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Submitted: 20 December 2025 - **Accepted:** 23 February 2026 - **Posted online:** 11 March 2026

To link and cite this article:

doi: [10.5710/AMGH.23.02.2026.3683](https://doi.org/10.5710/AMGH.23.02.2026.3683)

Manuscript LSID: [urn:lsid:zoobank.org:pub:4A722BBC-C1DE-49DA-8B3C-AA97C3305DC0](https://zoobank.org/pub:4A722BBC-C1DE-49DA-8B3C-AA97C3305DC0)

Species LSID: [urn:lsid:zoobank.org:act:7819EF34-50CD-473E-BDED-A4DD570875DD](https://zoobank.org/act:7819EF34-50CD-473E-BDED-A4DD570875DD)

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1 **New Gorstian (Ludlow, upper Silurian) graptolite faunas from the**
2 **olistostromic Rinconada Formation, Argentine Precordillera: new**
3 **insights on the Silurian graptolite biostratigraphy**

4
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12
13 47 pages (text + references); 8 figures

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15 Running Header: Lopez ET AL.: New Ludlovian graptolites from Precordillera

16 Short Description: New Silurian graptolite faunas from the Rinconada Formation allow
17 an up-to-date global biostratigraphic correlation

18
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20 **Abstract.** New graptolite faunas from the matrix of the Rinconada Formation at the La
21 Rinconada section, Eastern Precordillera of San Juan (Argentina), are documented. A
22 stratigraphic succession of 375.6 m initiated in a faulted zone was studied in the
23 southeastern part of the outcrops, yielding twelve fossiliferous levels. Lower layers
24 contain an assemblage dominated by *Saetograptus argentinus argentinus* and
25 *Uncinagraptus?* sp., associated with cf. *Neodiversograptus*. Higher levels include
26 *Bohemograptus bohemicus*, *Lobograptus progenitor*, *Pristiograptus frequens*, and
27 *Prolinograptus packhami*. The upper strata are almost exclusively composed of *S. a.*
28 *argentinus* and *S. rinconadensis* sp. nov, with a unique occurrence of *Lobograptus* sp.
29 cf. *L. scanicus* and *Uncinagraptus?* sp. Assemblages including *Saetograptus*,
30 *Uncinagraptus?*, and possibly *Neodiversograptus* indicate an early Gorstian age,
31 equivalent to the *Neodiversograptus nilssoni* Zone. Upwards, the occurrence of the
32 index species *L. progenitor* allows recognition of the homonymous biozone. Upper
33 assemblages are tentatively assigned to the upper Gorstian *L. scanicus* Zone or
34 equivalent levels, while the highest levels may reach the lowermost Ludfordian.
35 Accordingly, the new species would have an upper Gorstian to lowermost Ludfordian
36 age. The upper levels exhibit moderate to strong graptolite colony alignment, indicating
37 a WSW (246°) paleocurrent direction that coincides with sedimentary structures and
38 antecedents. This study adjusts Silurian biostratigraphy in Argentina, enabling more
39 accurate regional and global correlations, and expanding knowledge of Ludlow
40 graptolites in South America.

41 **Keywords.** Graptolites. Ludlow. Silurian. Rinconada Formation. Precordillera.
42 Argentina.

43 **Resumen.** Nuevas faunas de graptolitos gorstianos (Ludlow, Silúrico superior) del
44 olistostroma de la Formación Rinconada, Precordillera argentina: nuevas

45 **perspectivas sobre la bioestratigrafía silúrica de graptolitos.** Se presentan nuevas
46 faunas de graptolitos de la matriz de la Formación Rinconada, sección de La Rinconada,
47 Precordillera Oriental de San Juan (Argentina). Una columna estratigráfica de 375.6 m
48 fue relevada en el sector suroriental de los afloramientos, en la cual se hallaron doce
49 niveles fosilíferos. El tramo inferior está caracterizado por *Saetograptus argentinus*
50 *argentinus*, *Uncinatograptus?* sp. y cf. *Neodiversograptus*. Continúan luego niveles con
51 *Bohemograptus bohemicus*, *Lobograptus progenitor*, *Pristiograptus frequens* y
52 *Prolinograptus packhami*. El tramo superior está compuesto casi exclusivamente por *S.*
53 *a. argentinus* y *S. rinconadensis* sp. nov., exceptuando una única aparición de *L.* sp. cf.
54 *L. scanicus* y *Uncinatograptus?* sp. La presencia de *Saetograptus*, *Uncinatograptus?* y
55 posiblemente *Neodiversograptus* señalan una edad gorstiana temprana, equivalente a la
56 Zona de *N. nilssoni*. En niveles siguientes, la presencia de la especie guía *L. progenitor*
57 permite registrar la biozona homónima. Finalmente, el tramo superior podría asignarse a
58 la Zona de *L. scanicus* del Gorstiano superior o a niveles temporalmente equivalentes,
59 mientras que los últimos niveles podrían corresponder al Ludfordiano más bajo. La
60 alineación de colonias de graptolitos permitió calcular una corriente de flujo con
61 dirección OSO (246°), la cual coincide con lo indicado por estructuras sedimentarias y
62 antecedentes. Esta contribución ajusta la bioestratigrafía del Silúrico en Argentina,
63 permitiendo correlaciones regionales y globales más precisas, expandiendo así el
64 conocimiento de los graptolitos silúricos de Sudamérica.

65

66 **Palabras clave.** Graptolitos. Ludlow. Silúrico. Formación Rinconada. Precordillera.
67 Argentina.

68 **Introduction**

69 The Precordillera of Argentina constitutes one of the most important
70 sedimentary successions for studying the Silurian System of the whole region. There,
71 thick and well exposed sequences are present, characterized by abundant, well-
72 preserved, and varied fossil content. The latter has allowed important biostratigraphic
73 and stratigraphic conclusions, representing crucial regional milestones for the
74 subsequent studies.

75 The Silurian sequence of the Precordillera is developed in two age-confirmed
76 different areas: the Central Precordillera, with the La Chilca and Los Espejos formations
77 (Cuerda, 1969) and its equivalents; and the Eastern Precordillera, with the Don Braulio
78 and Rinconada formations (Amos, 1954; Baldis *et al.*, 1982). The Silurian of the
79 Central Precordillera shows stratigraphic continuity, outcrops almost uninterrupted
80 throughout the central area, and presents the most important fossiliferous record of the
81 region (Cuerda, 1965; Astini & Maretto, 1996; Ramos *et al.*, 2000; Lopez *et al.*, 2025a).
82 The fossil content of these units have been intensely studied, and through the
83 recognition of several taxa, allowed precise biostratigraphic conclusions (Benedetto *et*
84 *al.*, 1992; García-Muro & Rubinstein, 2015; Gómez *et al.*, 2021, 2024; Lopez *et al.*,
85 2024).

86 To the contrary, the Eastern Precordillera presents intermittent and isolated
87 outcrops, which are characterized by tectonic complexity, and reduced fossil content
88 (Amos, 1954; Benedetto & Franciosi, 1998; Ramos *et al.*, 2000; Voldman *et al.*, 2018;
89 Lopez *et al.*, 2023, 2025b; Drovandi *et al.*, 2024). In particular, the olistostrome of the
90 Rinconada Formation, despite possessing kilometric thickness, presents a reduced and
91 poorly-studied fossil content, which, together with its own sedimentary complexity and

92 tectonic repetitions, has denied a precise stratigraphic and paleontological
93 characterization of the succession.

94 This contribution introduces new graptolite faunas from the Ludlow (upper
95 Silurian) from the matrix of an olistostrome sequence in the Eastern Precordillera. The
96 latter refers to the first mention and description of most of the included taxa from
97 Argentina, together with a new species, improving the fossiliferous content of the
98 Precordillera. Furthermore, age considerations are proposed for the studied segment,
99 infilling the Silurian graptolite biostratigraphic chart of the region. Finally, a
100 paleocurrent analysis is developed based on uniserial graptolites, representing a new
101 approach for describing graptolitic sequences characterized by unidirectional currents.

102

103 **Institutional abbreviations.** UNSJ, Universidad Nacional de San Juan, San Juan,
104 Argentina; PISJ, Paleo Invertebrados San Juan, Repositorio del Instituto y Museo de
105 Ciencias Naturales, UNSJ, San Juan, Argentina.

106 **Anatomical abbreviations.** Th, Theca/Thecae; 2TRD, 2 Thecae Repeat Distance.

107

108 **GEOLOGICAL SETTING**

109 The Chica de Zonda Range, together with the Villicum, Marquesado, and
110 Pedernal ranges, form part of the Eastern Precordillera of San Juan, Argentina (Ortiz &
111 Zambrano, 1981). This region is structurally dominated by Andean deformation, which
112 produced major west-vergent thrust faults and related folds that affected the Paleozoic
113 and younger strata (Allmendinger *et al.*, 1990; von Gosen *et al.*, 1995). These thick-
114 skinned compressional structures have uplifted and exposed the oldest sedimentary
115 sequences of the Precordillera, forming a complex series of tectonic blocks and
116 imbricated thrust sheets. The stratigraphic framework of the area includes the Cambrian

117 La Laja, Zonda, and La Flecha formations, the upper Cambrian to Lower Ordovician La
118 Silla Formation, the Lower to Middle Ordovician San Juan and Gualcamayo
119 formations, and the La Cantera, La Pola, and Don Braulio formations, with an age from
120 the Middle to the lower Silurian (Ramos *et al.*, 2000; and references included therein).

121 In the Villicum Range (to the north of the studied area), the youngest Paleozoic
122 unit is the upper Llandoveryian to Lower Devonian Rinconada Formation (Amos, 1954),
123 representing a significant sedimentary and tectonic event. The Rinconada Formation
124 overlies the Don Braulio Formation in the Villicum Range, and rests unconformably
125 upon the San Juan Formation in the Chica de Zonda Range (Fig. 1). In the Pedernal
126 Range (to the south of the studied area), the Rinconada Formation overlies strata
127 tentatively assigned to the Don Braulio Formation (Amos, 1954; Mestre & Heredia,
128 2014; Lopez *et al.*, 2025b). Its top strata are covered by Carboniferous, Neogenic or
129 Quaternary deposits depending on the area (Ramos *et al.*, 2000). The latter, together
130 with internal structural repetitions due to faulting and folding, prevent an exact
131 measurement of its total thickness (Peralta & Medina, 1985; von Gosen *et al.*, 1995;
132 Lopez *et al.*, 2023).

133 The Rinconada Formation consists of an olistostromic succession comprising
134 blocks (olistoliths) of variable size and lithology, including limestones, black shales,
135 quartzites, and conglomerates, which are enclosed within a siliciclastic matrix of
136 sandstones, shales, and conglomerate lenses (Amos, 1954). The allochthonous blocks
137 originate from diverse stratigraphic sources: the San Juan, Gualcamayo, and possibly La
138 Cantera, La Pola, and Don Braulio formations, as well as olistoliths of “phantom
139 formations” (Voldman *et al.*, 2018; Lopez *et al.*, 2024). Internally, the Rinconada
140 Formation exhibits evidence of strong syndepositional and post-depositional

141 deformation, including fracturing, folding, and tectonic repetition of layers (von Gosen
142 *et al.*, 1995).

143 The *mélange* character is indicative of deposition by mass-transport processes
144 within a marine slope or submarine-fan setting, with olistoliths emplaced by gravity-
145 driven flows and turbidity currents (Peralta, 1993; Drovandi *et al.*, 2024). Overall, the
146 Rinconada Formation documents a dynamic interplay between sedimentation and
147 deformation within a tectonically active marine basin, marking a key episode in the
148 geologic evolution of the eastern Precordillera region.

149

150 **Paleontological antecedents**

151 The Rinconada Formation includes two groups of fossils: those coming from
152 olistoliths and those from the surrounding matrix. The first group is found in olistoliths
153 composed of limestones, black shales, quartzarenites, and green sandstones (*see*
154 Voldman *et al.*, 2018; Lopez *et al.*, 2024; and studies cited therein). These
155 allochthonous rock bodies presents specimens of conodonts, graptolites, brachiopods,
156 trilobites, sponges, and scolecodonts, and its age ranges from the Lower Ordovician to
157 the lower Silurian (Voldman *et al.*, 2018; Lopez *et al.*, 2024). On the other hand, the
158 group of fossils from the matrix, the focus of this study, are principally characterized by
159 graptolites, plant remains, conodonts, brachiopods, and trilobites, encompassing the
160 lower Telychian (upper Llandovery) to the Lower Devonian (Amos & Boucot, 1963;
161 Peralta, 1984, 1986; Peralta & Medina, 1985; Benedetto & Franciosi, 1998; Voldman *et*
162 *al.*, 2015; 2017; Lopez *et al.*, 2023, 2025b; Drovandi *et al.*, 2024).

163 In particular, the graptolite content of the Rinconada Formation matrix is scarce
164 and low in diversity. The first mention of graptolites was made by Heim (1948), who
165 identified the colonies as *Monograptus* sp. Later, Cuerda (1981) described a biserial-

166 monoserial assemblage in the southeast sector of the La Rinconada area, and interpreted
167 a Llandoveryan age for the level. Subsequently, in the outcrops of the Villicum and
168 Chica de Zonda ranges, Peralta (1984, 1986) described specimens of *Saetograptus*
169 *argentinus* (Cuerda, 1969), reporting the first confirmed Ludlovian ages for the unit.
170 Recently, Lopez *et al.* (2023) expanded the graptolite biochron in South America,
171 describing a lower Pridolian assemblage belonging to the *Skalograptus parultimus*
172 Zone, located in the easternmost outcrops of the La Rinconada area. Finally, at the basal
173 levels of the unit at the Don Braulio Creek section, Lopez *et al.* (2025b) described an
174 assemblage composed of *Glyptograptus* sp. cf. *G. tamariscus* (Nicholson, 1868) and
175 *Monoclimacis* spp., indicating a lower Telychian (upper Llandoveryan) age.

176

177 MATERIAL AND METHODS

178 The graptolite faunas are composed exclusively of uniserial taxa, showing a
179 strong to moderate alignment in the upper levels (see Section “Paleocurrent based on
180 graptolite colonies”). The strata consist of laminated greenish siltstones to fine-grained
181 green sandstones. The graptolite colonies are moderately- to poorly-preserved as
182 flattened carbon films, or in relief filled by the surrounding sediment. The taxonomic
183 classification of Maletz (2014) and Maletz in Bates *et al.* (2023) is followed herein.
184 Additionally, the fossiliferous levels usually include plant remains.

185 The graptolite specimens were illustrated using a conventional stereo
186 microscope (Leica S9D), embedded in liquid vaseline. The paleontological sampling is
187 endorsed by Secretaría de Cultura–Ministerio de Turismo, Cultura y Deporte, belonging
188 to the government of the San Juan Province (Resolution 0065-SC-2025, 2024-2025
189 period; Expedient N° 1203-000176-2014). The specimens were housed in the
190 Invertebrate Repository of the Instituto y Museo de Ciencias Naturales, Facultad de

191 Ciencias Exactas, Físicas y Naturales, Universidad Nacional de San Juan, under the
192 repository code PISJ-191—419.

193 The thickness of the surveyed stratigraphic section was determined using the
194 Jacob's rod method in conjunction with a Brunton-style compass (Compton and
195 Compton, 1985). For a better understanding of the outcrops, the stratigraphic section
196 was divided into two segments: the lower and middle levels, included into the
197 "Rinconada South West" segment (RSW); and the middle and upper levels, named as
198 "Rinconada South East" segment (RSE).

199 The paleocurrent was calculated based on the proposal of Moors (1970). This
200 author considered the colony axis of scandent graptolite specimens, together with the
201 siculae positions, and contrasted their locations with the north direction. In this study,
202 the applied technique consisted in recovering oriented fossiliferous samples of
203 monoserial graptolites (level RSE-06), which were later photographed immersed in
204 water. Orientations of the colonies and siculae were calculated using the software
205 ImageJ v.1.53e, and the rosette was built using the software GEORient v.9.5.0.,
206 including a total of 78 values. Finally, the obtained data were compared with flow
207 direction and sense interpreted from sedimentary structures (flute casts) and previous
208 studies (Milana, 1992).

209

210 **SYSTEMATIC PALEONTOLOGY (by F. E. Lopez)**

211 Hemichordata Bateson, 1885

212 Pterobranchia Lankester, 1877

213 Graptolithina Bronn, 1849

214 Graptoloidea Lapworth, 1875

215 Monograptidae Lapworth, 1873

216 *Genus Pristiograptus* Jaekel, 1889

217 **Type species.** *Pristiograptus frequens* Jaekel, 1889; from erratic boulders from North
218 Germany (lower Ludlow, *L. scanicus* Zone).

219

220 *Pristiograptus frequens* Jaekel, 1889

221 Figure 2B-D

222

223 *Pristiograptus frequens* Jaekel, 1889; p. 669, pl. 28, figs. 1–2.

224 *Pristiograptus frequens* Jaekel, 1889; Přibyl, 1943; pp. 24–25, pl. 3:13, text-fig. 3A.

225 *Monograptus dubius frequens* (Jaekel, 1889); Jaeger, 1991; p. 314, fig. 25:8, 11, 15.

226 *Pristiograptus dubius frequens* Jaekel, 1889; Urbanek *et al.*, 2012; pp. 600/602–603,
227 figs. 5M, 11A-C, F-H.

228 *Pristiograptus frequens* Jaekel, 1889; Štorch *et al.*, 2014; pp. 1014/1016, figs. 5L, N,
229 6A-C, E.

230

231 **Material.** Three mature colonies and two juvenile specimens (PISJ-236—
232 237/242/247/255), generally moderate-preserved as flattened carbon films.

233 **Stratigraphic occurrence.** Level RSW-04, middle levels of the Rinconada Formation,
234 lower Gorstian *L. progenitor* Zone, lower Ludlow, upper Silurian. Southeastern sector
235 of the La Rinconada section, Chica de Zonda Range, San Juan Province, Argentina.

236 **Description.** Tubaria slightly dorsally curved proximally (until Th3-4), and straight
237 from then on, with a maximum length of 19.54 mm (PISJ-236). The dorso-ventral width
238 is 0.57—0.60 mm at Th1, 0.82 mm at Th2, 0.82—0.87 mm at Th3, 0.83—1.04 mm at
239 Th5, 0.95—1.04 mm at Th7, 0.98—0.99 mm at Th10, and 0.85 mm at Th15,
240 maintaining constant values distally. The first theca grows directly upwards, and the
241 successive thecae are pristiograptid, with distinct thecal lips. The sicula is 1.75—1.90
242 mm long, and 0.32—0.52? mm wide at the aperture, which possesses an up to 0.48 mm
243 long virgella. Sicular apex reaches the level of the aperture of Th2 or slightly above.
244 The 2TRD is 1.36 mm at Th2, 1.41—2.23 mm at Th5, 1.85—2.04 mm distally. Thecal
245 spacing equals 5.75—6.25 thecae in 5 mm proximally, and 5 thecae distally. The thecal
246 inclination is 19°—25° throughout the colony.

247 **Remarks.** The measures of the material from the Precordillera agree with those
248 reported by Urbanek *et al.* (2012) and Štorch *et al.* (2014) for *Pristiograptus frequens*
249 Jaekel, 1889. This represents the first description of the species for Precordillera.
250 Previously, Stappenbeck (1910) and Clarke (1912) mentioned *P. aff. P. frequens* in
251 levels of the Los Espejos Formation at Loma de Los Piojos and Cerro del Fuerte
252 sections, north Central Precordillera.

253

254 *Genus Saetograptus* Přibyl, 1942

255 **Type species.** *Graptolithus chimaera* Barrande, 1850, by original description; from the
256 *Neodiversograptus nilssoni* Zone, lower Gorstian, Ludlow of Bohemia (Czech
257 Republic).

258

259 *Saetograptus argentinus argentinus* (Cuerda, 1969)

260 Figure 3A-F

261 *Monograptus argentinus*; Cuerda, 1969; pp. 231–234, pl. 1: a–d; pl. 2: 4–6.

262 *Monograptus argentinus* Cuerda, 1969; Cuerda, 1971; p. 399, pl. 5: 1–11, pl. 31: 4–6.

263 *Saetograptus* (?*Colonograptus*) *argentinus* (Cuerda, 1969); Rickards *et al.*, 1996; p.

264 120, figs. 7e–h, 11h.

265 *Saetograptus argentinus argentinus* (Cuerda, 1969); Maletz *et al.*, 2002; pp. 334–336,

266 text-fig. 2g, i–m, pl. 1: 2, 4.

267 *Saetograptus argentinus argentinus* (Cuerda, 1969); Lopez, 2022; pp. 28–30, figs. 3.1–

268 3, 3.5–8, 4.1–3.

269 *Saetograptus argentinus argentinus* (Cuerda, 1969); Lopez *et al.*, 2024; p. 360, Fig. 7A-

270 B, 8E/ I.

271

272 **Material.** Twenty-eight juvenile and mature tubaria and several fragmentary colonies

273 (PISJ-218/228/230/232/242/252/260—270/272—273/276/280—283/286—

274 292/294/303—305/319/322/348—351/353/357—361/363/374/381—

275 382/392/401/403/412/417), generally moderately preserved as flattened carbon films, or

276 rarely in relief filled by greenish siltstone.

277 **Stratigraphic occurrence.** Levels RSW-03—04, RSE-02?—03, and 06—07, middle

278 and upper levels of the Rinconada Formation, lower Gorstian to possibly lowermost

279 Ludfordian, Ludlow, upper Silurian. Southeastern sector of the La Rinconada section,

280 Chica de Zonda Range, San Juan Province, Argentina.

281 **Description.** Straight to slightly dorsally curved tubaria, with a maximum length of
282 23.02 mm (PISJ-267) in a distal fragmentary specimen. The dorso-ventral width is
283 0.67—0.97 mm at Th1, 0.79—1.16 mm at Th2, 0.90—1.21 mm at Th3, 0.91—1.16 mm
284 at Th5, 1.20—1.30 mm at Th7, 1.39—1.43 mm at Th10, 1.73 mm at Th15, 1.60 mm at
285 Th20, and reaches 2.66 mm distally. Thecae possess proximo-ventrally directed lateral
286 apertural spines until Th3-5, of up to 1.05 mm long, with a rapid transition to
287 pristiograptid thecae distalward. The sicula is 1.79—2.42 mm long, and 0.33—0.47 mm
288 wide at the aperture, which possesses up to 0.96 mm long virgella and 0.42 mm long
289 antivirgellar spine. Few specimens show double antivirgellar spines (PISJ-294/330).
290 Sicular apex usually reaches up to the level of the aperture of Th3, although one
291 specimen shows longer sicula (3.03 mm) and reaches the Th4 aperture (PISJ-261). The
292 2TRD is 0.92—1.22 mm at Th2, 1.36—1.49 mm at Th5, 1.57—1.69 mm distally.
293 Thecal spacing equals 7.25—8 thecae in 5 mm proximally, and 6 thecae distally. Thecal
294 overlap is one half proximally, and two-thirds to six-seventh distally. The common
295 canal is 0.32—0.39 mm wide proximally, and 0.48—1.27 mm wide distally. The thecal
296 inclination decreases from 40°—78° proximally to 24°—33° distally.

297 **Remarks.** The measures of the material from the Rinconada Formation agree with those
298 reported by Cuerda (1965), Cuerda (1969), Rickards *et al.* (1996), Maletz *et al.* (2002),
299 Lopez (2022), and Lopez *et al.* (2024) for *S. a. argentinus*. Similar specimens were
300 described from the Rinconada Formation at both the La Rinconada and Villicum
301 sections (Peralta, 1984, 1986). Recently, the same subspecies were described in the Los
302 Espejos Formation at the Poblete Norte and Ancha creeks sections, in levels dated as
303 lower Gorstian to lower Ludfordian (Lopez *et al.*, 2024; and studies cited therein).
304 Regionally, *S. argentinus* ssp. have been found in the Silurian Kirusillas Formation
305 from Bolivia (Cuerda, 1974; Maletz *et al.*, 2002; Toro & Maletz, 2018).

306

307 *Saetograptus rinconadensis* sp. nov.

308 Figures 3G-K; 4A-F

309

310 **Etymology.** From La Rinconada, a classic locality for the study of the Silurian System,
311 located nearly 24 km to the south of San Juan City, Chica de Zonda Range, San Juan
312 Province, Argentina.

313 **Type Material.** Holotype: PISJ-259 (Fig. 3G-H), mature colony preserved as a
314 carbonaceous film. Paratypes: PISJ-416, poorly-preserved complete colony; PISJ-380,
315 fragmentary mature colony; PISJ-306, specimen with proximal and medial features;
316 PISJ-305, poorly-preserved mature colony; PISJ-305, specimen with medial and distal
317 characteristics; PISJ-297, moderate preserved fragmentary colony; PISJ-293, mature
318 colony showing medial and distal features; PISJ-290, moderate preserved fragmentary
319 colony; PISJ-274, fragmentary specimen filled with oxide pyrite. All from the type
320 locality.

321 **Geographic occurrence.** Southeast area of the La Rinconada area, Chica de Zonda
322 Range, 24 km to the south of the San Juan City, San Juan Province, Argentina.

323 **Stratigraphic occurrence.** Levels RSE-01, RSE-06 and Sil-04, upper sampled levels,
324 Rinconada Formation, southeast area of the La Rinconada area, Gorstian to lowermost
325 Ludfordian, Ludlow, upper Silurian.

326 **Material.** Twenty-four mature tubaria and several fragmentary specimens (PISJ-
327 259/274/290/293/297/304—307/314/326/328—330/339/344—345/349/351—

328 352/357—362/367/379—380/408/414/416) generally moderate-preserved as flattened
329 carbon films, or rarely in relief filled by greenish siltstone.

330

331 **Diagnosis.** Thin and straight to slightly dorsally curved *Saetograptus*, which slowly
332 widens until 1.23—1.28 mm at Th15—20. First 3—5 thecae with lateral apertural
333 spines, getting pristiograptid distalward. Sicula with long virgella and proximo-dorsally
334 directed antivirgellar spine. Thecal number 6—8.5 in 5 mm proximally, and 6—7.25
335 distally. The 2TRD is 0.87—1.28 mm at Th2, 1.02—1.46 mm at Th5, 1.34—1.58 mm
336 distally. Thecae inclines 25°—44° proximally and 20°—36° distally.

337 **Description.** Thin tubaria usually straight to slightly dorsally curved, with 17.31 mm as
338 the maximum length (PISJ-297). The dorso-ventral width is 0.71—0.92 mm at Th1,
339 0.72—1.01 mm at Th2, 0.71—0.99 mm at Th3, 0.80—1.14 mm at Th5, 0.87—1.19 mm
340 at Th7, 0.80—1.07 mm at Th10, 1.26 mm at Th15, 1.28 mm at Th20, and 1.06—1.23
341 mm distally. Thecae are biform, possessing proximo-ventrally directed lateral apertural
342 spines until Th3—5 of up to 0.95 mm long, getting pristiograptid-shaped distalward.
343 The species presents a straight cone-shaped sicula of 1.44—2.08 mm long (one
344 specimen reaches 2.53 mm long), and 0.29—0.44 mm wide at the aperture. Sicula
345 possesses up to 0.82 mm long proximo-ventrally directed virgella, and 0.54 mm long
346 proximo-dorsally (most common) to dorsally (rare) directed antivirgellar spine. Sicular
347 apex usually reaches or locates slightly above the level of Th3. The 2TRD is 0.87—1.28
348 mm at Th2, 1.02—1.46 mm at Th5, 1.34—1.58 mm distally. Thecal spacing equals 6—
349 8.5 thecae in 5 mm proximally, and 6—7.25 thecae distally. Thecal overlap is two-
350 thirds proximally, and one half to three-fifth distally. The common canal is about 0.19
351 mm wide throughout the colony. The thecal inclination is 25°—44° proximally and
352 20°—36° distally.

353 **Remarks.** Common component of the upper sampled levels of the Rinconada
354 Formation. Specimens of *Saetograptus rinconadensis* sp. nov. present a thinner
355 tubarium than *S. argentinus argentinus* (Cuerda, 1969) and *S. a. robustus* Maletz *et al.*,
356 2002 (2.57 mm and 3.8 mm, respectively), subspecies that share geographic and
357 stratigraphic presence. *Saetograptus rinconadensis* differs from *S. varians* (Wood,
358 1900) in having a straight and more complex sicula, whose apex reaches higher thecae
359 in the colony, narrower medially and distally tubarium (1.4—1.5 mm at Th7—10,
360 1.32—1.69 mm distally; *see* Hutt, 1969; Palmer, 1986; Wilkinson, 2021), and in
361 presenting a proximo-dorsally directed antivirgellar spine (*S. varians* possesses a
362 proximal directed dorsal lapped; *see* Palmer, 1986, figs. 4–5; Lenz & Kozłowski-
363 Dawidziuk, 2004). Furthermore, the new species shows greater dorso-ventral widths,
364 2TRD values, and sicular length than *S. wandalensis* (Watney & Welch, 1911) (Taylor,
365 1998; Wilkinson, 2021; and studies cited therein). Finally, the presence of the proximo-
366 dorsally directed antivirgellar spine and biform thecae (spiny to pristiograptid thecae) in
367 *S. rinconadensis*, allow to differentiate the new species from *S. clunensis* (Earp, 1944),
368 *S. colonus colonus* (Barrande, 1850), *S. fritschi fritschi* (Perner, 1899), *S.*
369 *leintwardinensis leintwardinensis* (Lapworth, 1880), and *S. soperi* (Rickards &
370 Woodcock, 2005), species which lack the mentioned features, besides having different
371 dorso-ventral widths, sicular measures, and 2TRD values (*see* Taylor, 1998; Lenz &
372 Kozłowski-Dawidziuk, 2004; Rickards & Woodcock, 2005; Štorch *et al.*, 2014).

373

374 *Genus Uncinatograptus* Tsegelnyuk, 1976

375 **Type species.** *Monograptus uncinatus* Tullberg, 1883; 12a, lectotype, selected by
376 Přibyl, 1948: 35 (Tullberg, 1883: pl. 1: 25; ‘LO collection, specimen not identified);

377 12b-c, proximal end in lateral (3b) and ventral (3c) views; from the Ludlow of Bohemia
378 (Czech Republic).

379

380 *Uncinatograptus?* sp.

381 Figure 5A

382

383 **Material.** Five juvenile specimens and three fragmentary colonies (PISJ-
384 207/209/213/220/224—225/246/274), poorly preserved as flattened carbon films.

385 **Stratigraphic occurrence.** Levels RSW-03, RSW-04, and RSE-06, lower to upper
386 levels of the Rinconada Formation, lower to upper Gorstian, lower Ludlow, upper
387 Silurian. Southeastern sector of the La Rinconada section, Chica de Zonda Range, San
388 Juan Province, Argentina.

389 **Description.** Specimens are straight, with ventrally curved proximal end, and 9.29 mm
390 as maximum length. The dorso-ventral width is 0.52?—0.85 mm at Th1, 0.68—0.94
391 mm at Th2, 0.72—0.81 mm at Th3, 0.83?—0.88 mm at Th5, and 0.97 mm distally.
392 Thecae are uncinatograptid, showing hoods generally absent or broken, giving the
393 aspect of a pseudomonoclimacid-like thecae or apertural spines. Sicular is 1.50—1.85
394 mm long, and 0.30—0.40 mm wide in its aperture. A 0.37—0.60 mm virgella and a
395 0.19 mm dorsal tongue are present. Sicular apex usually reaches the level of the
396 aperture of Th2. The 2TRD is 1.53 mm proximally and 1.92 mm distally.

397 **Remarks.** The features shown by the material from Precordillera mostly agree with the
398 morphological description for the genus *Uncinatograptus* Tsegelnyuk, 1976. Moreover,

399 dorso-ventral width resembles *U. uncinatus notouncinatus* (Cuerda, 1969), although the
400 poor preservation of the tubaria denies a secure generic nor specific determination.

401

402 *Genus Bohemograptus* Přibyl, 1967

403 **Type species.** *Graptolithus bohemicus* Barrande, 1850, by original designation; Ludlow
404 of Bohemia, Czech Republic.

405

406 *Bohemograptus bohemicus* (Barrande, 1850)

407 Figure 5B-C

408

409 *Graptolithus bohemicus*; Barrande 1850; p. 40, pl. 1: 15–18.

410 *Monograptus bohemicus* (Barrande, 1850); Bouček, 1936; pp. 3–4, pl. 1: 1–3.

411 *Pristiograptus bohemicus* (Barrande, 1850); Urbanek 1958; pp. 77–80, figs. 46, 47, 49.

412 *Bohemograptus bohemicus* (Barrande, 1850); Přibyl, 1967; p. 136, pl. 1: 1–6.

413 *Bohemograptus bohemicus bohemicus* (Barrande, 1850); Lenz 1990; figs. 3A, B.

414 *Bohemograptus bohemicus bohemicus* (Barrande, 1850); Zhang and Lenz 1997; p.

415 1236, figs. 6M–S, 7I, 7K–M.

416 *Bohemograptus bohemicus* (Barrande, 1850); Nilsson 2002; p. 16, figs. 8B, 9B, C.

417 *Bohemograptus bohemicus bohemicus* (Barrande, 1850); Lenz and Kozłowska-

418 Dawidziuk, 2004; p. 32, pl. 37: 1–5, 7; pl. 44: 1–5.

419 *Bohemograptus bohemicus* (Barrande, 1850); Sachanski *et al.* 2012; pl. 1e.

420 *Bohemograptus bohemicus* (Barrande, 1850); Štorch *et al.* 2014; p. 1032, fig. 13D.

421 *Bohemograptus bohemicus* (Barrande, 1850); Lopez *et al.*, 2024; pp. 358–359, figs. 4K,

422 8A, B.

423

424 **Material.** Five juvenile and mature specimens (PISJ-248—249/254/257), moderately to
425 poorly preserved as flattened carbon films.

426 **Stratigraphic occurrence.** Level RSW-04, middle levels of the Rinconada Formation,
427 lower Gorstian *L. progenitor* Zone, lower Ludlow, upper Silurian. Southeastern sector
428 of the La Rinconada section, Chica de Zonda Range, San Juan Province, Argentina.

429 **Description.** Colonies from the Rinconada Formation are moderately to strongly
430 ventrally curved, with a maximum length of 8.83 mm. Dorso-ventral width is 0.60—
431 0.79 mm at Th1, 0.66—0.96 mm at Th2, 0.66—1.02 mm at Th3, 0.84—1.31 mm at
432 Th4, 1.47 mm at Th5, 1.54 mm at Th7, and 1.63 mm at Th8. Th1 shows a concave
433 ventral wall in profile, whereas Th2 and the following thecae are tube-like. Sricula is
434 1.47—1.93 mm long, 0.27—0.40 mm wide in its aperture, and reaches the Th1 or Th2
435 aperture. The 2TRD is 1.46—1.78 mm at Th2, 1.95 mm at Th5, and 1.87 mm at Th7.
436 Thecae inclines at 29°—49° proximally.

437 **Remarks.** The specimens from the Rinconada Formation agree with the description and
438 illustrations of Berry (1964), Urbanek (1970), Nilsson (2002), Koren' and Sujarkova
439 (2004), Lenz and Kozłowska-Dawidziuk (2004), Wilkinson (2021), and Lopez *et al.*
440 (2024) for *Bohemograptus bohemicus* (Barrande, 1850). It is important to mention that
441 the material studied herein gets thicker faster than the colonies describes by the cited
442 authors, although both the medial and distal width agree with the species description.

443

444 *Genus Lobograptus* Urbanek, 1958

445 **Type species.** *Monograptus scanicus* Tullberg, 1883; from the Ludlow of Scania

446 (Sweden).

447

448 *Lobograptus progenitor* Urbanek, 1966

449 Figure 5D-E

450

451 pars *Monograptus Nilssoni* (Barrande); Elles and Wood, 1911; pl. 37, figs. 1a-b.

452 *Lobograptus progenitor* Urbanek, 1966; p. 384, figs. 3–4; pls. 11–14.

453 *Cucullograptus (Lobograptus) progenitor* Urbanek, 1966; Palmer, 1971; p. 377, figs. 1–

454 2, 11–14.

455 *Lobograptus progenitor* Urbanek, 1966; Lenz, 1990; figs. 3E, F.

456 *Lobograptus progenitor* Urbanek, 1966; Zhang and Lenz, 1997; p. 1232, figs. 6A-F,

457 7H, 7N-P.

458 *Lobograptus progenitor* Urbanek, 1966; Lenz and Kozłowska-Dawidziuk, 2004; pp.

459 36–37, pl. 31, figs. 1–8, 10, 13–15; pl. 36, figs. 1–5; pl. 43, figs. 1–6.

460

461 **Material.** Three juvenile and mature specimens (PISJ-239/243/251), moderately

462 preserved as flattened carbon films.

463 **Stratigraphic occurrence.** Level RSW-04, middle levels of the Rinconada Formation,
464 lower Gorstian *L. progenitor* Zone, lower Ludlow, upper Silurian. Southeastern sector
465 of the La Rinconada section, Chica de Zonda Range, San Juan Province, Argentina.

466 **Description.** Ventrally curved to straight colonies, with 10.70 mm of maximum length.
467 The dorso-ventral width is 0.34—0.56 mm proximally, 0.47—0.53 mm medially, and
468 0.69—0.96 mm distally. Thecae are tube-like or slightly geniculated, with straight to
469 convex apertures, located orthogonal or in slightly obtuse angle to the tubarium axis.
470 Sricula and proximal end not preserved. The 2TRD is 1.60—1.95 mm medially, and
471 2.56—2.79 mm distally.

472 **Remarks.** The features observed in the material from the Precordillera agree with the
473 description given by Palmer (1971), Zhang and Lenz (1997), Nilsson (2002), and Lenz
474 and Kozłowska-Dawidziuk (2004) for *Lobograptus progenitor* Urbanek, 1966.
475 Although the proximal end is not preserved, the maximum dorso-ventral width reached
476 by the colonies studied herein (0.96 mm) allows to differentiate it from the narrower *N.*
477 *nilssoni* (Barrande, 1850) (up to 0.5—0.66 mm wide; Palmer, 1971; Štorch *et al.*, 2014),
478 species with which it is usually confused. This contribution represents the first mention
479 and description of the index species for South America. However, at age-equivalent
480 levels of the Los Espejos Formation (Central Precordillera), a single fragmentary colony
481 of *Lobograptus* sp. resembling *L. progenitor* was described by Lopez *et al.* (2024).

482

483 *Lobograptus* sp. cf. *L. scanicus* (Tullberg, 1883)

484 Figure 5F

485

486 cf. *Monograptus scanicus* Tullberg, 1883; p. 26, pl. 2, fig. 38.

487

488 **Material.** One fragmentary specimen with moderate preservation as a carbonaceous
489 film (PISJ-293).

490 **Stratigraphic occurrence.** Level RSE-06, upper sampled levels of the Rinconada
491 Formation, upper Gorstian to possibly lowermost Ludfordian, Ludlow, upper Silurian.

492 **Description.** Straight distal fragmentary colony of 21.33 mm long, with *ca.* 19 thecae
493 preserved. Dorso-ventral width varies from 0.94—1.18 mm across the tubarium. Thecae
494 are usually poorly-preserved, although show a kidney-shaped lateral apertural lobes,
495 prominent ventrally, and in contact with the ventral wall of the subsequent protheca
496 dorsally. The 2TRD varies from 1.61 mm in the lower thecae to 1.90 mm more distally.
497 Thecal spacing counts 5 thecae in 5 mm. Prothecal walls incline 30°—16°, and the
498 thecal overlap is one half to three-fifth.

499 **Remarks.** The measures of the material from Precordillera mostly agree with
500 *Lobograptus scanicus* (Tullberg, 1883) according to the description and illustrations of
501 Lenz and Kozłowska-Dawidziuk (2004), Štorch *et al.* (2014) and Wilkinson (2021).
502 The specimen described above shows a wider tubarium than most of the descriptions
503 given by the cited authors, although some illustrated material (*see* Štorch *et al.*, 2014,
504 fig. 12D) is 1.10—1.18 mm wide, similar values to the tubarium from Precordillera. In
505 any case, the absence of more complete and better-preserved material denies a
506 trustworthy specific determination.

507

508 *Genus Neodiversograptus* Urbanek, 1963

509 **Type species.** *Pristiograptus nilssoni* Barrande, 1850; from the Ludlow of the
510 Barrandian region, Czech Republic.

511

512 cf. *Neodiversograptus*

513 Figure 5G

514

515 **Material.** One proximal colony (PISJ-224), poorly preserved as a flattened carbon film.

516 **Stratigraphic occurrence.** Level RSW-03, lower layers of the Rinconada Formation,
517 lower Gorstian, lower Ludlow, upper Silurian. Southeastern sector of the La Rinconada
518 section, Chica de Zonda Range, San Juan Province, Argentina.

519 **Description.** Mostly straight proximal colony of 4.15 mm long. The dorso-ventral
520 width is 0.44 mm at the Th1, 0.55 mm at the Th2, and 0.59 mm at the Th3. Thecae are
521 tube-like, with straight aperture. The sicula is 1.65 mm long and 0.23 mm wide at its
522 aperture, and the apex locates slightly below the Th1 aperture. The 2TRD is 1.48 mm at
523 Th2.

524 **Remarks.** Thecal morphology and measures of the colony resemble to the genus
525 *Neodiversograptus* Urbanek, 1963, particularly to the species *N. nilssoni* (Barrande,
526 1850) according to the description of Palmer (1971) and Štorch *et al.* (2016), however
527 the absence of more, more complete, and better-preserved proximal ends denies a
528 secure generic determination

529

530 *Genus Prolinograptus* Rickards and Wright, 1997

531 **Type species.** *Prolinograptus packhami* Rickards and Wright, 1997; from the Ludlow
532 of New South Wales, Australia.

533

534 *Prolinograptus packhami* Rickards and Wright, 1997

535 Figure 5H-I

536

537 *Prolinograptus packhami* Rickards and Wright, 1997; pp. 226, figs. 9K, L, N, O, 10A.

538 *Prolinograptus packhami* Rickards and Wright, 1997; Lenz and Kozłowska-Dawidziuk,
539 2004; pp. 37–38, pl. 2, figs. 1–7.

540 *Prolinograptus packhami* Rickards and Wright, 1997; Chmierlarz and Kozłowska,
541 2014; pp. 142, 144–145, figs 5, 6.

542

543 **Material.** Two long fragmentary specimens with moderate preservation, as
544 carbonaceous films (PISJ-250/256).

545 **Stratigraphic occurrence.** Level RSW-04, middle sampled levels of the Rinconada
546 Formation, lower Gorstian *L. progenitor* Zone, lower Ludlow, upper Silurian.
547 Southeastern sector of the La Rinconada section, Chica de Zonda Range, San Juan
548 Province, Argentina.

549 **Description.** Long, sinuous and slender tubaria, of more than 77 mm of length. The
550 dorso-ventral width at the thecal apertures is 0.14—0.21 mm throughout the colony.
551 Thecae long, with simple, everted and straight apertures, usually with thick rims (Fig
552 5H-I), and located perpendicular or in obtuse angles to the colony axis. Sicula and

553 proximal end not preserved. The 2TRD is 2.68—3.09 mm, and the thecal spacing
554 counts 3.5 thecae in 5 mm.

555 **Remarks.** The morphological features of the material from the Rinconada Formation
556 agree with the descriptions given by Rickards and Wright (1997), Lenz and Kozłowska-
557 Dawidziuk (2004), and Chmielarz and Kozłowska (2014) for *Prolinograptus packhami*
558 Rickards and Wright, 1997. This contribution represents the first mention and
559 description of the genus and species for South America.

560

561 **Results**

562 **Analyzed stratigraphic segment**

563 The studied section initiates in a faulted zone, located 110 metres to the east of
564 the central limestone block (*see* Lopez *et al.*, 2023), and finishes in the easternmost
565 sector of the outcrops, at the unconformity with the Jejenes Formation (see Fig. 1). The
566 total thickness is 375.6 metres, although three decametric covered zones are located in-
567 between (Fig. 6). Taken into account the common presence of reverse faults affecting
568 the Rinconada Formation (see Fig. 1), together with syn-sedimentary structures (Peralta,
569 1986; von Gosen *et al.*, 1995; Lopez *et al.*, 2023), possible stratigraphic omissions or
570 repetitions of the sequence could have been included in the studied segment. For the
571 exposed, no security in the stratigraphic thickness can be assured.

572 The first half of the stratigraphic succession, named as “Rinconada South West”
573 (RSW), is characterized by the dominance of olive-green siltstones, which are
574 interbedded with thin to metre-scale green, fine-grained sandstones. Only two metric
575 olistoliths were observed in the studied section, although several small allochthonous
576 bodies are present throughout the outcrops. The presence of dip changes in the strata

577 associated with lineaments parallel to the strike of the succession, might indicate the
578 presence of possible minor faulting structures; however, no evidence of repetition or
579 omission was observed. In this segment, the samples RSW-02—05 were obtained (Fig.
580 6). In contrast, the upper half of the column, called “Rinconada South East” (RSE),
581 shows a dominance of fine- to middle-grained green sandstones, usually as lenses with
582 metric thickness, intercalated with green siltstones. Accordingly, eight fossiliferous
583 levels were found, named as RSE-01—08. It is worth mentioning that the fossil content
584 was almost always found in sandstone layers.

585

586 **Graptolite fauna and associated fossils**

587 The levels RSW show a generally impoverished faunal content, accentuated in
588 the basal layers, as in level RSW-02. This fossil stratum contains only a reduced amount
589 of poorly-preserved specimens of an unidentifiable monograptid, possibly retiolitid
590 lists, and abundant but fragmented fossil plant remains. The upper fossil level (RSW-
591 03) is characterized by the first appearance of the endemic *S. argentinus argentinus*
592 (Cuerda, 1969), together with few specimens of the genus *Uncinograptus?*, common
593 components of the Silurian of Precordillera. Additionally, a single proximal specimen
594 resembling the genus *Neodiversograptus* was found associated with the latter. The level
595 RSW-04 is characterized by the most varied graptolite fauna, which is composed of *S.*
596 *a. argentinus* and *Uncinograptus?* sp., together with the index species *Lobograptus*
597 *progenitor* Urbanek, 1966, *Bohemograptus bohemicus* (Barrande, 1850),
598 *Prolinograptus packhami* Rickards and Wright, 1997, and *Pristiograptus frequens*
599 Jaekel, 1889. In the mentioned levels, abundant and well-preserved plant remains were
600 found. Finally, the last fossil layer of the first half (RSW-05) is composed only of
601 possibly *S. a. argentinus* and plant remains.

602 The upper half of the column (RSE-01—08) is composed almost exclusively of
603 the genus *Saetograptus* (*S. argentinus argentinus* and *S. rinconadensis* sp. nov.), with
604 dozens to hundreds of specimens per sample. One unique fragmentary tubarium
605 compared with *Lobograptus scanicus* (Tullberg, 1883), and one juvenile
606 *Uncinatograptus?* colony were found in the upper levels (RSE-06). Additionally,
607 poorly-preserved proximal colonies that resemble the genus *Cucullograptus* and
608 *Prolinograptus* were found in the same stratigraphic level, although its preservation
609 denies a generic determination. In all cases, plant remains are common throughout the
610 layers.

611 To the north-northwest of the studied section, a single isolated fossiliferous level
612 was found (Sil-04). It is composed of abundant specimens of *S. rinconadensis* sp. nov.
613 and *S. a. argentinus*. This level is studied in the present contribution, although it cannot
614 be included in the stratigraphic column due to a faulting structure eastwards, the same
615 fault that limits the basal stratigraphic column (see Fig. 6).

616 As mentioned above, throughout the analysed stratigraphic section, abundant
617 plant remains are common and represent the most prevalent fossil content in specific
618 intervals. Regarding the megaflora remains, a fossil group consisting mostly of
619 fragmentary coalified compressions of sterile axes was identified, some of which
620 exhibited a dichotomous branching pattern. In contrast, coalified remains of fertile
621 structures of the *Cooksonia*-type were identified in the graptolite-bearing strata.

622

623 **Biostratigraphic remarks (Fig. 7)**

624 *Ludlovian assemblages (Fig. 7)*

625 As the Ludlovian graptolite assemblages from Precordillera are composed
626 almost exclusively of endemic species: *i.e.* *Uncinatograptus* spp. and *Saetograptus*
627 *argentinus* ssp. in the Los Espejos Formation; and *Saetograptus* spp. in the Rinconada
628 Formation (Lopez *et al.*, 2024; this study), the establishment of a trustful age data
629 results difficult. In isolated stratigraphic levels of the Los Espejos Formation,
630 cosmopolitan graptolites were found associated with Precordillera typical taxa,
631 providing the first biostratigraphic approximation for these faunas. In this way, the first
632 appearances of *Bohemograptus bohemicus* (Barrande, 1850) and *Uncinatograptus* spp.
633 indicate equivalent ages to the lower Gorstian *Neodiversograptus nilssoni* Zone, and the
634 association of *Saetograptus* sp. cf. *S. varians* and *Lobograptus* sp. with *S. argentinus*
635 *argentinus* correspond to equivalent ages to the lower Gorstian *Lobograptus progenitor*
636 Zone (Lopez *et al.*, 2024).

637 In the Rinconada Formation, the graptolite assemblages can be subdivided into
638 two segments: the first, characterized by the lower and middle levels (RSW-03—04),
639 which indicates a lower Gorstian age; and the second, located in the middle-upper levels
640 (RSW-05 and RSE-01—08), which corresponds to a Gorstian to possibly lowermost
641 Ludfordian age. The first assemblage initiates in the level RSW-03, with the first
642 appearance of *Saetograptus argentinus argentinus*, *Uncinatograptus?* sp. and cf.
643 *Neodiversograptus*. Upwards, the level RSW-04 is characterized by *Lobograptus*
644 *progenitor*, *Pristiograptus frequens*, *Prolinograptus packhami*, *S. a. argentinus*, and
645 *Uncinatograptus?* sp. According to Maletz in Bates *et al.* (2023), the genera
646 *Saetograptus*, *Uncinatograptus?*, and *Neodiversograptus* initiates globally in the lower
647 Gorstian *N. nilssoni* Zone, for which the level RSW-03 might correspond to equivalent
648 ages to the mentioned biozone. Moreover, the assemblage of level RSW-04 can be
649 assigned to the lower Gorstian *L. progenitor* Zone based on the presence of the index

650 species. It is worth to mention that the *L. progenitor* biochron reaches the basal *L.*
651 *scanicus*-*S. chimaera* Zone (Prague Synform biostratigraphic chart; Štorch, 2023, fig.
652 22), for which slightly younger ages should not be dismissed.

653 Upwards, the second assemblage is widely dominated by species of the genus
654 *Saetograptus*, and only one specimen compared to the cosmopolitan *Lobograptus*
655 *scanicus* (Tullberg, 1883) was recognized in the upper sampled levels. The latter
656 species has been found globally, encompassing from the upper Gorstian *L. scanicus*-*S.*
657 *chimaera* Zone to the lowermost lower Ludfordian *S. leintwardinensis* Zone (peri-
658 Gondwana and Prague Synform biostratigraphic charts; Štorch *et al.*, 2014; Štorch,
659 2023), or from the lower Gorstian *L. scanicus* Zone to the lower Ludfordian *S. linearis*-
660 *Monograptus ceratus* Zone (Arctic Canadian biostratigraphic chart; Lenz & Kozłowska-
661 Dawidziuk, 2004). Accordingly, the sampled level RSE-06 from the upper studied
662 stratigraphic section might present an upper Gorstian-lowermost Ludfordian age,
663 possibly from the *L. scanicus* Zone or slightly younger. Moreover, the existence of *S.*
664 *argentinus argentinus* in the uppermost levels (RSE-07) indicates an age not younger
665 than lower Ludfordian, due to the disappearance of the genus *Saetograptus* from the
666 stratigraphic record worldwide in the *S. leintwardinensis* Zone (Maletz in Bates *et al.*,
667 2023).

668 Furthermore, the graptolitic assemblage observed in the isolated level Sil-04, del
669 Medio Creek, which is characterized by *S. rinconadensis* and *S. a. argentinus*, is
670 tentatively correlated with the upper levels of the column (*i.e.*, RSE-02/07) and an upper
671 Gorstian-lowermost Ludfordian age can be estimated for the above-mentioned level.

672

673 *Regional and Global correlations (Fig. 7)*

674 In the Precordillera, similar Silurian graptolite assemblages have been described
675 from the middle and upper levels of the Los Espejos Formation (Central Precordillera).
676 There, specimens of *B. bohemicus* and *Uncinatograptus* spp.; and *Lobograptus* sp., *S. a.*
677 *argentinus*, *S. sp. cf. S. varians*, were included in equivalent levels to the *N. nilssoni* and
678 *L. progenitor* zones, respectively (Lopez *et al.*, 2024). These two assemblages can be
679 directly correlated with the levels RSW-03 and RSW-04 from the Rinconada
680 Formation. Moreover, the upper graptolitic layers of the Los Espejos Formation,
681 strongly dominated by *S. a. argentinus* and *Uncinatograptus* spp., have been dated as
682 upper Gorstian to lower Ludfordian, allowing a correlation with the upper segment of
683 the stratigraphic column studied herein (levels RSE-01—07).

684 In the Silurian Kirusillas Formation from Bolivia, Gorstian strata are composed
685 of *Monograptus bolivianus* Maletz *et al.*, 2002, *Neodiversograptus* sp., *S. a. argentinus*,
686 and *S. a. robustus* Maletz *et al.*, 2002, an assemblage that can be potentially correlated
687 with the middle and upper levels of the stratigraphic column studied herein (levels
688 RSW-03—04, RSE-01—07).

689 Lastly on a global scale, the studied levels of the Rinconada Formation could be
690 correlated with equivalent sections carrying the *N. nilssoni*, *L. progenitor*, and *L.*
691 *scanicus* zones (Štorch *et al.*, 2024).

692

693 **Paleocurrent based on graptolite colonies**

694 Graptolites, as lineal components of the fossiliferous samples, can be used as
695 indicators of direction and sense of the flow. Based on the proposal of Moors (1970),
696 colonies of graptolites that show alignment in response to unidirectional flows can be
697 located in different stable positions whose number depends on the force of the flow: *i.e.*

698 the stronger the flow, the fewer stable positions and the greater concentration of
699 colonies in the same direction. In moderate and slow currents, the balance of torsional
700 and frictional forces is higher and might considerably influence the normal position of
701 the colonies (Schwarzacher, 1963). In addition, Moors (1970) interpreted the colony
702 size as a primary factor that influence the orientations as well: the more similar the
703 sizes, the more concentration in a particular direction. Accordingly, the flow direction
704 represents the first stable position, where the graptolites are located parallel to it. The
705 latter is followed by a secondary stable position, which is located at 45° from the
706 current, and by a third position, which orients at 60° from the flow direction. The cited
707 author showed that not always the mean number of graptolites is oriented parallel to the
708 flow, but prefers to locate at 45° from it (the secondary stable position). In those cases,
709 comparing with sedimentary structures is crucial to correctly interpreting the current.
710 Finally, Moors (op. cit.) described a strong preference of siculae (thus, proximal ends)
711 for locating pointing up-current. In this way, the colony axis and the distal part of
712 graptolite specimens might indicate both direction and sense of the flow.

713 In the Rinconada Formation, particularly in the level RSE-06, monoserial
714 juvenile and mature graptolite colonies are in high numbers (several tens per sample),
715 and show a moderate to strong alignment (Fig. 8A-B). There, 10 samples were obtained
716 with orientation data, which possess 78 graptolite colonies. The building of a rosette
717 shows a mean direction of 288° (WNW), a secondary direction of 246° (WSW), and two
718 directions of 355° (N) and 215° (SW) with minor importance (Fig. 8C). In the studied
719 section, sedimentary structures suggest a WSW current direction, in accordance with
720 Milana (1992). Moreover, as the Rinconada Formation was interpreted as deposited in
721 an inner platform dominated by gravity flows and olistolith falls (Drovandi *et al.*, 2024;
722 and studies cited therein), strong currents can be inferred for the sampled levels.

723 Based on the previous paragraph, the most probable current direction would be
724 WSW (246°), which is consistent with the field observations and antecedents.
725 Furthermore, the mean location of the colonies (288°) might correspond to the
726 secondary stable position, which is separated by almost 45° away from the interpreted
727 flow direction. Additionally, the two minor important directions (215° and 355°) might
728 represent other expressions of stable positions.

729 Similar rosettes were built by Palmer (1986, figs. 2–3) for a monospecific
730 assemblage of *S. varians* of Gorstian age from Long Mountain, United Kingdom. The
731 mentioned graphics showed a double maxima without the sense of siculae, indicating
732 the direction of the flow. Contrarily, the rosettes with the sense of the siculae are more
733 complex and polymodal, showing a strong alignment with the sense of the current for
734 mature specimens (with its siculae located upstream), and a normal location to the latter
735 with indistinct position of the siculae for small tubaria. Unfortunately, the sample did
736 not possess orientation data, for which no real direction of current could be estimated by
737 the cited author. Comparing the rosettes of Palmer (1986, fig. 2a, 2d) with the obtained
738 herein, similarities can be observed: firstly, both graptolite assemblages show a high
739 number of aligned mature colonies (pointing to the sense of the flow), meanwhile
740 intermediate locations, interpreted here as minor stable positions *sensu* Moors (1970),
741 present a reduced number of specimens. In contrast, the assemblage from Precordillera
742 does not show a clear difference between juvenile a mature colonies, and both
743 astogenetic stages disposed indistinctly in the different stable positions.

744

745 **Conclusions**

746 New graptolite faunas from the matrix of the olistostrome of the Rinconada
747 Formation at the La Rinconada section, Eastern Precordillera, are presented herein. A

748 stratigraphic succession, which initiates in a faulted zone and finishes in an
749 unconformity, was studied in the southeastern area of the outcrops and twelve
750 fossiliferous levels were obtained. The lowermost layers are composed of an
751 unidentified monograptid and retiolitid lists. Upwards, the assemblage is characterized
752 by of *Saetograptus argentinus argentinus* and *Uncinatograptus?* sp., two well-known
753 taxa for Precordillera, associated with cf. *Neodiversograptus*, and further up with
754 *Bohemograptus bohemicus*, *Lobograptus progenitor*, *Pristiograptus frequens*, and
755 *Prolinograptus packhami*. The upper strata are almost exclusively composed of *S. a.*
756 *argentinus* and *S. rinconadensis*, a new species, associated in isolated cases with *L. sp.*
757 cf. *L. scanicus* and *Uncinatograptus?* sp.

758 The assemblage composed of the genera *Saetograptus*, *Uncinatograptus?*, and
759 possibly *Neodiversograptus* indicates a lower Gorstian age, equivalent to the *N. nilssoni*
760 Zone. Upwards, the existence of *L. progenitor* and associated taxa allows to record the
761 homonymous biozone from the early Gorstian. Lastly, the upper assemblage might
762 belong to the upper Gorstian *L. scanicus* Zone or equivalent levels, although a
763 lowermost Ludfordian age for the uppermost layers should not be dismissed.
764 Accordingly, *S. rinconadensis* sp. nov. would possess an upper Gorstian to lowermost
765 Ludfordian age.

766 This contribution enables a more precise biostratigraphic knowledge on the
767 Silurian in Argentina. Moreover, it allows accurate regional correlations with other
768 sections from the Precordillera (Los Espejos Formation) and Bolivia (Kirusillas
769 Formation), as well as global correlations with several equivalent sections worldwide.

770 Additionally, the upper levels of the studied section show a moderate to strong
771 alignment of the graptolite colonies. Taking into account their location to the magnetic

772 north, a WSW (246°) paleocurrent direction was estimated, and compared with
773 sedimentary structures and antecedents.

774 This study introduces new graptolite faunas from the Silurian of Precordillera,
775 most of them without previous reports in Argentina or South America so far, which
776 enriches our scarce knowledge of Ludlow faunas on this subcontinent at the ends of the
777 planktonic graptolite era.

778

779 **Acknowledgements**

780 The authors are grateful to Dr. Jörg Maletz, Dr. Jan Zalasiewicz, and editors of
781 Ameghiniana for their comments and suggestions, which considerately improved the
782 original manuscript. Thanks to the Consejo Nacional de Investigaciones Científicas y
783 Técnicas (CONICET) for its continuous support in the graptolite studies; and to the
784 Instituto y Museo de Ciencias Naturales (IMCN) and Universidad Nacional de San Juan
785 for their instrumental facility and workplace. Especial thanks to Agustín Gordillo,
786 Alejandro Braeckman, Samuel Schlamelcher, and Ulises Abarca for their field
787 assistance.

788

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1019

1020 **Figure captions**

1021 **Figure 1.** Geologic map of the La Rinconada section, Chica de Zonda Range, Eastern
1022 Precordillera. A, General geologic map of the outcrops of the Rinconada Formation and
1023 surrounding units; B, Detailed geologic map of the studied levels. Note to the north the
1024 isolated fossiliferous level Sil-04, located to the west of a fault. Abbreviations: dep.,
1025 deposits; Rinc., Rinconada; Cambr., Cambrian; Ordov., Ordovician; S. section, Studied
1026 section; F. level, Fossiliferous level;

1027 **Figure 2.** Graptolite drawings of the lower and middle levels of the Rinconada
1028 Formation. A-C, *Pristiograptus frequens* Jaekel, 1889, proximal and mature colonies.
1029 Lower Gorstian *L. progenitor* Zone, level RSW-04. PISJ-236/247/255. Scale bars equal
1030 1 mm.

1031 **Figure 3.** Photographs of graptolites of the upper levels of the Rinconada Formation. A-
1032 F, *Saetograptus argentinus argentinus* (Cuerda, 1969), juvenile and mature specimens.
1033 Lower Gorstian to possibly lowermost Ludfordian, levels RSW-03—05?, and RSE-
1034 06—07. PISJ-268/273/303/322/381/392. G-K, *Saetograptus rinconadensis* sp. nov. G-
1035 H, mold and counter-mold of the holotype, in general view (G) and detailed proximal
1036 end (H). PISJ-259; I-J, complete colonies, PISJ-306/416; K, long broken mature
1037 tubarium, PISJ-274. Upper Gorstian to lowermost Ludfordian age, levels RSE-01/06.
1038 Scale bars equal 1 mm.

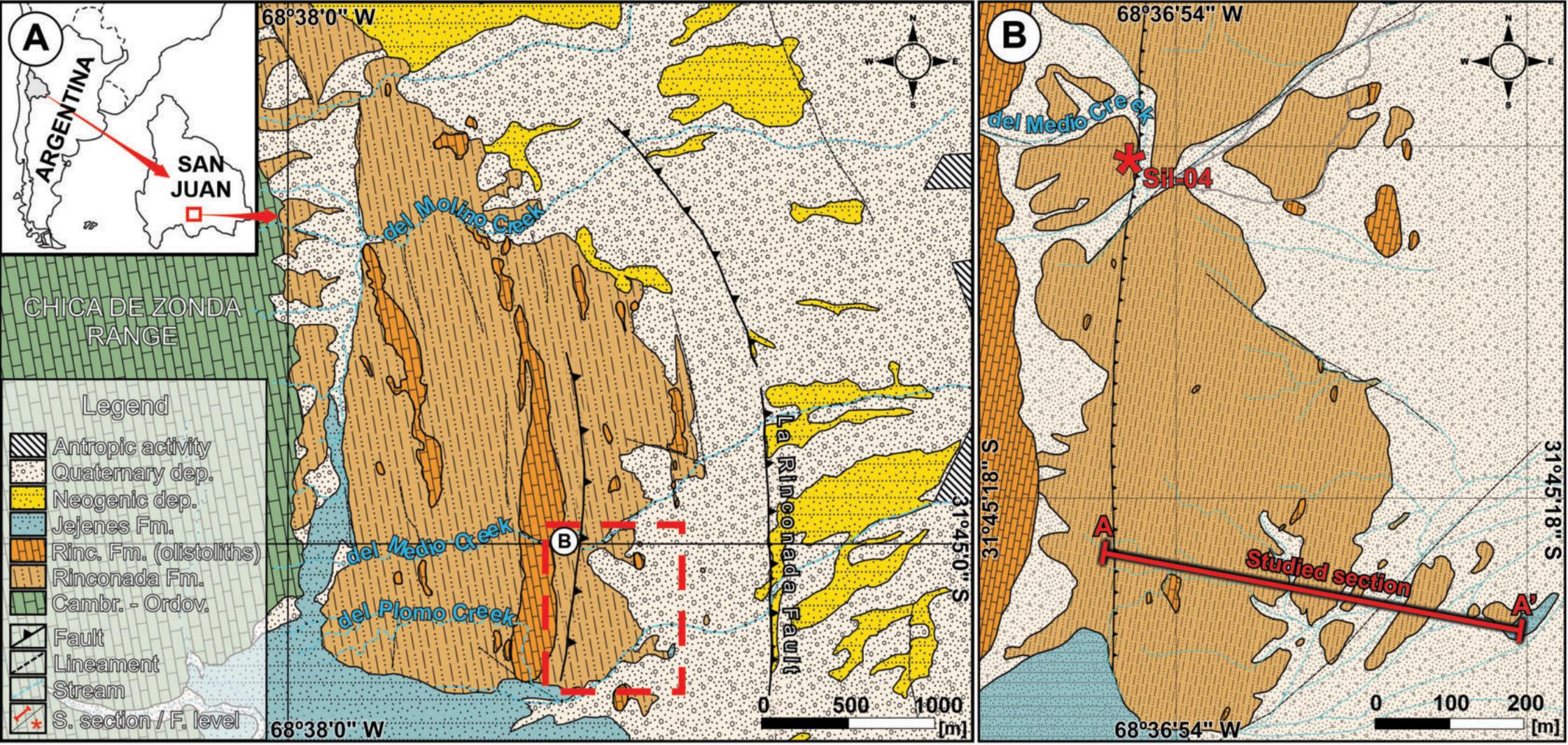
1039 **Figure 4.** Drawings of *Saetograptus rinconadensis* sp. nov., showing mature colonies in
1040 all the cases. PISJ-293/305/306/326/416. Upper Gorstian to lowermost Ludfordian age,
1041 levels RSE-01/06. Scale bar equals 1 mm.

1042 **Figure 5.** Graptolite drawings of the fossiliferous levels of the Rinconada Formation. A,
1043 *Uncinagraptus?* sp., juvenile colony. Lower Gorstian, levels RSW-03—04. PISJ-213;
1044 B-C, *Bohemograptus bohemicus* (Barrande, 1850), juvenile a mature colonies. Lower
1045 Gorstian *L. progenitor* Zone, level RSW-04. PISJ-248/254; D-E, *Lobograptus progenitor*
1046 Urbanek, 1966, fragmentary juvenile and mature tubaria. Lower Gorstian *L. progenitor*
1047 Zone, level RSW-04. PISJ-243/251; F, *Lobograptus* sp. cf. *L. scanicus* (Tullberg, 1883),
1048 Broken distal specimen. Possible upper Gorstian *L. scanicus* Zone, level RSE-06. PISJ-
1049 293; G, cf. *Neodiversograptus*, juvenile specimen. Possible lower Gorstian *N. nilssoni*
1050 Zone, level RSW-03. PISJ-224; H-I, *Prolinograptus packhami* Rickards and Wright,
1051 1997, long fragmentary distal colonies. Lower Gorstian *L. progenitor* Zone, level RSW-
1052 04. PISJ-250/256. Scale equals 1 mm: left for A-G, right for H-I.

1053 **Figure 6.** Stratigraphic column from the southeastern outcrops of the La Rinconada
1054 section. The fossiliferous levels, fossil content, general lithology, and graptolite taxa are
1055 pointed beside the column. Abbreviations: Foss. level, Fossiliferous level.

1056 **Figure 7.** Graptolite biostratigraphic chart of the Ludlow. The grey square points the
1057 time interval studied in the present contribution. Modified from Štorch *et al.* (2024).
1058 Abbreviations: DEVON, DEVONIAN; E. Baltic area, East Baltic area; *Neocu.* and
1059 *Neocucullogr.*, *Neocucullograptus*; *Polonogr.*, *Polonograptus*; *Neodiversogr.*,
1060 *Neodiversograptus*; *Wol.*, *Wolynograptus*; *Pseud.*, *Pseudomonoclimacis*; *Slov.*,
1061 *Slovinograptus*; *Bohem.*, *Bohemograptus*; *Lobo.*, *Lobograptus*.

1062 **Figure 8.** Paleocurrent interpretation from monoserial graptolites in bedding planes. A-
1063 B, Graptolitic sample showing aligned colonies, level RSE-06 (PISJ-345). Yellow
1064 arrows point the flow direction and sense. Scale bars equal 1 cm; C, Paleocurrent rosette
1065 obtained from monoserial graptolite tubaria considering the siculae location, showing a
1066 WSW more probably direction.

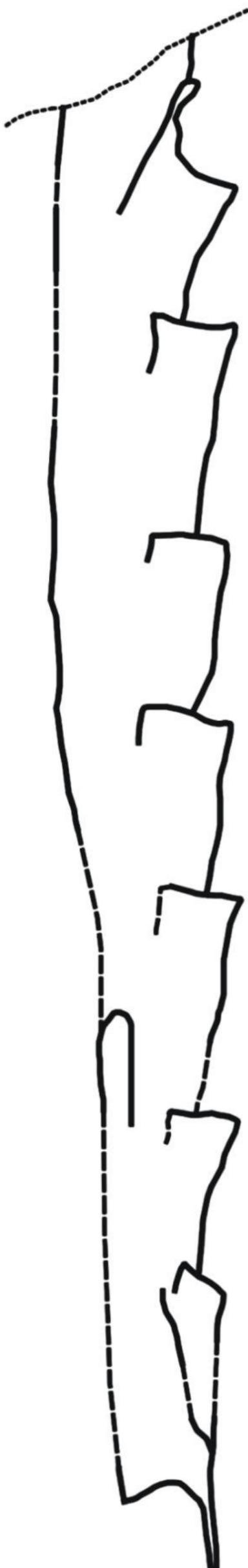




A



B

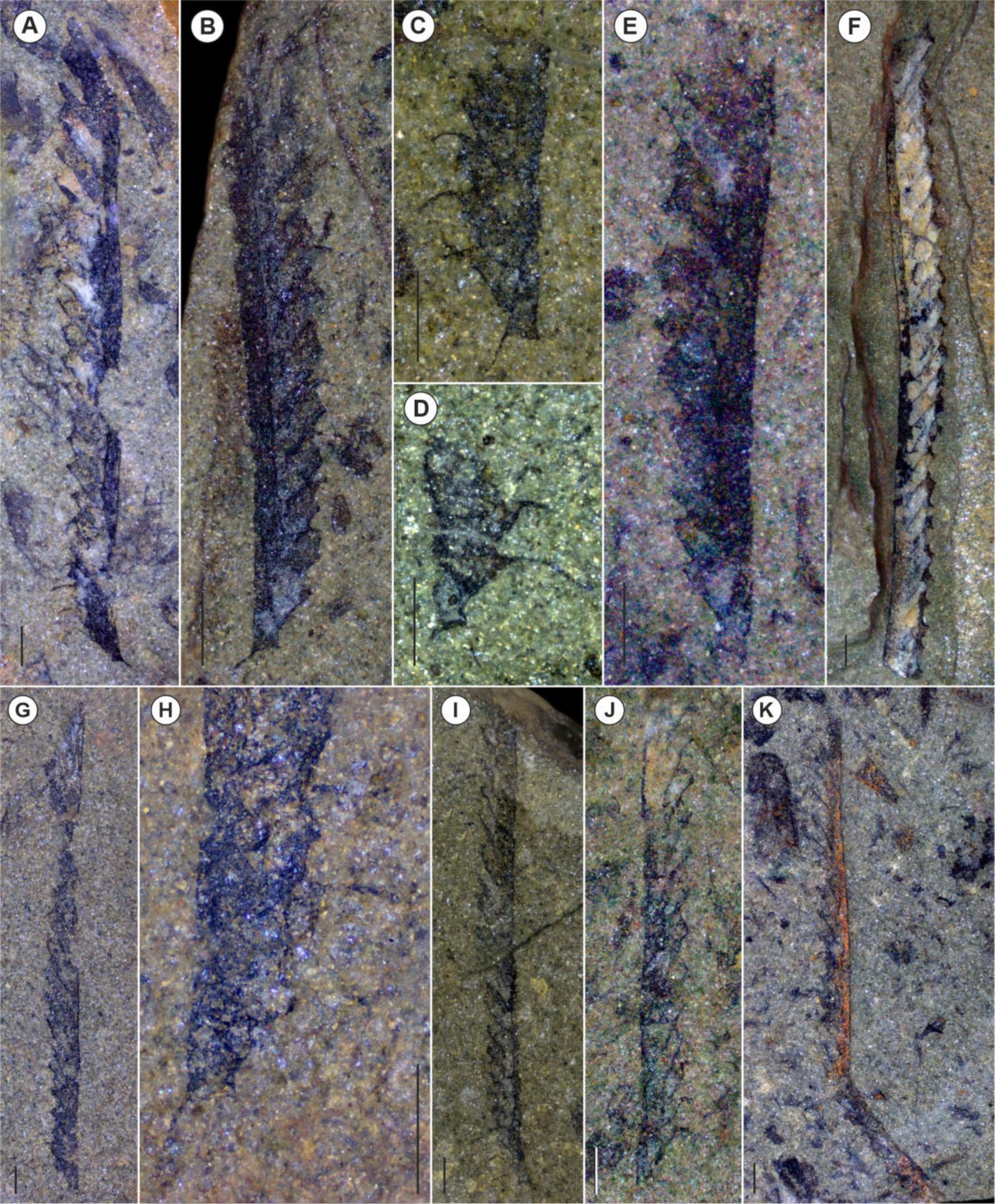


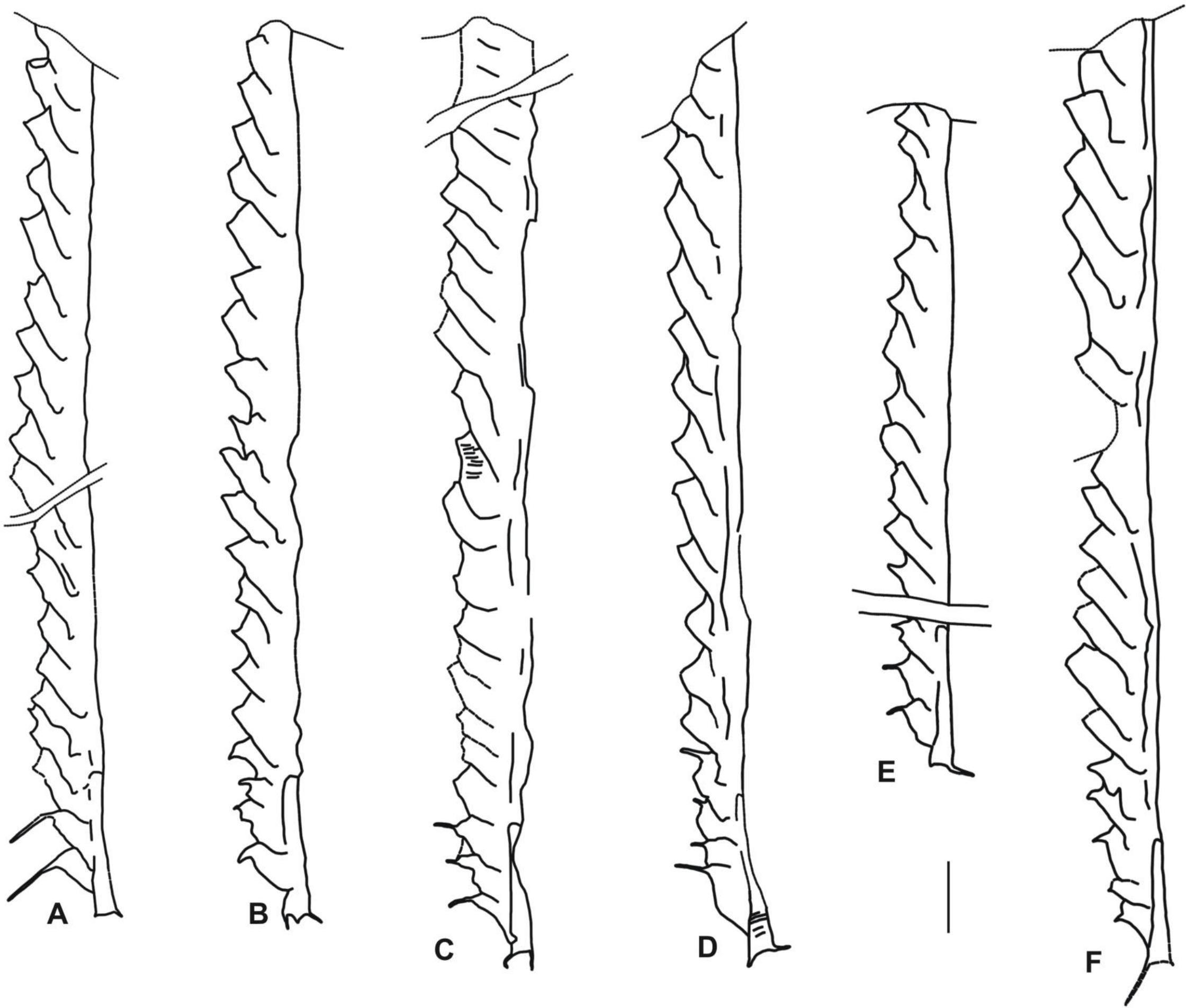
C

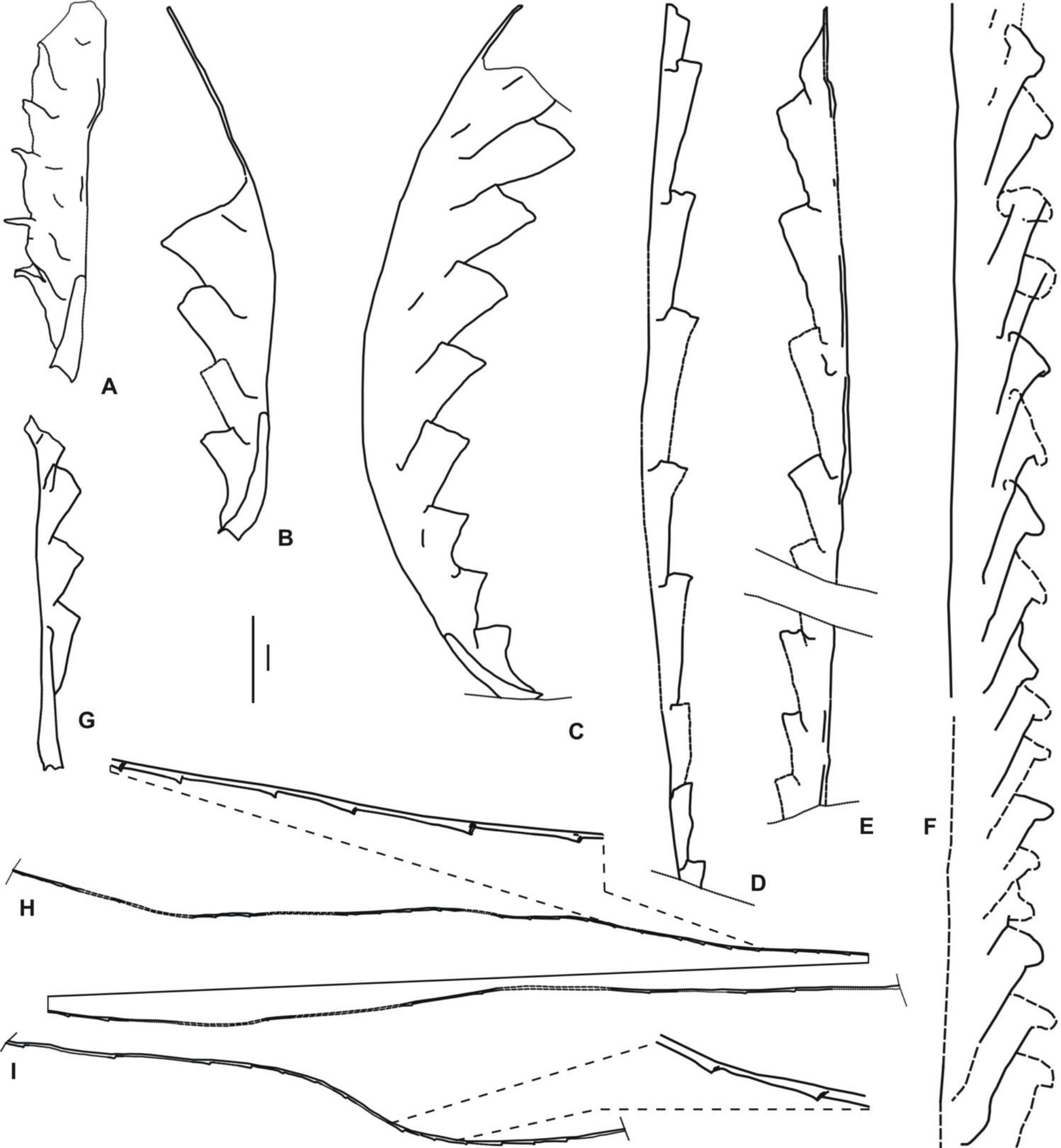


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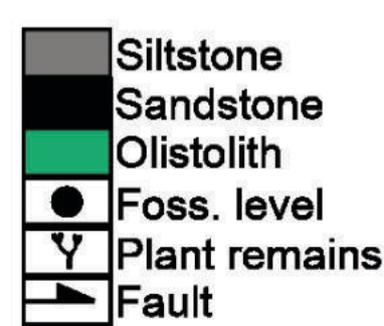
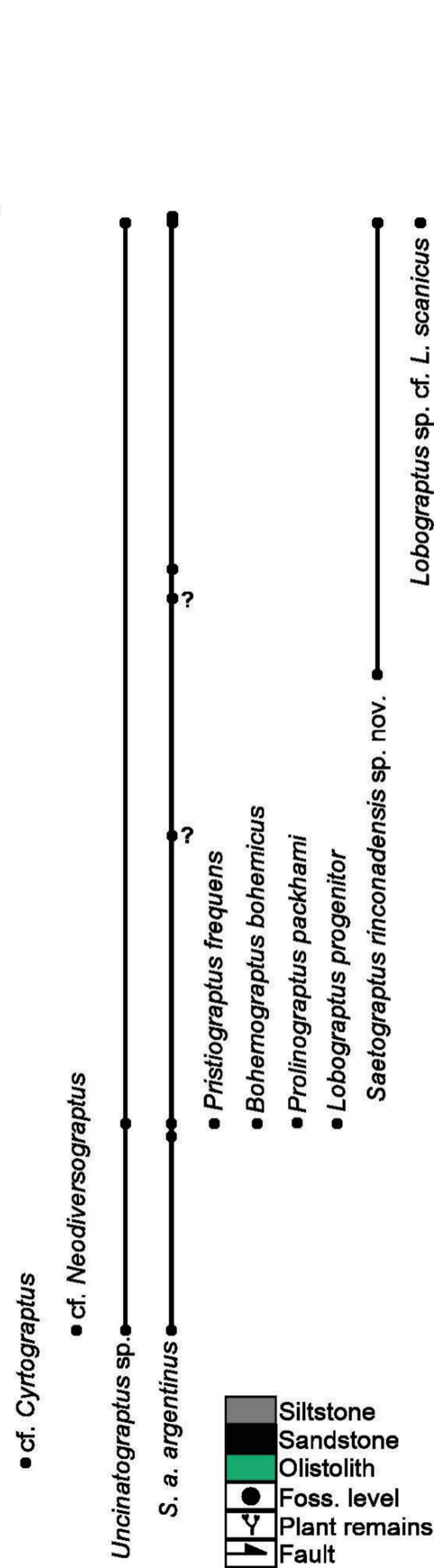
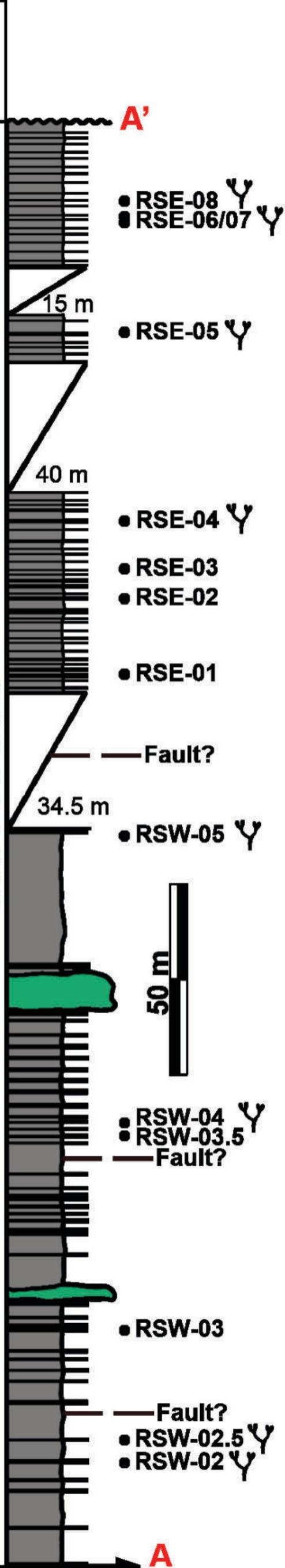








System	Series	Stages	Formation
SILURIAN	LUDLOW	Gorstian	Rinconada
WENL.	?	?	



SYSTEM	SERIES	SERIES	STAGES	GTS 2020 (standard biozonation)	Avalonia (British Isles)	Baltica (E. Baltic area)	European peri-Gondwana	Central Asia microplates	Laurentia (Arctic Canada)	PRECORDILLERA	
										Central (Lopez et al., 2024)	Eastern (this study)
DEVON	Lower	Ludlow	Ludfordian	<i>Formosograptus formosus</i>	?	<i>Wol. spineus</i>	<i>Pristiograptus fragmentalis</i>	<i>Formosograptus formosus</i> - <i>Uncinatograptus spineus</i>	<i>Formosograptus formosus</i>		
						<i>Wol. protospineus</i>					
<i>Wol. acer</i>											
<i>Pseud. latilobus</i> - <i>Slov. balticus</i>	<i>Pseud. latilobus</i> - <i>Slov. balticus</i>										
<i>Neocucullogr. kozlowskii</i>	<i>Neocucullogr. kozlowskii</i>			<i>Polonograptus podoliensis</i>	<i>Bohemograptus tenuis</i> - <i>Bohemograptus praecornutus</i>						
<i>Neocucullogr. podoliensis</i>	<i>Neocucullogr. inexpectatus</i>		<i>Neocucullogr. inexpectatus</i>								
<i>Bohemograptus</i>	<i>Bohemograptus</i>		<i>Bohem. tenuis</i>	<i>Bohemograptus tenuis</i>	<i>Bohemograptus tenuis</i>						
			<i>B. praecornutus</i>								
<i>Saetograptus leintwardinensis</i>	<i>Saetograptus leintwardinensis</i>		<i>Cucullograptus aversus</i>	<i>Saetograptus leintwardinensis</i>	<i>Saetograptus leintwardinensis</i>	<i>S. leintwardinen.</i> - <i>Monograptus ceratus</i>					
<i>Lobograptus scanicus</i>	<i>Saet. incipiens</i>		<i>Saet. incipiens</i>	<i>C. hemiaversus</i>	<i>S. chimaera</i> - <i>Lobo. scanicus</i>	<i>S. chimaera</i> - <i>Lobo. scanicus</i>	<i>Lobograptus scanicus</i>				
		<i>Lobograptus scanicus</i>	<i>L. parascanicus</i>								
			<i>L. invertus</i>								
<i>Neodiversogr. nilssoni</i>	<i>Neodiversogr. nilssoni</i>	<i>Lobograptus progenitor</i>	<i>Lobograptus progenitor</i>	<i>Lobograptus progenitor</i> - <i>Colonograptus colonus</i>	<i>Lobograptus progenitor</i>	≡ <i>Lobograptus progenitor</i>	<i>Lobograptus progenitor</i>				
		<i>Neodiversogr. nilssoni</i>	<i>Neodiversogr. nilssoni</i>			<i>Neodiversogr. nilssoni</i>	≡ <i>Neodiversogr. nilssoni</i>	≡ <i>Neodiversogr. nilssoni</i>			
<i>Colonograptus ludensis</i>	<i>Colonograptus ludensis</i>	<i>Colonograptus ludensis</i>	<i>C. ludensis</i> - <i>C. gerhardi</i>	<i>Colonograptus ludensis</i>	<i>Colonograptus ludensis</i>						
<i>C. praedeubeli</i> - <i>C. deubeli</i>			<i>C. deubeli</i>	<i>C. praedeubeli</i> - <i>C. deubeli</i>	<i>L. sherrardae</i> - <i>C. deubeli</i>	<i>C. praedeubeli</i> - <i>C. deubeli</i>					
			<i>C. praedeubeli</i>								
<i>Gothograptus nassa</i> - <i>Pristiograptus parvus</i>	<i>Gothograptus nassa</i>		<i>Gothograptus nassa</i>	<i>G. nassa</i> - <i>P. frequens</i>	<i>Gothograptus nassa</i> - <i>Pristiograptus dubius</i>	<i>Pristiograptus dubius</i> - <i>Gothograptus nassa</i>					
			<i>Pristiograptus parvus</i>				<i>Pristiograptus parvus</i>				
<i>Cyrtograptus lundgreni</i>	<i>Cyrtograptus lundgreni</i>			<i>M. flemingii</i>	<i>Cyrtograptus lundgreni</i> - <i>Testograptus testis</i>	<i>Cyrtograptus lundgreni</i>					
				<i>Cyrtograptus lundgreni</i>			<i>Cyrtograptus lundgreni</i>				
		Wenlock	Homerian								

