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MICROFOSSILS OF THE *YANGTZEPLACOGNATHUS CRASSUS* ZONE IN THE MIDDLE DARRIWILIAN OF THE ARGENTINE PRECORDILLERA



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THE San Juan Formation of the Eastern and Central Precordillera is composed mainly of fossiliferous limestone and marly limestone. The conodont biostratigraphy of the last meters of this unit has been studied on several localities such as: Don Braulio, La Pola, Cecilia (Villicúm range), Cerro La Chilca and Del Aluvión creeks, recording the *Y. crassus* and the *E. pseudoplanus* zones for this levels (Mestre, 2010; Mestre, 2012; Mestre, 2014, Heredia and Mestre, 2014) (Fig. 1A).

The microfossils associated to *Y. crassus* Zone are represented by sponge spicules, foraminifers and gastropod protoconchs, which are reported and illustrated in this work.

STRATIGRAPHY

The Ordovician carbonates exposed in the Del Aluvión creek (Huaco), Don Braulio, Cecilia, La Pola creeks (Villicúm range) and Cerro La Chilca section, are composed of grey to dark grey limestone, marls and mixed carbonate/siliciclastic sediments deposited in a ramp setting (Mestre, 2010).

In the Del Aluvión creek the very top of San Juan Formation composed by light grey to reddish brown bioclastic wackestone and bioclastic dolowackestone/dolopackstone (Fig. 1B-2). In the La Pola, Cecilia and Don Braulio creeks, top of this unit are represented by red ochre grainstone and burrowed greenish dark gray bioclastic wackestone (Fig. 1B-1). In the Cerro La Chilca section the *Y. crassus* Zone occurring between 1.5 and 9 m from the top of San Juan Formation are composed of greenish light grey bioclastic packstone-grainstone and nodular wackestone-packstone (Fig. 1B-3).

MICROFOSSILS

Foraminifers

Nestell *et al.* (2009) recovered the assemblage of agglutinate foraminifers from the upper most level of the San Juan Formation in the Del Aluvión creek and assigned them to the *Eoplacognathus pseudoplanus* / *Dzikodustablepointensis* Zone. This assemblage of foraminifers consists of the monothalamous agglutinated genera *Lakites*, *Amphitremoida*, *Lavella*, *Ordovicina* and *Pelosina* (Fig. 2, 1-3a,b).

Recent studies on Darriwilian conodonts of this section recorded the *Yangtzeplacognathus crassus* Zone for this level of the San Juan Formation, that enhances the biostratigraphical significance of this foraminifer assemblage (Mestre, 2010; Heredia and Mestre, 2013; Mestre *et al.*, 2013) proposing an older age for these microfossils.

Sponge spicule

The spicule is a simple tripodal tricanoclad with a nodular brachyome regularly preserved. It was recovered from the upper most levels of the San Juan limestone in the Del Aluvión creek (Huaco locality) (Fig. 1; Fig. 2, 4). This desma represents a typical spicule of the family Hindiidae of the class Demospongia. The tricanocladine sponges assigned to the suborder Eutaxi-cladina Rauff, 1893, are a conservative group consisting of the single family Hindiidae.

This desma represents the second mention of the family Hindiidae for the Middle Ordovician carbonates of the Precordillera. Hindiid stratigraphical ranges appear in the Ordovician to Middle Permian.

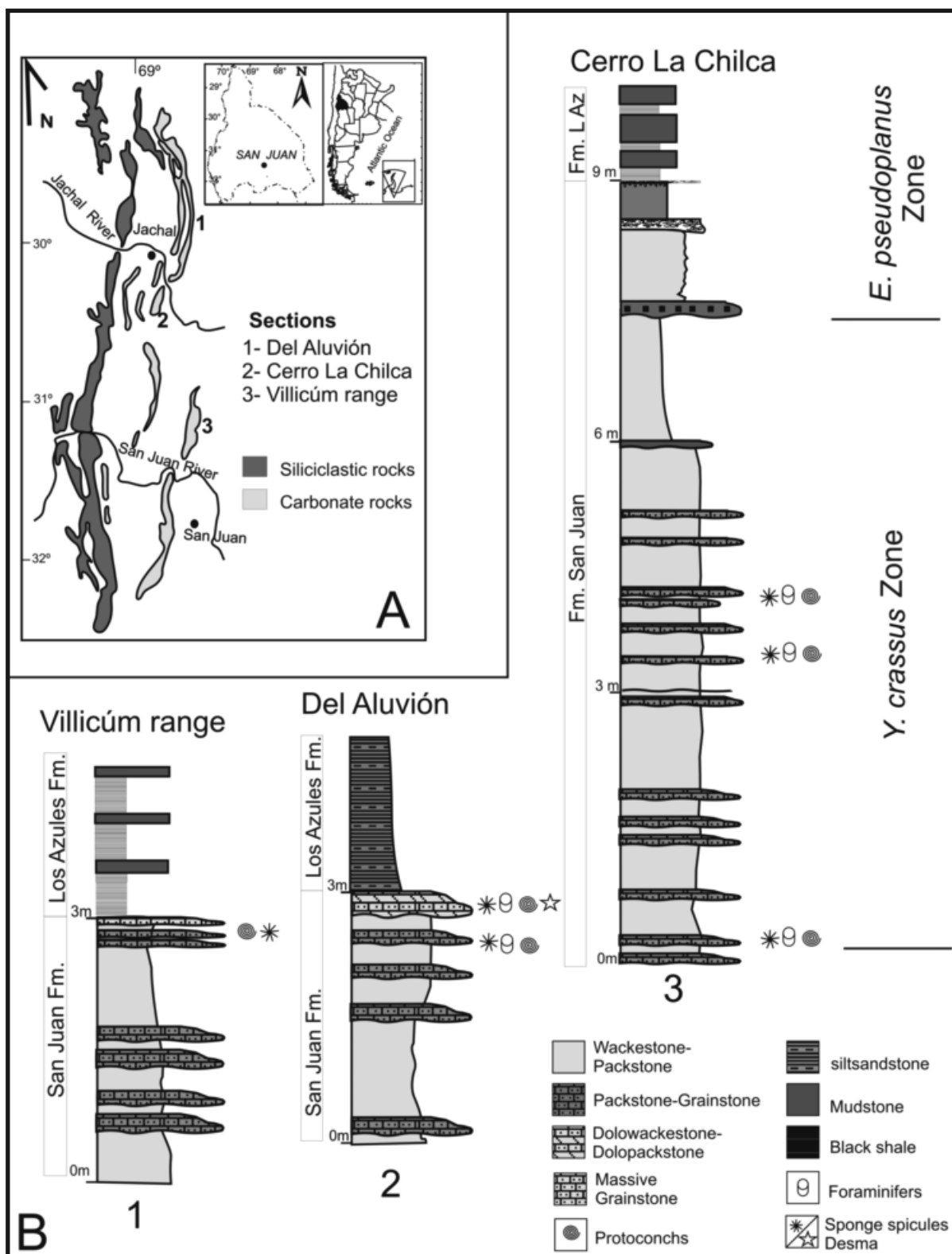


Figure 1. A, Location map of the study sections. B, The stratigraphical section of the upper part of the San Juan Formation and the lower part of the Los Azules Formation, with an indication of the beds of the microfossils species that were recovered, 1- Villicúm range; 2- Del Aluvión section; 3- Cerro La Chilca, section.

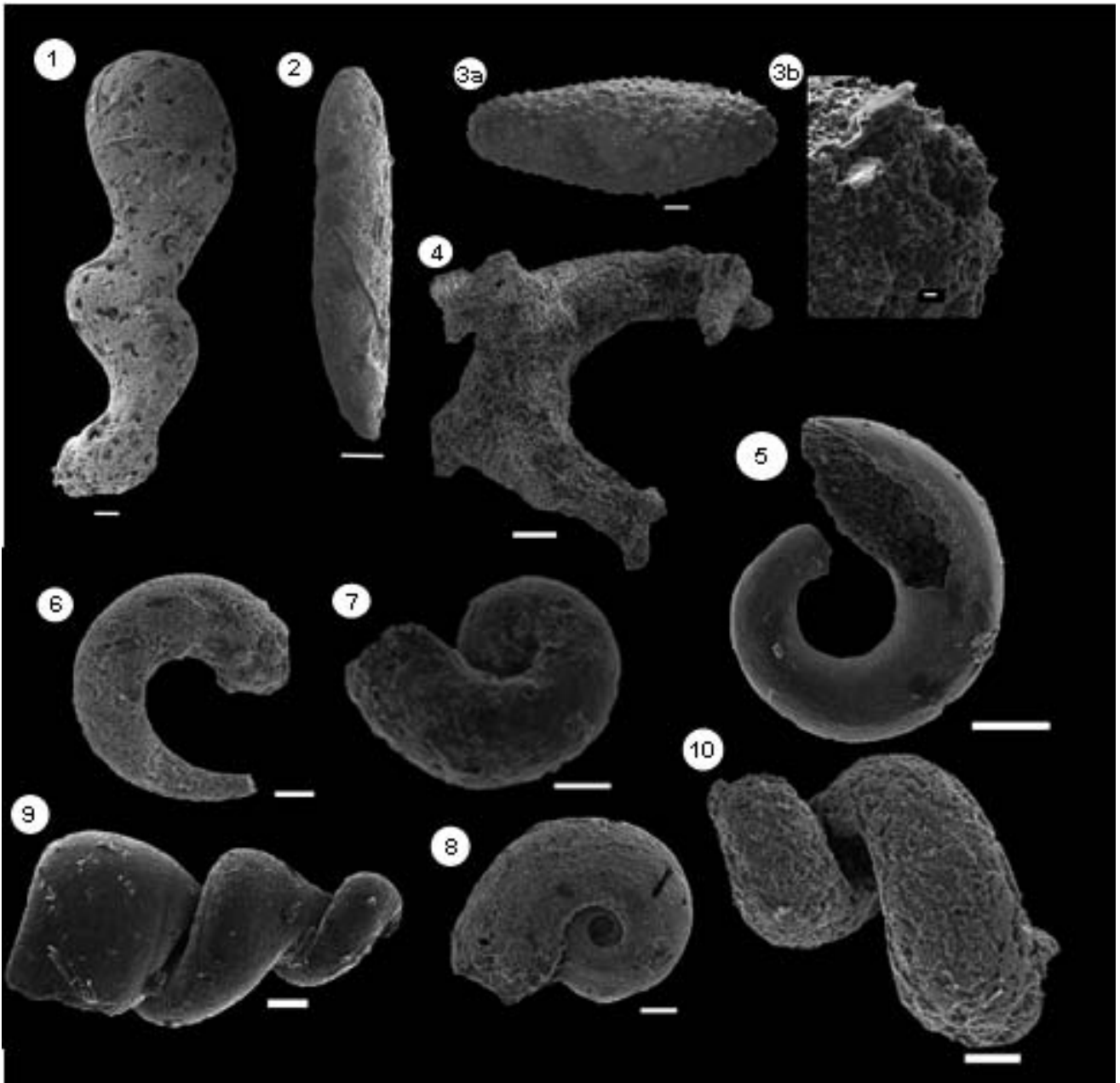


Figure 2. Scanning Electron Microscope Microphotographs. All figured elements are referred to the *Y. crassus* Zone, uppermost San Juan Formation, middle Darriviliano from Eastern and Central Precordillera. Scale bar = 100 μm . **1-3a-b, Foraminifers**; **1**, *Pelosina teschenhagensis* (Schallreuter 1983), sample DA5, Del Aluvión creek, INGeo-MP-306; **2**, *Lakites?* sp. sample DA2, Del Aluvión creeks, INGeo-MP-385; **3, 3a**, *Lavella?* sp., **3b**, view of the apertura, Scale bar= 10 μm , sample DA1, Del Aluvión creek, INGeo-MP no. 409. **4, Desma of Hindia Duncan 1879**, sample DA1, Del Aluvión creek, INGeo-MP-290 (1). **5-10, Gastropod protoconchs**; **5**, **Open coiled (Cyrtoneritomorpha?)**, sample CHL3, Cerro La Chilca, INGeo-MP-1061 (1); **6**, **Open coiled (Cyrtoneritomorpha?)**, sample DA1, Cerro Del Aluvión creek, INGeo-MP-291 (1); **7**, **Discoidal**, sample DA1, Cerro Del Aluvión creek, INGeo-MP-292 (1); **8**, **Discoidal**, sample TLP3, La Pola creek (Villicúm range), INGeo-MP-2568 (1); **9**, **Turrillate**, sample TLP3, La Pola creek (Villicúm range), INGeo-MP-2569 (1); **10**, **Turrillate**, sample DA5, Cerro Del Aluvión creek, INGeo-MP-293 (1).

This tricanoclad with a brachyome could belong to the widespread *Hindia* Duncan 1879. This genus has three-rayed spicules attach to convex shoulder of adjacent spicules firmly united by complex zigomes to the weakly knobby crest around the neck of a brachyome, formed at the ray junctions. Carrera

(2007) discovered *Eoscheiella concava* from the upper levels of the San Juan Formation at the Los Gatos creek in the Cerro Viejo section, located about 1 km to south of the Del Aluvión creek. This hindiid demosponge is considered the oldest genus known and displaced *Hindia* from the base of tricanocladine

evolutionary history by Carrera (2007). However, Finks (2003) and Finks and Rigby (2004), identified *Hindia* as the basal genus of the tricanocladines evolutionary record.

The desma studied here is distinctly different from the simple dipodal and tripodal tricanoclads without a brachyome, radial monaxons, and megarhizoclonas of *Eoscheiella concave*.

The discovery of this tricanoclad with a brachyome which possibly represents the *Hindia* lineage among tricanocladine sponges extends the early history of this genus back to the Middle Darriwilian. In this sense, two different lineages of tricanoclads are present in the Middle Darriwilian of the Argentine Precordillera: *Hindia* and *Eoscheiella*–*Scheiella* lineages which represent the oldest records of the tricanocladine sponges up to now known.

Gastropod protoconchs

Early ontogenetic shells of gastropod (protoconchs) are minute (usually less than 1 mm), thin-shelled, and aragonitic. Thus, protoconchs can be destroyed by diagenetic processes (Dzik 1994). However, many occurrences of gastropod protoconchs have been documented in recent years even from the Ordovician and the Darriwilian.

Many juvenile gastropod shells of diverse morphological types were recovered from the upper levels of the San Juan Formation at the Del Aluvión, La Pola creeks (Villicúm range) and Cerro La Chilca creek. Thus, there are at least three distinct types of Middle Ordovician morphotypes in the juvenile gastropod fauna: a) Type I: open coiled (Cyrtoneritomorpha?), in the samples of the Del Aluvión creek (Huaco locality) and Cerro La Chilca (Fig. 2, 5-6); b) Type IV: Discoidal in samples from the Del Aluvión and La Pola creeks (Fig. 2, 7-8) and c) Type V: Turriculate with world disjunct in samples from the Del Aluvión and La Pola creeks (Fig. 2, 9-10). These morphotypes of protoconch morphology are described according to Frýda and Rohr (2003). Many of these gastropod protoconchs are smooth and openly coiled. The openly coiled initial whorl is known from early Paleozoic and was gradually lost during the Middle and Late Paleozoic probably due to planktic predation (Nützel and Frýda, 2003). Early and Middle Paleozoic gastropod protoconchs generally differ strongly from their corresponding adult morphologies (Seuss *et al.*, 2012).

REMARKS

Microfossils associated to the *Y. crassus* Zone are represented by a demosponge spicule, foraminifers and gastropod protoconchs.

The foraminifer assemblage consists of the monothalamous agglutinated genera *Lakites*, *Amphitremoida*, *Lavella*, *Ordovicina* and *Pelosina* (described in detail by Nestell *et al.* 2009). A large assemblage of foraminifers was also recovered from beds which record the *Y. crassus* Zone of Cerro La Chilca section, these foraminifers will be described in further studies. However, in the Villicúm's sections foraminifers were not recovered in correlative beds suggesting this fossil group could be controlled by paleoenvironmental conditions, preferring shallow or more oxygenated waters of the ramp.

The sponge spicule discovered in the Middle Ordovician limestone of the Del Aluvión creek represents the second mention of the family Hindiidae for the Middle Ordovician carbonates of the Precordillera. It could belong to the hindiid lineage. This new tricanoclad and the sponge *E. concava* (Carrera, 2007) from the Darriwilian of the Precordillera represent the oldest records of the tricanocladine sponges known to date.

Three gastropod protoconch morphotypes from the studied localities of the Eastern and Central Precordillera occur at this stratigraphical level.

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