

“*Clavatula*” *pettkoi* n. sp. (Neogastropoda Clavatulidae) from the Badenian (Miocene) deep-water marine clays of the Studienka Formation (Vienna Basin, Central Paratethys)

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ABSTRACT

A fossil shell belonging to the gastropod family Clavatulidae Gray, 1853, previously recognised as *Clavatula* (*Clavatula*) *neudorfensis* (F. Schaffer, 1897), stored in the collections of the Natural History Museum of Slovak National Museum, Bratislava, Slovakia, is revised. The specimen was found in the upper Badenian (middle Miocene) deep-water marine clays of the Studienka Formation exposed in a former clay pit near Devínska Nová Ves, Bratislava, located in the eastern part of the Vienna Basin (Slovakia), which represented the western margin of the Miocene Central Paratethys Sea. As the results suggest, this specimen is not conspecific with *Megaclavatula neodorfensis* (Schaffer, 1898), also known from this locality and does not agree with any other Neogene Clavatulidae species. The shell bears peculiar morphological features that allow it to describe as a new species, “*Clavatula*” *pettkoi* n. sp. The species is provisionally placed in “*Clavatula*” *sensu lato* based on conchological characters.

KEY WORDS

Central Paratethys; “*Clavatula*” *sensu lato*; Clavatulidae; middle Miocene; Vienna Basin.

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INTRODUCTION

The members of the genera *Clavatula* Lamarck, 1801 and “*Clavatula*” (*s.l.*) are marine thermophilic gastropods within the family Clavatulidae Gray, 1853 belonging to the superfamily Conoidea J. Fleming, 1822 (e.g., Bouchet et al., 2011; Kovács & Vicián, 2021; Harzhauser et al., 2022; Landau & Harzhauser, 2022). In modern seas, they are widespread along the coast of tropical West Africa (e.g., Strebel, 1912; Knudsen, 1952; Kilburn, 1985; Nolf, 2007; Nolf & Verstraeten, 2007; Harzhauser et al., 2022) and inhabits inner to middle neritic environments (e.g., Kilburn, 1985; Ardovini & Cossignani, 2004;

Boyer & Hernández, 2004; Boyer & Ryall, 2006; Nolf & Verstraeten, 2007).

The first mentions of the Miocene clavatulid gastropods from the Slovak part of the Vienna Basin were published by Schaffer (1897), Toulou (1900) and Horusitzky (1917). New comprehensive data on the clavatulid diversity and their geographic and stratigraphic distribution were mentioned by Švagrovský (1958, 1971, 1981, 1982). More recently, their finds were listed by Hladilová (1991) and Ruman & Hudáčková (2015). Finally, several Clavatulidae species occurring in this area were presented by Harzhauser et al. (2022), who summarised and revised the Clavatulidae taxa from the Miocene Paratethys Sea. Starting with Schaffer

(1897), the middle Miocene Clavatulidae gastropods from Devínska Nová Ves – Brickyard have been surveyed since the 19th century. He described a clavatulid *Pleurotoma neudorfensis* based on a single incomplete shell. Another specimen treated as *Clavatula* (*Clavatula*) *neudorfensis* (F. Schaffer, 1897) was reported by Švagrovský (1981). More recently, as Harzhauser et al. (2022) proposed, *Pleurotoma neudorfensis* Schaffer, 1898 was placed into the newly described genus *Megaclavatula*. The shell presented by Švagrovský (1981) was excluded from the synonymy but without comparative remarks or

proposal for placement in any other Clavatulidae species. This paper describes it as a new species, “*Clavatula*” *pettkoi* n. sp., due to the peculiar shell morphology, which separates it from all other known *Clavatula* s.s. and “*Clavatula*” s.l. members.

MATERIAL AND METHODS

Geological setting and synopsis of previous research

The middle Miocene Vienna Basin can be regarded as an embayment situated in the north-western margin of the Central Paratethys Sea (Kováč et al., 2008; Lambert et al., 2008). In the Slovak part of the Vienna Basin, the upper Badenian (middle Miocene) marine strata are characterised by the Studienka Formation, represented by marginal shallow-water sediments of the Sandberg Member and basinal pelitic deposits (e.g., Baráth et al., 1994, 2003; Kováč et al., 2004, 2008; Fordinál et al., 2012).

The locality Brickyard at Devínska Nová Ves (formerly also known as Theben – Neudorf, Neudorf an der March, Dévény – Ujfalu), a borough of the city of Bratislava, is located in the eastern Vienna Basin, nearby the south-western margin of the Malé Karpaty Mts., Slovakia. The locality represents a former clay pit situated in the northern part of Devínska Nová Ves (GPS coordinates: 48°13'42.3"N, 16°58'24.4"E). The middle Miocene, upper Badenian (= lower Seravallian) deep-water marine clays of the Studienka Formation were exposed there (Tomašových, 1998; Hudáčková & Spezzaferri, 2002; Ruman & Hudáčková, 2015). The lowermost part of the section probably falls into the middle Badenian or middle to upper Badenian boundary based on foraminiferal data (Tomašových, 1998; Kováčová & Hudáčková, 2009). Massive and laminated grey calcareous clays with rare intercalations of sands and silts build up the sedimentary sequence attributed to the foraminiferal *Bulimina-Bolivina* Biozone (Hudáčková & Kováč, 1993; Hudáčková & Spezzaferri, 2002) and the NN6 nannoplankton Zone (Lehotayová, 1977; Hudáčková & Spezzaferri, 2002; Jamrich & Halásová, 2010). The late Badenian age (13.54 Ma) was also confirmed by the ⁸⁷Sr/⁸⁶Sr ratio derived from benthic

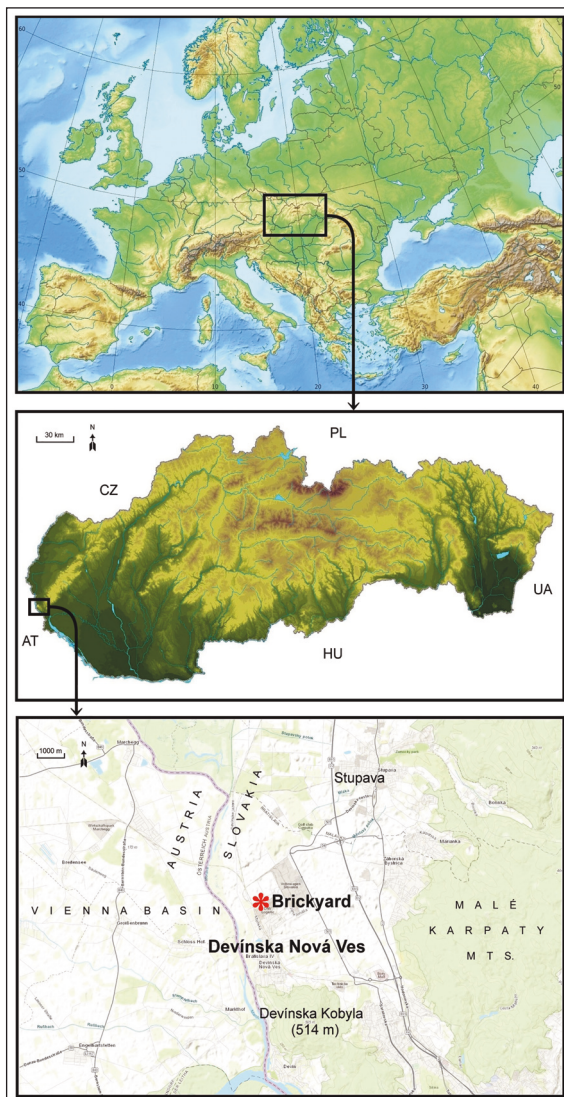


Figure 1. The geographic position of the site Devínska Nová Ves – Brickyard.

foraminifera *Pappina neudorfensis* (Toula, 1900) shells (Hudáčková et al., 2003b).

The locality has been studied since the 19th century, which resulted in a description of several new species, some of which are endemic or with high biostratigraphic importance (cf. Schaffer, 1897; Toula 1900, 1915; Košťák et al., 2016). The species-rich assemblages of molluscs comprise chitons, gastropods, scaphopods, bivalves and cephalopods (Schaffer, 1897; Toula, 1900, 1915; Seneš & Cicha, 1973; Švagrovský, 1981; Činčurová, 1990; Tomašových, 1998; Ruman & Hudáčková, 2015; Košťák et al., 2016, 2018). Several rare gastropods have been re-examined by Harzhauser & Landau (2021) and Harzhauser et al. (2022). Calcareous nannofossils (Lehotayová, 1977; Jamrich & Halášová, 2010), foraminifers (e.g., Hudáčková & Kováč, 1993; Kováčová & Hudáčková, 2009; Kováčová et al., 2009), polychaetes (Tomašových, 1998), bryozoans (Toula, 1915; Tomašových, 1998), brachiopods (Tomašových, 1998; Ruman & Hudáčková, 2015), echinoids (Schaffer, 1897; Toula, 1915; Tomašových, 1998; Kroh, 2005), ostracods

(Tomašových, 1998; Ruman & Hudáčková, 2015), decapods (Schaffer, 1897; Toula 1900; Hyžný, 2011), sharks (Holec, 2001), fishes (e.g., Holec & Sabol, 1996; Chalupová, 2001; Gregorová, 2009; Schultz, 2013) and terrestrial plants (Berger, 1951; Sitár & Kováčová-Slamková, 1999) were reported.

Methods

A single shell of “*Clavatula*” pettkoi n. sp. was found in a former clay pit at the Brickyard site at Devínska Nová Ves probably in the second half of the 20th century, but the exact date of finding and place of sampling in the pelitic section is unknown. The shell is relatively well-preserved and probably represents a fully-grown adult specimen. The protoconch and the earliest teleoconch whorls are not preserved. The holotype is housed in the collections of the Natural History Museum of Slovak National Museum, Bratislava, Slovakia, under the inventory number SNM Z 17510.

The higher systematics of the class Gastropoda Cuvier, 1795 follows Bouchet et al. (2017).

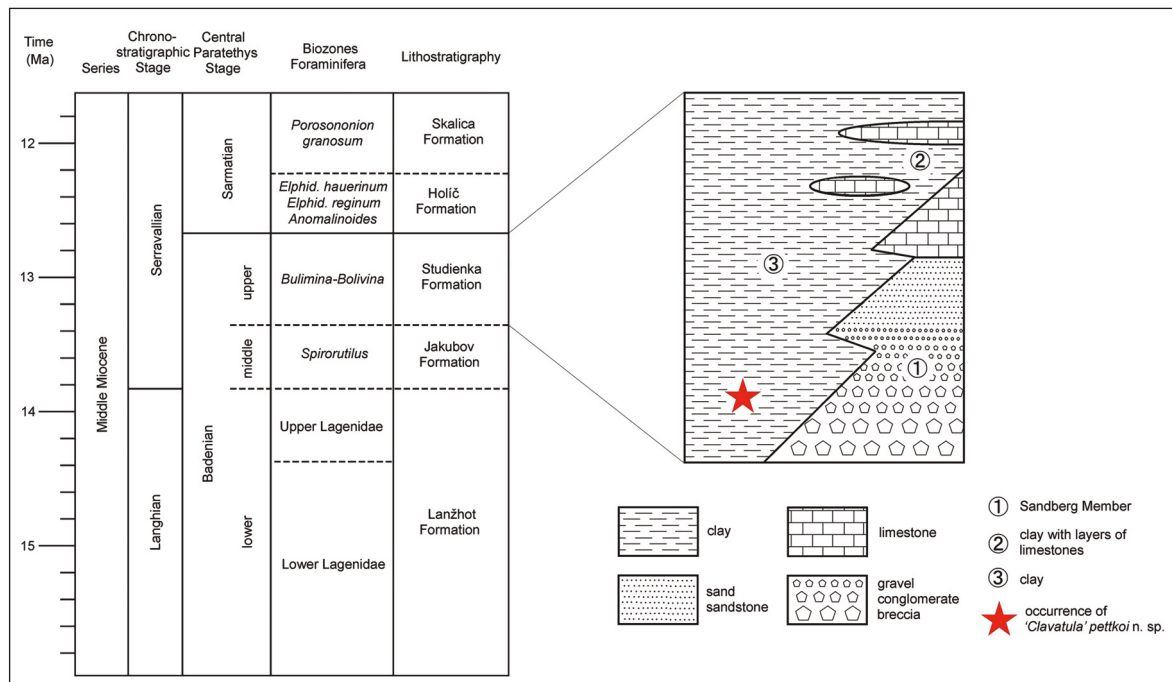


Figure 2. The Middle Miocene chronostratigraphic and biostratigraphic zonation and lithostratigraphic units of the Vienna Basin (modified after Harzhauser et al., 2018) and schematic illustration of lithology and lithostratigraphy of the upper Badenian Studienka Formation (modified after Fordinál et al., 2012) showing the assumed position of the pelitic section exposed at the locality Brickyard with the occurrence of “*Clavatula*” pettkoi n. sp.

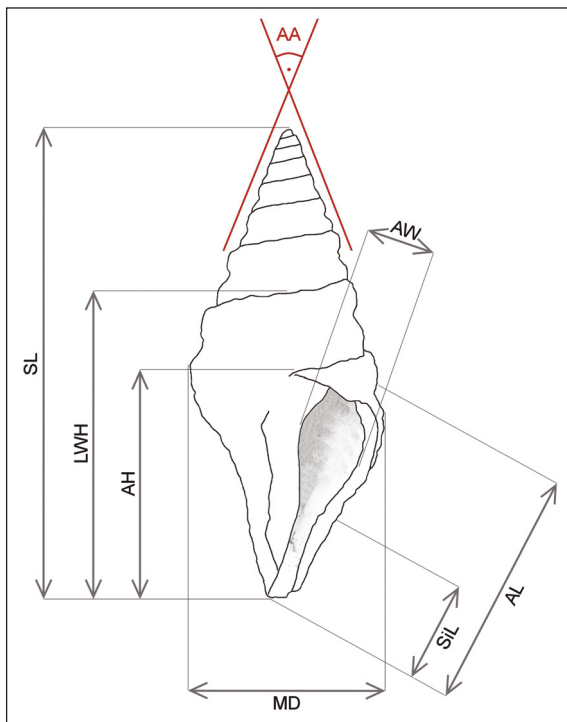


Figure 3. Measurements for shell morphology used in this study (modified after Harzhauser et al., 2022).

Taxonomic concepts of clavatulids, description terminology, morphometric dimensions and abbreviations are adopted from Harzhauser et al. (2022) and Landau & Harzhauser (2022). The species is placed within the “*Clavatula*” genus group but is unassigned to none of the clade in the sense of Harzhauser et al. (2022), and it is tentatively placed in “*Clavatula*” *sensu lato* based on conchological features.

ABBREVIATIONS. SL = shell length, MD = maximum diameter, AA = apical angle, LWH = last whorl height, AH = aperture height, AL = aperture length, AW = aperture width, SiL = length of the siphonal canal.

RESULTS

Systematics

Class GASTROPODA Cuvier, 1795
 Subclass CAENOGASTROPODA Cox, 1960
 Order NEOGASTROPODA Wenz, 1938
 Superfamily CONOIDEA J. Fleming, 1822

Family CLAVATULIDAE Gray, 1853
 Genus “*Clavatula*” *sensu lato*

“*Clavatula*” *pettkoi* n. sp. (Figs. 4–6)

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Clavatula (*Clavatula*) *neudorfensis* (F. Schaffer, 1897) – Švagrovský, 1981: p. 155, pl. 48, fig. 9. [*non Megaclavatula neodorfensis* (Schaffer, 1898)].

Clavatula (*Clavatula*) *neudorfensis* (Schaffer, 1897) – Zahradníková & Fordinál, 2021: fig. 8d. [*non Megaclavatula neodorfensis* (Schaffer, 1898)].

TYPE MATERIAL. Holotype: SNM Z 17510, SL: 30.65 mm, MD: 12.34 mm, AA: 45°, LWH: 20.60 mm, AH: 16.40 mm, AL: 16.40 mm, AW: 6.55 mm, SiL: 6.60 mm, figs. 4–6.

TYPE LOCALITY. Devínska Nová Ves – Brickyard (former clay pit), a borough of Bratislava, Vienna Basin, Slovakia.

STRATUM TIPICUM. Grey calcareous clays of the Studienka Formation, middle Miocene, upper Badenian (= lower Serravallian), *Bulimina-Bolivina* Biozone, NN6 nannoplankton Zone.

DIAGNOSIS. Shell medium-sized, solid, broad fusiform. Later whorls with deeply concave mid-whorl, thickened subsutural collar with nodules, and prominent suprasutural row of tubercles. Last whorl with pronounced, swollen subsutural collar with tubercles, deeply concave, well-developed subsutural ramp, tuberculous shoulder cord, and spiral cords with tubercles. Aperture wide, outer lip lirate within, siphonal canal moderately long.

DESCRIPTION. Shell medium-sized, solid, broad fusiform, with conical spire; apical angle 45°. Protoconch and earliest teleoconch whorls not preserved. Teleoconch composed of 8 whorls. Early teleoconch whorls abraded, almost flat-sided, sculpture and suture indistinct. From 3rd teleoconch whorl, spiral sculpture becoming concave mid-whorl with prominent subsutural cord and suprasutural row of tubercles, bearing well-defined nodules rounded in shape. Suture narrowly incised, weakly, and finely undulating. From 6th whorl, subsutural collar markedly thickened with

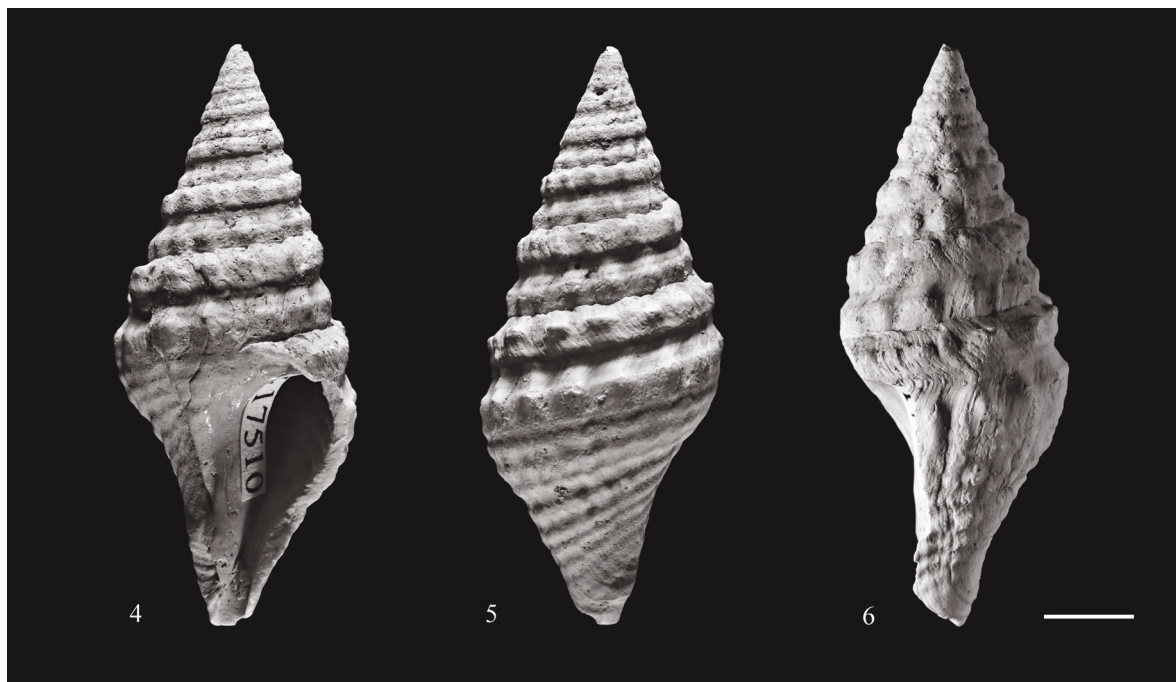
prominent beads subquadrate in outline, slightly bifurcated, with small spines slightly bent adapically. Suprasutural row of tubercles broad, decorated with nodules of round to slightly subquadratic shape; nodules slightly elongated adapically into concave mid-whorl portion, forming poorly defined, depressed opisthocline axial riblets. Suprasutural row of tubercles and subsutural collar well delimited by deeply concave mid-whorl, with 2 indistinct spiral furrows within. Suture narrowly impressed, weakly undulating. Last whorl 67% of total height. Subsutural collar strong, swollen, with beads subquadrate in outline, weakly bifurcated, with delicate spines slightly curved adapically, in last quarter of last whorl beads become gradually attenuated. Subsutural ramp well developed, deeply concave, delimited by broad, low, tuberculosis shoulder cord; convex below, moderately constricted at base. Shoulder cord sculptured by slightly convex, indistinctly pointed tubercles. Shoulder prominent, with convex outline; base slowly contracting; 3 mid-whorl cords below shoulder of similar strength well defined, separated by interspaces of equally wide. Base of regular 6 perifasciolar cords, weakening abapically. All

primary spiral cords below shoulder bearing weak developed tubercles. Penultimate and last whorl covered with delicate growth lines and striae, on last whorl resulting in sporadic fine folds. Axial sculpture poorly developed, characterised by lowered, barely visible opisthocline axial ribs, weakening in interspaces between spiral ribs and in subsutural ramp. Siphonal fasciole weakly swollen, indistinct, slightly twisted. Aperture wide, outer lip with 6 lirae within. Siphonal canal moderately long, anal sinus with moderately shallow depth and moderately narrow width. Columellar and parietal callus thickened, separated from fasciole by narrow pseudumbilical chink.

ETYMOLOGY. Named in memory of Ján Pettko (1812–1890), geologist, palaeontologist, and the first Slovak professor of geology.

STRATIGRAPHIC AND GEOGRAPHIC DISTRIBUTION. “Clavatula” pettkoi n. sp. is only known from the upper Badenian (middle Miocene) clayey deposits of the type locality Devínska Nová Ves – Brickyard (Vienna Basin, Slovakia).

REMARKS. The early whorls sculpture is considered one of the important characters that



Figures 4–6. “Clavatula” pettkoi n. sp., holotype, SNM Z 17510, upper Badenian, Devínska Nová Ves – Brickyard, scale bar = 5 mm.

distinguishes respective Clavatulidae genera, groups, and clades, as proposed by Harzhauser et al. (2022). The examined shell is relatively well-preserved, but the earliest whorls, including the protoconch, are damaged, and the neanic sculpture is abraded and barely visible. The new species is tentatively placed in “*Clavatula*” *sensu lato* based on overall shell morphology that differs it from the genus *Clavatula* Lamarck, 1801 and shows some superficial similarities with the “*Clavatula*” *interrupta* group within the *mystica*-clade (cf. Harzhauser et al., 2022). However, this suggested group-level placement cannot be confirmed because the neanic sculpture is hardly discernable. The first known early whorls sculpture is visible from the 3rd teleoconch whorl and seems bipartite; the suprasutural collar is pronounced, gibbose, and massive, covered by coarse nodules, the mid-portion is slightly concave, and the subsutural cord is poorly developed, flattened and less prominent. These early morphological characters and overall shell morphology do not agree with any other group or clade proposed by the authors mentioned above. Thus, the new species remains unassigned to none of them.

The shell of “*Clavatula*” *pettkoi* n. sp. was previously mentioned by Švagrovský (1981; p. 155, pl. 48, fig. 9.), who identified it as *Clavatula* (*Clavatula*) *neudorfensis* (F. Schaffer, 1897). However, as suggested by a revision of Harzhauser et al. (2022) and the results of this work, the specimen is not conspecific with *Megaclavatula neodorfensis* (Schaffer, 1898), having a large-sized shell, higher and elongated spire, slenderer apical angle, rounded suprasutural row of tubercles, and a more delicate spiral sculpture.

Due to the specific shape of whorls characterised by deeply concave mid-whorl and subsutural ramp, and thickened, prominent subsutural collar and suprasutural row of tubercles, “*C.*” *pettkoi* n. sp. differs from all other Neogene Clavatulidae species described from the North-East Atlantic and circum-Mediterranean regions. From the Miocene Central Paratethys, only a few species are comparable with that new one.

“*Clavatula*” *irisa*e Harzhauser, Landau et Janssen, 2022 is somewhat similar Badenian clavatulid belonging to the *mystica*-clade that occurred in Austria and Slovenia (Harzhauser et al., 2022). It differs from the new species in its somewhat

slenderer but larger shell, sharply angular shoulder, strongly constricted base, a more angulated and convex mid-whorl, weaker subsutural collar, broader mid-whorl portion with shallower concavity, and suprasutural row of beads covering by weakly developed spinous tubercles. On early teleoconch whorls, the spiral sculpture is more delicate, consisting of tripartite sculpture characterised by a prominent central beaded spiral cord and suprasutural spiral cord covered by fine small tubercles. In addition, the entire surface of the spire whorls is decorated by fine secondary spiral cords.

“*Clavatula*” *olgae* (Hoernes et Auinger, 1891) is another clavatulid within the *mystica*-clade, known from the Badenian Paratethys (Harzhauser et al., 2022), which is partly reminiscent of “*C.*” *pettkoi* n. sp. mainly in its deeply concave mid-whorl and subsutural ramp. Nevertheless, “*C.*” *olgae* has a more fusiform shell shape, which is much larger and has more delicate sculptural elements. The species is distinguished by its much higher spire, a slender outline of the shell, markedly elongated last whorl and siphonal canal, shallower and broader mid-whorl portion, a more pronounced shoulder; and first teleoconch whorls and the penultimate whorl bear delicate spiral lines. Moreover, “*C.*” *olgae* is characterised by tripartite early whorls sculpture.

“*Clavatula*” *vitalisi* Strausz, 1955, a member of the *mystica*-clade, described from the Badenian of Hungary and Romania (Harzhauser et al., 2022), is a species superficially similar to “*C.*” *pettkoi* n. sp. mainly in shell shape, but this clavatulid completely differs from the new species mainly in its larger shell, shallower concavity and broader mid-whorl portion, a more prominent shoulder, densely and finely developed spiral sculpture, broader siphonal canal, and tripartite early whorls sculpture.

DISCUSSION

Interestingly, at Devínska Nová Ves – Brickyard, only two rare clavatulids were identified: *Megaclavatula neodorfensis* (Schaffer, 1898) and “*Clavatula*” *pettkoi* n. sp., and each of them is presented only by a single specimen which indicates a low diversity and abundance of the family Clavatulidae at the locality.

The molluscan assemblages from Brickyard

mentioned by the early authors since the 19th century (cf. Schaffer, 1897; Toulou, 1900, 1915) are more diversified and are characterised by different taxonomic composition referring to more favourable conditions than the faunas reported since the second half of the 20th century (cf. Seneš & Cicha, 1973; Švagrovský, 1981; Činčurová, 1990; Tomašových, 1998; Ruman & Hudáčková, 2015; Košťák et al., 2016, 2018). As noted by Tomašových (1998), the locality was represented by two clay pits. The first initial clay pit was opened in 1870 and was exploited probably until 1925, while the new clay pit was opened sometime after 1918 and was located about 300 m north of the first one (Tomašových 1998; Zlochová, 1998). The differences in the molluscan faunas between these localities are evident and may indicate two distinct paleoenvironments. “*Clavatula*” pettkoi n. sp. has probably been found in the new clay pit (cf. Švagrovský, 1981).

Paleoecological conditions were studied in detail mostly in the last decades and were interpreted mainly on the results of microfossil analyses, suggesting deposition in the middle to outer neritic paleoenvironments (Seneš & Ondřejčková, 1991; Tomašových, 1998; Hudáčková et al., 2003a; Chalupová, 2001), in conditions of the stratified water column (Hudáčková & Kováč, 1993; Kováčová & Hudáčková, 2009; Kováčová et al., 2009), and affected by occasional hypoxia near sea-bottom (Hudáčková & Kováč, 1993; Tomašových, 1998; Hudáčková & Spezzaferri, 2002; Kováčová et al., 2009).

Similar deep-water marine conditions were established from another locality in the eastern Vienna Basin, revealing the basinal pelites of the Studienka Formation – at the site “northeast to Devín – Merice”, located on the southern slope of the Devínska Kobyla Hill. As suggested by the foraminiferal and molluscan faunas found in the pelites exposed in a wide area of Devín, deep-water marine dysoxic conditions are expected (Hyžný et al., 2012). Only one clavatulid species is known from this locality, *Oleginina szokolyensis* (Strausz, 1960) (Švagrovský, 1981; Harzhauser et al., 2022). The upper Badenian clays equivalent to the pelitic facies at Devínska Nová Ves – Brickyard were also uncovered at Rohožník – Konopiská. The faunal assemblages obtained from

a former clay pit point to marine conditions in the middle to outer neritic zone, and the oxygen depletion near the seafloor (e.g., Hladilová, 1991; Lambert et al., 2008; Biskupič, 2020, 2021). However, no shell of clavatulid was recorded in the pelitic section (personal observation of the author).

As sketched above, the unfavorable paleo-environmental conditions, such as lowered water dynamics, seasonal hypoxic events, and deep-water settings, could result in strongly reduced abundance and decreased species richness or absence of Clavatulidae in deeper parts of the basin.

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