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Original article

Plicathyridine brachiopods (Athyridida) from the Frasnian (Late Devonian) of Western Europe and Middle East☆

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ABSTRACT

Plicathyridine brachiopods (Athyridida) from the early–middle Frasnian of southern Belgium and northern France (Dinant Synclinorium) are systematically described for the first time. They include two species: *Anathyris* (*Anathyris*) *calestiennensis* nov. sp., and *A.* (*A.*) sp. indet. 1. They are uncommon in the mainly shally La Prée (Nismes Formation) and Ermitage (Moulin Liénaux Formation) members and are absent from the mixed argillaceous–carbonate late Frasnian succession in this area contrary to what is observed in Russia, notably in the East-European Platform and Siberia. In the Middle East, two species of *Anathyris* are recognized on the basis of a limited material from the Dascht-e-Nawar area in Afghanistan (*A.* (*A.*) sp. indet. 2) and the Kuh-e Kaftar mountains in Central Iran (*A.* (*A.*) sp. indet. 3). *Anathyris* (*A.*) *calestiennensis* nov. sp. is sometimes encrusted by epizoans (tabulate and rugose corals, and bryozoans) and rarely displays single, small circular drill holes. The past and current epizoan–brachiopod interactions are also discussed (*Anathyris vs. Lingula*, respectively).

1. Introduction

Athyridides rank among the most abundant elements of the Devonian brachiopod assemblages. They were particularly diverse as witnessed by the high number of genera described for this period (Grunt, 1986; Alvarez and Rong, 2002; Alvarez, 2007). One of the most emblematic Devonian athyridide subfamilies is the plicathyridines, with their mixed folding (e.g., Alvarez, 1990) which seems to be restricted to the Lockhovian–Frasnian interval, although some early Carboniferous (Tournaisian) species from Hunan, Guizhou and Tibet were assigned to *Anathyris* (e.g., Tan, 1986; Hou and Tan in Hance et al., 1994) but need to be revised according to Alvarez and Rong (2002) and Modzalevskaya et al. (2013). The occurrence of Mississippian plicathyridines in Southeast Asia remains particularly dubious as until now, no plicathyridines have been reported in Famennian strata. They would disappear during the late Frasnian crisis along with the representatives of the long-ranging orders Pentamerida and Atrypida that were so abundant in mixed carbonate–clastic environments from tropical and subtropical regions (Copper, 1986). After a period of decline during the Middle Devonian, mainly in the course of the Givetian, the plicathyridines display a great abundance and diversification during the Frasnian on the Russian Platform and in the Altai-Sayan province (for references, see Alvarez, 1990; Rzhonsnitskaya and Modzalevskaya, 1996; Modzalevskaya et al., 2013), where many endemic species have been recognized, untill their final disappearance during the late Frasnian biological crisis (e.g., Grunt and Racki, 1998; Alvarez and Modzalevskaya, 2001; Alvarez, 2003). These athyridides are also known from Frasnian-aged rocks of Western Europe [southern Belgium: Maillieux, 1940a; Mottequin et al., 2013; western Germany (Aachen Basin): Sartenaer, pers. com., Feb. 2015] and the Middle East (Iran and Afghanistan; Brice, 1971; Mistiaen et al., 2000; Mottequin and Brice, 2010; Mottequin et al., 2013) but they only occur sporadically in these regions where they constitute a minor part of the Frasnian brachiopod assemblages.

The purposes of this paper are:

- to describe for the first time the Frasnian plicathyridines from southern Belgium and northern France, and to discuss those from Iran and Afghanistan;
- to discuss the interactions between *Anathyris* and epizoans on the basis of the Belgian material;
- to discuss the Devonian migration of the plicathyridines.

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2. Stratigraphy and biostratigraphy

2.1. Belgium and northern France

In southern Belgium, the Frasnian succession is well-exposed in the Vesdre area, the Dinant Synclinorium, the Durbuy–Philippeville Anticlinorium, the Brabant Parautochthon, and the Haine-Sambre-Meuse Overturned Thrust Sheets (the two latter units were formerly included in the Namur Synclinorium; see Belanger et al., 2012 for discussion about this structural unit) (Fig. 1). These Variscan structural elements constituted the Namur–Dinant Basin that developed along the southeastern margin of Laurussia during Devonian and Mississippian times. The Frasnian lithostratigraphy of Belgium was summarized by Bultynck and Dejonghe (2002). In the course of the Frasnian, the facies succession reflected a ramp–platform setting with a mixed siliciclastic–carbonate sedimentation and several breaks of slope as well as the development of carbonate mound levels in its distal part (southern flank of the Dinant Synclinorium) (Boulvain et al., 2004; Fig. 2). In the course of the early–middle Frasnian, a proximal northern area with carbonate-dominant facies developed in opposition with a distal southern, usually deeper area, in which argillaceous facies and reefs were dominant; the latter now corresponds to the southern margin of the Dinant Synclinorium. This setting continued during the late Frasnian, but argillaceous deposits predominated everywhere, with some occurrences of carbonate levels mainly in the northern part of the basin and small mudmounds in the southern area. Moreover, the late Frasnian succession is also characterized by the development of dysoxic to anoxic shaly facies, especially at the end of the Frasnian (Upper Kellwasser Event; Mottequin and Poty, 2015).

The material described in this paper comes from several Belgian localities mainly located along the south and southeastern borders of the Dinant Synclinorium (Fig. 1), as well as a French locality (Givet) also located on the southern flank of this major structural unit. Plicathyridines were mentioned in the former stratigraphic units "F2b" and "F2e" by Maillieux (1941) that were based on palaeontological and lithological criteria (Maillieux and Demanet, 1929). They are equivalent now to the shaly La Prée (Nismes Formation) and Ermitage (Moulin Liénaux Formation) members, respectively. The two first members of the Nismes Formation (ca. 39 m thick on the southern margin of the Dinant Synclinorium), namely the Pont d'Avignon (ca. 1 m) and the Sourd d'Ave (ca. 16 m) members, consist of argillaceous (sub)nodular limestones and nodular shales, contrary to the last member (La Prée Member; ca. 22 m), which includes greenish to brownish shales with rare calcareous nodules and limestone lenses. Except the Givetian Pont d'Avignon Member (Lower *falsiovalis* Zone), the Frasnian Sourd d'Ave and La Prée members of the Nismes Formation spans the interval, in terms of conodont zones, of the Lower *falsiovalis* Zone to the lower part of the *transitans* Zone (Bultynck and Coen, 1999; Bultynck and Dejonghe, 2002). The first occurrence of the conodont *Ancyrodella rotundiloba*, which corresponds to the base of the Frasnian, is located in the lowermost part of the Sourd d'Ave Member (Bultynck et al., 1988). The Moulin Liénaux Formation comprises three members, from base to top: Chalon (shales and argillaceous nodular limestones; ca. 5–7 m thick), Arche (carbonate mudmounds; up to 120 m thick), and Ermitage (ca. 115 m) members. The Ermitage Member mainly consists of greenish shales with some occurrences of argillaceous limestone beds (Bultynck and Mouravieff, 1999; Bultynck and Dejonghe, 2002). The Moulin Liénaux Formation is early and middle Frasnian in age [upper part of the *transitans* Zone to the lower part of the *hassi* s.l. Zone (Vandelaer et al., 1989)]. In order to protect the outcrops from unauthorized collecting and vandalism, locality information is voluntarily excluded from the present paper but is deposited with the studied material and available to qualified personnel.

2.2. Afghanistan

The specimens studied originate from three Frasnian localities (Bokan, Doni Yarchi, Saïd Habib) situated in the northeast part of the Dascht-e-Nawar area in eastern Afghanistan (Fig. 3(1)), ca. 150 km southwest of Kabul (for more details, see Brice, 1971). They were recovered from argillaceous limestones, the age of which is not constrained by conodont data.

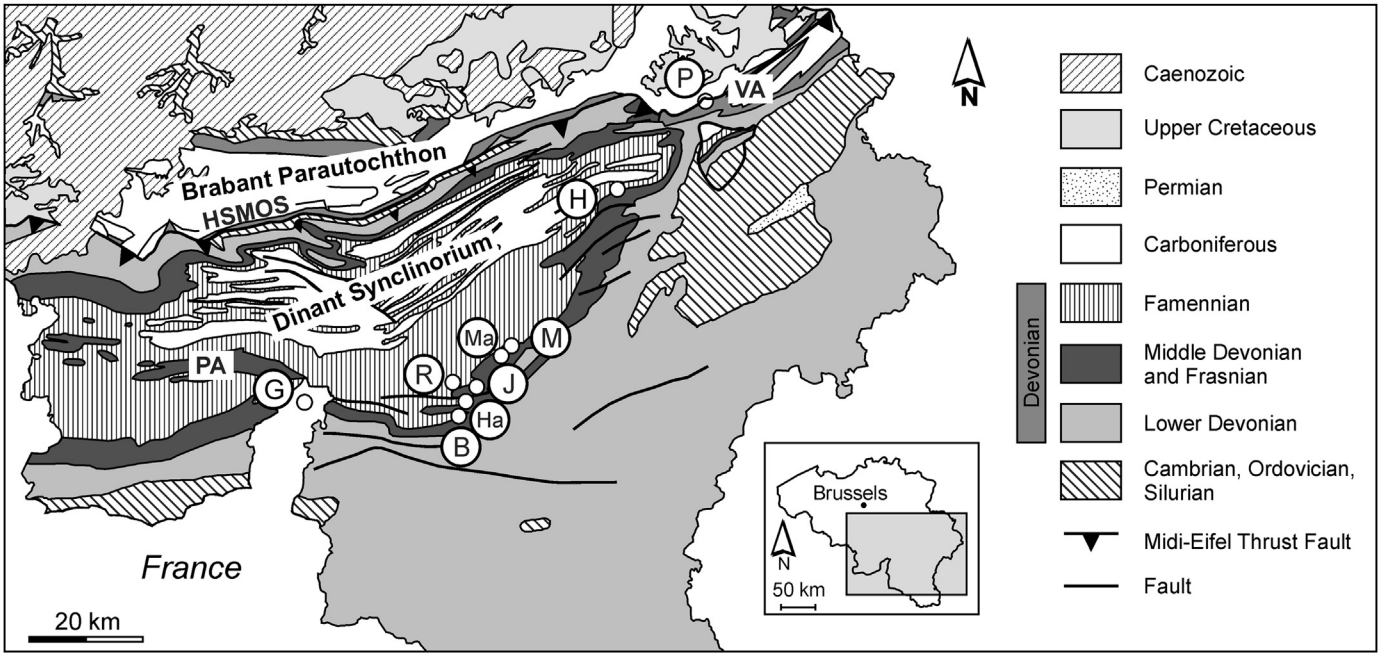

Fig. 1. Schematic geological map of southern Belgium (modified from de Béthune, 1954; see also Belanger et al., 2012). Abbreviations for the localities and structural units listed in the text: B: Belvaux; G: Givet; H: Hamoir; Ha: Han-sur-Lesse; HSMOS: Haine-Sambre-Meuse Overturned Thrust Sheets; J: Jemelle; M: Marche-en-Famenne; Ma: Marloie; P: Pepinster; PA: Philippeville Anticlinorium; R: Rochefort; VA: Vesdre area.