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NEW RECORDS OF TREMADOCIAN CONODONTS (EARLY ORDOVICIAN) FROM THE ZENTA RANGE, JUJUY PROVINCE, ARGENTINA

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THE study area is located nearby the Santa Ana village, province of Jujuy, in the Zenta Range of the Cordillera Oriental, northwestern Argentina. Localities can be reached by the national Route 9 to the town of Humahuaca, then continue to the East through the provincial Route 73 up to the Santa Ana village (Fig. 1). In this contribution we analyze an Ordovician conodont fauna from 15 levels of calcarenites and coquinas, along with graptolites, trilobites and associated fauna from siltstones and claystones. The studied collection of 2263 conodont elements is housed in the Museum of Paleontology at the National University of Córdoba, under repository code CORD-MP 21941 to 22023.

GEOLOGICAL FRAMEWORK

Rocks exposed in the surroundings of the Santa Ana village consist of Ordovician gray-green shales and yellowish gray sandstones interbedded with sparse gray and lenticular layers of coquinas and subordinate calcarenites. These rocks form the core of an anticline, with NNE direction, whose basal portion is not observable. The collection of conodonts analyzed in this study comes from the core (sample StaAna8), the eastern flank (samples Zen1, Zen2, Zen3, Zen4, StaAna5, StaAna6, ValleCol5) and the western flank (Zen6.2, Zen7.2, Zen8.6, Zen10, Zen11) of the anticline (Fig.1.2). Furthermore, StaAna1 corresponds to a sample with trilobites, and Zen13 and Zen2 correspond to samples with graptolites. Additionally, we studied two samples with conodonts from the Abra de Zenta (AZ1 and AZ2; Figure 1.1).

The fossiliferous levels described here correlate with the upper part of the Santa Rosita Formation (members Alfarcito and Rupasca) and the Parcha Formation; nevertheless, the strata that crop out in the Santa Ana area have not received a formal name so far.

The Santa Rosita Formation was originally described by Turner (1960) in the Santa Victoria Range, and was formally defined by Buatois *et al.* (2006) in the Tilcara Range. The latter authors described this unit as consisting of the members Tilcara, Casa Colorada, Pico de Halcón, Alfarcito, Rupasca and Humacha, although this nomenclature should be restricted to the type locality wherever defined.

The studies carried out on the basis of fossil evidence of the Santa Rosita Formation (Benedetto, 1977; Zeballo and Tortello, 2005; Zeballo *et al.*, 2005; Zeballo and Albanesi, 2009) indicate an age covering the late Furongian up until the middle Tremadocian (Tr2; Bergström *et al.*, 2009). In the eastern domain of the Cordillera Oriental the correlative strata are overlain by the Parcha Formation (Keidel, 1937). The San Bernardo Formation (Harrington and Leanza, 1957) correlates with the latter unit in the western domain. These units were deposited during the late Tremadocian (Tr3) and the Floian (Monteros and Moya, 2003; Toro *et al.*, 2003; Ortega and Albanesi, 2005; Waisfeld *et al.*, 2006).

A more extensive review of the geology of the Zenta Range, which consists of marine sedimentary rocks deposited from the Neoproterozoic to Devonian, and Carboniferous, Cretaceous and Cenozoic continental strata, can be found in the works of Amengual and Zanettini (1973), Aráoz *et al.* (2008), and Astini (2008), among others.

BIOSTRATIGRAPHY

The *Cordylodus angulatus, Paltodus deltifer* and *Acodus deltatus-Paroistodus proteus* zones were identified in the stratigraphic successions analized. These conodont zones were previously recorded in other localities of the northwestern Argentina (Rao and Flores, 1998; Rao and Tortello, 1998; Zeballo *et al.*, 2005; Zeballo and Albanesi, 2013a, among others).

Cordylodus angulatus Zone?

Two samples collected from the Abra de Zenta (samples AZ1 and AZ2) yielded a low abundance conodont fauna (29 elements) that consists of *Teridontus gallicus* Serpagli, Ferretti, Nicoll and Serventi, *Variabiloconus crassus* Zeballo and Albanesi and *Semiacontiodus* sp. The *Cordylodus angulatus* Zone, which typically documents those species in the Cordillera Oriental sequences, indicates the upper lower Tremadocian, but the absence of the index conodont *Cordylodus angulatus* Pander precludes such assignment to the bearer strata.

Paltodus deltifer Zone (*P. deltifer pristinus* Subzone)

The sample StaAna8 from the anticline core produced a more diversified and abundant fauna (333 elements) that includes *Paltodus deltifer pristinus* (Viira) together with *Drepanodus* sp., *Drepanoistodus chucaleznensis* Albanesi and Aceñolaza, *Hispidodontus* sp., *Semiacontiodus minutus* Zeballo, Albanesi and Ortega, *Teridontus gallicus, Tilcarodus humahuacensis*

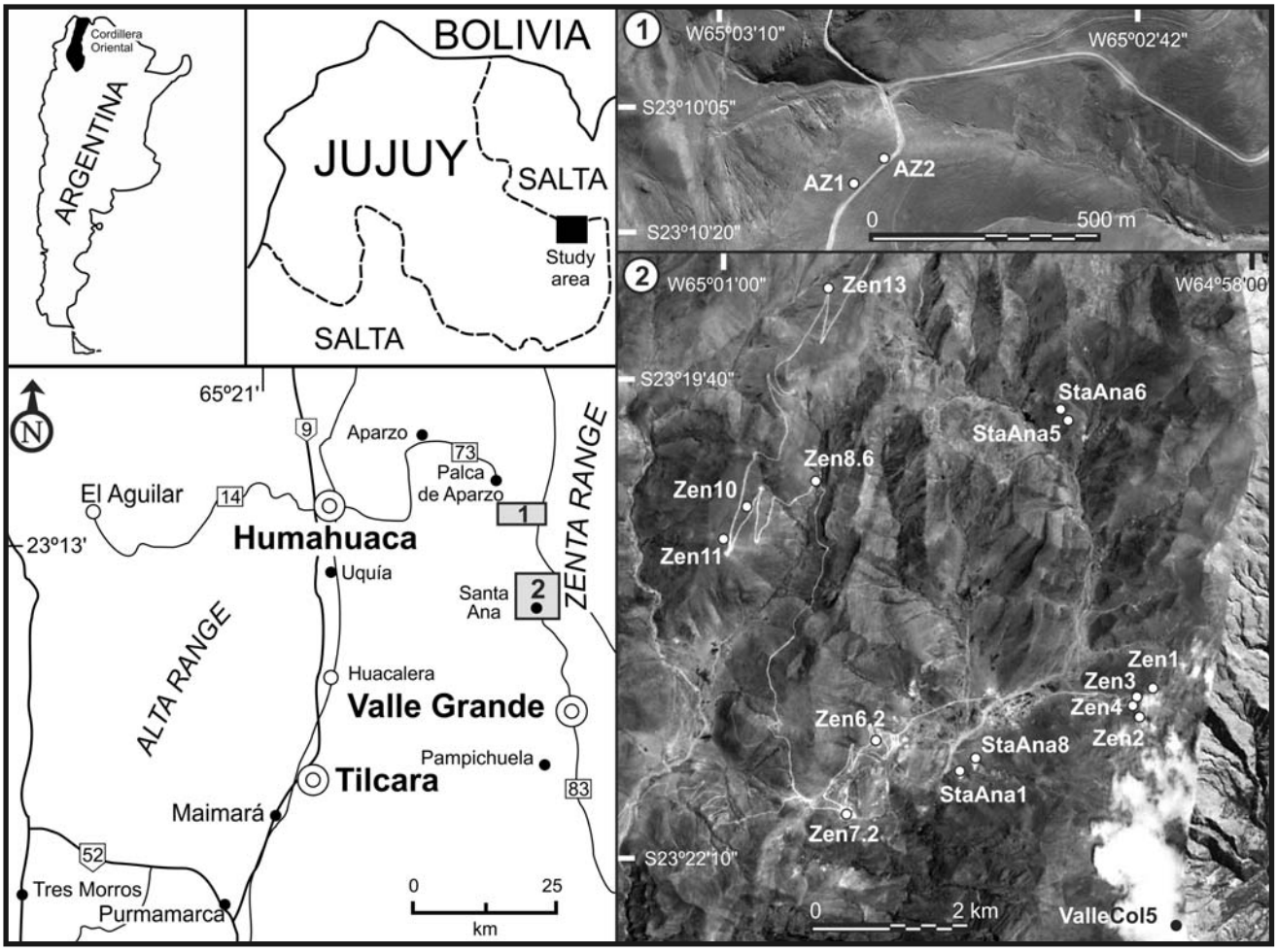

Figure 1. Location map of the study area (left), satellite images with the sample points (right): 1, Abra de Zenta, 2, Abra and Santa Ana village.

(Albanesi and Aceñolaza), *Variabiloconus crassus*, and the protoconodonts *Phakelodus elongatus* (Zhang), and *P.* cf. *savitzkyi* (Abaimova). This conodont association indicates an early middle Tremadocian (Tr2) age.

***Acodus deltatus-Paroistodus proteus* Zone**

This biozone is represented by the stratigraphic interval that includes samples ValleCol5, Zen1, Zen2, Zen3, Zen4, StaAna5, StaAna6, in the eastern flank of the Santa Ana anticline, and the samples Zen6.2, Zen7.2, Zen8.6, Zen10 and Zen 11, from the western flank of the same anticline (Fig. 1). The conodont fauna of these productive samples consists of *Acanthodus* cf. *humachensis* Zeballo and Albanesi, *Acodus apex* Albanesi and Zeballo, *Acodus* n. sp., *Cornuodus* sp., *Drepanodus arcuatus* Pander, *Drepanoistodus chucaleznensis, D*. aff. *chucaleznensis, D. costatus* (Abaimova), *Iapetognathus aengensis* (Lindström), *Kallidontus* sp., *Paltodus deltifer deltifer* (Lindström), *P. subaequalis* Pander, *P.* cf. *subaequalis, Paroistodus proteus* (Lindström), *Striatodontus* n. sp., *Trapezognathus? primitivus* Voldman, Albanesi and Zeballo, *Tropodus* sp., *Utahconus* sp. and *Variabiloconus* sp., associated to the protoconodonts *Phakelodus elongatus*, and *P. tenuis* (Müller).

DISCUSSION

The conodont association from samples AZ1 and AZ2 from the Abra de Zenta is not diagnostic due to the absence of the index taxon; however, it presents a close similarity with the samples of low diversity from the lower Tremadocian (Tr1) of the Tilcara Range, where *Teridontus gallicus* and *Variabiloconus crassus* co-exist. The low diversity fauna is not given by a sampling bias, but it could be controlled by environmental factors, such as possible restrictions in the habitat for the nektobenthic forms (Zeballo and Albanesi, 2013b). Tortello and Aceñolaza (2010) report the record of the trilobites *Asaphellus catamarcensis* Kobayashi, *Leptoplastides marianus* (Hoek), and *Kainella* sp., in the Abra de Zenta, indicating an early Tremadocian age for the bearer levels as well.

On the other hand, the strata of the anticlinal core are referred to the lower middle Tremadocian (Tr2). In a neighboring creek, a few meters from the sample StaAna8, the sample StaAna1 provided disarticulated remains of *Asaphellus catamarcensis*, which reinforces the age of the conodont association. Although the *Paltodus deltifer deltifer* Subzone has not been identified, which is indicative of the upper middle Tremadocian, a new more detailed sampling of the overlying strata could verify the presence of such subzone.

The *Acodus deltatus-Paroistodus proteus* Zone in the study area is only characterized by *P. proteus.* Despite the absence of *Acodus deltatus* Lindström and the scarce contribution of *P. proteus,* the association of *Acodus apex, Drepanoistodus costatus* and *Paltodus deltifer deltifer* refers to the early late Tremadocian (Tr3), such as indicated by Albanesi *et al.* (2011).

The authors document a similar fauna in their sample Z5 of the Abra de Santa Ana, which is equivalent to the sample Zen1 in this work. Apparently, *Acodus apex* is a species phylogenetically related to *A. deltatus*, even if the co-existence at global scale has not been recorded so far.

Trapezognathus? primitivus is recorded in the sample Zen11, which is apparently related to *Trapezognathus? argentinensis* Rao, Hünicken and Ortega, as both forms are recorded together in younger levels (Carlorossi and Heredia, 2013; Voldman *et al.*, 2013). *Trapezognathus?* could correspond to a different though related lineage than the Baltic genus *Trapezognathus*, and all of the collections housed in the same repository as the current collection are under revision. Considering the disappearance of *Paltodus deltifer deltifer* and the presence of *Trapezognathus?* in the conodont association, we infer an approximation to the Tremadocian/Floian boundary. The age is remarked by the record of the graptolites *Hunnegraptus* cf. *novus* (Berry) and *Hunnegraptus* sp., which refer to the *H. copiosus* Zone of the latest Tremadocian.

The conodont faunas are representative of the Southwestern Gondwana Province of the Cold Domain from the Shallow-Sea Realm. Previous contributions consider this paleobiogeographic determination for the Cordillera Oriental of Northwestern Argentina (see Zeballo and Albanesi, 2013b, for more details).

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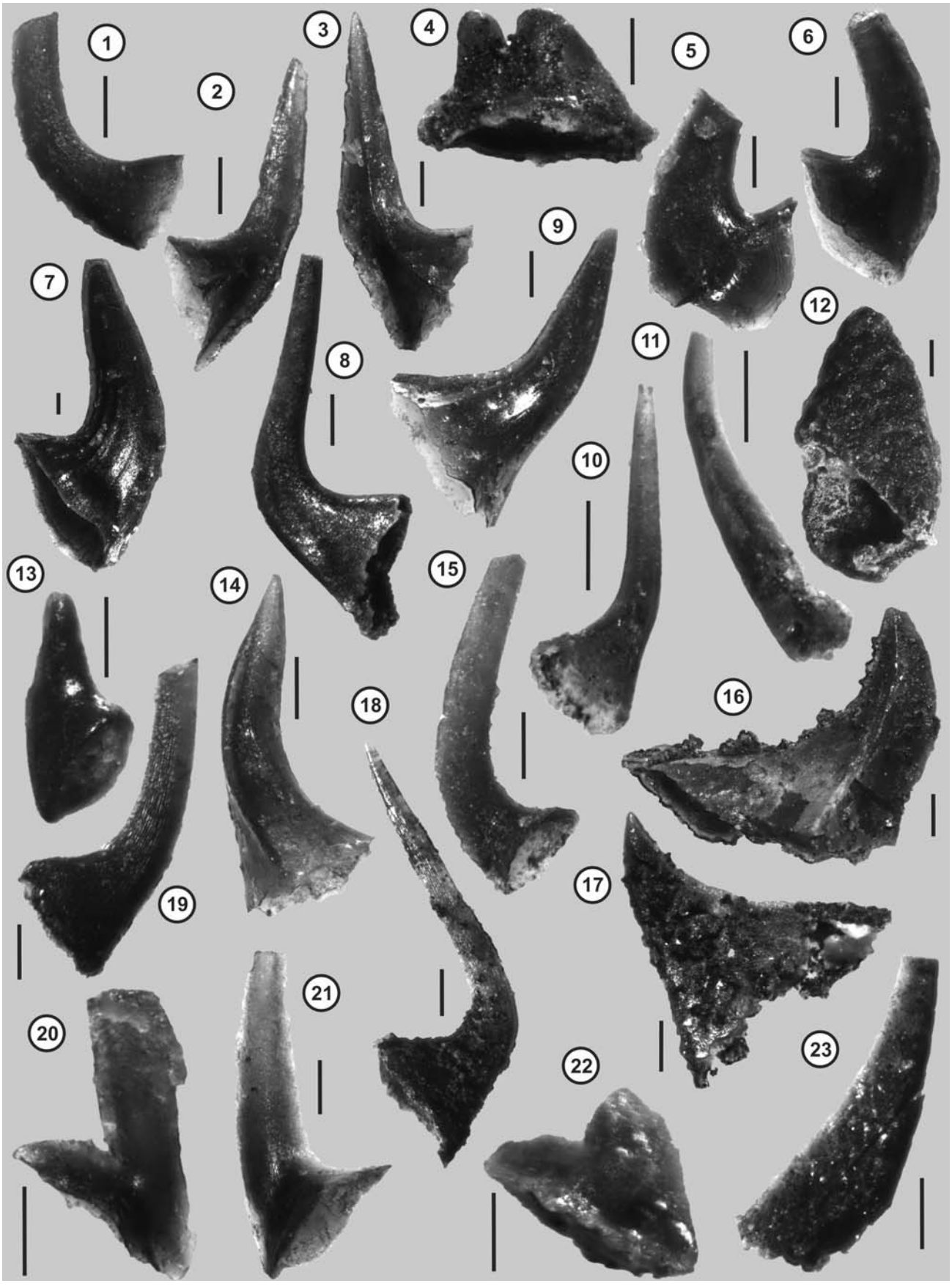
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Figure 2. Conodonts from the studied area. **1**, *Acanthodus* cf. *humachensis* Zeballo and Albanesi, Sa element (CORD-MP 21951/2). **2**, *Acodus* apex Albanesi and Zeballo, Pa element (CORD-MP 21945/141). **3**, *Acodus* n. sp., Pa element (CORD-MP 21946/130). **4**, Iapetognathus aengensis (Lindström) (CORD-MP 21978/1). **5**, *Drepanodus arcuatus* Pander, Pb element (CORD-MP 21954/3). **6**, *Drepanoistodus chucaleznensis* Albanesi and Aceñolaza, M element (CORD-MP 22014/1). **7**, *Drepanoistodus costatus* (Abamoiva), M element (CORD-MP 21947/1). **8**, *Variabiloconus crassus* Zeballo and Albanesi, M element (CORD-MP 22023/1). **9**, *Acodus* n. sp., Pb element (CORD-MP 21946/212). **10**, *Teridontus gallicus* Serpagli, Ferretti, Nicoll and Serventi, P element (CORD-MP 22009/1). **11**, *Phakelodus elongatus* (Zhang) (CORD-MP 22012/1). **12**, *Hispidodontus* sp. (CORD-MP 22010/1). **13**, *Semiacontiodus minutus* Zeballo, Albanesi and Ortega, P element (CORD-MP 22008/1). **14**, *Tilcarodus humahuacensis* (Albanesi and Aceñolaza), Pa element (CORD-MP 22006/19). **15**, *Utahconus* sp., M element (CORD-MP 21950/1). **16-17**, *Trapezognathus? primitivus* Voldman, Albanesi and Zeballo, Pa and Pb elements (CORD-MP 21988/20, CORD-MP 21988/37). **18-19**, *Striatodontus* n. sp., M and Pa elements (CORD-MP 21998/1, CORD-MP 21949/1). **20**, *Paltodus deltifer deltifer* (Lindström), M element (CORD-MP 21958/1). **21**, *P. deltifer pristinus* (Viira), M element (CORD-MP 22018/1). **22**, *P. subaequalis* Pander, M element (CORD-MP 21982/1). **23**, *Phakelodus* cf. *savitzkyi* (Abaimova) (CORD-MP 22013/1). All inner lateral views except 1, 11-12, 23 (lateral views), 2-3, 5, 16-17 (outer lateral views), 4 (posterior view) and 14-15 (postero-lateral views). All specimens from sample Zen3 except 4 (sample Zen10), 6, 10-14, 21, 23 (sample StaAna8), 8 (sample AZ2), 16-18 (sample ValleCol5) and 22 (sample Zen11). Scale bar: 0.1 mm.

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