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Jardamarekia enigma, a new Early Devonian tryblidioidean from Royal Creek area (Yukon Territory, Canada), and paleobiogeography of the Early Devonian of northwestern Canada

JIŘÍ FRÝDA[1,5], ROBERT B. BLODGETT[2], ALFRED C. LENZ[3] & BARBORA FRÝDOVÁ[4]

[1]*Faculty of Environmental Sciences, Czech University of Life Sciences Prague, Kamýcká 129, Praha 6 – Suchdol, 165 21, and Czech Geological Survey, P.O.B. 85, 118 21 Prague 1, Czech Republic. E-mail: bellerophon@seznam.cz*
[2]*Geological Consultant, 2821 Kingfisher Drive, Anchorage, Alaska 99502, USA. E-mail: robertbblodgett@yahoo.com*
[3]*Department of Earth Sciences, University of Western Ontario, London, Ontario N6A 5B7, Canada. E-mail: aclenz@.uwo.ca*
[4]*VÚRV v.v.i., Research Institute, Drnovská 507, 161 06 Prague – Ruzyně, Czech Republic. E-mail: frydovab@seznam.cz*
[5]*Corresponding author. E-mail: bellerophon@seznam.cz*

The Tryblidia (= Monoplacophora) represents the conchiferan class with the fewest Recent taxa in the phylum Mollusca (Haszprunar 2008) and its phylogeny is still poorly known. This group is known already in Cambrian strata (Early Paleozoic) more than 500 Ma ago. Present-day tryblidian species are known mainly from hadal environments (Schwabe 2008, but see also Wilson *et al*. 2009) in contrast to Paleozoic species, which have been described only from shallow environments of continental shelves of many paleocontinents (e.g., Horný 1962). A typical feature of fossil as well as living tryblidian species is their rarity. The vast majority of species are known only from several specimens (Haszprunar 2008). Furthermore, description of Paleozoic tryblidian molluscs is strongly underrepresented in the literature, despite the existence of diverse material. This is also true for fossils described in the present study based on a diverse silicified molluscan fauna of mostly gastropods collected from Lower Devonian strata of the Royal Creek area, Yukon Territory (Fig. 1) by Alfred C. Lenz and David G. Perry from 1970–1980. Lists of all hitherto described molluscan species as well as detailed information on their age and locality can be found in Lenz (1977a), Blodgett *et al.* (2001, 2010) and Frýda *et al.* (2008). Prior to our studies of the Royal Creek tryblidian and gastropod fauna, no descriptions or illustrations were available for Lower Devonian molluscs of north-western Canada, although a short discussion and faunal lists were provided by Blodgett *et al.* (1988) for Lower Devonian tryblidians and gastropods from the relatively nearby Delorme Formation of Northwest Territories, and early Emsian (late Early Devonian) tryblidians and gastropods from the Mt. Lloyd George area, northeastern British Columbia. The poor knowledge of Paleozoic tryblidians and gastropods faunas of Laurentia (North America) caused difficulties in the evaluation of Early Devonian paleobiogeography (Blodgett *et al.* 1999). The present paper is focused on the taxonomy of a new Devonian tryblidian limpet, but it provides also useful data for paleobiogeography and biostratigraphy of the Lower Devonian of western Canada.

Molluscan shells from middle Early Devonian (Pragian) strata of the Royal Creek area (Yukon Territory, Canada) are silicified and were extracted by hydrochloric acid from limestone samples at the Department of Geology, University of Western Ontario, London (Ontario, Canada) beginning 45 years ago. The specimens (holotype and paratype) described in this paper are deposited in the National Type Collection of Invertebrate and Plant Fossils of the Geological Survey of Canada, Ottawa, Canada K1A 0E8 (GSC 134793-134794).

Class Tryblidia (= Monoplacophora)

Family Ladamarekiidae Frýda, 1998

Remarks. Horný (1992) placed his new genus *Ladamarekia* in the order Tryblidioidea of the class Monoplacophora (= Tryblidia; = Tergomya). Horný also noted that the shell ornamentation of *Ladamarekia* is unique among described Paleozoic tryblidian genera. Frýda (1998), on the basis of newly collected material of the Pragian (middle Early Devonian) *Ladamarekia miranda* Horný, 1992, established a new family, Ladamarekiidae, for the genus. He mentioned that no morphological character of *L. miranda* supports the taxonomic position within the class Monoplacophora. The

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limpet shape of the shell has independently evolved in several groups of gastropods and also in the class Monoplacophora (Lindberg 2008, Geiger *et al.* 2008, Ponder *et al.* 2008, Wägele *et al.* 2008). As such, this shell feature cannot be used as a class-level taxonomic character, and thus, Frýda (1998) expressed doubt on the class-level position of *Ladamarekia*. This uncertainty was also included in a proposal of gastropod classification published by Bouchet *et al.* (2005). Recent study of newly gathered material of *L. miranda* by one of us (JF) shows that initial part of its shell is cap-shaped, which is a morphology of typical for living tryblidian taxa (e.g., Warén & Gofas 1997, and references herein). Modern gastropods with limpet-like shells such as Patellogastropoda or Cocculinoidea have protoconchs formed by a tubular embryonic shell (Sasaki 1998). Neritimorpha or Caenogastropoda gastropods with limpet-like shells have even more complex protoconchs, being formed by embryonic as well as larval shells. Such types of protoconch in limpets have been already documented from the middle Paleozoic (see discussion in Cook *et al.* 2008). Muscle scars pattern often used in the past as a class-level character in Paleozoic limpets (see Frýda *et al.* 2008 for references) was not preserved is *L. miranda*. Taken together, the cup-like protoconch suggests tryblidian affinity of Ladamarekiidae, and not limpet gastropods.

Horný (1961) described the new genus *Pilinopsis* Horný, 1961, based on *Helcionopsis eminens* Perner, 1903, from the Pragian age (middle Early Devonian), Koněprusy Limestone (see discussion in Carls *et al.* 2008), of the Praha Formation (Barrandian area, Czech Republic). The general shape of the shell in *Jardamarekia enigma* **gen. et sp. nov.** forms a transition between those of *Ladamarekia* Horný, 1992, and *Pilinopsis*. Considerable differences in general shell shapes of the latter two genera are probably the reason why Horný (1992) did not mention his *Pilinopsis* as being possibly related to his *Ladamarekia.* Nevertheless, the shared type of unusual shell ornamentation among the described Paleozoic limpets supports placement of *Ladamarekia* and *Jardamarekia*, and most probably also *Pilinopsis* in the family Ladamarekiidae. The placement of *Pilinopsis* in the latter family has to be, however, confirmed by more detailed study of new material.

Genera included. *Ladamarekia*, *Jardamarekia*, and *Pilinopsis*.

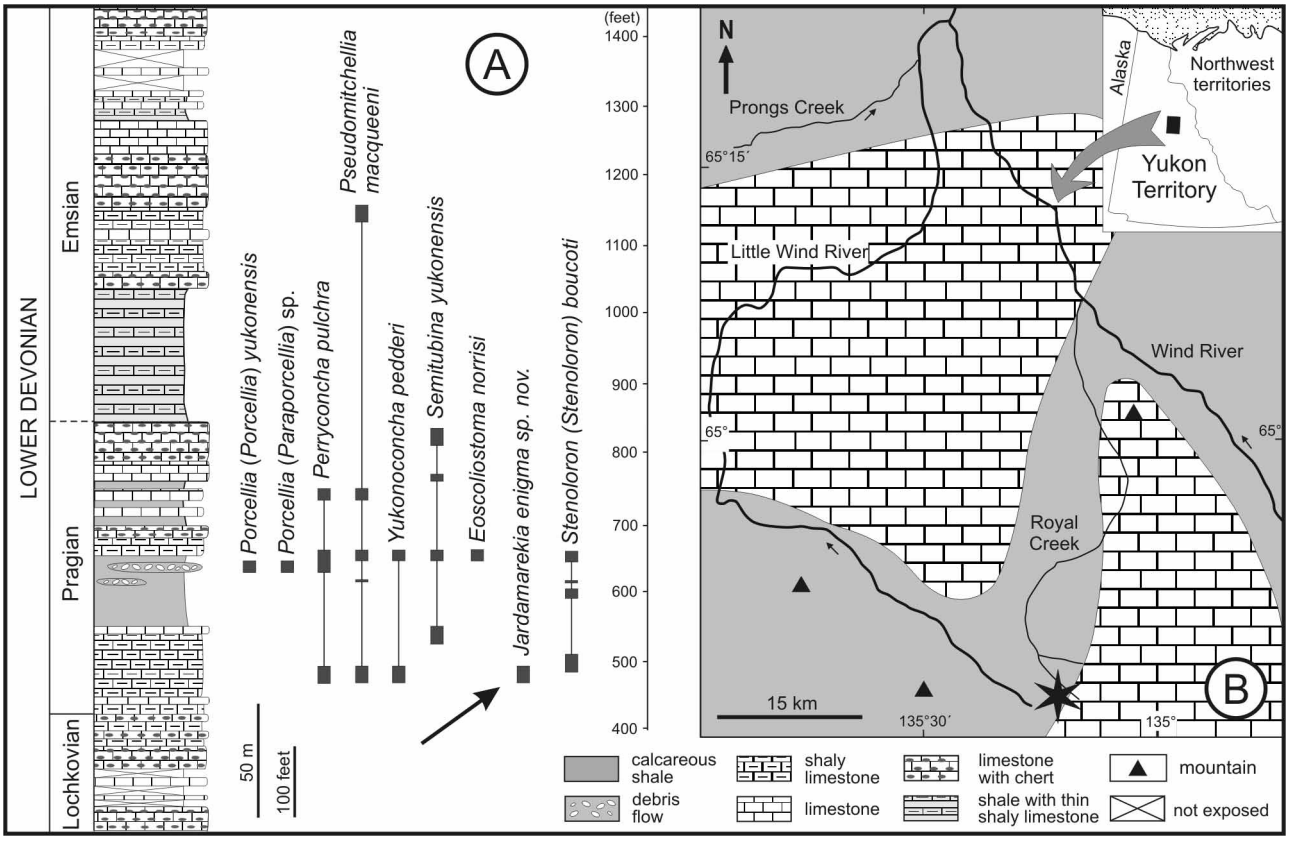

FIGURE 1. A—Stratigraphic section 1 showing a distribution of all hitherto described molluscs species from Royal Creek, northern Yukon. B—Generalized maps showing location of section 1 (asterisk) in the Yukon Territory, Canada. Modified from Lenz (1977b).

***Jardamarekia* gen. nov.**

Type species: Jardamarekia enigma **sp. nov.** from middle Early Devonian (Pragian) age strata of the Road River Formation in the Royal Creek area, Yukon Territory, Canada (64.8° N, 135.2° W).

Diagnosis. Medium-sized limpet shell (maximal shell diameter about 26 mm) with rounded apertural outline; apex overhanging, apex position at half of shell height; maximum shell height about half of shell length; shell slightly wider than high; shell ornamentation consists of strong collabral and slightly adapically curved ribs; height of ribs about double that of their width; space between ribs ornamented by radial threads, intersecting with collabral ribs to form distinct, regular, reticular pattern.

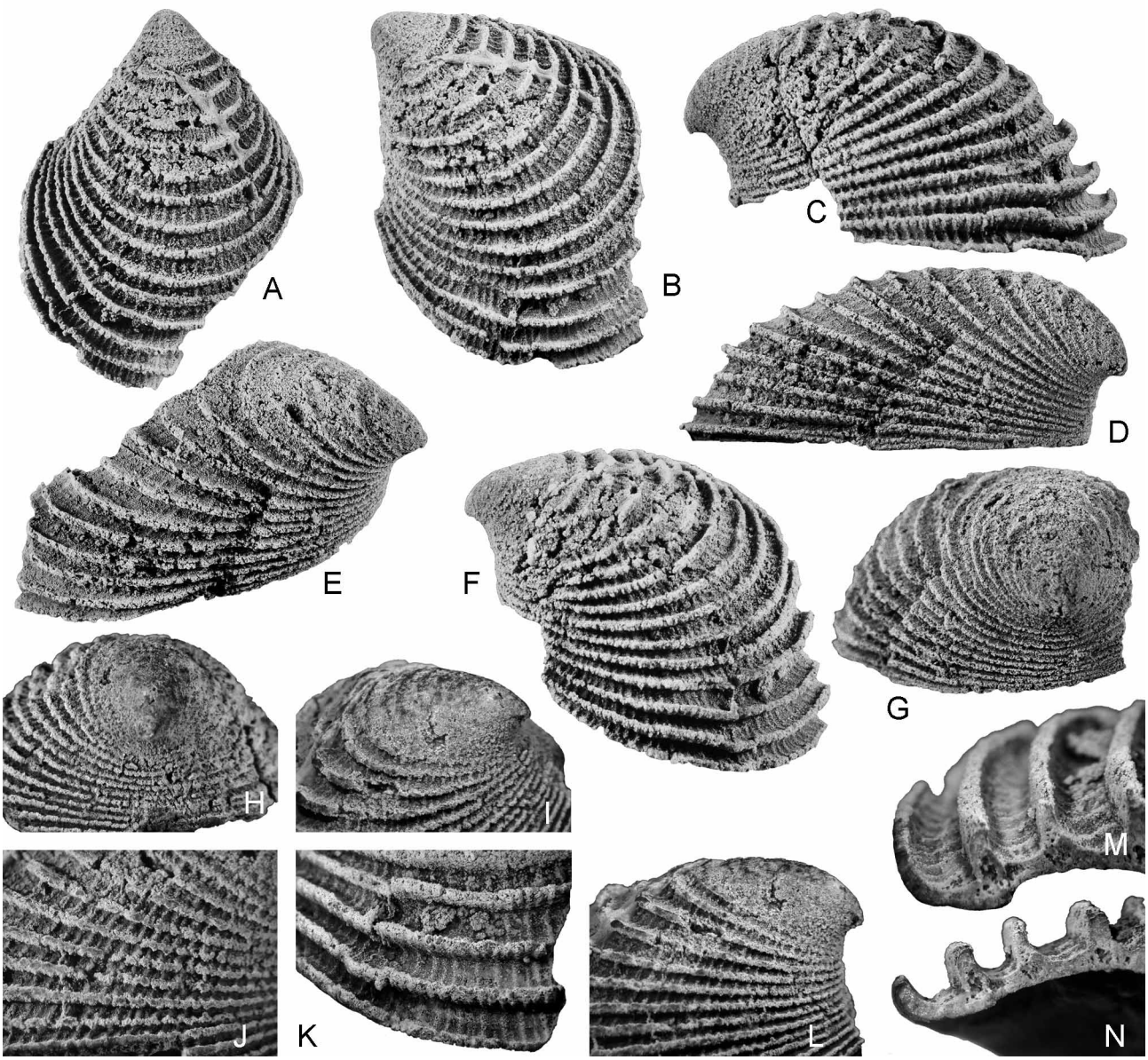

FIGURE 2. *Jardamarekia enigma* **sp. nov.** from middle Early Devonian (Pragian) age strata of the Road River Formation in the Royal Creek area, Yukon Territory, Canada. The species is from interval 142.0–150.0 m of section 1 (Fig. 1A). Holotype GSC 134793: A–C, F, H–N, shell length 18 mm, width 14 mm, height 10 mm; figure width of shell details: H—11 mm, I—10 mm, J—8 mm, K—3,5 mm, L—10 mm, M, N—3 mm. Paratype: GSC 134794: D–E, G, shell length 26 mm, width 21 mm, height 11 mm.

Differences. ***Jardamarekia* gen. nov.** resembles *Ladamarekia* from the Early Devonian Pragian strata of the Prague Basin in its shell ornamentation, but is easily distinguished by the shape and size of its shell. The type and only known species of *Ladamarekia*, *L. miranda* has a much higher shell than *J. enigma* (Fig. 2). Also the expansion rate of the shell in the former species is much slower than in *J. enigma*. The shells of the latter species are about four times larger than

those of *L. miranda*. The new genus also resembles the type and only known species of genus *Pilinopsis*, *P. eminens* (Perner, 1903). Because only a single shell of the latter species is known (see Horný 1962: p. 10), knowledge of its shell features is limited. *Jardamarekia* differs from *Pilinopsis* in having a higher shell (because of faster expansion rate of its shell), protruding shell apex, much thicker shell and a very distinct shell ornament (compare figures 6–8, pl. III, in Horný 1962 with Fig. 2).

Etymology. *Jardamarekia* (femininum), in honor of Jaroslav Marek, Czech paleontologist and teacher at Charles University (Prague).

***Jardamarekia enigma* sp. nov.**
Fig. 2A–N

Holotype. GSC 134793 (Fig. 2A–C, F, H–N).

Paratype. GSC 134794 (Fig. 2D–E, G).

Type locality. Middle Early Devonian (Pragian) age strata of the Road River Formation in the Royal Creek area, Yukon Territory, Canada. It comes from interval 142.0–150.0 m (466–492 feet) of section 1 (Fig. 1), which belongs to the fauna of Pragian age with the brachiopod *Davidsoniatrypa johnsoni* Lenz, 1968 (Lenz 1977b).

Etymology. *enigma* —from Latin *aenigma* (something inexplicable).

Diagnosis. Because of monotypic genus, see that of genus.

Description. Two well-preserved, silicified, almost complete shells. Shells medium-sized, spoon shaped with distinctly protruding apex; maximum length about 27 mm. Shell as high as wide, twice as long. Aperture elliptical, apertural margin in one plane. Protruding shell apex in middle of shell height, distinctly overhanging anterior margin of aperture (Fig. 2C–E). Outer shell surface ornamented by strong concentric lamellae, comarginal with aperture. Lamellae crossed by radial threads. Comarginal lamellae, radial threads regularly spaced, forming distinct reticular shell ornamentation at their intersections (Fig. 2A–C, J, K). Distance between lamellae about twice distance between radial threads. Because of more rapid shell growth in dorsal part of shell, distance between comarginal lamellae in dorsal region higher than in anterior region below shell apex. Lamellae adapically bent, height equals to their distance of separation. Width of each lamella about half of its height (Fig. 2M–N). Shell apex blunt, cap-shaped without traces of spiral coiling (Fig. 2C, H–I). Shell thickness about equal to width of comarginal lamellae (Fig. 2N).

Paleobiogeographic significance of the fauna

From the nine hitherto described molluscan genera from the Royal Creek fauna (Yukon Territory)—*Yukonoconcha* Frýda, Blodgett & Lenz, 2002, *Pseudomitchellia* Frýda, Blodgett & Lenz, 2002, *Perryconcha* Frýda, Blodgett, Lenz & Manda, 2008, *Stenoloron* (*Stenoloron*) Oehlert & Oehlert, 1888, *Porcellia* (*Paraporcellia*) Blodgett and Johnson, 1992, *Porcellia* (*Porcellia*) Léveillé, 1835, *Semitubina* Cossmann, 1918, *Jardamarekia*, *Eoscoliostoma* Frýda, Blodgett & Lenz, 2002—three genera are endemic to this locality (*Eoscoliostoma*, *Yukonoconcha*, *Perryconcha*) and the remaining genera are known from the Old World Realm. In addition, *Stenoloron* (*Stenoloron*), *Pseudomitchellia*, and *Semitubina* are known only from this realm (the latter two genera are known to occur otherwise only in the Barrandian area, Czech Republic). The strong faunal affinity of the Royal Creek fauna to the Old World Realm fauna of central Europe may be also demonstrated at the family level. Three families (two gastropod families Tubinidae and Crassimarginatidae and one monoplacophoran family Ladamarekiidae) and one gastropod subfamily (Scoliostomatinae of Scoliostomatidae), to which belong some of above-mentioned species from the Royal Creek fauna, are known only from this locality and contemporaneous Old World Realm faunas of Central Europe. Members of subfamily Mitchelliinae (Scoliostomatidae) are known only from Old World Realm faunas of SE Australia and the Royal Creek fauna. Early Devonian members of the subfamily Agnesiinae have been documented from the Royal Creek fauna and Old World Realm faunas of central Europe, SE Australia, as well as from the Farewell terrane (west-central Alaska). The Farewell terrane has stronger faunal connections to regions like the Alexander terrane of southeast Alaska, Siberia, Variscan Europe, and eastern Australia than to cratonic North America (Laurentia) (Blodgett *et al*. 2002; Frýda & Blodgett 2004, 2008).

In our first contribution on Lower Devonian gastropods from Royal Creek, Yukon Territory (Blodgett *et al.* 2001), we established the term “Western Canada Province” to comprise a biogeographic unit of provincial rank within the Old World Realm during the Early Devonian. The occurrence of the here described limpet, *Jardamarekia enigma*, belonging to a family hitherto known only from central Europe (Barrandian area, Czech Republic) is additional evidence supporting the Old World Realm character of Western Canada Province.

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