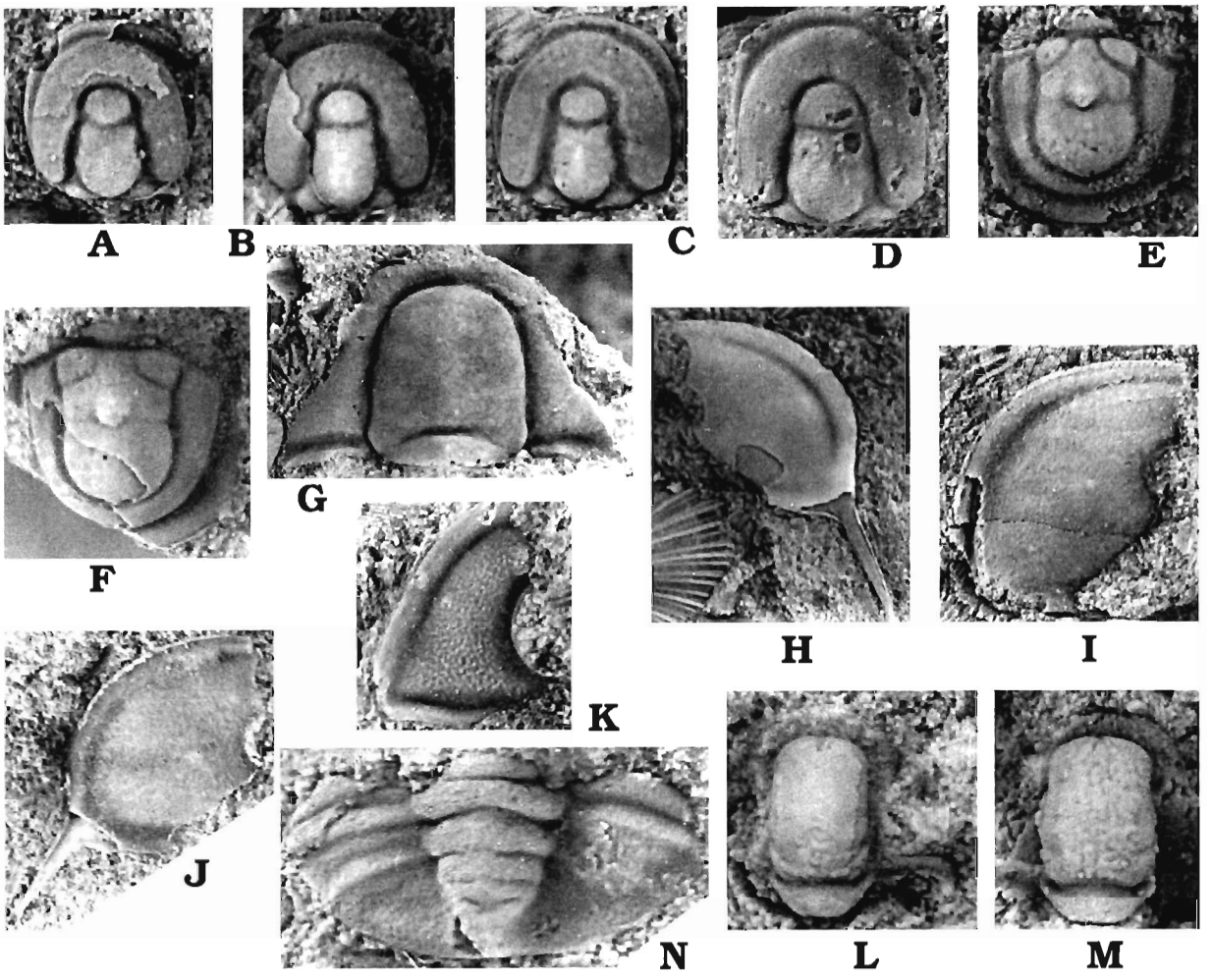

Fig. 4

A–F. *Micragnostus chiushuensis* (KOBAYASHI). Cephalon, PIL 13936, × 9 (**A**); cephalon, PIL 13937, × 10.4 (**B**); cephalon, PIL 13940, × 10.4 (**C**); cephalon, PIL 13951, × 12.6 (**D**); pygidium, PIL 13941, × 16 (**E**); pygidium, PIL 13932, × 11.6 (**F**). **G–J**. *Leptoplastides marianus* (HOEK). Cranidium, PIL 13949, × 7 (**G**); librigena, PIL 13936, × 3.4 (**H**); fragmentary librigena, PIL 14085, × 5 (**I**); librigena, PIL 14089, × 6.4 (**J**). **K**. ?Kainellidae indet., fragmentary librigena, PIL 13931, × 7.7. **L–N**. *Brackebuschia acheila* HARRINGTON *et* LEANZA. Fragmentary cranidium, PIL 14085, × 14 (**L**); fragmentary cranidium, PIL 14085, × 14.1 (**M**); pygidium, PIL 14087, × 15.5 (**N**).

Order **Ptychopariida** SWINNERTON, 1915
Suborder **Olenina** BURMEISTER, 1843
Family **Olenidae** BURMEISTER, 1843
Subfamily **Pelturinae** HAWLE *et* CORDA, 1847

Genus *Leptoplastides* RAW, 1908

Type species: *Conocoryphe salteri* CALLAWAY, 1877.

Remarks. — Generic concepts of HENNINGSMOEN (1957: pp. 264–265) are followed here (see also FORTEY and OWENS 1989).

Leptoplastides marianus (HOEK, 1912)
(Fig. 4G–J)

1912. *Parabolinopsis mariana* sp. nov.; HOEK in STEINMANN and HOEK: p. 226; pl. 7: 1–3.

1957. *Parabolinopsis mariana* HOEK; HARRINGTON and LEANZA: pp. 89–93; figs 29, 30: 1–10.

1957. *Leptoplastides marianus* (HOEK); HENNINGSMOEN: 266 (see for synonymy).

1968. *Leptoplastides marianus* (HOEK); ROBISON and PANTOJA-ALOR: pp. 791–792; pl. 100: 8, 9, 11–14.

1977. *Parabolinopsis mariana* HOEK; ACEÑOLAZA and GONZALEZ: pp. 132–133, fig. 2.

1980. *Leptoplastides marianus* (HOEK); PŘIBYL and VANEK: pl. 7: 4, 5; pl. 10: 7–9.

Material. — Thirteen cranidia and 43 librigenae, PIL 13930–13939, 13941–13945, 13949–13951, 14085, 14086, 14088, 14089. Level 3.

Remarks. — HARRINGTON and LEANZA (1957) described in detail numerous specimens of *Leptoplastides marianus* from northwestern Argentina. Based on material from the uppermost Cambrian–Tremadoc of Mexico, ROBISON and PANTOJA-ALOR (1968) identified variations related to the ontogeny which is also noticeable in the material studied here (e.g. small cranidia have better developed lateral glabellar furrows).

The cephalon of *L. marianus* differs from the cephalon of the type species, *Leptoplastides salteri* (CALLAWAY), from the Tremadoc of Great Britain (see FORTEY and OWENS 1991: fig. 8c–j), mainly by having wider pleural regions and more posteriorly situated genal spines (cf. HENNINGSMOEN 1957).

Order **Asaphida** SALTER, 1864 emend. FORTEY *et* CHATTERTON, 1988
Suborder **Asaphina** SALTER, 1864 emend. FORTEY *et* CHATTERTON, 1988
Family ?**Kainellidae** ULRICH *et* RESSER, 1930

Gen. et sp. indet.

(Fig. 4K)

Material. — Three fragmentary librigenae, PIL 13931, 13946, 14087. Level 3.

Remarks. — The fragmentary character of the material prevents a precise identification. The librigenae of kainellid type, are characterized by a granulated ornamentation. In general, they resemble *Pseudokainella lata* (KOBAYASHI) (see HARRINGTON and LEANZA 1957: figs 53, 54: 1–9), a species widely distributed in the upper part of the lower Tremadoc of northwestern Argentina.

Additionally, librigenae assigned to *Pseudokainella* sp. from the Cambrian–Ordovician boundary interval in Antarctica (WRIGHT *et al.* 1984: fig. 2J, K), and to *Pseudokainella variagranula* (ROBISON *et* PANTOJA-ALOR 1968: pl. 104: 5–11) from the uppermost Cambrian–Tremadoc of Mexico, are similar to the material studied here, but have slightly more advanced genal angles. *Apatokephalus tibicen* PŘIBYL *et* VANEK (1980: pl. 12: 3, 4; see also HARRINGTON and LEANZA 1957: fig. 56: 1–10) and *Apatokephalus exiguus* HARRINGTON *et* LEANZA (1957: figs 57, 58: 1–5) from the Tremadoc of northwestern Argentina, and *Pseudokainella variagranula* from the uppermost Cambrian–Tremadoc of Mexico, have facial sutures more divergent in front of the eyes.

Order et Family Uncertain

Genus *Brackebuschia* HARRINGTON *et* LEANZA, 1957

Type species: *Brackebuschia acheila* HARRINGTON *et* LEANZA, 1957.

Brackebuschia acheila HARRINGTON *et* LEANZA, 1957

(Fig. 4L–N)

1957. *Brackebuschia acheila* sp. nov.; HARRINGTON and LEANZA: p. 226; fig. 124: 1a–d.

Material. — Four incomplete cranidia and 10 pygidia, PIL 13935, 13936, 14085–14087, 14089. Level 3.

Remarks. — The collected cranidia are fragmentary. They are characterized by a long, parallel sided, anteriorly subtruncated glabella, with very faint indications of four lateral glabellar furrows; and a depressed frontal area, without anterior border. Pygidia transversely elongated, having a convex, tapered axis, with four well defined rings and a terminal piece. Pleural fields have indications of two or three ribs, and the pygidial border furrow is absent. These characters resemble those of *Brackebuschia acheila*, a species previously described for the upper part of the lower Tremadoc of the Santa Victoria area (northern Cordillera Oriental of Argentina) (HARRINGTON and LEANZA 1957).

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TREMADOC CONODONTS AND TRILOBITES FROM THE CARDONAL FORMATION, INCAMAYO CREEK, SALTA PROVINCE, NORTHWESTERN ARGENTINA

PLATE 1

Cordylodus angulatus PANDER, 1856 33

1. Compressed element, lateral view. CORD-MP 1372/1, × 200.
2. Rounded element, lateral view. CORD-MP 1372/2, × 150.
3. Compressed element, lateral view. CORD-MP 1372/3, × 180.
6. Rounded element, lateral view. CORD-MP 1372/4, × 200.

Cordylodus cf. *proavus* MÜLLER, 1959 33

4. Rounded element, lateral view. CORD-MP 1374, × 200.

Drepanodus sp. s.f. 35

5. Drepanodiform element, lateral view. CORD-MP 1378, × 160.

Cordylodus intermedius FURNISH, 1938 33

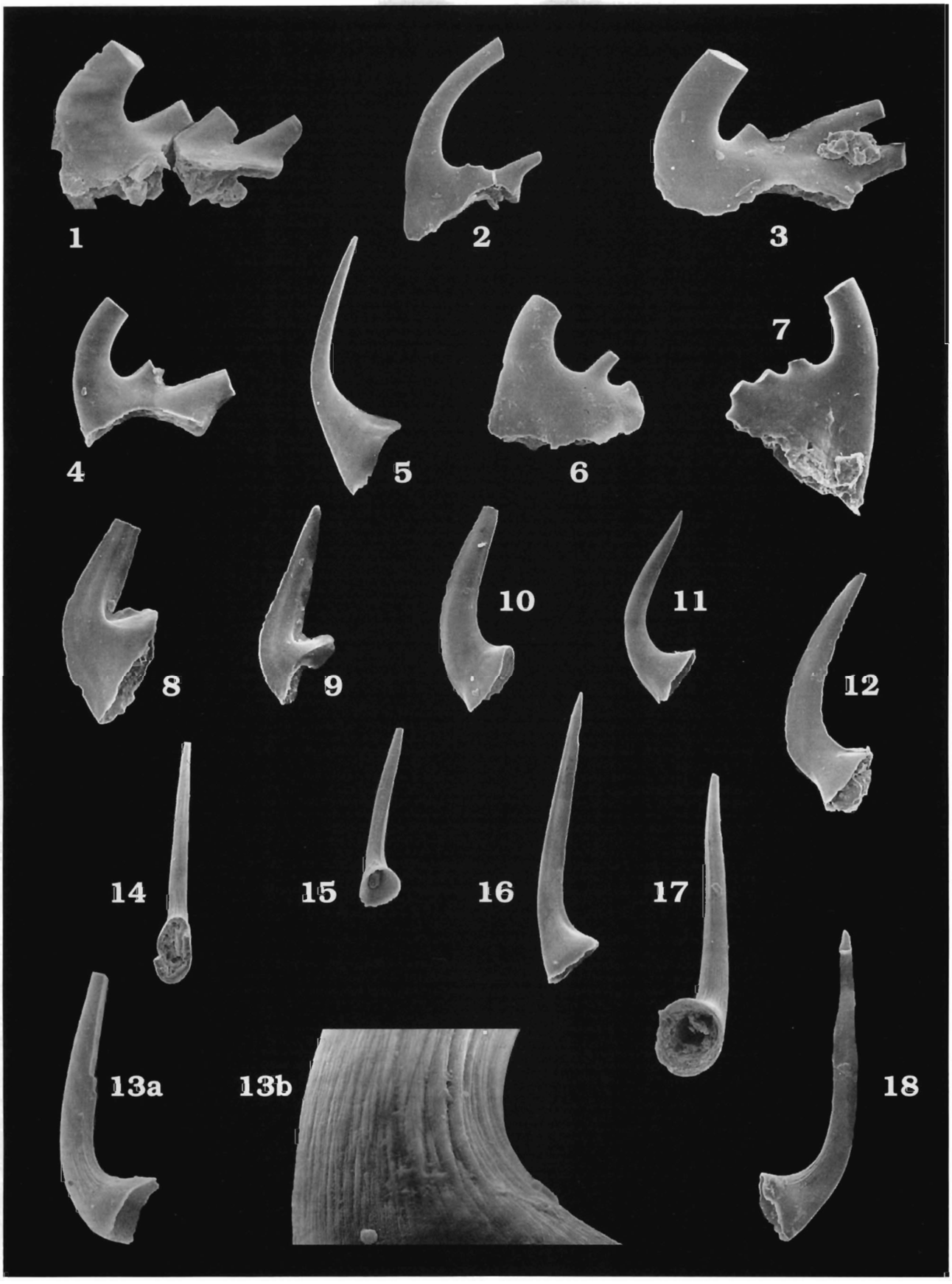
7. Rounded element, lateral view. CORD-MP 1373/1, × 160.

Drepanoistodus sp. n. A 35

8. **e** element, lateral view. CORD-MP 1379/1, × 150.
9. **e** element, lateral view. CORD-MP 1379/2, × 100.
10. **a** element, lateral view. CORD-MP 1379/3, × 100.
11. **a** element, lateral view. CORD-MP 1379/4, × 100.
12. **a** element, lateral view. CORD-MP 1379/5, × 150.

Monocostodus sevierensis (MILLER, 1980) 36

13a. **a** element, lateral view. CORD-MP 1382/1, × 200.
13b. Detail of the **a** element shown on 13a, × 2000.
14. **b** element, posterior view. CORD-MP 1382/2, × 110.
15. **a** element, posterior view. CORD-MP 1382/3, × 110.
16. **b** element, lateral view. CORD-MP 1382/4, × 130.
17. **a** element, posterior view. CORD-MP 1382/5, × 130.
18. **e** element, lateral view. CORD-MP 1382/6, × 130.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TREMADOC CONODONTS AND TRILOBITES FROM THE CARDONAL FORMATION, INCAMAYO CREEK, SALTA PROVINCE, NORTHWESTERN ARGENTINA

PLATE 2

Teridontus obesus Ji *et* BARNES, 1994 37

1. **a** element, lateral view. CORD-MP 1375/1, × 100.
2. **b** element, lateral view. CORD-MP 1375/2, × 100.
3. **c** element, postero-lateral view. CORD-MP 1375/3, × 150.
4. **c** element, postero-lateral view. CORD-MP 1377/1, × 86.
5. **e** element, lateral view. CORD-MP 1377/2, × 86.
6. **b** element, lateral view. CORD-MP 1375/4, × 130.
7. **a** element, lateral view. CORD-MP 1377/3, × 120.

Utahconus aff. *longipinnatus* Ji *et* BARNES, 1994 38

8. **a** element (subsymmetric), lateral view. CORD-MP 1386/1, × 100.
9. **e** element, postero-lateral view. CORD-MP 1386/2, × 110.
10. **a** element (asymmetric), lateral view. CORD-MP 1386/3, × 100.
11. **e** element, postero-lateral view. CORD-MP 1386/4, × 100.
12. **e** element, postero-lateral view. CORD-MP 1386/5, × 100.

Striatodontus sp. 37

13a. Postero-lateral view. CORD-MP 1389/1, × 189.
13b. Detail of the element shown on 13a, × 1300.

Gen. et sp. indet. 38

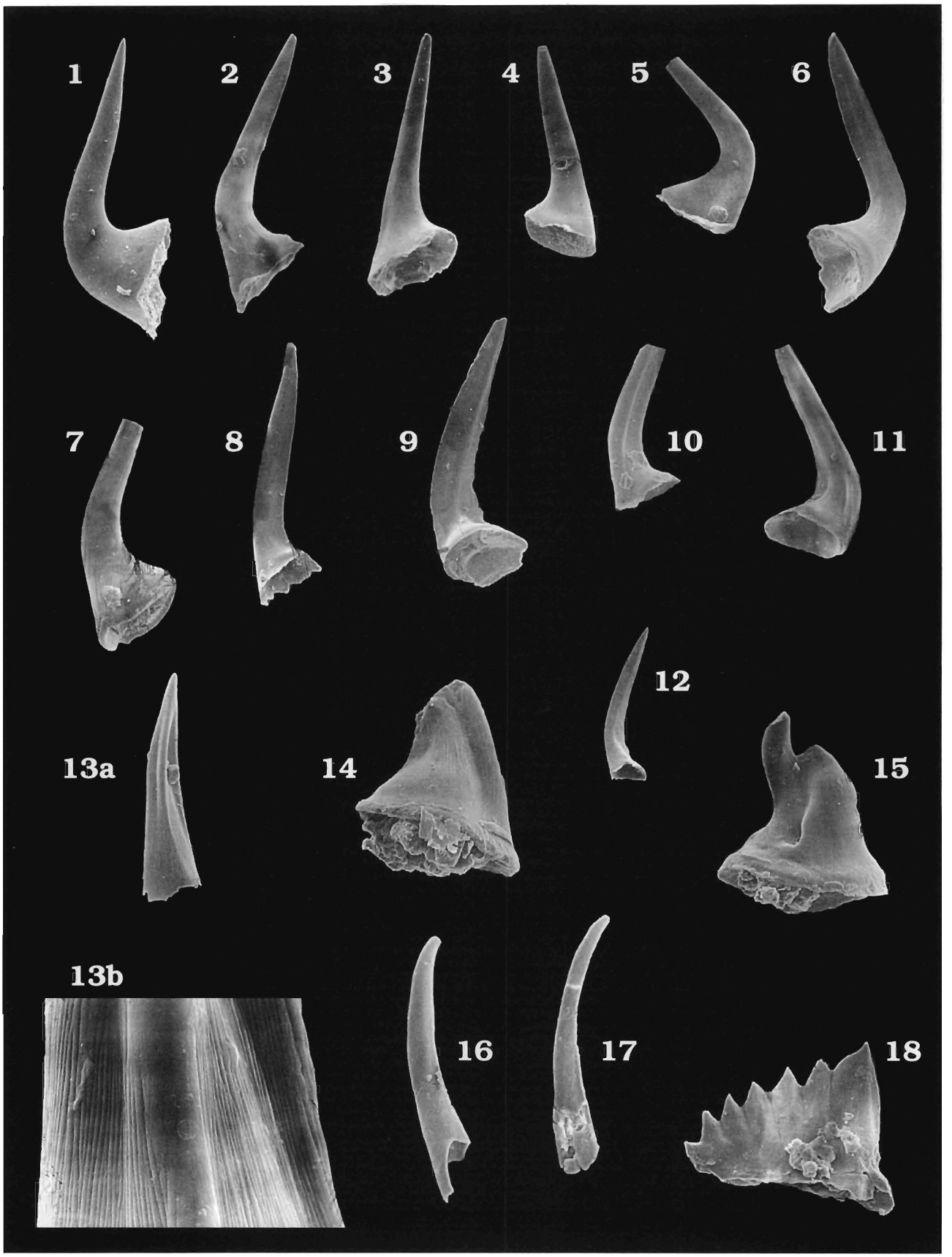
14. Lateral view. CORD-MP 1393/1, × 180.
15. Lateral view. CORD-MP 1393/2, × 180.

Phakelodus elongatus (AN) 33

16. Lateral view. CORD-MP 1370/1, × 260.
17. Lateral view. CORD-MP 1370/2, × 260.

Cristodus? sp. 35

18. Inner-lateral view. CORD-MP 1371, × 200.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