New insights on the Silurian graptolite biostratigraphy of the La Chilca Formation, Poblete Norte section, Central Precordillera of San Juan, Argentina: faunal replacement and paleoenvironmental implications

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ABSTRACT. New data and a biostratigraphic review on Silurian graptolites of the La Chilca Formation are presented. Silurian retiolitids and monoserial graptolites are described for the first time in the lower layers of the Salto Macho Member at the Poblete Norte section, exposed in the Central Precordillera, San Juan Province, western Argentina. This member (late Hirnantian-early Wenlock) begins with a pebble paraconglomerate covered by a sedimentary succession of dark grey shales and greenish-yellowish siltstones. Two graptolite assemblages were collected therein. The first association includes *Pseudoplegmatograptus reticulatus*, *Stimulograptus sedgwickii*, *Talacastograptus leanzai*, *Metaclimacograptus ajejradi*, *Coronograptus* sp., and biserial and monoserial indeterminate graptolites. The second contains *Retiolites geinitzianus*, *Monograptus priodon*, *Stimulograptus* sp., *Pristiograptus* sp., and unknown monoserial colonies. The late Aeronian *Stimulograptus sedgwickii* Zone is recorded due to the presence of the index taxon in the middle levels of the Salto Macho Member. The second graptolite fauna has been related to the early Sheinwoodian *Cyrtograptus murchisoni* Zone, based on the presence of palynomorph assemblages from the La Chilca Formation, previously studied in another sections. The biotic changes of the graptolite faunas, sedimentary variations, and prevalent paleoenvironmental conditions observed in the lower beds of the Salto Macho Member, could indicate the first evidence of the Sedgwickii Event in Precordillera, which is recognized globally and involves comparable features.

Keywords: Retiolitids, Graptolites, Silurian, Sedgwickii Event, Precordillera, Argentina.

RESUMEN. Nuevos aportes sobre la bioestratigrafía de graptolitos del Silúrico de la Formación La Chilca, sección de Poblete Norte, Precordillera Central de San Juan, Argentina: reemplazo de faunas e implicaciones paleoambientales. Se presentan nuevos datos y una revisión bioestratigráfica sobre graptolitos silúricos de la Formación La Chilca. Se describen por primera vez graptolitos retiolitidos y monoserialidos silúricos provenientes del Miembro Salto Macho de la sección Poblete Norte, expuestos en la Precordillera Central de la provincia de San Juan, oeste de Argentina. Este miembro (Hirnantiano tardío-Wenlockiano temprano) comienza con un paraconglomerado, el cual es cubierto por una sucesión sedimentaria que comprende pelitas grises oscuras a negras y limolitas verdosas-amarillentas. Se recolectaron en esta sucesión dos asociaciones de graptolitos. La primera incluye *Pseudoplegmatograptus reticulatus*,...
Stimulograptus sedgwickii, Talcastograptus leanzai, Metaclimacograptus asejradi, Coronograptus sp., además de biseriados y monoseriados indeterminados. La segunda contiene Retiolites geinitzianus, Monograptus priodon, Stimulograptus sp., Pristiograptus sp. y colonias de monoseriados indeterminados. La Zona de Stimulograptus sedgwickii (aeroniano tardío) se registra sobre la base de la presencia del taxón guía en niveles medios del Miembro Salto Macho. La segunda asociación podría ser correlacionada con la zona de Cystograptus murchisoni del Sheinwoodiano temprano, debido a la presencia de asociaciones de palinomorfos en niveles equivalentes previamente estudiadas en otras secciones. Los cambios bióticos observados en las composiciones de las graptofaunas, las variaciones en la sedimentación y las condiciones paleoambientales dominantes durante la deposición de los estratos inferiores del Miembro Salto Macho, podrían indicar las primeras evidencias del Evento Sedgwickii en la Precordillera, el cual se reconoce a nivel global y presenta comparables características.

Palabras clave: Retiolitidos, Graptolitos, Silúrico, Evento Sedgwickii, Precordillera, Argentina.

1. Introduction

The Precordillera Geological Province, from western Argentina, is a fold-thrust belt characterized by extensive Paleozoic carbonate and silicilastic marine successions. It extends meridionally along the south of La Rioja, San Juan, and north of Mendoza provinces.

Silurian units from Precordillera have been studied in their stratigraphy, sedimentology, and paleontological content at Cerro del Fuerte, Loma de Los Piojos, La Chilca Hill, Ancha Creek, and Los Baños de Talacasto Creek sections (Cuerda, 1965; Baldis et al., 1984; Cuerda et al., 1988; Benedetto et al., 1992; Rubinstein, 1992; among others).

La Chilca Formation is an Upper Ordovician-Lower Silurian unit mainly composed of shales and sandstones. Two members can be recognized in the La Chilca Formation (Baldis et al., 1984): Salto Macho Member (late Hirnantian to early Wenlock) and Cuarctas Azules Member (early to middle Wenlock). The basal portion of the Salto Macho Member generally consists of a pebble conglomerate with black chert clasts, covered by a dark grey shale and greenish siltstone succession. The upper part of this member grades upwards into green yellowish fine-grained sandstones of the overlying Cuarctas Azules Member (Baldis et al., 1984).

The sedimentary record of the La Chilca Formation at the Poblete Norte section (Talacasto area) has been studied in its stratigraphic and paleoenvironmental aspects by León et al. (2016) and Asurmendi et al. (2017, 2018). These studies described reworked glaciomarine deposits in high stand levels and tidal influence for the initial metres of the Salto Macho Member.

The presence of graptolites in the La Chilca Formation has been reported by several authors (Cuerda et al., 1982, 1988; Peralta, 1985; Rickards et al., 1996; Lenz et al., 2003a, b; among others) at different sections of the Central Precordillera. The graptolite fauna recovered at the Los Baños de Talacasto section by Cuerda et al. (1988), allowed them to establish a biostratigraphic scheme for the Salto Macho Member. Three biozones were proposed embracing the first metres of the unit, starting with the late Hirnantian Metabolograptus persculptus Zone, followed by the early Rhuddanian probable Parakidograptus acuminatus Zone, and concluding with the possible Atavograptus atavus Zone.

In the Poblete Norte section, the graptolite assemblages studied by López et al. (2018, 2020), belong to the M. persculptus and possibly the A. atavus zones, in association with brachiopods and scolecodonts. Recently, Gómez et al. (2021) mentioned the presence of Hirnantian palynomorphs in the first levels of the Salto Macho Member at this section.

1.1. The Sedgwickii Event worldwide

During the late Aeronian sedgwickii (or Sedgwickii) Event (Štorch and Frýda, 2012), the graptolite diversity decreases markedly. Some species were extinct and other ones were gradually replaced. These faunal changes coincide with differences in lithology and sedimentation, positive excursion in the δ13C values, and fluctuations of total organic carbon (TOC). This event has been recorded in the North Hemisphere (Loydell, 2007; Melchin and Holmden, 2006; Štorch and Frýda, 2012), located temporarily in the middle part of the homonymous biozone. The graptolite extinction is coincident with a δ13C positive excursion and a lower eustatic sea level interval derived from glaciation in South America (Gondwana) (Loydell, 2007); although, its influence on the South American stratigraphy and graptolite fauna is unknown so far.
1.2. Background on graptolites and retiolitids

The monoserial *Stimulograptus sedgwicki* is mentioned in Silurian successions worldwide (Argentina, Toro, 1995; North America, Churkin and Carter, 1996; Spain, Álvarez, 2014; China, Maletz *et al.*, 2021; Malaysia, Saparin and Ismail, 2022; among others) and its presence allows to record the late Aeronian homonymous biozone. According to Loydell (2012), this biostratigraphic unit succeeds the *Lituigraptus convolutus* Zone, and is succeeded by the *S. halli, Rastrites linnaei, Spirograptus guerichi*, or the *S. guerichi-S. turriculatus* zones.

In Precordillera, Rubinstein and Brussa (1999) record unmentioned graptolites from the upper *Stimulograptus sedgwickii*-lower *Spirograptus turriculatus* zones (Upper Aeronian-Lower Telychian) in the Talacasto area; and Albanesi *et al.* (2006) identified a few colonies of *Stimulograptus?* sp. from the La Chilca Formation at the Ancha Creek section, Talacasto area.

Reticolitids (Reticolitidae Lapworth, 1873) are frequent constituents of the Silurian graptolite faunas in this geological province. They are characterized by having a tubarium with poor development of fuselli and are composed mainly of cortical bandages (Maletz *et al.*, 2017; Kozlowska *et al.*, 2019). The colonies have lists forming a mesh-like framework, which gives it a distinctive morphology among diplograptids, known as ancora, and developed outside the thecal walls.

Peralta (1985) mentioned for the first time the presence of retiolitids in the La Chilca Formation (at the Talacasto section). The author identified *Reticolites* sp. and assigned an early Llandovery age due to the presence of *climacograptids* in the assemblage.

Lenz *et al.* (2003a) described *Pseudoplegmatograpthus obesus reticulatus*, later classified as *P. reticulatus* (Lenz *et al.*, 2003b), together with *Metaclimacograptus* cf. *M. asjeadi*. This association was collected at the Los Baños de Talacasto and Salto Macho sections, in the Talacasto area. The mentioned beds have been assigned to an early Telychian age through the presence of this graptolite association.

The present contribution deals with the graptolite biostratigraphy of the Salto Macho Member, La Chilca Formation, at Poblete Norte section. An actualized graptolite biostratigraphy scheme is proposed and specimens belonging to the Family Reticolitidae are identified and described herein. The paleontological and paleoenvironmental knowledge of the study area is enhanced, which, associated with the graptolite content, indicates possible evidence of the Sedgwickii Event in Precordillera. The new and precise data obtained by sampling the succession and the re-evaluation of data previously published by the authors, allow to develop an updated biostratigraphic scheme that enables a local, regional and global correlation with equivalent units.

1.3. Geology of the Poblete Norte section

The Poblete Norte section is located approximately 77 km north of San Juan city, at the western flank of the Talacasto Range, eastern boundary of the Central Precordillera (Fig. 1).

La Chilca Formation exposed at the Poblete Norte section, paraconformably overlies the San Juan Formation (Floian-Darriwilian) and is covered by the Los Espejos Formation (Wenlockian-Lochkovian). Graptolites analysed in the present study come from the Salto Macho Member of the La Chilca Formation. In the Poblete Norte section, this unit consists of a basal paraconglomerate covered by dark grey shales, greenish and yellowish shales, siltstones, and fine-grained sandstones. At the upper part of the Salto Macho Member, yellowish siltstones with brownish-greenish concretions are found. Above these levels, overlies the Cuarcitas Azules Member.

The local stratigraphy is completed by the Talacasto Formation (Lower Devonian), the Punta Negra Formation (Lower to Upper Devonian), and Cenozoic undifferentiated deposits (Fig. 1).

2. Studied material

The studied material comes from the Salto Macho Member, La Chilca Formation, at the Poblete Norte section. The graptolites were collected from samples PN-011.5, PN-012 and PN-014 (Fig. 2). Several conodont elements were found at PN-008/009, PN-011.5, and PN-012. The graptolite assemblages include nine graptolite and retiolitid taxa (Figs. 3 and 4), and unknown biserial and monoserial colonies. The tubaria were observed on bedding planes together with conodont elements (Fig. 5A-C), scolecodonts (Fig. 5D), spicules (Fig. 5E), and quitinozoans (Fig. 5F). The studied specimens are housed in the Instituto de Geología Dr. Emiliano Aparicio, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de San Juan, under the repository codes INGEPO-PI-1835/1908-1919/1921-1934.
FIG. 1. Geologic map of the Talacasto area, Central Precordillera, Argentina. The red star indicates the Poblete Norte section; 1. Los Baños de Talacasto Creek. 2. Ancha Creek. 3. Salto Macho Creek.
2.1. Graptolite biostratigraphic remarks

Graptolite faunas from the late Aeronian *sedgwicki* biozone are recognized globally and the presence of the index species is widely known (Northwestern Argentina, Toro, 1995; North America, Churkin and Carter, 1996; Spain, Álvarez, 2014; China, Maletz *et al*., 2021; Malaysia, Saparin and Ismail, 2022; among others).

In the Argentine Precordillera, the species has not been mentioned yet. Albanesi *et al.* (2006) described a graptolite assemblage from the La Chilca Formation at the Ancha section, Talacasto area. These authors enumerate some colony fragments of *Pristiograptus* aff. *P. nudus*, *Monograptus* cf. *M. priodon*, and *Stimulograptus*? *sp*. The latest means the only mention of the genus for Precordillera.

As already mentioned by several authors, the presence of retiolitid graptolites in Silurian successions indicates at least an Aeronian (middle Llandoverian) age (Kozlowska-Dawidziuk, 2002; 2004; Bates *et al*., 2005; Melchin *et al*., 2011). The earliest retiolitid known is *Pseudoretiolites* from the early Aeronian, however this group of graptolites strongly diversified in the middle Telychian, late Llandovery (Melchin, 1999).

Globally, the genus *Pseudoplegmatograptus* has been described from the late Aeronian *Stimulograptus sedgwickii* Zone, to the late Telychian *Cyrtograptus lapworthi* or *C. insectus* Zone (Lenz and Melchin, 1987; Štorch, 1994; Loydell *et al*., 2003; Kozlowska-Dawidziuk, 2004; Bates *et al*., 2005; Melchin *et al*., 2017; Loydell, 2020).

**FIG. 2.** Stratigraphic column of the La Chilca Formation at the Poblete Norte section. The samples position and fossils are included. SJF: San Juan Formation. CAM: Cuarcitas Azules Member.
Furthermore, the genus *Retiolites* has a biostratigraphic range that spans from the early Telychian *Spirograptus turriculatus*-Streptograptus *crispus* zones (Kozlowska-Dawidziuk, 2004; Bates et al., 2005; Melchin et al., 2017) to the early Sheinwoodian (Wenlockian) *Cyrtograptus murchisoni* Zone (Štorch, 1994; Zalasiewicz and Williams, 1999; Loydell et al., 2003). However, Kozlowska-Dawidziuk (2004) and Bates et al. (2005) extend its range to the early Homerian *Cyrtograptus lundgreni* Zone. On the other hand, Piras et al. (2012) record the genus *Retiolites* from the early Telychian *Spirograptus guerichi* Zone to the early Sheinwoodian (Wenlock) *Cyrtograptus centrifugus*-C. *murchisoni* zones from the Carnic Alps (Italy).

The presence of *Retiolites* sp. in Precordillera was documented by Peralta (1985) at the Talacasto section, together with climacograptid graptolites, indicating for this association an early Llandoveryan age. Later, Lenz et al. (2003a, b) described *P. reticulatus* with specimens of *Metaclimacograptus* cf. *M. asejradi*, in the La Chilca Formation at the Ancha Creek section, suggesting an early to middle Telychian age, equivalent to the *Spirograptus turriculatus*-Streptograptus *crispus* zones.

In the present contribution, two associations of graptolite faunas have been identified. The first one, found in the levels PN-011.5/012, is composed of *Pseudplegmatograptus reticulatus* (Boucek and Münch) (Fig. 3A-B), *Stimulograptus sedgwickii* (Portlock, 1843) (Fig. 3E-H), *Talacastograptus leanzai* Cuerda et al., 1988 (Fig. 3I), *Metaclimacograptus asejradi* Legrand, 1993 (Fig. 3C-D), *Coronograptus* sp. (Fig. 3J), and indeterminate biserial and monoserial graptolites. The presence of the index fossil allows to record the *Stimulograptus sedgwickii* Zone (late Aeronian). The second graptolite assemblage, collected from the level PN-014, contains *Retiolites geinitzianus* (Barrande, 1850) (Fig. 4I), *Monograptus priodon* (Bronn, 1835) (Fig. 4A-H), *Stimulograptus* sp. (Fig. 4J-M), *Pristiograptus* sp. (Fig. 4N), and several indeterminate monoserial colonies. This association...
could indicate the Lower Sheinwoodian (Wenlock), based on the presence of a palynomorph assemblage at equivalent uppermost beds of the Salto Macho Member at the Jáchal River, Las Chacritas River, La Chilca, and Ancha Creek sections (García-Muro and Rubinstein, 2015), and related to the early Sheinwoodian *Cyrtograptus murchisoni* Zone of Avalonia, Baltic, and Laurentia (Fig. 6).

### 3. Results

#### 3.1. Local and regional graptolite correlation

Previous to the present contribution, two mentions have been made of the genus *Stimuograptus* and other graptolites related to the *Stimuograptus sedgwickii* Zone in the Precordillera of San Juan Province.

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The first one corresponds to the correlation based on palynomorphs and graptolites from the La Chilca and Los Espejos formations, in a contribution carried out by Rubinstein and Brussa (1999). These authors recorded the upper Stimulograptus sedgwickii-lower Spirograptus turriculatus zones (upper Aeronian-lower Telychian) in agreement with the palynomorph assemblage number 2, but with no record of the index graptolite. In addition, Albanesi et al. (2006) describe a few colonies of Stimulograptus? sp. from the La Chilca Formation at the Ancha section, Talacasto area.

Similar studies from other sections of South America were developed. Toro (1995) describes specimens of S. sedgwickii in the Lipeón Formation, associated with Clinoclimacograptus retroversus and Paraclimacograptus innomatus, in middle-late Llandovery strata, Eastern Cordillera from Northwestern Argentina. Furthermore, S. sedgwickii-Spirograptus turriculatus zones were recorded in the Vargas Peña Formation by Paraguay by Uriz et al. (2008), who mentioned the presence of Stimulograptus aff. S. sedgwickii, Monograptus aff. M. priodon, and ?Demirastrites sp.

In agreement with the biostratigraphic chart proposed by Loydell (2012), the presence of the S. sedgwickii Zone allows to correlate the studied strata from the La Chilca Formation, with sections from Avalonia, Baltica, Peri-Gondwana, Laurentia, and NE of Africa (Fig. 6).

3.2. Paleoenvironmental remarks

The study of Silurian graptolite faunas reveals several degrees of faunal provincialism during this period. Certain low latitude graptolite species were identified in the Llandovery succession from Cape Phillips Formation, Canada (Melchin, 1987), and strong endemism was noted at the Rhuddanian from North Africa deposits (Legrand, 2003). A pronounced provincialism is recorded at mid-Sheinwoodian (Wenlock) in response to some parameters (e.g., low and high latitude) (Lenz et al., 2012), whereas at mid-Homerian the assemblages were widely spread (eurythermal taxa). The distribution patterns of Silurian graptolite assemblages indicate faunal differentiation along paleolatitudinal belts in correspondence with paleolatitude and sea surface temperature (SST) (Goldman et al., 2013; Loydell et al., 2018).

The graptolite assemblages from La Chilca Formation at the Poblete Norte section include some taxa that are characteristic of Precordillera Geological Province, such as Talacastograptus leanzai and Lagarograptus praeacinaces (Lopez et al., 2020). T. leanzai is also recorded in Silurian beds from Bolivia (Lipeón Formation, Rickards et al., 2002).

However, other taxa are extensively distributed in many paleogeographic regions, like Metaclimacograptus asejradi (Paraguay, Tortello et al., 2012; Spain, Gutiérrez-Marco and Štorch, 1998; Álvarez, 2014) and Stimulograptus sedgwickii (Toro, 1995; Churkin and Carter, 1996; Álvarez, 2014; Maletz et al., 2021; Saparin and Ismail, 2022).

In addition, the presence of Pseudoplegmatograptus reticulatus is mentioned in Canada, by Lenz (1979; 1982), and in the United Kingdom by Hutt (1974) and Rickards (1976). In Precordillera, Lenz et al. (2003a, b) identified this species in the La Chilca Formation, Salto Macho, and Ancha sections. On the other hand, Retiolites geinitzianus specimens have been mentioned in Denmark (Bjerreskov, 1975), Turkey (Sachanski et al., 2010), China (Wang and Zhang, 2010), Spain (Álvarez, 2014), and Czech Republic (Hopfensperger et al., 2021), among other countries.

Based on the presence of endemic graptolite taxa (T. leanzai, L. praeacinaces), pandemic taxa (S. sedgwickii, R. geinitzianus, among others), and the paleoenvironmental reconstruction of the La Chilca Formation proposed by Asurmendi et al. (2018), the siliciclastic ramp facies of this unit might have been deposited in an intermediate palaeolatitudinal setting (around 40° S), according to the paleogeographic reconstruction of Cocks and Torsvik (2002). This location of Precordillera at Llandovery-Wenlock times might have enabled a moderated faunal exchange, allowing partial graptolite endemicism, and the colonization of the Precordillera basin only by cosmopolitan taxa.

3.3. Sedgwickii Event: possible evidence in Precordillera

The middle part of the S. sedgwickii biozone records the Sedgwickii Event (Melchin et al., 1998) which shows the peak of the late Aeronian graptolite extinction with minimum diversity of the faunas. The stressing conditions prevailing during this event were identified worldwide, and affected the pelagic organisms, resulting in taxonomic changes in graptolite faunas, which were impoverished and
showed the dominance of some species assemblages (Melchin et al., 1998; Štork and Frýda, 2012; among others). Lower sea-level conditions and positive δ13C excursion were mentioned in concordance with this event by Loydell (2007). In agreement, Štork and Frýda (2012) identified sedimentary changes during the late Aeronian Prague Synform, evidenced by black shale deposits with high TOC (Total Organic Carbon) values, and lower graptolitic richness related to this event.

However, the sea level-Sedgwickii Event relation has no global consensus. In Baltica, Loydell (2007) describes the Sedgwickii Event as associated with a pronounced marine regression, generating erosion and a lack of deposits in some sections of the continent. On the other hand, Uriz et al. (2008) mentioned a marine transgression that covered contemporary several areas of South America (e.g., Venezuela, Perú, Bolivia, Paraguay, Argentina), coincident with a graptolite fauna from Eastern Cordillera (Northwestern Argentina), assigned by Toro (1995) to the S. sedgwickii Zone.

At the Poblete Norte section, the yellowish siltstones (level PN-011.2), which contain a graptolite fauna dominated by *Normalograptus* and *Talacastograptus*, are covered by black shales with high content of organic matter (levels PN-011.5 and PN-012), where abundant graptolites with low taxonomic diversity were identified (e.g., *S. sedgwickii*, *T. leanzai*, *P. reticulatus*) and indicate the S. sedgwickii Zone. These beds have been linked by Astini and Maretto (1996) with the highest relative sea level in the Silurian of the Precordillera basin.

In Poblete Norte, between the yellowish siltstones (level PN-011.2) and the black shale beds (level PN-011.5/012), lithological and taxonomic changes are recognized, which might indicate the evidence of the Sedgwickii Event in Precordillera. This would be associated with the presence of the eponymous graptolite species and also with a high sea level stage (in agreement with Uriz et al., op. cit.).

### 3.4. Comments on some graptolite species

A brief paleontological description of some graptolites recovered from Salto Macho Member, La Chilca Formation at the Poblete Norte section, is presented herein. These species are indicative of certain paleoambiental conditions and represent precise biostratigraphic data.

**Stimulograptus sedgwickii** *(Portlock, 1843)*

*Figure 3E-H*

The specimens from the La Chilca Formation are in great numbers, although complete mature specimens are absent. Generally, the colonies are in relief, filled by coloured clay or pyrite, or flat as a carbon film. The analysed material possesses a straight tubaria with slightly dorsally curved proximal end. The longest colony is 33 mm in length. The width increases from 0.49 mm at Th2 and 0.52 mm at Th3, to the maximum of 1.8 mm without spines observed in distal fragments. Thecae have an extroverted shape proximally, and a triangular shape distally, and their apertural region formed a hook. Some apertures showed spines of 0.3 mm in length, slightly proximally curved. The sicula is 1.4 mm long and its apex reaches to the top of Th1. 2TRD at the proximal portion of the tubaria is 1.86 mm. Distally, 2TRD attains 2.2 mm. Thecal spacing counts 9 to 10 in 10 mm, and the thecal overlap is ½. This measures agrees with those given by Toro (1995), Chunkin and Carter (1996), Štork and Massa (2006), and Maletz et al. (2021) for *Stimulograptus sedgwickii*.

Specimens of *S. sedgwickii* allow to record the homonymous zone. The assemblage completes with *Pseudoplegmatograptus reticulatus*, *Metaclimacograptus asejradi*, *Talacastograptus leanzai*, *Coronograptus* sp., and indeterminate biserial and monoserial colonies. Conodont elements of *Dapsilodus obliquicostatus* (Branson and Mehl, 1933) (Fig. 5A-C) were found on bedding planes at these levels.

**Pseudoplegmatograptus reticulatus** *(Boucek and Münch, 1944)*

*Figure 3A-B*

The collection from the La Chilca Formation (Poblete Norte section) has fragmentary material corresponding to this species, preserved as a carbonaceous film (Fig. 3A-C). The maximum length measured is 6.42 mm. The width of the tubaria increases rapidly from 1.32 mm proximally, 2.96 mm in the middle portion, and reaches 3.67 mm distally (in specimen INGEO-PI-1913). Thecae are orthograptid in profile (see Fig. 3C). Spines are mainly straight, ventrally projected from thecal lips, and 0.72-0.85 mm long. Some bifurcations appear to join with those below to form a thin lacinia.
Thecal spacing varies from 12 to 15 thecae in 10 mm. 2TRD value is 1.4-1.47 mm with a maximum of 1.66 mm in distal fragments. Sicula is not observed in the collected material. The material studied is assigned to *P. reticulatus* due to their similar dimensions, thecae morphology, presence of thecal spines, and thecal concentration (Lenz, 1982; Lenz *et al.*, 2003a, b).

Specimens of *P. reticulatus* were found in the *S. sedgwickii* Zone, together with *Stimulograptus sedgwickii*, *Metaclimacograptus asejradi*, *Talacastograptus leanzai*, *Coronograptus sp.*, and indeterminate biserial and monoserial colonies.

**Retiolites geinitzianus** (Barrande, 1850)  
**Figure 4I**

Many specimens of *R. geinitzianus* were collected from the La Chilca Formation, which are fragmentary and poorly preserved. The tubaria are straight and the longest fragment measured is 12.83 mm long, with 3.79 mm width (INGEO-PI-1915). Thecae are parallel-sided straight tubes. They are inclined 50-55º at the middle part and 55-60º, distally. The thecal count is 11 in 10 mm. 2TRD value is 1.67 mm. This species presents a typical meshwork of lists developed externally. The material from Poblete Norte Creek agrees with the description of *R. geinitzianus* by Bjerreskov (1975), Lenz (1982), Sachanski *et al.* (2010), and Hopfensperger *et al.* (2021). The assemblage with *R. geinitzianus* also contains *Monograptus priodon*, *Stimulograptus sp.*, *Pristiograptus sp.*, and indeterminate monograptids.

### 4. Discussion

The biostratigraphic range of two graptolite species is discussed here. While the record of *Talacastograptus leanzai* reaches the *Atavograptus atavus* biozone on Rhuddanian beds at the Los Baños de Talacasto section (as reported by Cuerda *et al.*, 1988), in the present study its presence is verified in the younger *S. sedgwickii* Zone, at the Poblete Norte section. Conforming to Lenz *et al.* (2003a, b), *Pseudoplegmatograptus reticulatus* had been identified within *Spirograptus turriculatus-Streptograptus crispus* zones (early Telychian), whereas the interval of *P. reticulatus* spans to the *S. sedgwickii* zone (late Aeronian) at Poblete Norte, reaching older ages in the La Chilca Formation.

In a recent contribution of Lopez *et al.* (2020), a graptolite assemblage composed by *Atavograptus atavus*, *Normalograptus? acceptus* and *Monograptus* sp. were identified at the Poblete Norte section, recording the *A. atavus* Zone (level PN-013) and indicating a middle to late Rhuddanian age (Lower Llandovery). Additional sampling and later studies on graptolites recovered from the levels PN-011.5 and PN-012 allow to increase the knowledge and a biostratigraphic review from La Chilca Formation is made in this study. *S. sedgwickii*, associated with *P. reticulatus*, *M. asejradi*, and *Coronograptus sp.* were identified from these levels, allowing to record the *S. sedgwickii* Zone (late Aeronian). This assemblage, located 1.8 m below the PN-013 (*A. atavus* Zone of Lopez *et al.*, 2020) indicates the latest Aeronian, and the start of the Telychian in the following levels. In this way, level PN-013 might possess an early Telychian age, the *A. atavus* Zone would not be located in the latest beds, and a more accurate position might be below the level PN-011 at least. Further fieldwork and a larger graptolite collection might give light on this proposal and adjustment.

### 5. Conclusions

According to new data on Silurian graptolite assemblages, a review of their biostratigraphy is proposed for the La Chilca Formation at the Poblete Norte section, Central Precordillera.

As it has been demonstrated in the present study, the biostratigraphic range of *Talacastograptus leanzai* spans to late Aeronian levels; in addition, the retiolitid *Pseudoplegmatograptus reticulatus* was also found in late Aeronian strata, given the oldest age for this species in Precordillera.

Two retiolitid species, *Pseudoplegmatograptus reticulatus* and *Retiolites geinitzianus*, are described for the first time in the same section in Precordillera. The occurrence of *Stimulograptus sedgwickii*, associated with *P. reticulatus*, *Metaclimacograptus asejradi*, *T. leanzai*, and *Coronograptus sp.*, allows to record the late Aeronian *S. sedgwickii* Zone. These levels can be correlated with equivalent beds at the Ancha and Cerro del Fuerte sections in Precordillera; with the Lipeon and Vargas Peña formations in South America; and with comparable deposits from Avalonia, Baltica, Peri-Gondwana, Laurentia, and NE of Africa sections.
The presence of *R. geinitzianus* with specimens of *Monograptus priodon*, *Stimulograptus* sp., and *Pristiograptus* sp., would indicate an early Sheinwoodian age for the bearing strata in the La Chilca Formation, which could be related to the *Cyrtograptus murchisoni* Zone of Avalonia, Baltica, and Peri-Gondwana biostratigraphic schemes.

Evidences of the Sedgwicki Event might be recognized in Precordillera for the first time, supported by a faunal replacement and paleoenvironmental changes that occurred during the deposition of the Salto Macho Member, La Chilca Formation, and validating the global character of this event.

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