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Early Jurassic (middle Hettangian) marine gastropods from the Pogibshi Formation (Alaska) and their paleobiogeographical significance

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ABSTRACT. A middle Hettangian marine gastropod assemblage is reported from the Kenai Peninsula of south-central Alaska supplying new paleontological evidence of this group in Lower Jurassic rocks of North America. *Pleurotomaria pogibshiensis* sp. nov. is described from the middle Hettangian marine succession informally known as Pogibshi formation, being the first occurrence of the genus in the Kenai Peninsula and the oldest occurrence of the genus in present-day Alaska and North America. One species of the genus *Lithotrochus,* namely *Lithotrochus humboldtii* (von Buch), is also reported for the first time from the Kenai Peninsula. *Lithotrochus* has been considered as endemic to South America for a time range from the early Sinemurian to the late Pliensbachian. The newest occurrence of *Lithotrochus* in rocks of the Pogibshi formation extends the paleobiogeographical and chronostratigraphical distribution of the genus into the present-day Northern Hemisphere. However, the Southern Hemisphere affinities are consistent with the hypothetical interpretations (although supported both by paleobiogeographical and paleomagnetic data) that the Peninsular terrane of south-central Alaska is far-traveled and may have originated at much more southerly paleolatitudes than its present-day position. Two other Early Jurassic caenogastropods typical of the Andean region of South America and of the Tethyan epicontinental seas are described for the first time in the Pogibshi formation, and these are *Pseudomelania* sp. and *Pictavia* sp. The new gastropod assemblage reported here shows close affinities with coeval South American and European gastropod faunas, supplying new evidence to interpret their distribution during the Early Jurassic.

Keywords: Gastropods, Mid-Hettangian, Pogibshi Formation, Alaska, Taxonomy, Paleobiogeography.

RESUMEN. Significado paleogeográfico de la presencia de gastrópodos marinos en rocas del Jurásico Temprano (Hettangiano medio) de la Formación Pogibshi, Alaska. Una nueva asociación de gastrópodos del Hettangiano medio reconocida en la región sur central de Alaska, aporta nueva evidencia paleontólogica sobre la presencia de este grupo en el Jurásico Inferior de América del Norte. *Pleurotomaria pogibshiensis* sp. nov. está presente en depósitos marinos del Hettangiano medio de la unidad informalmente conocida como formación Pogibshi, y es la primera ocurrencia del género en la Península Kenai y el registro más antiguo para Alaska y Norte América. Una especie del género *Lithotrochus, Lithotrochus humboldtii* (von Buch), también se reporta por primera vez en Alaska. *Lithotrochus* ha sido considerado hasta el momento un género endémico de América del Sur para un intervalo de tiempo, que se extiende desde el Sinemuriano temprano al Pliensbachiano tardío. El nuevo registro de *Lithotrochus* en rocas de la Formación Pogibshi permite extender su distribución paleobiogeográfica y cronoestratigráfica en el actual hemisferio Norte. Sin embargo, las afinidades con el hemisferio Sur están en consonancia con la interpretación (apoyada por datos paleobiogeográficos y paleomagnéticos) de que el territorio peninsular del centro-sur de Alaska es alóctono y pudo haberse originado en paleolatitudes mucho más al sur que su posición actual. Otros dos caenogastrópodos típicos de la región andina de América del Sur y de los mares epicontinentales del Tethys, tales como *Pseudomelania* sp. and *Pictavia* sp., se describen por primera vez para el Jurásico Inferior de la formación Pogibshi. La nueva asociación de gastrópodos aquí descrita muestra estrechas afinidades con faunas coetáneas de América del Sur y Europa, lo que otorga nuevas evidencias para interpretar sus patrones de distribución paleobiogeográfica durante el Jurásico temprano.

Palabras clave: Gastrópodos, Hettangiano medio, Formación Pogibshi, Alaska, Taxonomía, Paleobiogeografía.

1. Introduction

Early Jurassic marine gastropods from the Andean region of South America have been the subject of study by several authors (Bayle and Coquand, 1851; Gottsche, 1878, 1925; Behrendsen, 1891, 1922; Möricke, 1894; Burckhardt, 1900, 1902; Jaworski, 1925, 1926a, b; Weaver, 1931; Feruglio, 1934; Piatnitzky, 1936, 1946; Wahnish, 1942; Gründel, 2001; Damborenea and Ferrari, 2008; Ferrari, 2009, 2011, 2012, 2013, 2014, 2015a, b, 2017; Ferrari *et al.,* 2014, 2015). Ferrari (2009, 2011, 2012, 2013, 2014, 2015a, b, 2017) and Ferrari *et al*. (2014, 2015) have recently supplied new and updated taxonomic information of this group in the Argentinean Jurassic describing several species from the Sinemurian-Toarcian marine deposits of the Neuquén and Chubut basins. Ferrari (2009, 2011, 2014, 2015a, b) also provided qualitative and quantitative paleobiogeographical schemes of gastropod fauna in Argentina in order to interpret the distributional patterns of Mesozoic benthic gastropods along the Andean region of South America.

Jurassic gastropods from North America, however, have received less attention in recent years than their counterparts in South America, and specially the Early Jurassic ones. Sohl (1965) contributed to the taxonomic study of these faunas in North America describing representatives of some families and genera from the Middle Jurassic (Bajocian-Bathonian) of Utah. The author also pointed out that the Alaskan Jurassic sequences may contain a greater diversity of gastropods than other areas in North America, although the difficulty of collecting samples from Alaska limited the basis for evaluating their abundance. Sohl (1965) also argued that the greatest diversity of gastropods in Alaska occurs in the Middle Jurassic (Aalenian-Bathonian) of the Kialagvik Formation and mentioned some gastropod genera (*Pleurotomaria*, *Ambercyclus*, *Oonia*, *Cloughtonia* and *Procerithium*) from the Lower Jurassic of the Talkeenta Formation (north of Anchorage); even though few reports have attempted to provide updated taxonomic information and descriptions regarding gastropods from the Early Jurassic of south central Alaska.

Recent studies (Ferrari *et al.,* 2017; Hodges *et al.,* 2018) have supplied new information about Early Jurassic gastropods from the Kenai Peninsula near Seldovia, but without giving detailed taxonomic descriptions. Most of the prior studies have been focused on Paleozoic and Late Triassic gastropod groups (and also on other Jurassic invertebrates such as cephalopods, bivalves, belemnites and brachiopods) (Imlay 1953, 1981, 1982; Lazar *et al.,* 2009, 2015; Sandy and Blodgett, 2009; Dzyuba *et al.,* 2018).

New findings of a middle Hettangian marine gastropod association from the Peninsular terrane of south-central Alaska (Fig. 1) provide new paleontological evidence and supply updated taxonomic information of this group in the Early Jurassic of North America. This new material of middle Hettangian gastropods was collected on July 2, 2016 in the July member of the informal unit known as Pogibshi formation from locality JL198 (Fig. 2). GPS coordinates for the locality are 59.43739° N and 151.82033° W. The fossil bed of this locality extends laterally along the sea cliff for several hundred meters and occurs again around the point at JL199 in a faulted area to the west. This locality is topographically situated in the NW1/4, SW1/4, SW1/4 of section 34, T. 8 S., R. 15 W., Seldovia (B-5) quadrangle map (scale 1:63,360), 1951 edition (minor revisions 1961).

A new *Pleurotomaria* species, *Pleurotomaria pogibshiensis* sp. nov., is described here. One species of the genus *Lithotrochus* is also reported for the first time from the same location and unit/bed(s), and this is *Lithotrochus humboldtii* (von Buch). *Lithotrochus* has been considered by Damborenea and Ferrari (2008) as endemic to South America for a time range from the early Sinemurian to the late Pliensbachian. The new occurrence of *Lithotrochus* extends the paleobiogeographical and chronostratigraphical distribution of the genus into the Northern Hemisphere. Finally, two other Early Jurassic caenogastopods typical of the Andean region of South America and of the Tethyan epicontinental seas are described for the first time from the Pogibshi formation in the Kenai Peninsula. These are *Pseudomelania* sp. and *Pictavia* sp.

The new gastropod assemblage reported here from the middle Hettangian marine deposits of the Pogibshi formation shows close affinities with South American and European gastropod faunas supplying new evidence to interpret their paleobiogeographical distribution during the Early Jurassic.

2. Geologic setting

The outboard boundary of the Peninsular terrane of southern Alaska is demarked by the Border Range

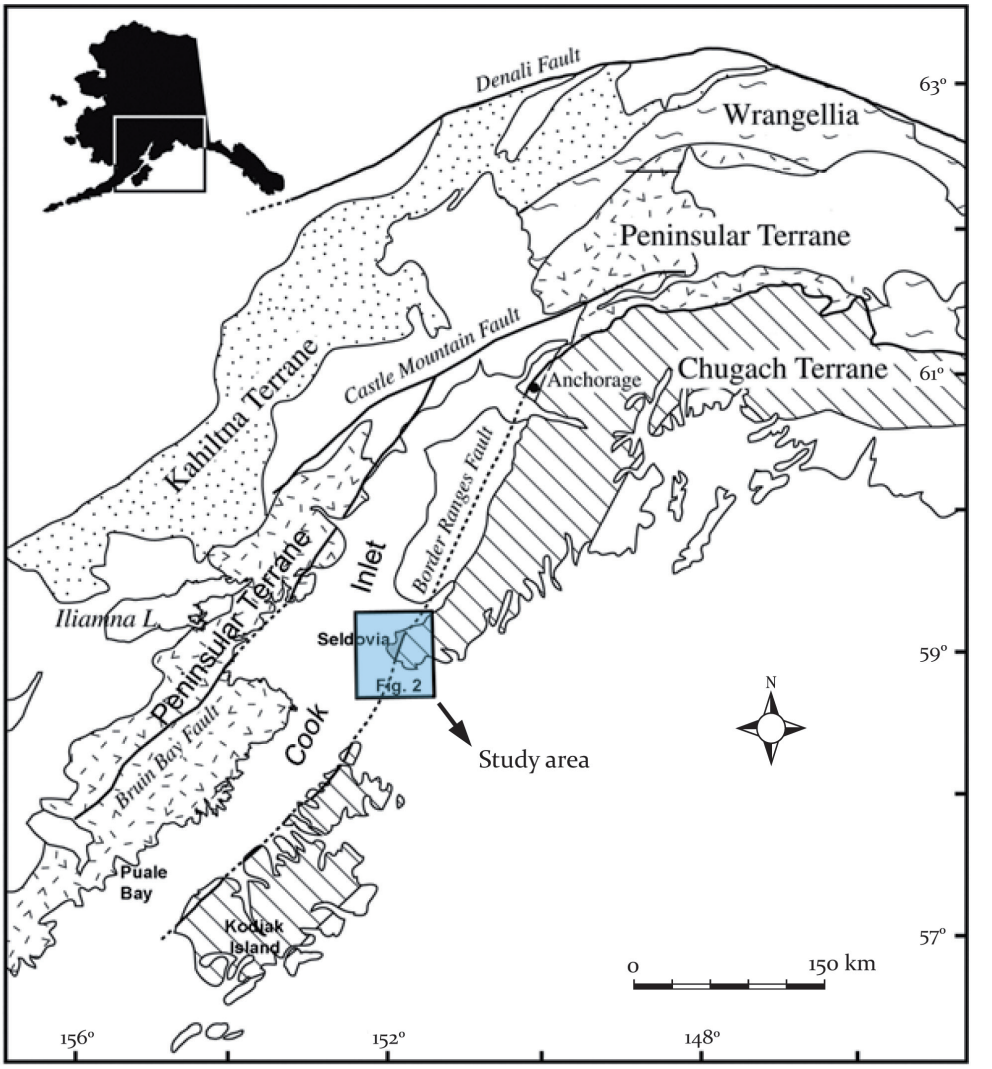

FIG. 1. Terrane map of south-central Alaska showing in gray the sliver of the Peninsular terrane where the Pogibshi formation crops out near Seldovia on the southern Kenai Peninsula (modified from Rioux *et al.,* 2007; Ferrari *et al.,* 2017 and Hodges *et al.,* 2018). See figure 2 for a detailed geologic map of the Seldovia area.

fault system that extends from southwest of Afognak Island to the northeast along the western margin of the Chugach Mountains (Fig. 1). The northeastern limit of the Peninsular terrane occurs in the southern Talkeetna Mountains. Within the Peninsular terrane are the elements of volcanic island arc including prearc rocks, the mainly sedimentary rock sequences of the Upper Triassic Kamishak Formation and the volcanic arc and postarc sedimentary sequences of the Lower Jurassic Talkeetna Formation (Wilson *et al.,* 2012). The boundary between the Kamishak and Talkeetna Formations had been assumed to be the Triassic-Jurassic but high precision geochronology data indicates the Kamishak continues into the early Hettangian (Pálfy *et al.,* 1999; Barbacka *et al.,* 2006). On the Kenai Peninsula only a sliver of the Peninsular terrane outcrops on the southwestern side of Kachemak Bay southwest of Seldovia (Fig. 2). The sea cliffs in the area contain a fairly well-exposed continuous sequence of Late Triassic to Early Jurassic age deposits (Martin *et al.,* 1915; Martin, 1926; Kelley 1980, 1984). The study area

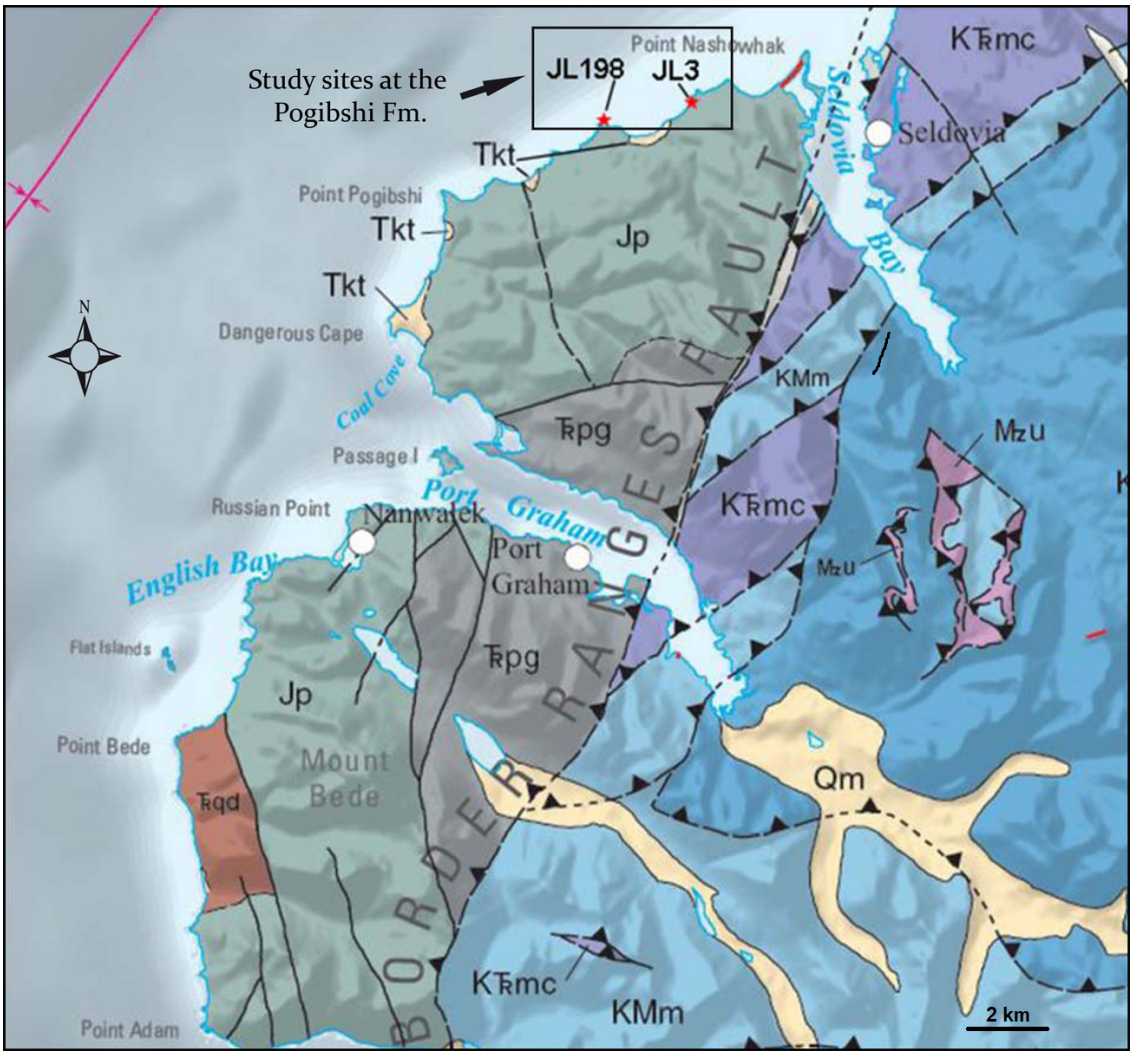

FIG. 2. Geologic map of the Pogibshi formation (Jp) west and southwest of Seldovia Bay. Localities JL198 (= JL199) and JL3 are shown by red stars (modified from Ferrari *et al*., 2017 and Wilson *et al.*, 2012).

is located in the sea cliffs southwest of Seldovia and has been informally referred to as the Pogibshi formation to distinguish it from the Lower Jurassic Talkeetna Formation. Although the Pogibshi unit has been referred to as a formation it has not been formally named and shows many similarities to the Talkeetna Formation to which some authors have assigned it (Magoon *et al.,* 1976; Bradley *et al.,* 1999). Both the Pogibshi and Talkeetna are of Early Jurassic age and compose thousands of meters of volcanic, volcaniclastic and both marine and non-marine strata (Martin, 1926; Detterman and Reed, 1980; Draut *et al.,* 2006). The informally defined Pogibshi formation of Kelley (1980) exposed on the east side of Cook Inlet consists of volcaniclastic rocks interbedded with small amounts of limestone, coal, and tuffaceous argillite. Kelley (1980) divided the unit into three members on the basis of rock type, modal composition, and depositional texture (Fig. 3). The July member consists of dacitic pyroclastic rocks, tuffaceous sandstone, granule conglomerate, and mudstone (Ferrari *et al.,* 2017; Hodges *et al.,* 2018).

Stanton and Martin (1905), Moffitt (1906), Martin (1915, 1916, 1926), Imlay (1981) and Blodgett (2009) reported a diverse Lower Jurassic fauna along the

coast southwest of Seldovia. Fossils noted in the above cited publications included scleractinian corals, numerous bivalves, gastropods, and ammonites. Blodgett (2009) briefly visited a section of early Sinemurian age, exposed about 3 km west of Seldovia, and found numerous pectinacean bivalves of the genus *Weyla*, gastropods, and scleractinian corals.

The bivalve *Weyla*, an Early Jurassic index fossil, is found primarily along the western coast of North and South America. At least two species of *Weyla* are present in the July member, one species being middle Hettangian in age and the other being early Sinemurian (Blodgett, personal observation). Early Jurassic ammonites from these same rocks were discussed and, in part, illustrated in Imlay (1981), who recognized both Sinemurian and Hettangian fossil assemblages. The oldest fossils identified within the Pogibshi formation are early Hettangian ammonites (placed here in the mid-Hettangian) found at the base of the July member (Imlay, 1981), suggesting the strong possibility that the lowest member, the Dangerous member may be entirely or in part of Late Triassic age (Ferrari *et al.,* 2017; Hodges *et al.,* 2018). The gastropod genera reported here occur at the JL198 site, in the lower part of the July member (Fig. 3), and are considered here as of mid-Hettangian age (see below).

3. Age of the gastropod-bearing strata reported here

Two rock samples from sea cliff exposures of the lower July member were collected for detrital zircon extraction. The upper sample JL3 was collected in a light green-gray tuffaceous volcanic sandstones

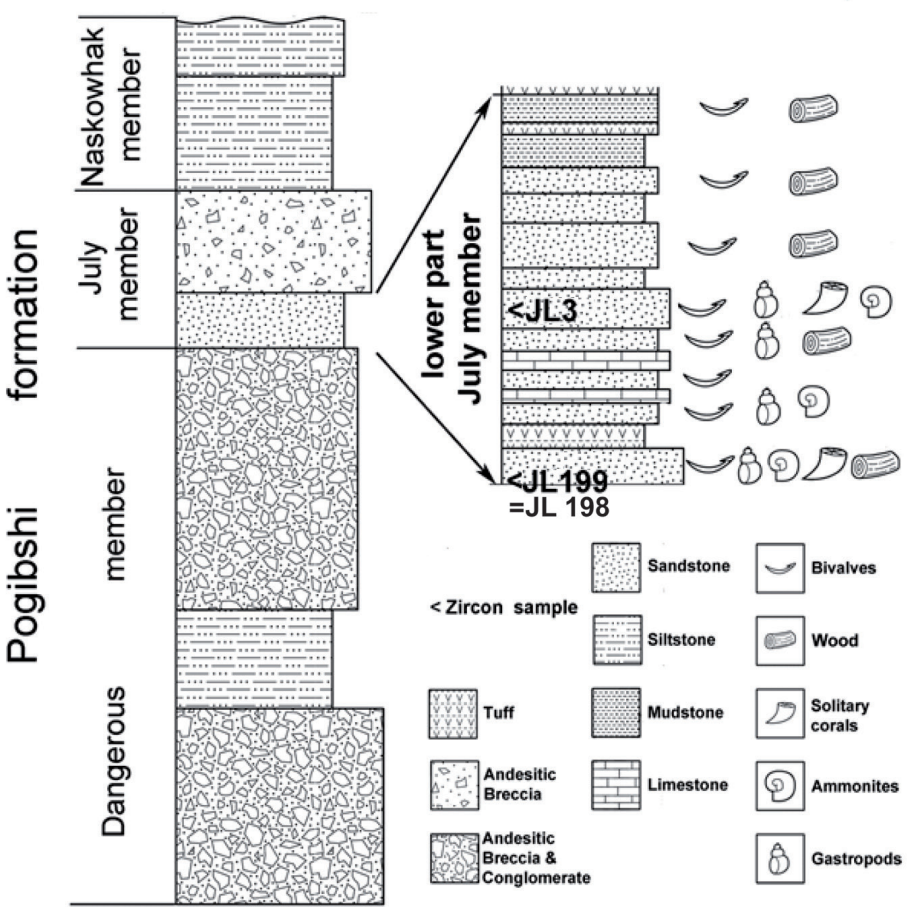

FIG. 3. Stratigraphic composite section of the Pogibshi formation. The position of localities JL198, JL199 and JL3 in the lower part of the July member are indicated (modified from Ferrari *et al.,* 2017 and Hodges *et al.,* 2018).

interbedded with fossiliferous limy mudstones that contain bivalves, gastropods, ammonites and corals (Fig. 3). This site is well-known for fossiliferous beds and was labeled as 76Jk34 by Kelley (1980) and 31650 by Imlay (1981). The lower sample was collected from Kelley locality 76Jk41 which we designate JL199 at the base of the July member in a tuffaceous volcanic granular red-to-brown conglomerate interbedded with mudstones containing bivalves and occasional corals and ammonites. Other occurrences of the fossil strata at JL199 occur to the east across a fault at JL198 (Fig. 3) and in float material still further east at JL197. The gastropod yielding rocks at JL198 site are considered here as coeval to JL 199 strata and, thus, mid-Hettangian in age. The ages of JL3 and JL199 (=JL198) were confirmed also by comparison to ammonite ages determined by Imlay (1981). Beds near the lower locality (JL199) contain only a single ammonite species identified by Imlay as *Psiloceras* (*Franziceras*) cf. *P*. (*F*.) *ruidum* (Buckman), and were assigned an early Hettangian age. Subsequent work by Taylor *et al.* (2001) suggests that this ammonite interval should instead be considered as the *Coronoides* zone which is approximately mid-Hettangian (see Taylor *et al.,* 2001). In the beds near JL3 Imlay had previously identified two ammonites, *Paracaloceras rursicostatum* Frebold and *Coroniceras* (*Paracoroniceras*) sp. which indicated an early Sinemurian age. The agreement between the U-Pb (200.5±2.5±1.8 Ma) ages and ammonite zonation ages strongly confirms the Hettangian age of the *Weyla,* corals, and the gastropod fauna described here.

4. Materials and methods

The gastropod material described here was collected by Montana Hodges, Christopher Hodges and Robert Blodgett in 2016 during several fieldtrips to the southern Kenai Peninsula near Seldovia, in rocks of the Pogibshi formation, south-central Alaska. Stratigraphical sections for localities yielding gastropods in the Pogibshi formation were described by Ferrari *et al*. (2017) and Hodges *et al*. (2018).

The gastropod material is stored in the IPGP (Instituto Patagónico de Geología y Paleontología, CONICET-CENPAT, Puerto Madryn) invertebrate collection (Colección Paleontología de Invertebrados e Icnología, CNP-PIIc) and was prepared by technical staff (Tec. Santiago Bessone) at IPGP laboratory. The specimens were subsequently coated with ammonium chloride to enhance sculpture details for photography. Photographs were taken using a digital camera at IPGP. The systematic classification of the gastropod taxa follows Bouchet *et al*. (2017).

Institutional abbreviations: IPGP (Instituto Patagónico de Geología y Paleontología), CCT CONICET-CENPAT (Centro Científico Tecnológico, Consejo Nacional de Investigaciones Científicas y Técnicas, Centro Nacional Patagónico).

5. Systematic paleontology

Subclass Vetigastropoda Salvini-Pläwen, 1980
Order Trochida (Cox and Knight, 1960a)
Superfamily Trochoidea Rafinesque, 1815
Family Trochidae Rafinesque, 1815
Genus *Lithotrochus* Conrad, 1855

Type species. *Turritella andii* d'Orbigny, 1842 (*Pleurotomaria humboldtii* von Buch, 1839).
Occurrence. Early Jurassic (middle Hettangian-late Pliensbachian); Perú, Chile, Argentina, North America.
Remarks. The genus *Lithotrochus* has been considered as endemic to South America (see Damborenea and Ferrari, 2008; Ferrari and Bessone, 2015) with its southernmost occurrence in the southwestern region of the Chubut Province, Patagonia Argentina (Ferrari, 2013; Ferrari and Bessone, 2015). The *Lithotrochus* material reported here provides the first evidence of the genus in the Early Jurassic (mid-Hettangian) strata of North America, extending its paleobiogeographical and chronostratigraphical distribution into the present day Northern Hemisphere.

Lithotrochus humboldtii (von Buch, 1839) (Fig. 4A-Y)

1839 *Pleurotomaria humboldtii* von Buch: 9, pl. 2, fig. 26.
non 1942 *Lithotrochus humboldti* (von Buch); Wahnish: 60, pl. 2, fig. 4.
2008 *Lithotrochus humboldtii* (von Buch); Damborenea and Ferrari: 202, fig. 4.1-4.21, 7.1 (with complete synonymy).
2013 *Lithotrochus humboldtii* (von Buch); Ferrari: 581, fig. 2A.
2015 *Lithotrochus humboldtii* (von Buch); Ferrari and Bessone, p. 353, fig. 3E-H.

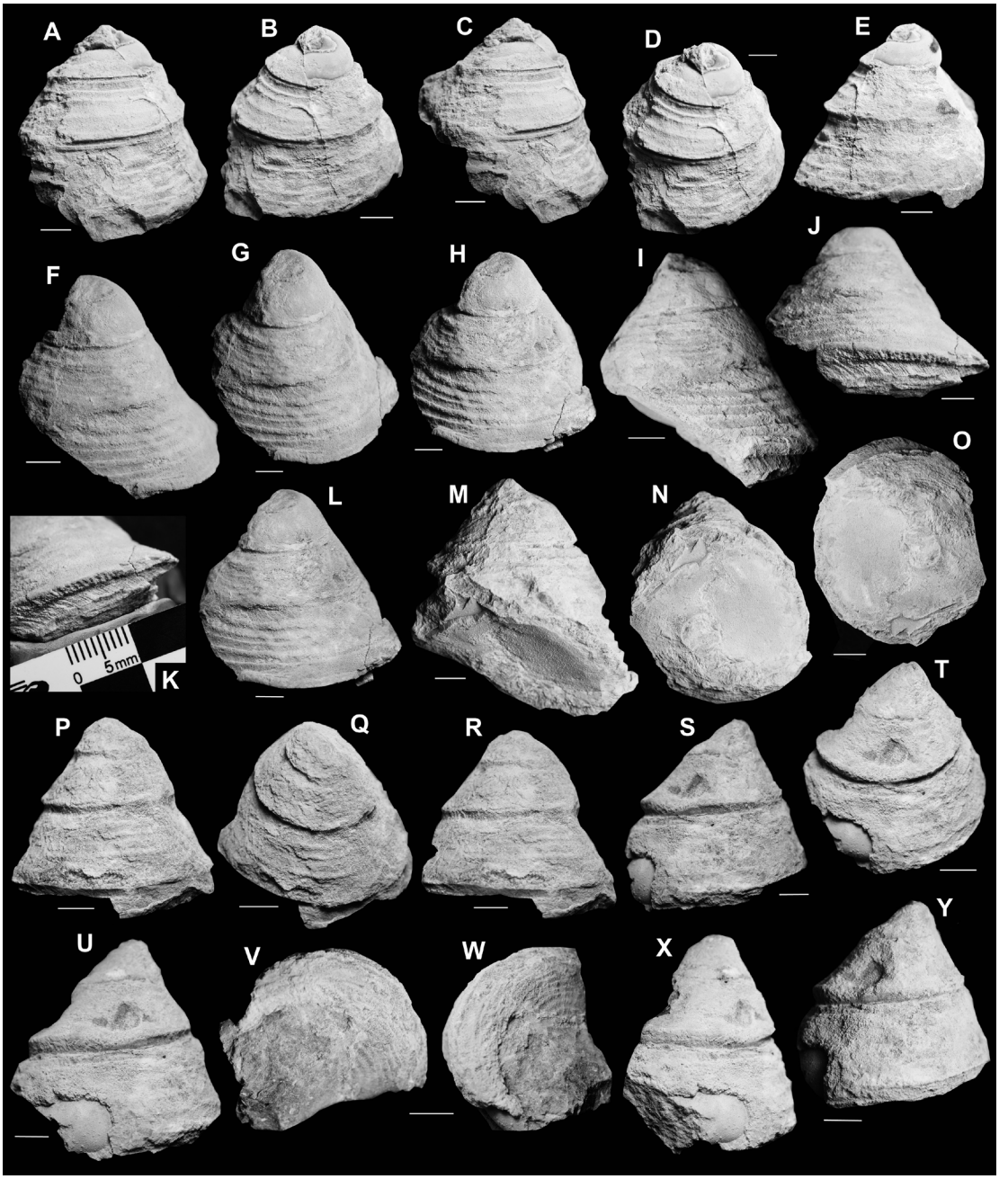

FIG. 4. **A-Y.** *Lithotrochus humboldtii* (von Buch, 1839). **A-E.** CNP-PIIc 0435, lateral views; **F-O.** CNP-PIIc 0434; **F-I, L.** Lateral views; **J-K.** Ornamentation detail of the outer face of last whorl; **M-O.** Basal and apertural views; **P-R.** CNP-PIIc 0436; **P, R.** Lateral views; **Q.** Apical and lateral view; **S-Y.** CNP-PIIc 0437; **S, U, X, Y.** Lateral views; **T.** Lateral and apical views; **V-W.** basal view and ornamentation detail. Scale bars=5 mm.

Material. CNP-PIIc 0434, CNP-PIIc 0435, CNP-PIIc 0436, CNP-PIIc 0437, CNP-PIIc 0438; five replaced teleoconchs, well preserved and complete specimens.

Description. Dextral, anomphalous, conical shell, with trochiform shape on juvenile whorls to cyrtoconoid shape on mature whorls. In the best preserved

specimens the teleoconch comprises up to 4 whorls. A strong peripheral carina and imbricate whorls are developed on adult growth stages. Suture impressed in a spiral furrow. The shell surface is ornamented by regularly spaced spiral cords intercepted by fine prosocline growth lines. Growth lines strongly prosocline on the outer face of last whorl (Fig. 4 J-K). The base is flattened with spiral ribs intercepted by weak prosocline growth lines. The aperture is holostomatous and subcircular.

Dimensions (mm). CNP-PIIc 0434: height, 40.86*; width, 38.98. CNP-PIIc 0435: height: 36.16*; width, 34.02. CNP-PIIc 0436: height, 25.30*; width, 30.42. CNP-PIIc 0437: height, 30.65*; width, 27.31*. * = measurements taken from fragmentary specimens.

Remarks. According to the emended diagnosis proposed by Damborenea and Ferrari (2008, p. 201), the material described here certainly belongs to *Lithotrochus humboldtii* (von Buch). This is the first record of the species in the Early Jurassic (Hettangian) marine sequences of North America (Alaska), extending its paleobiogeographical and chronostratigraphical distribution into the Northern Hemisphere. Most specimens were found in well-preserved condition, enabling morphological characterization of the species. For comparisons with other representatives of *Lithotrochus humboldtii* from the Andean region of South America and with other similar species see Damborenea and Ferrari (2008, p. 204), Ferrari (2013, p. 581), Ferrari (2015a, p. 922), Ferrari and Bessone (2015, p. 353).

Occurrence. Perú, Chile, Argentina (form the early Sinemurian *Agassiceras* Zone to the late Pliensbachian *Fanninoceras* Zone); Site JL198, middle Hettangian beds of July member, the Pogibshi formation (Coronoides zone), Seldovia, Alaska (Peninsular terrane, south-central Alaska)

Order Pleurotomariida (Cox and Knight, 1960b)
Superfamily Pleurotomarioidea Swainson, 1840
Family Pleurotomariidae Swainson, 1840
Genus *Pleurotomaria* Defrance, 1826

Type species. *Trochus anglicus* Sowerby, 1818; Early Jurassic (late Pliensbachian), south-western England, subsequent designation.

Remarks. The systematic position of the type genus *Pleurotomaria* was recently revised by Monari and Gatto (2013), who proposed a reevaluation of the genus based on seven *Pleurotomaria* species from the Middle Jurassic (lower Bajocian) of Luxembourg. They gave a detailed morphological characterization of the genus (see Monari and Gatto, 2013, p. 753). The material described here from the middle Hettangian of North America closely fits their emended diagnosis. The earliest and certain *Pleurotomaria* species in North America is reported here from middle Hettangian strata of the lower part of the July member of the informally named Pogibshi formation, confirming its paleobiogeographical distibution during the Early Jurassic in the northern Paleo-Pacific region.

***Pleurotomaria pogibshiensis* sp. nov.**
(Fig. 5 A-N)

2017 *Pleurotomaria* sp.; Ferrari *et al*., p. 13, fig. 7.

Derivation of name. Referred to the first occurrence of the genus *Pleurotomaria* in the middle Hettangian of the Pogibshi formation (south-central Alaska), where the material was found.

Type material. Holotype, CNP-PIIc 0439; Paratype, CNP-PIIc 0440; two well preserved and replaced teleoconchs.

Additional material: CNP-PIIc 6000; one incomplete and replaced teleoconch.

Type locality. Site JL198, middle Hettangian beds of July member, Pogibshi Formation (Coronoides zone), Seldovia, Alaska (Peninsular terrane, south-central Alaska).

Diagnosis. Trochiform and gradate shell; wide ramp; peripheral angulation with a spiral swelling of 20-22 nodes; spiral cords on the shell surface intercepted by prosocline growth lines; broad selenizone at mid-whorl with a median spiral cord; base with spiral cords, and opisthocyrt and prosocyrt growth lines; small, rounded nodes on base; umbilicus closed; aperture subcircular to subtrapezoidal.

Description. Dextral, trochiform, medium-sized and moderately low-spired shell. The protoconch is not preserved. The adult shell is gradate and consists of 5 angulate whorls. The whorl ramp is moderately wide, flattened to slightly concave and horizontal, with a maximum width of 3.92 mm on last whorl. The outer face is sub-vertical on both juvenile and mature teleoconch whorls. The suture is weakly impressed. The peripheral angulation is delimited by a spiral swelling made up of about 20-22 rounded nodes visible on spire whorls. The shell surface is ornamented by regularly spaced spiral cords.

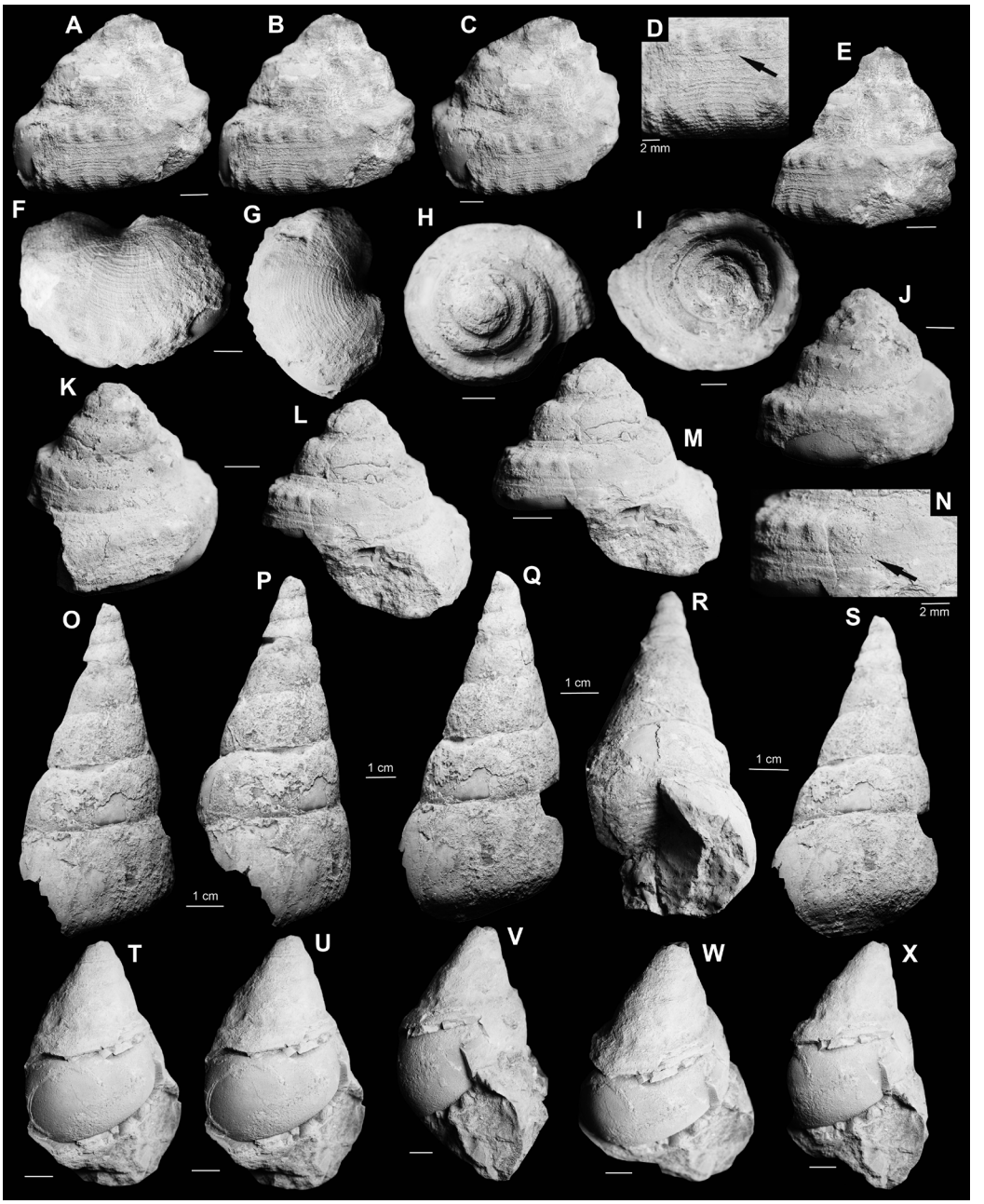

FIG. 5. **A-N.** *Pleurotomaria pogibshiensis* sp. nov.; **A-G.** CNP-PIIc 0440, paratype; **A, B, C, E.** Lateral views; **D.** Ornamentation detail on the outer face of last whorl and selenizone (black arrow); **F-G.** Basal view and ornamentation detail; **H-N.** CNP-PIIc 0439, holotype; **H-I.** Apical views; **J-K.** Lateral views; **L-M.** Lateral and apertural views; **N.** Detail of the outer face of last whorl and selenizone (black arrow); **O-S.** *Pseudomelania* sp., CNP-PIIc 0441; **O, P, Q, S.** Lateral views; **R.** Lateral, basal and apertural views; **T-X.** *Pictavia* sp., CNP-PIIc 0442, lateral and apertural views. Scale bars=5 mm, except where otherwise indicated.

The spiral cords are crossed by prosocline to prosocyrt growth lines, giving the ornament a reticulate appearance. The selenizone is broad and developed at mid whorl of the outer face; it is flat and bordered by two sharp spiral cords; a median spiral cord on the selenizone is also visible. Lunulae are

imperceptible on the selenizone. The base is flat to slightly convex and ornamented by fine and regularly spaced spiral cords which are intersected by opisthocyrt to feebly prosocyrt growth lines. The crossing points of the spiral and collabral elements form small and rounded nodes on the base. The umbilicus is closed or covered by a reflection of the callus of the inner lip. The aperture is subcircular to subtrapezoidal.

Dimensions (mm). Holotype, CNP-PIIc 0440. Height, 38.04; height of the peristome, 11.84*; height of last whorl, 23.88*; width, 37.23; width of the peristome, 21.59.

Paratype, CNP-PIIc 0439. Height, 26.51; height of the peristome, 12.44; height of last whorl, 18.45; width, 30.22; width of the peristome, 14.49*. CNP-PIIc 6000. Height, 14.54*; width, 21.46*. *=measurements taken from fragmentary specimens.

Remarks. According to the updated diagnosis of Monari and Gatto (2013), the specimens here described fit the characterization of *Pleurotomaria*. The type species *Pleurotomaria anglica* (Sowerby, 1818), from the upper Pliensbachian of England, differs from *Pleurotomaria pogibshiensis* sp. nov. in having more acute spiral cords on the shell surface, more conspicuous and rounded nodes, and a slightly more gradate shell outline (Monari and Gatto, 2013, p. 756, fig. 3). Two other early Hettangian species are *Pleurotomaria cognata* Chapuis and Dewalque, 1853, from Belgium and Luxembourg, and *Pleurotomaria* sp. from Burmerange (south-eastern Luxembourg) (Monari *et al*., 2011). *Pleurotomaria cognata* is very similar in shell size and shape to the new species described here, although it differs in having a wide, open and funnel shaped umbilicus, a stronger spiral cord on the outer face of the shell within the selenizone, and more conspicuous and rounded nodes (Monari *et al.,* 2011, p. 365, fig. 11B, C). *Pleurotomaria* sp. (Monari *et al.,* 2011, p. 366, fig. 11D) has a more coeloconical shell and a subrounded angulation of the whorls. *Pleurotomaria wanderbachi* Terquem, 1855, from the upper Hettangian of Luxemburg, has a more gradate shell outline than the species described here, has the selenizone running on or slightly above the middle of the outer face, has bulge-shaped adult whorls, and collabral ornament with more densely and regularly spaced threads (Monari *et al.,* 2011, p. 262, fig. 9). *Pleurotomaria hettangiensis* Terquem, 1855, from the upper Hettangian of Luxemburg, differs from *P. pogibshiensis* sp. nov. in having a less gradate shell and a much narrower whorl ramp, the selenizone running at or slightly below the middle of the outer face and delimited by a sharp spiral line, stronger spiral and nodular elements, and a narrow umbilicus (Monari *et al.,* 2011, p. 263, fig. 10A-D). *Pleurotomaria hennocquii* Terquem, 1855, also from the upper Hettangian of Luxemburg, differs from *P. pogibshiensis* sp. nov. in having a more cyrtoconical and less gradate shell, less conspicuos and smaller nodes on the peripheral angulation, and the selenizone on adult whorls running below mid whorl (Monari *et al.,* 2011, p. 365, fig. 11A). *Pleurotomaria*? sp. (in Sohl, 1965, p. 15, pl. 1, figs. 9, 13), from the Middle Jurassic (Bathonian) of Utah, differs from *P. pogibshiensis* sp. nov. in being broadly umbilicate with no distinct selenizone, in lacking nodes on the whorl ramp, and in having only fine spiral lirae visible on the base.

The earliest Jurassic *Pleurotomaria* species described so far from the western European epicontinental seas are from the early and late Hettangian (see above). The new pleurotomarid species reported here from the middle Hettangian marine deposits of Seldovia is the earliest report of a *Pleurotomaria* species in North America.

Four other poorly preserved *Pleurotomaria* species have been described from the Middle/ Late Jurassic (Bathonian-Portladian) of North America (see Sohl, 1965). For the most part they are based on poor material, but representatives are to be found from west Texas to Alaska in beds of Bathonian to Portlandian age (Sohl, 1965). These are: *P. skidegatensis* Whiteaves (Yakoun Formation, Vancouver Island, B.C.), *P. circumtrunca* Cragin (Malone Formation, Texas), *Pleurotomaria*? *borealis* Warren (Fernie shale, Canada) and *Pleurotomaria* cf. *P. rozete* (de Loriol) (Portlandian, East Greenland), however, these species do not retain sufficient character for certain assignment.

Haas (1953) reported a doubtful representative of *Pleurotomaria* from the Upper Triassic of Perú as *Pleurotomaria*? aff. *haueri* Hörnes (in Haas, 1953; p. 30, pl. 2 fig. 1-8); however, following Haas's characterization of the species, it does not seem to be a true representative of the genus. The fragmentary specimen does not show the typical shell morphology and ornament pattern of *Pleurotomaria* (see Monari and Gatto, 2013); it does not show the broad selenizone running in the middle of the outer face at mid- whorl, and only the presence of a slit

band on the peripheral keel may refer this species to the Pleurotomariidae.

Subclass Caenogastropoda Cox, 1960
Order Uncertain
(according to Bouchet *et al*., 2017)
Superfamily Uncertain
(according to Bouchet *et al*., 2017)
Family *Pseudomelaniidae* R. Hornes, 1884
Genus Pseudomelania Pictet and Campiche, 1862

Type species. *Pseudomelania gresslyi* Pictet and Campiche, 1862, by subsequent designation by Wenz (1938); from the Lower Cretaceous (Neocomian) of Switzerland.
Occurrence. Triassic-Cretaceous (Kaim, 2004). Europe, Asia, Africa, Madagascar, New Zealand and America.

***Pseudomelania* sp.**
(Fig. 5O-S)

Material. CNP-PIIc 0441; one complete and replaced teleoconch.
Description. Dextral, anomphalous, turriculate, high-spired and large-sized shell. The protoconch is not preserved. The teleoconch has a height of 80.94 mm and a width of 41.76 mm, and comprises seven whorls; the juvenile whorls are flattened to slightly convex and mature whorls become more convex. The spire has a pointed apex and the last teleoconch whorl is more expanded than the spire. Suture is incised. The ornament is poorly developed on the shell surface. A weak angulation delimits the outer face of last whorl. The base is angular to slightly convex and ornamented by regularly spaced spiral striae. The aperture is holostomatous and suboval.
Remarks. *Pseudomelania* groups high-spired, elongated (pointed spire), not umbilicated, thick shells of simple morphology, usually ornamented with growth lines and with an oval aperture (see Ferrari, 2013; Kaim, 2004). *Pseudomelania* sp. (Ferrari, 2013, p. 585, fig. 3E), from the Lower Jurassic (upper Pliensbachian-lower Toarcian) of the Andean region of Argentina resembles the *Pseudomelania* species here described in having regularly spaced spiral striae on the base; however, the North American species is much larger, and has a more acute spire and less incised sutures. *Pseudomelania feruglioi* Ferrari, 2013 (p. 582, figs. 2F-I, 3A-D; Ferrari, 2017, p. 252, fig. 2.29-37), from the Lower Jurassic (Pliensbachian-Toarcian) of the Andean region of Argentina differs from the North America form in having a more slender shell with the last whorl less expanded, and more flattened whorls with a convex swollen belt in the adapical sutural area. Representatives of *Pseudomelania* were also reported from the Lower Jurassic (middle Toarcian) of Chile. The species described by Gründel as *Pseudomelania* sp. 3 (in Gründel, 2001, p. 57, pl. 4, fig. 13-14) differs from *Pseudomelania* sp. here described in having a slenderer shell, with more concave to flattened whorls, and with a convex swollen belt in the adapical sutural area. *Zygopleura* (*Anoptychya*) *tilarniocensis* Haas, 1953 (p. 125, pl. 7, figs. 44-50, 55, 56) from the Upper Triassic of Perú, is very similar to *Pseudomelania* sp. here described in shell shape and in its basal ornamentation with spiral cords; however, the species from Perú is smaller, sometimes showing an umbilical niche and collabral growth lines. *Pseudomelania*? sp. (in Sohl, 1965, p. 21, pl. 3, fig. 7), from the Middle Jurassic (Bathonian) of Utah, is much smaller than the species described here, the whorls are more flattened and the last whorl is slenderer and less expanded.

The species here described is the first occurrence of *Pseudomelania* in the middle Hettangian of North America.
Occurrence. Site JL198, middle Hettangian beds of July member, Pogibshi formation (Coronoides zone), Seldovia, Alaska (Peninsular terrane, south-central Alaska).

Grade Architaenioglossa Haller, 1892
(according to Bouchet *et al*., 2017)
Subcohort Campanilimorpha Haszprunar, 1888 (according to Bouchet *et al*., 2017)
Family Ampullinidae Cossmann, 1919
Genus *Pictavia* Cossmann, 1925

Type species. *Natica pictaviensis* d'Orbigny, 1852 (=*Natica bajocensis* d'Orbigny, 1852) from the Middle Jurassic (Bajocian) of France.
Occurrence. Early Jurassic-Middle Jurassic; Europe, South America.
Remarks. *Pictavia* shows close resemblance with representatives of the genus *Oonia* Gemmellaro, 1878; but, members of *Pictavia* have a narrow ramp which may be smooth or ornamented by spiral rows of fine pits (see Gründel, 2001; Ferrari, 2017).

***Pictavia* sp.**
(Fig, 5T-X)

Material. CNP-PIIc 0442; one fragmentary teleoconch.
Description. Dextral, slightly globose to egg-shaped, medium to large-sized and moderately high-spired shell, with a height of 47.65 mm and a width of 31.74 mm. The protoconch is not preserved. The teleoconch consists of 4-5 whorls; the spire is acute and has a pointed apex and the last whorl is fragmentary. Spire whorls are flattened to slightly convex becoming more convex in mature growth stages. Last whorl more expanded than spire whorls. Suture is weakly impressed and the sub-sutural ramp is narrowly horizontal. The shell is smooth and prosocline growth lines are not visible. The base is convex and the aperture is oval.
Remarks. The single described specimen represents a member of *Pictavia*, considering the egg-shaped shell with a narrowly developed sutural ramp as the main diagnostic features. *Pictavia rothi* Ferrari, 2017 (p. 257, figs. 3.27-3.31, 4.1-4.5), from the Lower Jurassic (Pliensbachian-Toarcian) of the Andean region of Argentina, resembles the species here described in shell shape, although the North American form is larger and has less incised sutures. *Oonia* sp. indet. (in Gründel, 2001, p. 59, pl. 5 figs. 1-4), from the Lower Jurassic (Hettangian-Pliensbachian) of Chile, is very similar to *Pictavia* sp., although the species from Chile has more convex whorls and growth lines are visible on the last whorl. *Omphaloptycha jaworskii* Haas, 1953 (p. 137, pl. 8, figs. 1-28, 31), from the Upper Triassic of Perú, resembles the species from North America; however, *O. jaworskii* is much smaller, growth lines and spiral cords sometimes appear in some specimens, and the sutural ramp is slightly more developed than in *Pictavia* sp.

The species described here represents the first occurrence of *Pictavia* in the middle Hettangian of North America.
Occurrence. Site JL198, middle Hettangian beds of July member, Pogibshi formation (Coronoides zone), Seldovia, Alaska (Peninsular terrane, south-central Alaska).

6. Paleobiogeography

The vetigastropod genus *Lithotrochus* was considered by Damborenea and Ferrari (2008) as endemic of the Andean region of South America, showing a restricted chronostratigraphic distribution in the Early Jurassic from the early Sinemurian to the late Pliensbachian. The species *Lithotrochus humboldtii* (von Buch, 1839) was one of the first mollusc species reported in the Jurassic of South America in several localities along the Andean region of Perú and Chile, and reaching its southernmost occurrence in the Chubut Province of Argentina (Damborenea and Ferrari, 2008; Ferrari, 2013, 2015a; Ferrari and Bessone, 2015). *Lithotrochus rothi* Damborenea and Ferrari, 2008 was also reported from the upper Pliensbachian of west-central Argentina (Damborenea and Ferrari, 2008; Ferrari, 2015), also found southernmost in coeval deposits of the Chubut Province (Ferrari, 2013). The newest occurrence of *Lithotrochus humboldtii* in middle Hettangian marine deposits of the Peninsular terrane (Alaska) refutes the idea that *Lithotrochus* is endemic of South America and extends its paleobiogeographical distribution into strata found now in the present-day Northern Hemisphere. Additionally, the record of these species in Seldovia (Alaska) extends the chronostratigraphic distribution of the genus to the earliest Jurassic (middle Hettangian). This suggests a possible origin of *Lithotrochus* in the present-day south-central Alaska during the middle Hettangian, becoming a component of the benthic marine communities in the Early Jurassic in North and South America after the Late Triassic mass extinction event. However, as noted elsewhere, the exact position of the Peninsular terrane during the Hettangian is still up for debate, but it was probably situated at a more southerly position, possibly as far south as northern South America. One of us (Blodgett) has earlier speculated that the Peninsular terrane and associated southern Alaskan terranes were probably situated off the western coast of the Americas, possibly as far as northern South America during the Late Triassic/Early Jurassic (see also Weems and Blodgett (1996) for further speculation on the rapid northerly motion evidenced by the Peninsular terrane during the Jurassic). Though the Peninsular terrane evidenced globally significant northward motion during the Jurassic, it seems to have docked more or less into its present-day northern Boreal position by the Late Jurassic (Weems and Blodgett, 1996; Blodgett, 2012; Blodgett *et al*., 2015).

Ferrari (2015) interpreted the Late Triassic/Early Jurassic faunal turnover after the Late Triassic crisis in

South America and established a paleobiogeographical scheme for the gastropod fauna across the Perúvian Paleo-Pacific seaway. Here we provide the first approach to interpret the relationships and connections of the different records of one of the most common Early Jurassic gastropod genera in South America, *Lithotrochus*, after the Late Triassic crisis.

Lithotrochus follows a distribution pattern and migration routes along the Americas during the Early Jurassic very similar to that of the coeval bivalve genus *Weyla* (see Damborenea and Manceñido, 1979; Damborenea, 2011; Hodges *et al.,* 2018). Thus, the Paleo-Pacific seaway may have been the most plausible mechanism for biotic exchange of *Lithotrochus* from the Peninsular terrane during the middle Hettangian to the Andean region of South America during the Sinemurian-Pliensbachian (Fig. 6A).

The vetigastropod genus *Pleurotomaria* shows a wide chronostratigraphic distribution from the Middle Triassic to the Recent and is found all over the world. Begg and Grant-Mackie (2003) supported the idea of an origin of *Pleurotomaria* in the late Anisian-Ladinian (Mid-Triassic) in the south-western Pacific sea. In the European epicontinental seas, *Pleurotomaria* first appeared during the early Hettangian and reached a widespread distribution in the European region through dispersal along the southern Tethyan margin (Monari and Gatto, 2013). The Late Triassic?- Early Jurassic radiation of *Pleurotomaria* from the western Tethys to North and South America may be related to the opening of a mid-Atlantic seaway, the Hispanic Corridor. According to Blodgett and Frýda (2001) and Frýda and Blodgett (2003) the strong similarities between western North American Late Triassic gastropods with those of the western Tethys suggests that the Hispanic Corridor may have been open as early as the Norian. However, Porter *et al*. (2013) provided evidence by Os isotope data that connectivity between the Eastern Pacific and Tethyan oceans initiated during the latest Sinemurian. The earliest -although doubtful- occurrence of *Pleurotomaria* in the Western Hemisphere dates from the Late Triassic (Norian-Rhaetian) of Perú (Haas, 1953; as *Pleurotomaria?* aff. *haueri*). However, following the characterization of Haas (1953), the Perúvian form does not seem to be a true representative of *Pleurotomaria*. The oldest certain record of the genus in the Americas is reported here from the middle Hettangian of south-central Alaska. Most probably the genus became widespread across the Paleo-Pacific seaway to the Andean region of South America as early as the Sinemurian. Gründel (2001) and Ferrari (2014) mentioned some *Pleurotomaria* species from the lower Sinemurian of northern Chile and from the upper Pliensbachian-lower Toarcian of central and south western Argentina. Ferrari and Damborenea (2015) also reported a representative of *Pleurotomaria* in the lower Bajocian of Argentina, coinciding with a time span of maximum species radiation (see Monari and Gatto, 2013).

7. Conclusions

The new gastropod assemblage from the southwestern Seldovia region (Alaska) reported here supply new taxonomic and palaeobiogeographical evidence of this taxa in the very Early Jurassic of North America, showing also close affinities with coeval South American and European gastropod faunas. These records have elements in common with the Andean associations in the Southern Hemisphere. Thus, this can help to infer ancient marine connections between both areas during the Early Jurassic.

Based on the general shell morphology with a gradate shape and angulated outer edge of the ramp, broad selenizone, strongly prosocyrt nodular elements and spiral ornament dominant on adult shell, our middle Hettangian *Pleurotomaria*, *Pleurotomaria pogibshiensis* sp. nov., represents a new species and its stratigraphic occurrence suggest it is the earliest species of the genus reported in present-day North America. The new findings reported here from just one locality in the Peninsular terrane of southern Alaska, manifest that new localities of North American Jurassic gastropods may greatly extend our knowledge and stimulate further research in the future, facilitating new taxonomic information and appropriate interpretation of the palaeobiogeographical distribution of marine gastropods in North America during the Jurassic.

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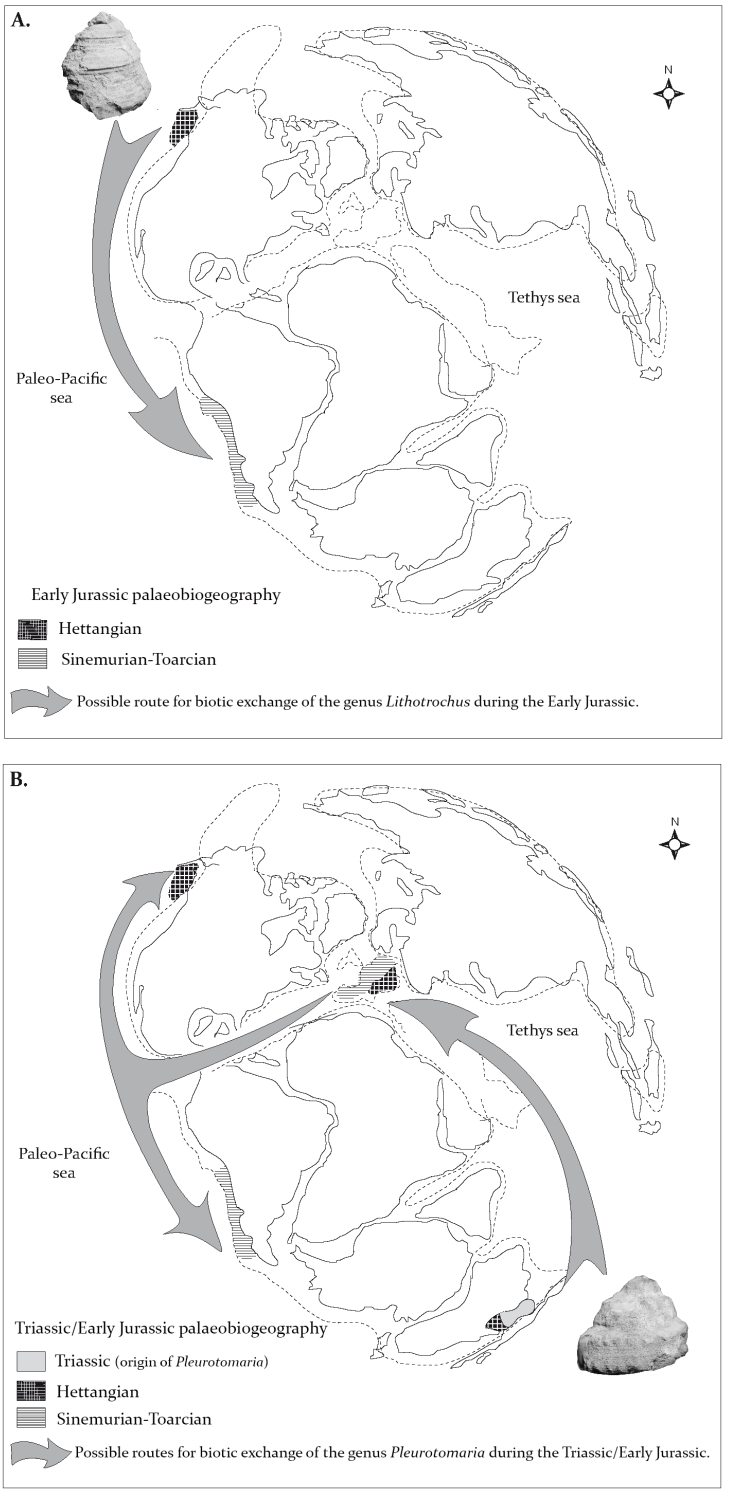

FIG. 6. Map showing the paleogeographic distribution of the genera *Lithotrochus* and *Pleurotomaria* here reported during the Late Triassic/Early Jurassic. **A.** Possible route for biotic exchange of the genus *Lithotrochus* during the Early Jurassic. **B**. Possible routes for biotic exchange of the genus *Pleurotomaria* during the Triassic/Early Jurassic.

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