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The pioneering research activity of Georg Gottlieb Pusch on the Middle Miocene of Poland and present-day western Ukraine

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ABSTRACT:

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This paper shows that Georg Gottlieb Pusch (1790–1846), the most outstanding Polish geologist of the 19th century, was the author of the first catalogue of Middle Miocene fossils from the territories of the then Kingdom of Poland (1815–1832) and Eastern Galicia (now south-eastern Poland and western Ukraine). This catalogue, containing 400 species-level names, was published in the second volume of the monumental treatise, i.e., *Geognostische Beschreibung von Polen*, about the geology of Poland (Pusch 1836). Out of the 137 species-level names of bivalves, five were introduced as new: *Venericardia annulata*, *Astarte crassatellaeformis*, *Cardium gracile*, *Venericardia lima*, and *Pecten nodosiformis*. All newly described species were subsequently re-described and illustrated in the comprehensive volume *Polens Paläontologie* devoted to the palaeontology of Poland, in which Pusch (1837a) included descriptions of three new taxa: *Mactra biangulata*, *Pecten lilli*, and *Pecten Burdigalensis* var. *polonica*, as well as a revised list of the Middle Miocene fauna of Poland, Volhynia and Podolia, previously published in the *Geognostische Beschreibung von Polen*. In the present work the taxa described by Pusch (1836, 1837a) have been critically revised. The species *Cardium gracile* Pusch, 1836, *Pecten nodosiformis* Pusch and de Serres in Pusch, 1836, and *Pecten lilli* Pusch, 1837 are considered taxonomically valid. *Astarte crassatellaeformis* Pusch, 1836 is newly synonymized with the present-day *Venus foliaceo-lamellosa* Dillwyn, 1817. *Venericardia annulata* Pusch, 1836 and *Venericardia lima* Pusch, 1836 are regarded as *nomina dubia*. The names *Pecten Burdigalensis* var. *polonica* Pusch, 1837 and *Mactra biangulata* Pusch, 1837 are recognised as *nomina oblita.* In addition, it has been shown that an approach to knowledge about the rhodolith-bearing sediments of southern Poland began in the 1820s with the works of Georg Gottlieb Pusch, who is also the author of modern geological maps and the first profiles of the Middle Miocene sediments from the Kingdom of Poland and Eastern Galicia. Finally, Pusch's position regarding the age of the gypsum deposits of the Nida River region is presented.

Key words: Georg Gottlieb Pusch; Tertiary; Kingdom of Poland (1815–1832) and Eastern Galicia; History of Geology; Middle Miocene; Bivalvia; Taxonomy; Rhodoliths; Age of gypsum.

INTRODUCTION

A new record of the pectinid species *Gigantopecten nodosiformis* (Pusch and de Serres in Pusch, 1836) in Skotniki Quarry, its type locality, the first since Pusch's fieldwork, urged me to search for information about his collection (Studencka 2025a). The data provided by Trejdosiewicz (1883) has proved invaluable. It was thanks to this author that I realised that the *Tertiary* fauna (now dated to the Middle

Text-fig. 1. Portrait of Jerzy [Georg Gottlieb] Pusch (1790–1846). Lithograph by Henryk Aschenbrenner. Copied from Wiślicki (1859).

Miocene) of the Kingdom of Poland was first described by Pusch but not in the *Polens Paläontologie* (Pusch 1837a) but earlier, in the second volume of the monumental treatise about the geology of Poland, i.e., *Geognostische Beschreibung von Polen* (Pusch 1836). This discovery contributed not only to establishing the correct authorship of *Pecten nodosiformis* (Studencka 2025a), but above all, to the recognition of the great merits of Pusch in the understanding of the Middle Miocene of Poland.

The purpose of this article is to present Pusch's pioneering research on the bivalve fauna of the Kingdom of Poland and Eastern Galicia, collected from sediments dating to the post-Cretaceous and pre-Quaternary time interval, which was then formally recognised as the Tertiary period. It should be noted that the International Commission on Stratigraphy (ICS) decided to abandon the term Tertiary in 2008. However, as reported by Knox *et al*. (2012), although the term Tertiary had ceased to be used as a formal period, it was used as an informal unit in fewer than half of newly published articles. I believe that the enormous effort Pusch had put into identifying the bivalve fauna from the sediments he then considered to be *Tertiary* fully justifies the use of this term (in italics), even though it is no longer a formal stratigraphic unit.

Before doing so, however, I would like to introduce Georg Gottlieb Pusch (the Polish version of his name was also commonly used: Jerzy Bogumił or Jerzy), an outstanding scientist who initiated modern geological and palaeontological research in Poland.

GEORG GOTTLIEB PUSCH — MINER, GEOLOGIST, PALAEONTOLOGIST

Georg Gottlieb Pusch (Text-fig. 1) arrived in Kielce between August 1816 and January 1817. This time interval is marked by his two letters published in the *Leonhards Taschenbuch für die Mineralogie*: the first one was written on the 20th of August 1816 in Kohren[1], Pusch's hometown (Pusch 1817a, p. 626), while the second one on the 25th of January 1817 in Kielce (Pusch 1816, pp. 605–608).

The reasons for his arrival were twofold. Firstly, it was the lack of employment prospects in the Saxon mining industry. In 1815, after graduating from Leipzig University, where he studied Protestant theology in the years 1810–1815 (Kleczkowski 1970), Pusch began to work at the Saxon mining office in Suhl in the southern Thuringian Forest. However, he was dismissed after the Congress of Vienna — Saxony, an ally of Napoleon, had to accept the loss of two-thirds of its territory after his defeat. Pusch returned to Kohren, where he prepared an article containing critical remarks on the chemical classification of minerals proposed by the eminent Swedish chemist Jöns Jacob Berzelius (Pusch 1817b).

Secondly, the authorities of the Kingdom of Poland were looking for educated people to work in the Main Mining Directorate they had established on the 1st of June 1816 and in the Academic School of Mining in Kielce (*Szkoła Akademiczno-Górnicza w Kielcach*) operating under its auspices. The location of both the Main Mining Directorate and the Academic School of Mining in the town of Kielce was chosen by Stanisław Staszic, who in 1816–1824 was the actual Minister of Industry of the Kingdom of Poland (officially the Director of the Department of Trade, Crafts and Industry) and who initiated the construction of the Staropolski Industrial District.

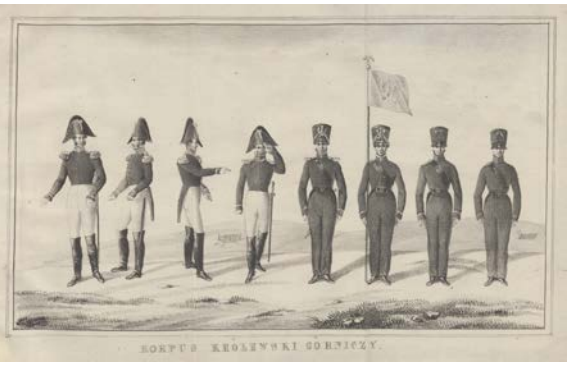
[1] Since 2018, Kohren-Salis is part of the town of Frohburg in Saxony, Germany.

The director of the Academic Mining School, which began its operations in January 1817, was Johann Ehrenhold Ullman, who also headed the Main Mining Directorate, which was entrusted with overall supervision of the state-owned mines and steelworks.

Pusch, who was a graduate of the Mining Academy in Freiberg (*Bergakademie*), a student of the famous geologist Abraham Gottlieb Werner in 1806–1810, and co-author of a work on the chemical experiments conducted by August Lampadius in the academic year 1809–1810 at the *Bergakademie* (Borcht and Pusch 1810), was appointed to deliver lectures on chemistry (*allgemeine Chemie*) and metallurgy (*Hüttenkunde*) (Pusch 1816). Since 1826 his duties also included teaching mining[2] (Wójcik 2005, p. 255).

In his first letter, written in January 1817 after his arrival in Kielce, Pusch reported that the Kingdom of Poland was completely unknown in terms of mining and mineralogical knowledge, and therefore he considered as his duty to gradually clarify this issue. As Wiślicki (1859, p. 123) clearly emphasized, he fully fulfilled this obligation both towards science and towards his second chosen homeland. Apart from his duties as a lecturer at the academy and an assessor in the Main Mining Directorate (he was responsible for zinc and lead mining, and issues related to salt exploration), Pusch had already started intensive geological research in 1817, although, as he noted, it was more difficult and inconvenient to explore one square mile in the Kingdom of Poland than 10 square miles in Saxony (Pusch 1816, p. 607).

From the very beginning of his work in Kielce, Pusch conducted systematic geological research. Between 1817 and 1826, he undertook numerous longer research journeys (Pusch 1831, pp. 1–3). The Tatra Mountains, which he saw in 1821, were described in a separate work (Pusch 1824), whilst his first field experiences from 1817 in the Kingdom of Poland were included in the *Geognostischer Katechismus* (1819), the first work completed and published after his arrival in Kielce, which was a summary of the lectures given by Abraham Gottlieb Werner at the *Bergakademie* (Text-fig. 2). Printed in a pocket-sized format, divided into 10 chapters, the book was intended to be a compendium of modern geological knowledge for fieldwork. Chapter two contains five



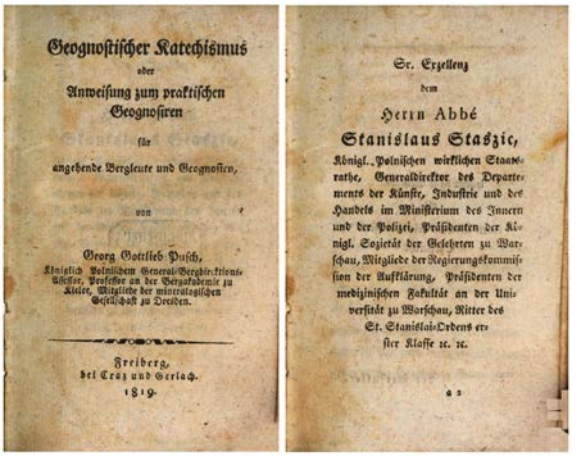
Text-fig. 2. Uniforms of the eight classes of the Royal Mining Corps. Copied from Pusch (1830a).

main commandments for 19th century *geognosists*, which are still relevant today. They are:
- perceive neither more nor less than is in nature;
- adhere strictly and conscientiously to the existing sequence of layers;
- do not get lost in the details when observing but look at the whole thing comprehensively and holistically;
- do not be misled by accepted hypotheses, present the facts faithfully and conscientiously;
- do not trust your memory too much.

Also, in 1817 the Royal Mining Corps was established, organized hierarchically into eight classes, modelled on the French formula, which included both miners and Directorate employees. Members of the corps wore separate uniforms and insignia for each class (Pusch 1830a; Text-fig. 3). Pusch, who held the position of assessor in the Mining Directorate and as a professor at the Kielce Academic School of Mining [as noted on the title page of the *Geognostischer Katechismus* (Text-fig. 2) and the first volume of the *Geognostische Beschreibung* (Text-fig. 4)], belonged to the third class of the Royal Mining Corps. In 1832, when he was appointed mining counsellor (as noted on the title page of the second volume of the *Geognostische Beschreibung*), Pusch belonged to the second class of the Royal Mining Corps. In 1833, after the reorganization of mining, which was subordinated to the Bank of Poland, he was appointed head of the Steelworks Department (Wójcik 2005).

The main tasks of Pusch included reconnaissance of mineral deposits in the Kingdom of Poland, especially copper, lead, zinc, and iron ores, and salt

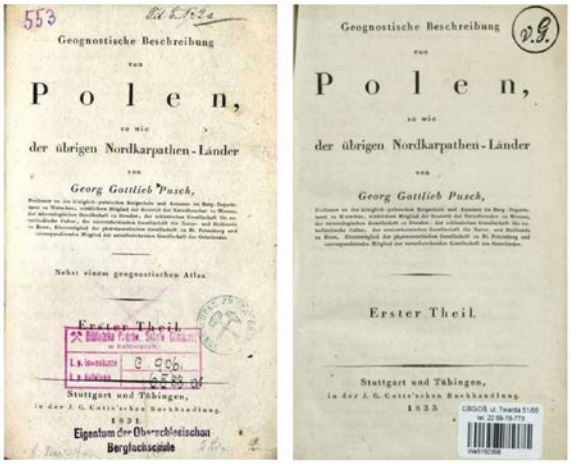
[2] The library collections of the Saint Petersburg Mining University of Empress Catherine II in St. Petersburg, Russia (widely known as the Mining Institute), contain a manuscript of a mining course (*Bergbaukunst*) for the Academic Mining School in Kielce, prepared by Pusch between 1820 and 1825. The manuscript, containing 363 pages (240 of which were written by Pusch), originally came from the collection of Manuscripts from the Mining Department of the Government Commission for the Revenue and Treasury of the Kingdom of Poland (Kleczkowski 1977a). It was not mentioned by Pągowski (1847).



Geognostischer Katechismus
oder
Anweisung zum praktischen
Geognosiren
für
angehende Bergleute und Geognosten,
von
Georg Gottlieb Pusch,
Freiberg,
bei Craz und Gerlach.
1819.

Sr. Excellenz
dem
Herrn Abbé
Stanislaus Staszic,
Königl. Polnischen wirklichen Staatsrathe, Generaldirektor des Departements der Künste, Industrie und des Handels im Ministerium des Innern und der Polizei, Präsidenten der Königl. Societät der Gelehrten zu Warschau, Mitgliede der Regierungskommissionen der Aufklärung, Präsidenten der medizinischen Fakultät an der Universität zu Warschau, Ritter des St. Stanislaus-Ordens erster Klasse ꝛc. ꝛc.

Text-fig. 3. The title page of the *Geognostischer Katechismus oder Anweisung zum praktischen Geognosiren für angehende Bergleute und Geognosien* by Pusch (1819) together with the dedication page written as follows: "*To His Excellency Father Stanisław Staszic, Royal Counsellor of State of Poland, Director General of the Department of Art, Industry and Trade of the Ministry of Internal Affairs and Police, President of the Warsaw Society of Friends of Learning, Member of the Governmental Enlightenment Commission, Chairman of the Faculty of Medicine of the University of Warsaw, Knight of the Order of Saint Stanislaus, First Class... I dedicate this small book as a token of my deepest respect*". From the collection of the Bavarian State Library, Münich [Bayerische Staatsbibliothek, München], Germany.



Geognostische Beschreibung
von
Polen,
so wie
der übrigen Nordkarpathen-Länder
von
Georg Gottlieb Pusch,
Nebst einem geognostischen Atlas.
Erster Theil.
Stuttgart und Tübingen,
1833.
Eigentum der Oberschlesischen Berglschule

Geognostische Beschreibung
von
Polen,
so wie
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von
Georg Gottlieb Pusch,
Erster Theil.
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1833.

Text-fig. 4. Two title pages of the first volume of *Geognostische Beschreibung von Polen* by Pusch. The date of this publication is imprecisely specified. Pągowski (1847, p. 288) gives 1831 as the date of publication (left). The same year is also given by Kleczkowski (1977, pp. 59, 60), adding that the first volume was already printed in 1830, but could not be distributed due to the November Uprising in 1830. Therefore, almost all copies of *Geognostische Beschreibung von Polen* were issued with the date 1833 (right) and this date is usually cited.

formations. Therefore, he conducted a thorough analysis of earlier literature, particularly the papers of Carosi (1781–1784) and Staszic (1815), and then verified their descriptions in the field. First, based on the fossils collected personally by him, Pusch determined the age of the main stratigraphic units, which coincided with the introduction of modern principles of biostratigraphy. Pusch presented the results of his findings for the first time at the meeting of the Association of German Naturalists and Physicians in September 1828 in Berlin (Pusch 1829a), organised by Alexander von Humboldt. During this meeting, Pusch handed over to the publishing house of J.G. Cotta in Stuttgart the manuscript of the first volume of *Geognostische Beschreibung von Polen* and geological maps with cross-sections and profiles (Kleczkowski 1977b, p. 59). The Polish abridged version of his fundamental work on the geology of the Kingdom of Poland was printed in 16 episodes of the weekly magazine *Sławianin* (1829–1830), and in a separate publication (Pusch 1830b), the French version of which appeared in the same year (Pusch 1830c).

At the same time, Pusch was interested in the palaeontology of the Kingdom of Poland. He thoroughly studied the fossils of this region in order to — as he stated in the introduction to *Polens Paläontologie* (Pusch 1837a) — supplement the two volumes of *Geognostische Beschreibung von Polen* with information about the organic world of each of the formations described in this monumental treatise on the geology of Poland, as he knew them from his own experience until 1827. Pusch, however, deemed it unnecessary to present all fossil species from Poland, especially those that were indistinguishable from species found in other countries and that had already been well-illustrated and described in other works. Therefore, he limited himself to illustrating and describing only those species from the Kingdom of Poland, Podolia, and Volhynia that were still completely unknown, undescribed, misdescribed, or characteristic of selected geological formations. Ultimately, Pusch decided to present also those that were merely varieties of already known species, to avoid the growing tendency to describe new species based on every local specimen or every insignificant modification. In his opinion, this practice resulted from the selfish vanity of some researchers and collectors and was detrimental to science.

Eventually, 15 lithographed plates were prepared, depicting 185 species (in 395 engravings), of which 74 species had not yet been illustrated or were new to science. For each illustrated species, Pusch provided a diagnosis in Latin, a more detailed description, the exact location and age of formation and, where necessary, other notes. In 1833, Pusch submitted the completed manuscript containing a list of all known fossils from ten geological formations in Poland, the Northern Carpathians, Volhynia and Podolia, along with 15 plates presenting species of his choice, to the publishing house of E. Schweizerbart in Stuttgart. This happened when Pusch took up the position of intendant (i.e., technical deputy director) at the Mint of the Kingdom of Poland in Warsaw, subordinated to the Bank of Poland, as noted on the title page of the *Polens Paläontologie*.

Despite such a significant change of place of employment, Pusch continued his geological research. One of the first studies contains comments on the division of selected formations, including the division of the Triassic *Muschelkalk*, as well as a general discussion of the formations in Poland and their comparison to those in Germany (Pusch 1839). During this period, he devoted several works to palaeontological considerations, described the discovery of a crab fossil species, which he named *Astacus leucoderma* (Pusch 1838), two species of fossil deer (Pusch 1840a), and frogs and snakes from the Cretaceous of Podolia (Pusch 1842). He also dealt with the taxonomic position of the aurochs and the bison (Pusch 1840b). In addition, he prepared an extensive bibliography containing over 2,000 items from the period 1740–1830 in the field of mining, metallurgy and halurgy (Pusch 1841).

After the period of 1833–1842, during which mining was subordinated to the Bank of Poland, in 1843 the Mining Department was reactivated, subordinated to the Government Commission of Revenue and Treasury, headed by artillery colonel Ilya Schenchine. In 1843, Pusch was entrusted with developing a general plan for the economic development of mining and metallurgy, and then in 1844 he became the head of the Technical Section (Wójcik 2005).

The value of Pusch's research was appreciated by many scientific societies, including: the Mineralogical Society in Dresden (in 1818), the Pharmaceutical Society in St. Petersburg (in 1819), the Nature Research Society of Altenburg (in 1824), the Moscow Society of Naturalists (1829),

Text-fig. 5. The grave of Jerzy Bogumił [Georg Gottlieb] Pusch and his family in the Evangelical Augsburg Cemetery in Warsaw, as seen in November 2022. Photograph by B. Studencka.

the Geological Society of France and the Warsaw Society of Friends of Learning[3] (both in 1830), and the London Geological Society (in 1841), which according to Pągowski (1847, pp. 286, 287), was then the highest proof of Pusch's growing fame in the scientific world.

Georg Gottlieb Pusch, a Saxon by birth (15th of December 1790 in Sahlis near Kohren), and a Pole by choice, died on the 2nd of October 1846 in Warsaw and was buried at the Evangelical Augsburg Cemetery in Warsaw (Text-fig. 5). The bibliography of his works, both published and left in manuscripts, can be found in: Pągowski (1847, pp. 287–292), Wiślicki (1859, pp. 125, 126), Fleszarowa (1966, pp. 301–303), and Kleczkowski (1972, pp. 147, 148; 1974, pp. 100, 101). His scientific legacy consisted of several manuscripts, including a series of seven articles devoted to selected geological periods constituting

[3] In Polish *Warszawskie Towarzystwo Przyjaciół Nauk*, also known since 1808 as the *Warszawskie Królewskie Towarzystwo Przyjaciół Nauk* (Warsaw Royal Society of Friends of Learning), one of the earliest Polish scientific societies, active in Warsaw from 1800 to 1832, until its dissolution by the Russian authorities as part of the repressions after the November 1830 Uprising, also known as the Polish–Russian War of 1830–1831.

the *Neue Beiträge zur Geognosie von Polen* (Pusch 1844), whose Polish titles were provided by Pągowski (1847, pp. 291, 292) in his posthumous memoir about Pusch. Six of them (excluding the article on the salt formation) were published in the annual *Physiographic Memoirs* (*Pamiętnik Fizyograficzny*) in the years 1881–1885, translated by Bronisław Rejchman. A scientific legacy of Pusch included also a manuscript on palaeontology entitled *Allgemeine Palaeontology oder vollstandige Versleinerungskunde*, which — as Pągowski wrote (1847, p. 291) — was an extremely extensive work, sufficient for four large volumes, with lots of comparative plates and lists of all fossil species of animals and plants along with information about their age. According to Pągowski, it should have been published. Unfortunately, however, this was never done, and the further fate of the manuscript is unknown.

THE FIRST CATALOGUE OF THE POLISH MIDDLE MIOCENE FOSSILS

The greatest merits in research on the geology and palaeontology of the Kingdom of Poland in the 19th century are attributed to Georg Gottlieb Pusch, and some of his publications should be considered milestones for the geology and palaeontology of Poland. The study of the *Tertiary* mollusc fauna was one of the scientific interests of Pusch, the most prominent Polish geologist of the 19th century, widely known to European geologists of that century. Kontkiewicz (1882), Trejdosiewicz (1883), Kosiński (1884), and Michalski (1884, 1887, 1888) noted that the information given by Pusch (1836) continues to serve as the foundation stone of our knowledge of the *Tertiary* sediments. Moreover, the data published by Pusch (1836) became the basis for the search of the salt formation in the Kielce and Radom governorates. To obtain more precise scientific information, the authorities of the St. Petersburg Mining Department delegated two mining engineers, Stanisław Kontkiewicz and Aleksander Michalski, to carry out geological research under the supervision of Wincenty Stanisław Kosiński, who at that time supervised mining in the entire Kingdom of Poland (Trejdosiewicz in Kosiński 1884, p. 69). It is therefore surprising that the work of Pusch (1836), which also contains important data on the *Tertiary* fauna, was omitted by Eichwald (1840), Zejzner[4] (1856), and Hörnes (1859–1869). Similarly, in the 20th century, for some unknown reason, all of us studying the Middle Miocene overlooked the fact that Pusch (1836) had already provided such important and detailed information concerning the Middle Miocene fossils and facies from the Kingdom of Poland and Eastern Galicia.

The comprehensive chapter 14 of the second volume of the *Geognostische Beschreibung von Polen* (Pusch 1836, pp. 473–557) entitled *Die Formation des tertiären Muschelsandsteins und seiner Nebenglieder im westlichen Polen* is devoted to the *Tertiary* formations and fossils of the Kingdom of Poland together with the Grand Duchy of Kraków within the borders set by the Congress of Vienna (1814–1815) and Eastern Galicia (Podolia and Volhynia, excluding the Tarnopol district acquired by Austria). Certainly, paragraph 221 of this chapter (Pusch 1836, pp. 495–549), i.e., the list of fossils from Polish *Tertiary* deposits (*Verzeichnis der polnischen Tertiär-Petrefacten*) should be considered as the first attempt to document and estimate the diversity of fossils from sediments currently dated to the Middle Miocene.

Over ten years or so, molluscan material was steadily accumulated by Pusch himself from various fossiliferous sites during numerous expeditions in the Kingdom of Poland (Pusch 1831, pp. 1–3; Kleczkowski 1972, pp. 134–137, fig. 3). Among them, Korytnica (spelled by Pusch as *Korytnice*) located not far from Kielce, was given his special attention (Pusch 1825, 1829a, 1830b). Most, but by no means all, of the well-preserved molluscan fossils from the clay-rich sediments in Korytnica were listed: out of 50 collected species, as Pusch stated in a letter to Christian Keferstein from December 1825 (Kleczkowski 1980, pp. 121–129), he published only 35 species-level names (Pusch 1830a, p. 38). Nevertheless, Pusch (1825, 1829a, b, 1830b, c) repeatedly emphasized that Korytnica, due to the richness of molluscan species, can be considered the Polish equivalent of Grignon, a classic site in the Paris Basin, which has been of rising interest since the early days of geology (Cuvier and Brongniart 1811).

In the first decades of the 19th century, the *Tertiary* molluscan fauna of Eastern Galicia was described in the pioneering works of Eichwald (1829, 1830a, b), Andrzejowski (1830, 1832a, 1833), Pusch (1830d), and du Bois de Montpéreux (1831), while relatively little was known about fauna of the Kingdom of Poland. Indeed, except for molluscan faunas from Korytnica (Pusch 1829b, pp. 45, 46; Zeuschner 1830, p. 75), Karwów in the Opatówka valley (Pusch 1829b, p. 72),

[4] Misprint; Zejszner in Polish, also known as Zeuschner.

and Wieliczka (Lill von Lilienbach 1830, pp. 206, 208), no attempt was made to mention any other Polish fauna. The only information concerned the number of over 160 species identified by Pusch (1829a, p. 41; 1830b, p. 37), who was convinced that the impressive diversity of the molluscan fauna of Eastern Galicia was not reflected in the available literature.

Pusch performed an extensive identification- and registration-work on the fossil material collected by himself during the several-month-long geological expeditions in the years 1817–1827 to the Kingdom of Poland (Pusch 1831, pp. 1–3). His study was supplemented by a few specimens from Korytnica stored in the private collection of Ludwig Zeuschner and those kept at the Society for the Friends of Learning collections in Warsaw. When preparing the report, Pusch had access to a large collection of the *Tertiary* fauna of Podolia and Volhynia, collected mainly by Antoni Andrzejowski and Willibald von Besser, and housed at the Krzemieniec Lyceum[5], and to the private collection of Karl Lill von Lilienbach.

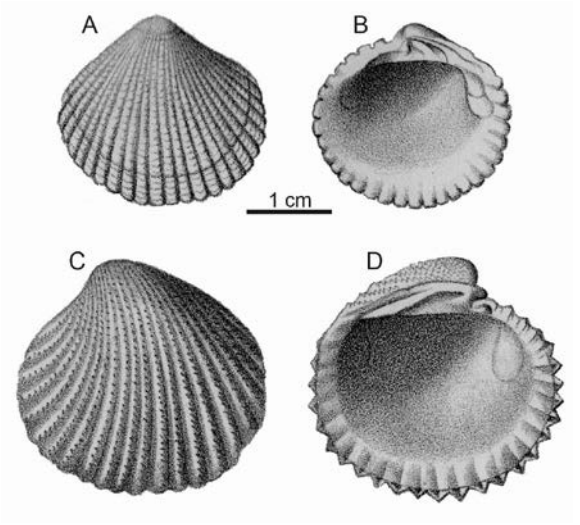
In total, 400 species-level names have been listed by Pusch (1836, pp. 495–549). Thus, the *Verzeichnis der polnischen Tertiär-Petrefacten* summarizes all accumulated information on the taxonomy, nomenclature and geographic distribution from all available collections and publications together with his own conclusions on the generic and specific synonyms of many taxa, and brief taxonomic comments on selected species described by Eichwald (1829, 1830b), Andrzejowski (1830), and du Bois de Montpéreux (1831). Out of the 137 species-level names used for bivalves (Pusch 1836, pp. 498–516), 7 species were described, and 5 of them were introduced as new: *Cardium gracile nob.* (*nova sp.*) for one specimen from Kamionka in Podolia (Transnistria, the territory of present-day Moldova; Moldavian spelling Camenca), *Astarte crassatellaeformis nob.* (*nova sp.*) for specimens from Korytnica, *Pecten nodosiformis nob. et* Serres, and two species of the genus *Venericardia* Lamarck, 1801, namely *annulata nob.* and *lima nob.* for specimens from an unknown site in Volhynia. Out of 238 species-level names used for gastropods (Pusch 1836, pp. 517–547), 8 species were described, and 5 species were introduced as new: *Ranella Korytnicensis nob.* (*nova sp.*) for a sole specimen from Korytnica, *Fasciolaria polonica nob.* (*nova sp.*) and *Buccinum mitraeformis nob.* (*nova sp.*) both for specimens from Korytnica and Warowce in Podolia (the territory of present-day Ukraine; Ukrainian spelling Varovtsi), *Trochus Andrzeiowscii nob.* (*nova sp.*) for specimens from Żukowce in Podolia (Ukrainian spelling Zhukivtsi), and *Cerithium Zeuschneri nob.* for a specimen from Korytnica. Undoubtedly, Korytnica — with two scaphopod species, 24 bivalve species and 69 gastropod species mentioned here — is a unique fossil site, which, according to Pusch, deserves the name of the Polish Grignon.

This catalogue, which contributed largely to the description and classification of the poorly known *Tertiary* fossils of this part of Europe, was submitted to the J.G. Cotta publishing house in December 1830 (Kleczkowski 1977b, pp. 60, 61). Supplemented by a brief comparison of the *Tertiary* fossils of the Kingdom of Poland, Podolia and Volhynia with those of other *Tertiary* basins and a consideration of the age of Polish *Tertiary* deposits, it was intended to be a prelude to the *Polens Paläontologie* (Pusch 1837b). According to Pusch (1836, pp. 549–557), the *Tertiary* deposits of the Podolia and Volhynia both in terms of facies and fauna composition are most like those from the 'Tertiary Piedmont Basin' in north-western Italy, albeit that the fauna also includes species known from the Paris Basin and England. On the other hand, the *Tertiary* carbonate deposits of the Kingdom of Poland in terms of faunal composition most closely resemble those of the Paris Basin, especially Grignon. From a facies point of view, the main difference between the French and Polish *Tertiary* is the lack of any *pisolithenartiger Grobkalk* (red-algal limestones) in the Paris Basin, which are very common in the Kingdom of Poland.

A CRITICAL REVIEW OF THE BIVALVE SPECIES NAMED BY PUSCH

The bivalve species introduced by Pusch (1836, 1837a) from the Middle Miocene of the Kingdom of Poland and Eastern Galicia are based almost exclusively on material collected by himself during numerous expeditions in that part of the Europe in the first half of the 19th century. As already mentioned, Pusch (1836) distinguished 5 new species of bivalves, namely *Cardium gracile*, *Astarte crassatellaeformis*, *Pecten nodosiformis*, *Venericardia annulata*, *Venericardia lima*. In the *Polens Paläontologie* published

[5] The catalogue of this collection was published by Andrzejowski (1832b) in the year when the Krzemieniec Lyceum was closed by the Russian authorities. Afterwards, under the decree of Emperor Nicholas I of Russia, the collection (including specimens donated by Pusch) was transferred to Kiev to the newly created Saint Vladimir Royal University (Garbowska 1993, p. 56).



Text-fig. 6. '*Venericardia*' *annulata* Pusch, 1836, lectotype (A, B) and '*Venericardia*' *lima* Pusch, 1836 lectotype (C, D); copied from Pusch (1837a, pl. 7, fig. 10a, b and fig. 11a, b, respectively). A – Exterior of the right valve; B – Interior of the same specimen; C – Exterior of the left valve; D – Interior of the same specimen. The specimens are from unknown localities in Volhynia, Ukraine (see Table 1).

a year later, Pusch (1837a) both re-described these 5 species mentioned above and described 3 more species introduced by himself, namely *Pecten Lilli*, *Pecten Burdigalensis* Lam., var. *Polonica*, *Mactra biangulata*.

These species are revised herein and assigned to appropriate modern genera. A brief list of synonyms is given, stating only those references — in addition to the original one — in which the material is illustrated or new combinations were provided. The type material originally illustrated in an attractive lithograph by Mr. Blödner is re-illustrated herein; the results are also summarized in Table 1.

Institutional abbreviations:

MZ – Polish Academy of Sciences, Museum of the Earth in Warsaw, Poland;
NHMWien – Natural History Museum Vienna, Austria;
ZNG PAN – Geological Museum of the Institute of the Geological Sciences, Polish Academy of Sciences, Kraków, Poland.

***annulata* Pusch, 1836 [*Venericardia*]**

'*Venericardia*' *annulata* Pusch, 1836
(Text-fig. 6A, B)

1836. *Venericardia annulata nob.*; Pusch, p. 508, no. 92.
1837a. *Venericardia annulata* m; Pusch, p. 69, pl. 7, fig. 10a, b.
1856. [*Venericardia*] *annulata*, Pusch; Zejzner [Zeuschner], p. 189, no. 380.

TYPE MATERIAL: At least two specimens, based on the different number of ribs given by Pusch (1836 and 1837a). The syntypes were irretrievably lost to science in September 1939 when the buildings of the University of Warsaw burned down during the German bombing of Warsaw (Różycki 1968, pp 24, 25).

TYPE LOCALITY: No precise indication of the locality, Volhynia, the territory of present-day western Ukraine; most probably Upper Badenian, Middle Miocene.

REMARKS: The name along with a short diagnosis: "*testa suborbicularis antiquala, costis 28 elevatis versus marginem rotundatis, costae transversim eleanter annulatae*" was introduced by Pusch (1836, p. 508) for the specimen from an unknown location in Volhynia. It is probably one of the specimens collected by Feliks Paweł Jarocki (1790–1865), professor of zoology at the Royal University of Warsaw, during his scientific expeditions to Eastern Galicia. According to Pusch (1836), this elegant species is allied to *Venericardia imbricata* (Gmelin, 1791) but is distinguished by a larger number of ribs (28 compared to 20) and more visible, rounded tubercles decorating the radial ribs. A year later, Pusch (1837a, p. 69) wrote that this almost orbicular shell (25 mm long and 26 mm high), decorated with 25 distinctly projecting, rounded ribs that are wider than the spaces between them, each of them decorated with broad, blunt tubercles, did not resemble any species of *Venericardia* Lamarck, 1801 known to him, and therefore he decided to distinguish it as a new species.

Based on the available literature, it can be stated that *Venericardia annulata* was only mentioned by Eichwald (1840, p. 6) and Zejzner [Zeuschner] (1856, p. 189), who included this species in the list of the *Tertiary* biota of Poland, containing 562 species names compiled on the sources available at that time (Zejzner [Zeuschner] 1856, pp. 169–200). Neither Eichwald (1840) nor Zejzner [Zeuschner] (1856) mentioned Pusch's work (1836), in which the name *annulata* had been introduced. On the other hand, Eichwald (1840, p. 6) in his comments to *Polens Paläontologie* by Pusch (1837a) only wrote: *"Meine* Venericardia laticosta *lässt H. Pusch als neu passiren; nicht so*

Original name	Revised name	Type locality	Illustrated by Pusch (1837a)	Original Pusch illustrations reproduced herein
Astarte crassatellaeformis Pusch, 1836	*Circomphalus foliaceolamellosus* (Dillwyn, 1817)	Korytnica	pl. 8, fig. 2a, b	Text-fig. 9A, B lectotype
Cardium gracile Pusch, 1836	*Plicatiforma gracile* (Pusch, 1836)	Kamionka	pl. 7, fig. 4a, b	Text-fig. 10A, B holotype
Mactra biangulata Pusch, 1837	*Podolimactra eichwaldi* (Laskarew, 1914)	Krzemieniec or Kamionka	pl. 8, fig. 4a, b	Text-fig. 7A, B lectotype
Pecten Burdigalensis var. Polonica Pusch, 1837	*Cristatopecten cristatus badensis* (Fontannes, 1882)	Pińczów	pl. 6, fig. 1	Text-fig. 8A lectotype
Pecten Lilli Pusch, 1837	*Pseudamussium lilli* (Pusch, 1837)	Wieliczka	pl. 5, fig. 5	Text-fig. 11A lectotype
Pecten nodosiformis Pusch et Serres in Pusch, 1836	*Gigantopecten nodosiformis* (Pusch and de Serres in Pusch, 1836)	Skotniki	pl. 5, fig. 9a, b	Text-fig. 12A, B lectotype
Pecten nodosiformis var. β Pusch et Serres in Pusch, 1836		Korytnica	pl. 5, fig. 9c	Text-fig. 12C syntype
Venericardia annulata Pusch, 1836	'*Venericardia*' *annulata* Pusch, 1836	unknown	pl. 7, fig. 10a, b	Text-fig. 6A, B lectotype
Venericardia lima Pusch, 1836	'*Venericardia*' *lima* Pusch, 1836	unknown	pl. 7, fig. 11a, b	Text-fig. 6C, D lectotype

Table 1. List of original names introduced by Pusch (1836, 1837), their present taxonomic position, type localities, data concerning their original illustrations by Pusch (1837), and reproductions in this paper.

möchte ich es aber mit seinen beiden V. annulata *und* lima *thun."* [Mr. Pusch considers my *Venericardia laticosta* to be a new species; but I would not do the same with his two *V. annulata* and *lima;* translated herein]. However, Eichwald (1840) did not provide the slightest suggestion as to what species *annulata* might belong to. Similarly, Pusch's species *annulata* was not mentioned by either Hörnes (1865) or Friedberg (1934). Therefore, the identity of *Venericardia annulata* is unclear and inaccessible, I consider it a *nomen dubium*.

***biangulata* Pusch, 1837 [*Mactra*]**

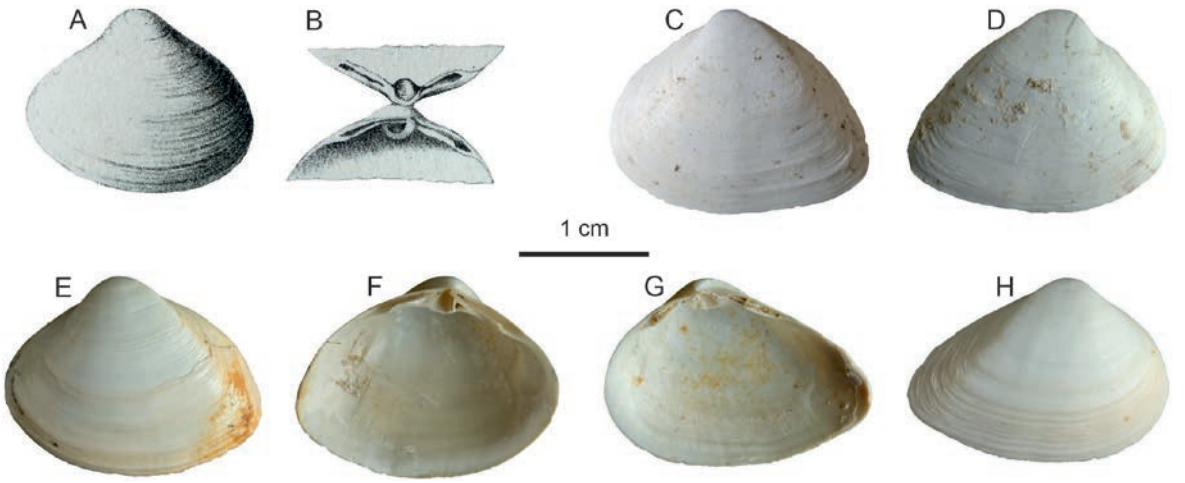
Podolimactra eichwaldi (Laskarew, 1914)
(Text-fig. 7)

1837a. *Mactra biangulata* m; Pusch, pp. 76, 77, pl. 8, fig. 4a, b.
1903. *Mactra fragilis* n. sp. var. *buglovensis* Lask.; Laskarew, pp. 84–90, pl. 4, figs 1–10.
1914. *Mactra Eichwaldi* m. (=*M. fragilis* Lask. *pridem*); Laskarew, p. 661.
1934. *Mactra podolica* Eichw.; Friedberg, pp. 31, 32 (*partim*), pl. 5, figs 7a, b, 8a, b.
1934. *Mactra podolica* Eichw. var. *buhlovensis* Lask. [sic!]; Friedberg, p. 33, pl. 7, figs 1a, b, 2a, b.
1986. *Mactra* (*Sarmatimactra*) *eichwaldi* Laskarew, 1914; Studencka, pp. 78, 79, pl. 12, figs 7a, b, 8a, b.
2023. *Podolimactra eichwaldi* (Laskarew, 1914); Signorelli, p. 840, figs 8.3–8.6.

TYPE MATERIAL: The type series was collected in Krzemieniec (50º09'64.3" N, 25º73'10.4" E) in Volhynia, the territory of present-day western Ukraine, and Kamionka (48º01'64.86" N, 28º71'81.21" E) in Podolia, the territory of present-day Moldova. As reported by Laskarew (1903, p. 84), after a thorough search, no specimens of *M. biangulata* were found in the Pusch Collection housed at that time in the Geological-Palaeontological Cabinet of the Imperial University of Warsaw (1863–1919).

TYPE LOCALITY: Not provided by Pusch (1837a); Lower Sarmatian (Volhynian), Middle Miocene.

REMARKS: According to Friedberg (1934, pp. 31, 32), Pusch's species is a junior synonym of *Mactra podolica* Eichwald, 1830 (currently *Sarmatimactra podolica*). Friedberg undoubtedly overlooked the fact that Eichwald's species *podolica* was discussed by Laskarew (1903, pp. 86–90), who, in order to clarify the status of *podolica*, presented both the Middle Sarmatian (Bessarabian) specimens from Yagorlyk in Moldova (housed in the Eichwald Collection at the St. Petersburg University, Russia) very similar to the specimen originally presented by Eichwald (1851, pl. 6, fig. 9), and specimens from Ploti near Kherson in Ukraine collected by himself (Laskarew



Text-fig. 7. *Podolimactra eichwaldi* (Laskarew, 1914). A – Exterior of left valve, lectotype; B – Interior of both valves with detail of the hinge plate; copied from Pusch (1837a, pl. 8. fig. 4a, b, as *Mactra biangulata* Pusch, 1837); C – Exterior of left valve (MZ VIII Ml 4340/1), real length 19.5 mm; D – Exterior of right valve (MZ VIII Ml 4340/2), real length 23.5 mm; E – Exterior of left valve (MZ VIII Ml 4341/1); F – Interior of the same specimen, real length 29.5 mm; G – Interior of right valve (MZ VIII Ml 4341/2); H – Exterior of the same specimen, real length 29.0 mm. The specimens come from: Krzemieniec, Ukraine or Kamionka, Moldova; Lower Sarmatian (Volhynian) (A, B), Vaskivtsi near Shumsk (C, D) and Vyzhhorodok (E–H), Ukraine; Lower Sarmatian (Volhynian). Photographs C–G by D. Nast.

1903, pl. 4, figs 11–14 and pl. 4, figs 15, 16, respectively). Moreover, Laskarew (1903, pp. 86–90) discussed the relationship of Eichwald's species *podolica* and his species *fragilis*, showing that they are two entirely separate species.

Similarly to Andrusov (1902, pp. 364, 365), Laskarew (1903, p. 88) assumed that *Mactra biangulata* described by Pusch (1837a, pp. 76, 77) was very similar, and perhaps allied identical, to the specimens he had previously named *Mactra variabilis* Sinzov var. *fragilis* (Laskarew 1897, p. 250). However, according to Laskarew, the description and drawing of *biangulata* are not sufficient; only a study of the original Pusch material could dispel these doubts. Since no specimens of *Mactra biangulata* were found in the Pusch Collection and this species should be considered lost, Laskarew (1903, p. 84) decided to introduce a new name *fragilis*, which he then (Laskarew 1914, note 1 on p. 661) replaced with the name *eichwaldi* (now accepted as *Podolimactra eichwaldi*), because the name *fragilis* had already been used by Gmelin (1791).

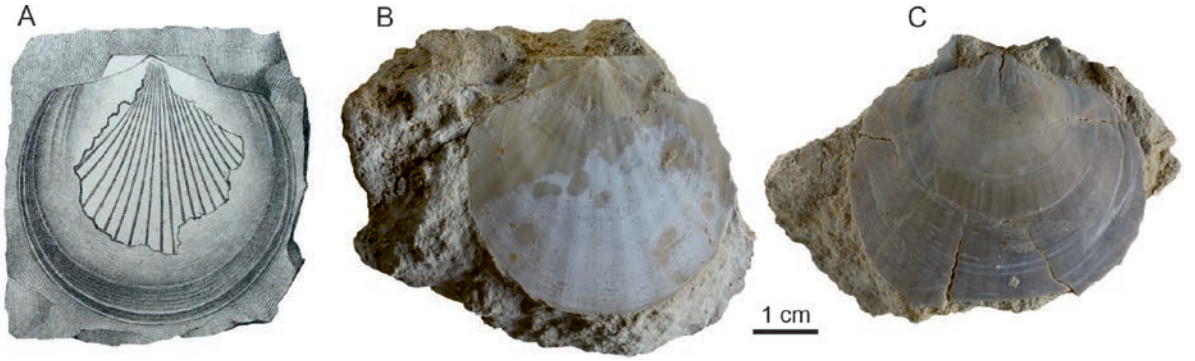
Having studied material from several Lower Sarmatian sites in Ukraine (Vaskivtsi north of Shumsk, Kunyniets near Kremenets, Vyshgorodok) I can state that they represent one species characterised by a quite variable outline of the triangular shell — from almost equilateral (Text-fig. 7C–F), similar to *biangulata* presented by Pusch (1837a, pl. 8, fig. 4a; Text-fig. 7A herein), to strongly inequilateral with the posterior margin almost twice as long as the anterior one (Text-fig. 7G, H), similar to those presented by Laskarew (1903, pl. 4, figs 2, 5, 7) and Signorelli (2023, figs. 8.3–8.6.) as *Podolimactra eichwaldi*.

However, the current statement that *fragilis* should be considered a junior synonym of *biangulata* does not change anything. The specific name *biangulata* used by Pusch (1837a) was forgotten and since its origins it has never been raised a valid status in the scientific community and should be treated as a *nomen oblitum*.

Burdigalensis **Lamarck var.** ***Polonica*** **Pusch, 1837 [*Pecten*]**

Cristatopecten cristatus badense (Fontannes, 1882)
(Text-fig. 8)

1836. *Pecten Burdigalensis Lam.*; Pusch, p. 500, no. 28.
1837a. *Pecten Burdigalensis* Lam. var. *Polonica*; Pusch, pp. 42, 43, pl. 6, fig. 1.
1882. *Pleuronectia Badensis*; Fontannes, p. 199.
1928. *Amussium cristatum* Mut. *badensis* Fontannes; Depéret and Roman, pp. 174–176, pl. 25, figs 1–6.
1936. *Amussium cristatum* Bronn mut. *badensis* Font.; Friedberg, pp. 254, 255, pl. 42, figs 10–12.



Text-fig. 8. *Cristatopecten cristatus badense* (Fontannes, 1882). A – left valve embedded in sandy limestones, lectotype; copied from Pusch (1837a, pl. 6, fig. 1 as *Pecten Burdigalensis* Lam. var. *Polonica* Pusch, 1837); B – Exterior of left valve (MZ VIII Ml 4151/1), real length 38.0 mm; C – Exterior of right valve (MZ VIII Ml 4151/2), real length 43.0 mm. Specimens come from Pińczów, Wójcza–Pińczów Ridge, Poland; Lower Badenian. Photographs B and C by D. Nast.

2001. *Amusium cristatum badense* (Fontannes, 1882); Schultz, pp. 157–161, pl. 15, fig. 13a, b.
2004. *Cristatopecten cristatus badense* (Fontannes, 1882); Bongrain and Cahuzac, p. 503.
2004. *Costellamussiopecten cristatus badense* (Fontannes, 1882); Mandic, p. 157, fig. 5.5–5.7.
2024. *Cristatopecten cristatus badense* (Fontannes, 1882); Studencka, pp. 2–4, text-figs 2, 3.

TYPE MATERIAL: Two specimens. The holotype was not designated. As reported by Friedberg (1936, p. 255), both specimens, i.e., the lectotype presented by Pusch (1837b, pl. 6, fig. 1) and the syntype which was illustrated by himself (Friedberg 1936, pl. 42, fig. 10), were still in the Pusch Collection in the 1930s. Destroyed in September 1939 (Małkowski 1948, pp. 5, 26).

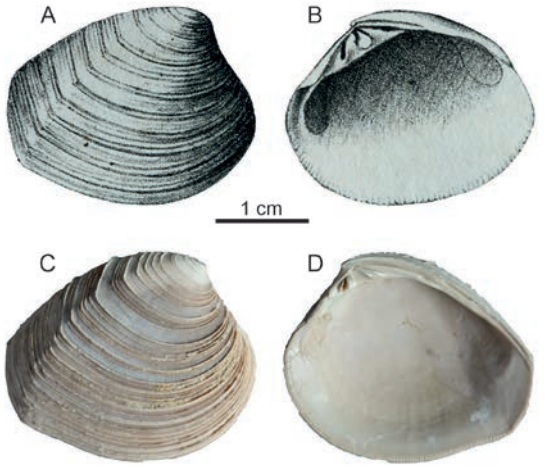
TYPE LOCALITY: Pińczów (50º53'65.4" N, 20º51'79.4" E), Wójcza–Pińczów Ridge, Central Poland; Lower Badenian, Middle Miocene.

REMARKS: The specimens collected in Pińczów, initially recognised by Pusch (1836, p. 500) as *Pecten Burdigalensis* Lamarck, 1806, were later distinguished as a variety of this species named *Polonica* (Pusch 1837a, pp. 42, 43, fig. 6, fig. 1). For incomprehensible reasons Friedberg (1936, pp. 254, 255) referred to them as *Amussium cristatum* mut. *badensis* Fontannes (1882) and illustrated under this name one of syntypes of Pusch's taxon (Friedberg 1936, pl. 42, fig. 10). As a result, the name introduced by Pusch in 1837, which took precedence over the name given by Fontannes (1882), was forgotten and since its origins it has never been raised to a valid status in the scientific community. Consequently, the name *Pecten burdigalensis* var. *polonica* Pusch, 1837 has been formally recognised as *nomen oblitum*, and the well-known *Pleuronectia badensis* Fontannes, 1882 has been considered as a *nomen protectum* (Studencka 2024).

However, some doubts remain regarding the generic affiliation of Fontannes' species *badensis*. Starting from the monograph by Depéret and Roman (1928), this species has been invariably placed in the genus *Amussium* Herrmannsen, 1846 (now invalid: unjustified amendment *Amusium* Röding, 1798) or, less frequently, in *Amusium*, as best demonstrated by the extensive list of synonyms of *Amusium cristatum badense* presented by Schultz (2001, pp. 157, 158 with references).

Bongrain and Cahuzac (2004, p. 503) were the first to recognise Fonntanes' species *badensis* as belonging not to *Amussium*, but to the genus *Cristatopecten* they had just established. Furthermore, they stated that *Amussiopecten* Sacco, 1897 can no longer be considered an independent taxon, because *Pecten burdigalensis* Lamarck, 1806 designated by Sacco (1897) as the type species of *Amussiopecten*, indeed represents *Flabellipecten* Sacco, 1897 as already pointed out by Depéret and Roman (1910).

The genus *Cristatopecten*, as originally designated, includes, in addition to its type species *Pecten* (*Amussiopecten*) *benoisti* Cossmann and Peyrot, 1914, the following taxa: *Pecten* (*Amussiopecten*) *burdigalensis* Lamarck var. *minor* Roth von Telegd, 1914, *Amussiopecten* (*Costellamussiopecten*) *praehaueri* Bongrain, Cahuzac and Freneix, 1994, *Pecten haueri* Michelotti, 1847, *Amussium miogallicum* Cossmann and Peyrot, 1914, *Amussiopecten*



Text-fig. 9. *Circomphalus foliaceolamellosus* (Dillwyn, 1817), A – Exterior of right valve, lectotype; B – Interior of the same valve; copied from Pusch [1837a, pl. 8, fig. 2a, b as *Venus* (*Astarte*) *crassatellaeformis*]; C – Exterior of right valve (MZ VIII Ml 4217); D – Interior of the same specimen, real length 36.5 mm. Specimens come from Korytnica, Poland; Lower Badenian. Photographs C and D by D. Nast.

burdigalensis Lamarck var. *spinosella* Sacco, 1897, *Pecten galloprovincialis* Matheron var. *baranensis* Almera and Bofill y Poch, 1897, *Pleuronectia badensis* Fontannes, 1882, *Amussiopecten vinassai* Ugolini, 1907, *Pecten koheni* Füchs, 1876, *Pecten spinulosus* Münster in Goldfuss, 1833, *Chlamys* (*Aequipecten*) *spinulosa* var. *attenuata* Kojumdgieva, 1960, *Pecten hosiusi* Lehmann, 1892, *Pecten duwelzi* Nyst, 1861, and *Pecten cristatus* Bronn, 1827.

The species listed above also include those characterised by thorny ornamentation of the distinct external ribs, which were previously classified by Bongrain *et al*. (1994) to a new subgenus *Costellamussiopecten* of the genus *Amussiopecten* Sacco, 1897. However, neither Fonntanes' species *badensis* of nor Bronn's species *cristatus* were assigned by Bongrain *et al*. (1994) and could not be placed in the subgenus *Costellamussiopecten* due to the completely different sculpture of the external surface: almost smooth, with very delicate growth lines in *cristatus* and decorated with 12 very weak, slightly raised, flat, wide ribs, disappearing towards the ventral margin in the case of *badensis*.

Therefore, the currently accepted name for *Pleuronectia badensis* should be *Cristatopecten cristatus badense*, and not *Costellamussiopecten cristatus badense* as proposed by Mandic (2004), who elevated the subgenus *Costellamussiopecten* Bongrain, Cahuzac and Freneix, 1994 to the rank of genus. Its placement in *Costellamussiopecten* is inappropriate because Fontannes' species *badensis* lacks the characteristic spiny ornamentation of the distinct external ribs that is diagnostic of *Costellamussiopecten*.

***crassatellaeformis* Pusch, 1836 [*Astarte*]**

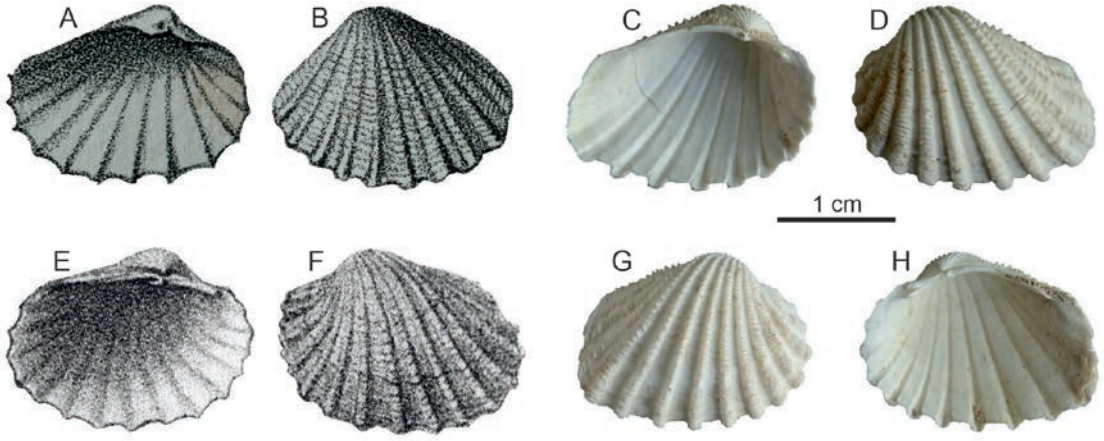
Circomphalus foliaceolamellosus (Dillwyn, 1817)
(Text-fig. 9)

1836. *Astarte crassatellaeformis, nob.* (*nova sp.*); Pusch, p. 511, no. 115.
1837a. *Venus* (*Astarte*) *crassatellaeformis* m; Pusch, p. 74, pl. 8, fig. 2a, b.
1852. *Venus subplicata* d'Orb.; d'Orbigny, p. 107, no. 1987.
1862. *Venus plicata* Gmel.; Hörnes, pp. 132–134, pl. 15, figs 4–6.
1934. *Venus* (*Chione*) *subplicata* d'Orb.; Friedberg, pp. 64, 65, pl. 10, fig. 9.
1936. *Venus* (*Circomphalus*) *plicata* Gmelin var. *subplicata* d'Orb.; Kautsky, p.10.
1974. *Circomphalus folliaceolamellosus* (Dillwyn, 1817); Malatesta, pp. 135–137, pl. 10, fig. 6, pl. 11, fig. 1a–e.

TYPE MATERIAL: Two specimens. The holotype was not designated and the lectotype was figured by Pusch (1837b, pl. 8, fig. 2a, b). Destroyed in September 1939 (Małkowski 1948, pp. 5, 26).

TYPE LOCALITY: Korytnica (50º66'12.38"N, 20º52'13.53"E), southern slopes of the Holy Cross Mountains, Central Poland, Lower Badenian, Middle Miocene.

REMARKS: The name along with a short diagnosis: "*testa transversa triangularis, latere anteriore angulato, transuersim 1–8 eostis acutis, angulatis distantibus, interstitiae subtiliter sulcata*" was introduced by Pusch (1836, p. 511) for the two specimens from Korytnica. One of them, the right valve, was illustrated a year later (Pusch 1837a, pl. 8, fig. 2a, b) as *Venus* (*Astarte*) *crassatellaeformis* m. Hörnes (1862, pp. 132–134), having at his disposal material from Korytnica (spelled by him as *Korytnice*), considered Pusch's species *crassatellaeformis* as a junior synonym of Gmelin's species *plicata*, although earlier (Hörnes 1845, p. 797) he treated it as an independent species. His synonymy list of *Venus plicata* also included *Venus subplicata* d'Orbigny, 1852 (Hörnes 1862, p. 133). Friedberg (1934, pp. 64, 65), on the other



Text-fig. 10. *Plicatiforma gracile* (Pusch, 1836), holotype, A – Interior of left valve; B – Exterior of the same specimen; copied from Pusch (1837a, pl. 7, fig. 4a, b as *Cardium gracile* Pusch, 1836); C – Interior of left valve (MZ VIII Ml 2304/2), real length 21.5 mm; D – Exterior of the same specimen; E – Exterior of left valve; F – Interior of the same specimen; copied from Eichwald (1851, pl. 4, fig. 20a, b as *Cardium plicatum* Eichwald, 1830); G – Exterior of right valve (MZ VIII Ml 2304/1), real length 19.0 mm; H – Interior of the same specimen. Specimens come from Kamionka, Moldova; Lower Sarmatian (Volhynian). Photographs C, D, G and H by D. Nast.

hand, based on his own material from Korytnica, considered *Venus crassatellaeformis* Pusch, 1837 (giving an incorrect date of its origin) to be a synonym of *Venus subplicata* d'Orbigny, 1852, although Pusch's name *crassatellaeformis* should have retained priority. Friedberg (1934, p. 65), sharing Dollfus' opinion, believed that the name *Venus plicata* Gmelin referred exclusively to the present-day species living in the Atlantic.

Based on the description and illustrations of the Korytnica specimen given by Pusch (1837a), as well as other specimens from Korytnica (stored in the Friedberg Collection under the numbers ZNG PAN A-I-73/255 and A-I-73/256), Pusch's species *crassatellaeformis* should be considered a junior synonym of *Venus foliaceolamellosa* Dillwyn, 1817 (currently *Circomphalus foliaceolamellosus*). The species is one of the rarest in Korytnica.

***gracile* Pusch, 1836 [*Cardium*]**

Plicatiforma gracile (Pusch, 1836)
[=*Cardium plicatum* Eichwald, 1830]
(Text-fig. 10)

non 1829. *G.*[*lycymeris*] *plicata* n.; Eichwald, p. 279, pl. 5, fig. 2. [= *Adacna plicata* (Eichwald, 1829) = *Cardium* (*Adacna*) *plicata* (Eichwald, 1829) = *Hypanis plicata* (Eichwald, 1829)]

1830b. [*Cardium*] *plicatum* m.; Eichwald, footnote 79 on p. 209.

1836. *Cardium gracile nob.* (*nova sp.*); Pusch, p. 507, no. 77.

1837a. *Cardium gracile* m.; Pusch, p. 66, pl. 7, fig. 4a, b.

1844. *Cardium gracile*, Pusch; d'Orbigny, pp. 472, 473, pl. 6, figs 6–8.

1851. *Card.*[*ium*] *plicatum* m.; Eichwald, pp. 61, 62, pl. 4, fig. 20.

1856. [*Cardium*] *gracile* Pusch; Zejzner [Zejszner], p. 190, no. 399.

1929. *Cardium gracile* Pusch; Kolesnikov, pp. 37–40, pl. 12, figs 293–308.

1934. *Limnocardium plicatum* Eichw.; Friedberg, pp. 143–145, pl. 23, figs 7a, b, 8.

1935. *Cardium gracile* Pusch; Kolesnikov, pp. 112, 113, pl. 16, figs 23–28.

1940. *Cardium gracile* Pusch; Simionescu and Barbu, p. 165.

1969. *Cardium* (*Cerastoderma*) *plicatum plicatum* Eichwald, 1929 [sic!]; Kojumdgieva, p. 48, pl. 16, figs 1–5.

1971a. *Cardium* (*Plicatiforma*) *plicata* (Eichwald); Paramonova, footnote on p. 248, pl. 16, figs 9–22 [as *Cardium plicatum plicatum* Eichwald].

1978. *Plicatiforma plicata* (Eichw., 1829) [sic!]; Bagdasarian, p. 36, pl. 9, figs 5–8.

2013. *Plicaliformes plicatus* (Eichwald, 1830); Nevesskaja *et al*., p. 347, fig. 125.9a, b.

TYPE MATERIAL: The only specimen. Destroyed along with other specimens from the Pusch Collection in a fire of the buildings of the University of Warsaw in September 1939, started by the German Air Force at the beginning of the Second World War (Różycki 1968, pp. 24, 25).

TYPE LOCALITY: Kamionka (48º01'64.86" N, 28º71'81.21" E) in Podolia, the territory of present-day Moldova; Lower Sarmatian (Volhynian), Middle Miocene.

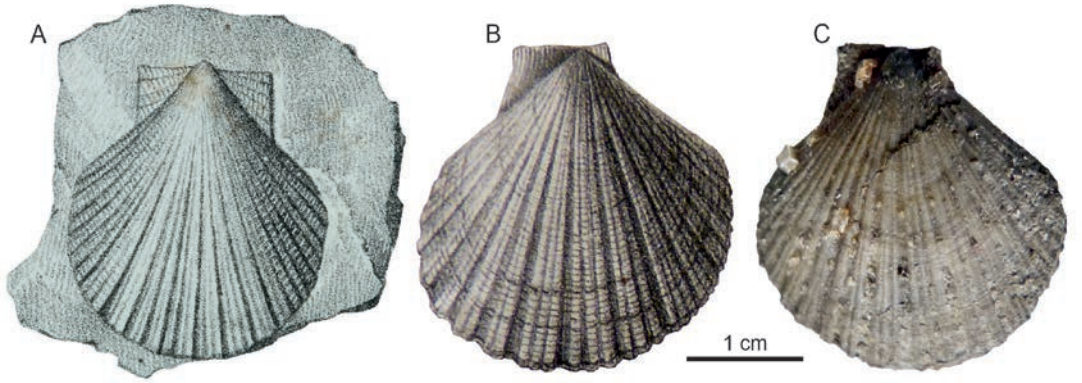
REMARKS: The name along with a short diagnosis: "*testa ovato-transversa, fragilis, latere antico truncato, costis 14 distantibus rotundatis rugosis, interstitiis glabris, margine crenato*" was introduced by Pusch (1836, p. 507). In his opinion, this charming *Cardium* specimen, which somewhat resembles *Cardium lima* Lamarck, 1805 [now accepted as *Loxocardium sublima* (d'Orbigny, 1850)] from the Eocene deposits in Grignon in France, has never been illustrated.

A year later, Pusch (1837a, p. 66) pointed out the similarity of *gracile* to Eichwald's species *plicatum*, also established on the material from Kamionka, whose diagnosis is as follows: "*testa dilatato-abbreviata, costata, costae sulcis profundioribus diremptae, squamulis tubulosis numerosis munitae*" (Eichwald 1830b, footnote 79 on p. 209). Although Eichwald's diagnosis is so imprecise and the specimen was not illustrated, Bronn (in Pusch 1837a, footnote on p. 66) nevertheless considered Pusch's species *gracile* as a synonym of Eichwald's species *plicata*, to which he gave priority. On the other hand, according to d'Orbigny (1844, pp. 472, 473, pl. 6, figs 6–8), the Bessarabian material collected by Xavier Hommaire de Hell corresponds well to the illustration and description of Pusch's species *gracile* from Kamionka in Podolia. A few years later, d'Orbigny (1852, p. 119, no. 2232) reported *gracile* at Kamionka.

Eichwald (1840, p. 5), in turn, expressed surprise, wondering why Pusch introduced the new name *gracile* for his species *plicatum*, forgetting that he had neither described nor illustrated this species, doing so only in 1851. The identity of the species *gracile* and *plicatum* was confirmed by Eichwald himself (1851, pp. 61, 62, pl. 4, fig. 20) in the *Palaeontology of Russia*, where he illustrated *Cardium plicatum* for the first time. However, the very insufficient diagnosis and the lack of a detailed description and illustration of *plicatum* by Eichwald (1830b) led Kolesnikov (1929, p. 12, figs 293–308) to consider the name *gracile* as valid name for this species. His opinion was confirmed by Davitashvili (1932, pp. 23, 24, pl. 7, figs 7–9), who a year later (Davitashvili 1933, p. 68) assigned another Eichwald's species, *Adacna plicata* (originally wrongly included in the genus *Glycymeris* da Costa, 1778), to the genus *Cardium* Linnæus, 1758, and thus *Cardium plicatum* Eichwald, 1830 became a secondary homonym of *Cardium plicata* (Eichwald, 1829). Acceptance of Kolesnikov's (1929) opinion regarding the taxonomic position of *gracile*, maintained by him later (Kolesnikov 1935), would have prevented many misunderstandings concerning Eichwald's species *plicatum*. Contrary to Kolesnikov (1929) and Davitashvili (1932), Friedberg (1934, pp. 143–145) confirmed Bronn's opinion regarding the status of *Cardium gracile* as a junior synonym of *Cardium plicatum* Eichwald, 1830. On the other hand, Simionescu and Barbu (1940, p. 165) confirmed Kolesnikov's decision regarding Pusch's species *gracile*.

Kolesnikov (1948, p. 20) established three informal sections among the Sarmatian representatives of *Cardium*, named *Obsoletiformes*, *Plicatiformes* and *Protractiformes*, and designated *Cardium gracile* Pusch = *Cardium plicatum* Eichwald as the type species for *Plicatiformes*. Twenty years later, Kojumdgieva (1969) distinguished all three sections established by Kolesnikov (1948) as informal groups within the genus *Cerastoderma* Poli, 1795 and added one more — *Inaequicostates* — with the type species *Cardium suessi* Barbot de Marny, 1869. Kojumdgieva (1969, p. 47) also wrote that a type species for the *Plicatiformes* group, according to the original designation by Kolesnikov (1948), is *Cardium gracile* Pusch, 1831 (=*Cardium plicatum* Eichwald, 1829). While the year 1831 given for Pusch's species *gracile* is merely a printing error, the year 1829 for the species Eichwald *plicatum* refers to a completely different taxon, which is currently a type species of the genus *Hypanis* Ménétries, 1832. This is not a typographical error made by Kojumdgieva (1969), who included Eichwald's 1829 work in her synonymy list of *Cerastoderma plicata*. The same record, i.e., *Cardium gracile* Pusch, 1831 [=*Cerastoderma plicatum* (Eichwald, 1829)] was repeated by Paramonova (1971a, p. 147) who established an informal section with the name *Plicatiformes* distinguished by Kolesnikov (1948) as the subgenus *Plicatiforma* within the genus *Cerastoderma*, and by Bagdasarian (1978, p. 36) who, following Popov (1977, p. 73), recognized *Plicatiforma* as a separate genus. The same mistake regarding the year of description of Eichwald's species *plicatum* was repeated by Studencka (1986, p. 77) and Kojumdgieva (1987, p. 5).

According to Vokes (1980, pp. 244, 245) the names of sections — *Obsoletiformes*, *Plicatiformes*, and



Text-fig. 11. *Pseudamussium lilli* (Pusch, 1837), lectotype. A – Exterior of left valve embedded in clays; copied from Pusch (1837a, pl. 5, fig. 5 as *Pecten Lilli* Pusch, 1837); B – Exterior of left valve; photograph of the engraving kept in the collections of the NHM in Vienna, published in Reuss (1867, pl. 6, fig. 5a as *Pecten scabridus* Eichwald, 1830); C – Exterior of the same specimen, one of the three syntypes (NHMWien 1867/VII/83), real length 24.0 mm. The specimens are from Wieliczka, Poland; Lower Badenian. Photographs B and C by B. Studencka.

Protractiformes — used by Kolesnikov (1948) to separate Sarmatian representatives of the genus *Cardium* Linnæus, 1758 are invalid and colloquial (*vernacular name*), and therefore do not meet the requirements of Article 11.8 of the ICZN. The correct names — *Plicatiforma* and *Obsoletiforma* — were introduced by Paramonova (1971b) and assigned to new subgenera of the genus *Cerastoderma*, and the authorship should be attributed to her (compare Paramonova 1994, pp. 100–107). Therefore, it is incomprehensible to consider Kojumdgieva's names as valid, as was done by Nevesskaja *et al*. (2001, *S*179–*S*180), especially since Kojumdgieva (1987) recognised Paramonova's authorship of *Plicatiforma* and *Obsoletiforma*, but, like her, repeated the error regarding the identity of *Cardium gracile* Pusch, 1831 with *Cardium plicatum* Eichwald, 1829.

I believe that retaining the name *gracile* for this species, as proposed by Kolesnikov (1929), is fully justified and should help avoiding further confusion regarding *plicatum*. The latter was expressed by Hylleberg (2004, p. 701) who included *Limnocardium plicatum* described by Friedberg (1934, pp. 143–145) and *Plicatiforma plicata* mentioned by Popov (1977, p. 73) in his list of synonyms of *Hypanis plicata* (Eichwald, 1829), one of the living representatives of the subfamily Lymnocardiinae Stoliczka, 1870.

***Lilli* Pusch, 1837 [*Pecten*]**

Pseudamussium lilli (Pusch, 1837)
(Text-fig. 11)

1837a. *Pecten Lilli* m; Pusch, pp. 40, 41, pl. 5, fig. 5.
1856. [*Pecten*] *Lilli* Pusch; Zejzner [Zeuschner], p. 193, no. 439.
1867. *Pecten scabridus* Eichw.; Reuss, pp. 140–143 (*partim*), pl. 6, figs 5–7.
1882. *Pecten Lilli* Pusch; Hilber, p. 23, pl. 2, figs 29, 30.
1936. *Chlamys* (*Flexopecten*) *Lilli* Pusch. *et* var.; Friedberg, pp. 241–244, pl. 40, figs 11–17.
1945. *Pecten* (*Pallium*) *lilli* Pusch, 1837; Glibert, pp. 73–77, pl. 5, fig. 1a–j.
1965. *Pseudamussium* (*Zygochlamys*) *lilli* (Pusch, 1837); Glibert and Van de Poel, p. 36.
1999. *Pseudamussium lilli* (Pusch, 1837); Marquet and Dijkstra, pp. 49, 50, pl. 2, fig. 2.
2001. *Flexopecten lilli* (Pusch, 1837); Schultz, pp. 212, 213, pl. 19, figs 1, 2a, b.

TYPE MATERIAL: Two specimens. The holotype was not designated. According to Friedberg (1932, pp. 57, 58), despite extensive searches, neither of the two specimens was found in the Pusch Collection, which since 1915 had been housed in the Museum of the Faculty of Geology and Palaeontology of the restored University of Warsaw, headed by Adam Łuniewski in the years 1923–1939. They should be considered lost.

TYPE LOCALITY: Wieliczka (49º98'40.4"N, 20º06'02.6"E), southern Poland; Lower Badenian, Middle Miocene.

REMARKS: According to Hilber (1882, p. 23), specimens of *Pecten lilli* from Wieliczka were incorrectly identified and illustrated by Reuss (1867, pl. 6, figs 5–7) as *Pecten scabridus* Eichwald, 1830. This opinion was confirmed by Friedberg (1936, p. 242,

pl. 40, figs 11–13), who, having access to the Reuss Collection (housed in the Natural History Museum Vienna, Austria), illustrated all three specimens under the name *Chlamys* (*Flexopecten*) *Lilli*. The above specimens are probably the only specimens from the type locality of Pusch's species *lilli* available for study. The original material from Wieliczka described and illustrated by Pusch (1837a, pp. 40, 41, pl. 5, fig. 5) had not been discovered by Friedberg in the Pusch Collection as early as the 1920s and was probably lost (Friedberg 1932, pp. 57, 58), whilst Friedberg's own material from Wieliczka (ZNG PAN A-I-73/1079) consists of small fragments of a few valves of this species. For almost a century, no specimens have been collected in Wieliczka, nor are there any in the collections of the Kraków Saltworks Museum in Wieliczka.

Currently, Pusch' species *lilli* is placed in *Pseudamussium* Mörch, 1853, although some researchers (e.g., Waller 2006, p. 19) assigned this species to *Karnekampia* Wagner, 1988, even though Wagner himself did not do so. Waller (2006) justified his position on the assignment of the species Pusch's *lilli* to *Karnekampia* with data presented by Roger (1939, p. 214), written as follows: "*Ch. septemradiata* se trouve déjà dans le Tortonien à faciès de Tegel du Bassin de Vienne (Baden)." Based on these data, Waller concluded that representatives of *Pseudamussium* are not known in the pre-Tortonian fossil record. In fact, Roger even reported that in the Vienna Basin, specimens of *Chlamys septemradiata* (Müller, 1776) (= *Ostrea peslutrae* Linnæus, 1771, see Dijkstra 1999, pp. 388, 427, 428, fig. 7E, F), a type species of *Pseudamussium*, were found at a site in Baden in clayey deposits that were then dated to the Tortonian. However, the sediments in which specimens of *septemradiata* were found (the so-called *Tegel von Baden*) are now dated to the Early Badenian (Langhian of the Mediterranean) (Rögl *et al*. 2008), which means that *Pseudamussium peslutrae* in the Vienna Basin co-occurred with Pusch's species *lilli*, an extremely variable species with many subspecies and synonyms, known both in the Middle Miocene of Central Paratethys (Studencka 1986, 2025b; Schultz 2001 and references therein) and the North Sea Basin (Glibert 1945; Glibert and Van de Poel 1967; Marquet and Dijkstra 1999 and references therein). Furthermore, Marquet and Dijkstra (1999), as well as Dijkstra and Kilburn (2001) found that *Karnekampia* shows morphological characters identical to *Pseudamussium* and should therefore be considered its junior synonym. This was made even more explicit by Dijkstra and Gouda (2002, p. 53), who stated the following "*Pseudamussium* and *Karnekampia* are similar in shape (both are subcircular to oblong and slightly equilateral), have compressed valves with primary radial plicae or costae and delicate radial ridges and/or striae, and an antimarginal microsculpture. The auricles are unequal in size, and the byssal notch is shallow. Therefore, *Karnekampia* is placed in the synonymy of *Pseudamussium*." Moreover, Dijkstra and Goud (2002, p. 53) pointed out that Wagner (1988, p. 42) compared the newly established genus *Karnekampia* exclusively with *Chlamys* Röding, 1798 and *Manupecten* Monterosato, 1889, belonging to the subfamily Chlamydinae von Teppner, 1922, but omitted *Pseudamussium*, a genus of the subfamily Pectininae Rafinesque, 1815 (see Waller 1993). Ultimately, I agree with the decision of Marquet and Dijkstra (1999), Dijkstra and Kilburn (2001), and Dijkstra and Goud (2002) that the genus *Pseudamussium* is indeed a senior synonym of the genus *Karnekampia*, and I believe Pusch's species *lilli* is a species of *Pseudamussium*.

***lima* Pusch, 1836 [*Venericardia*]**

"*Venericardia*" *lima* Pusch, 1836
(Text-fig. 6C, D)

1836. *Venericardia lima nob.*; Pusch, p. 508, no. 91.
1837a. *Venericardia lima* m; Pusch, p. 69, pl. 7, fig. 11a, b.
1856. [*Venericardia*] *lima,* Pusch; Zejzner [Zeuschner], p. 189, no. 391.

TYPE MATERIAL: At least two specimens. The holotype was not designated and the lectotype was presented by Pusch (1837b, pl. 7, fig. 11a, b). The material was destroyed in September 1939 (Małkowski 1948, pp. 5, 26).

TYPE LOCALITY: "Stammt mit der vorigen aus *Volhynien*. Fundort ungewiss" [It comes from Volhynia, just like *Venericardia annulata*. Location uncertain (translated herein)] (Pusch 1836, p. 508). No precise indication of the locality, Volhynia, present-day western Ukraine; most probably Upper Badenian.

REMARKS: The name along with a short diagnosis: "*Testa subcordata, costis 28–30 elevatis acutissimus*" had already been provided by Pusch (1836, p. 508). According to Pusch (1837a, p. 69), this species, similar in outline to *Venericardia annulata* but slightly larger, resembles *Venericardia carinata*

Sowerby, 1819 (p. 106, pl. 259, fig. 2), which, however, has only 20 nearly smooth corrugated ribs. Moreover, according to Pusch, it also resembles *Cardita imbricatus* from Sowerby (1820, pl. 116, fig. 4), in which, however, both beaks are more visible, and the two main teeth are more erect than in the Volhynian specimens. However, it is difficult to see any similarity between Pusch's *lima* and Sowerby's species *carinata*. A slightly greater similarity can be observed between the Pusch's *lima* and *Venericardia imbricata* (Gmelin, 1791), the species common in the Eocene of the Paris Basin. The name *biangulata* introduced by Pusch should be treated as a *nomen dubium*.

***nodosiformis* Pusch et Serres, 1836 [*Pecten*]**

Gigantopecten nodosiformis
(Pusch and de Serres in Pusch, 1836)
(Text-fig. 12)

1836. *Pecten nodosiformis nob.* et Serres.; Pusch, pp. 500, 501, no. 28.
1837a. *Pecten nodosiformis* M. de Serres; Pusch, p. 42, pl. 5, figs 9a–c.
1867. *Pecten latissimus* (Brocchi, 1814); Hörnes, pp. 395–397, pl. 56, figs 1–4, pl. 57, figs 1–4.
1870. *Chlamys latissimus* Defrance [sic!]; Roemer, pp. 396, 397, pl. 46, figs 1–3.
1905. *P.* [*ecten*] *Melii* Ugol.; Ugolini, p. 117.
1906. *Chlamys* (*Flexopecten*) *sardous*; Ugolini, pp. 180, 181, pl. 10, fig. 5, pl. 12, fig. 1.
1906. *Chlamys* (*Lyropecten*) *nodosiformis* Serr.; Ugolini, pp. 184–186, pl. 10, figs 7a–c.
1928. *Pecten* (*Oopecten*) *latissimus* Brocch. var. *austriaca* nov. var.; Kautsky, pp. 246, 252, 253.
1936. *Pecten* (*Grandipecten*) *latissimus* Brocc.; Friedberg, pp. 215–217, pl. 35, fig. 1, pl. 36, figs 1, 2.
1965. *Oopecten* (*Gigantopecten*) *latissimus nodosiformis* (De Serres in Pusch, 1837); Glibert and van de Poel, p. 17.
1987. *Gigantopecten latissima nodosiformis* (Serres in Pusch); Freneix *et al*., p. 31.
1992. *Gigantopecten nodosiformis* (Pusch); Bongrain, p. 83, fig. 1.B1.
2004. *Macrochlamis nodosiformis* (de Serres in Pusch, 1837); Mandic, pp. 141, 142, fig. 6.1, 6.2.
2025a. *Gigantopecten nodosiformis* (Pusch and de Serres in Pusch, 1836); Studencka, pp. 8–20, text-figs 4–10.

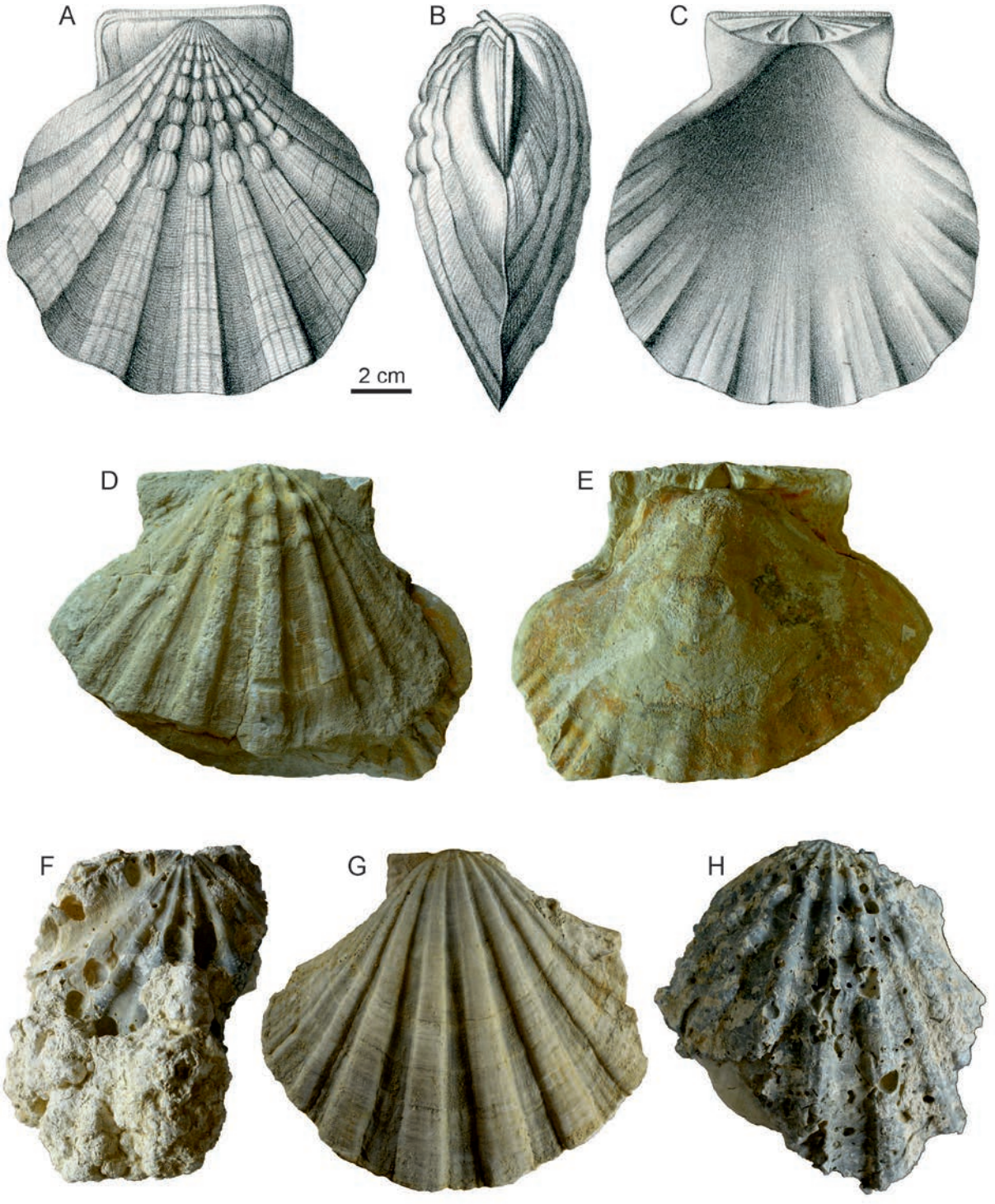
TYPE MATERIAL: The type series was collected in Skotniki, Kików near Stopnica and Widuchowa near Busko (Pusch 1836, p. 500). The holotype was not designated. The type series seems to have included at least 7 specimens (Pusch 1836, pp. 500, 501; 1837, p. 42), one of them illustrated by Pusch (1837a, pl. 5, fig. 9a, b) was designated by Švagrovský (1981, p. 58) as the lectotype. Currently, only an overcast of the first plaster cast of the lectotype of *G. nodosiformis* is available (see Studencka 2025a, text-fig. 5C, D). It is housed in the Type Collection of the Faculty of Geosciences, Université Claude Bernard, Lyon, France under inventory number UCBL-FSL 29270. As reported by Friedberg (1936, p. 217) in the early 1930s, there was only one small syntype remaining in the Pusch Collection at that time. It should be considered lost.

TYPE LOCALITY: Skotniki (50º25'30.24" N, 20º39'17.49" E), Wójcza–Pińczów Ridge, Central Poland; Lower Badenian, Middle Miocene.

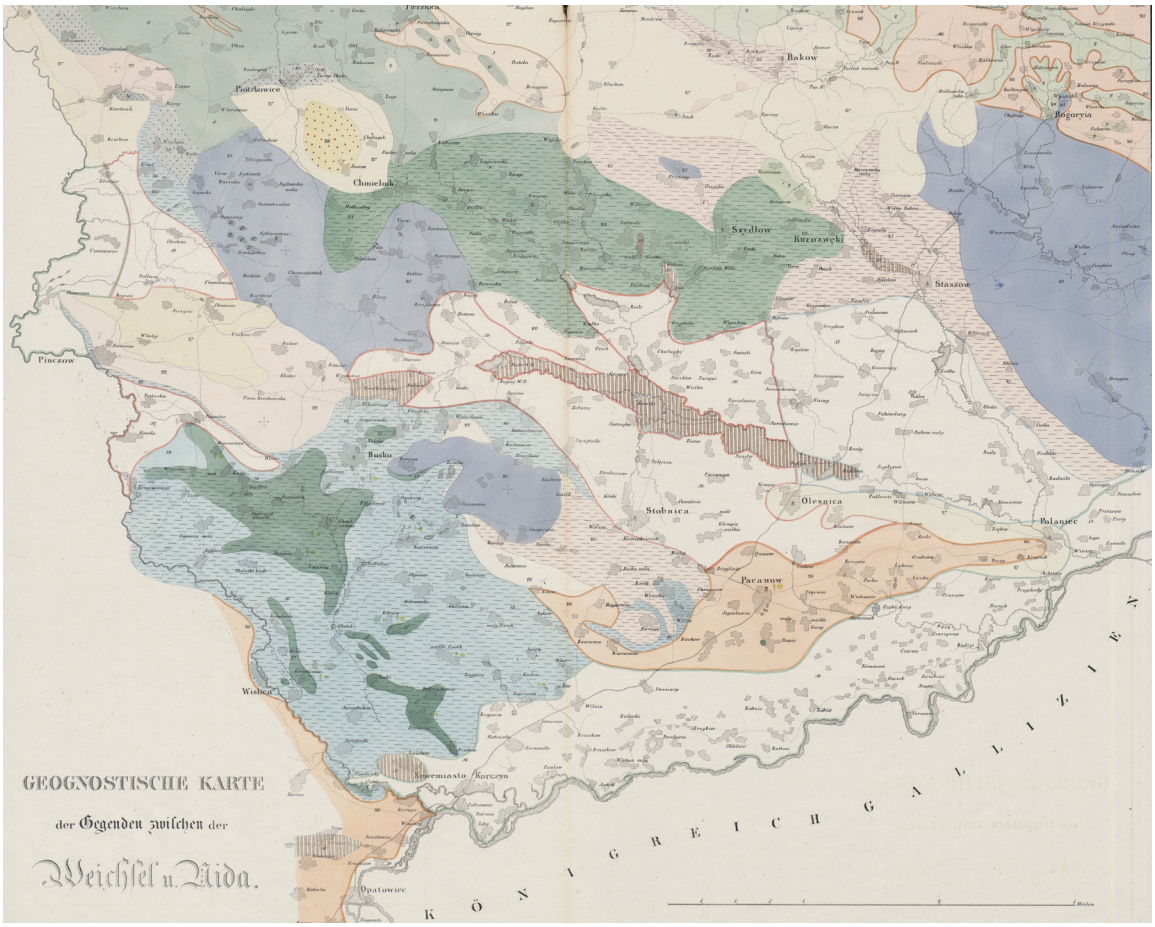
REMARKS: The name along with a short diagnosis: "*Testa ovato-subrotunda, aequivalvis, transversim subtilissime undulatim striata, radiis novem vel decem crassis, latis longitudinaliter sulcatis, in parte superiori nodoso vesicularibus, interstitiis longitudinaliter plicatis, auriculis aequalibus perpendiculariter rugosis*" had already been provided by Pusch (1836, p. 500). Roemer (1870, pp. 396, 397) and Friedberg (1936, pp. 215–217), following Hörnes (1867, pp. 395–397), considered *nodosiformis* to be a synonym of the species *latissimus* Brocchi, 1814. Furthermore, Friedberg placed *latissima* in the subgenus *Grandipecten* Cossmann and Peyrot, 1914, although Cossmann (1920) considered *Grandipecten* to be an unnecessary replacement name for *Macrochlamys* Sacco, 1897, since Rovereto had already done so in 1899, when he introduced the name *Gigantopecten*. Currently accepted name of *Pecten nodosiformis* is *Gigantopecten nodosiformis*. For detailed information, see Studencka (2025a).

THE FIRST CONTRIBUTION TO THE KNOWLEDGE OF RHODOLITH-BEARING DEPOSITS FROM POLAND

For the first time, information on the Middle Miocene carbonate deposits of the Kingdom of Poland was presented by Pusch at the meeting of the Association of German Naturalists and Physicians on September 18th, 1828, in Berlin. Two sets forming this series named *sandiger Grobkalk* and *pisolithenartiger Grobkalk* were briefly described (Pusch 1829a) and distinguished as lithological units marked on the map



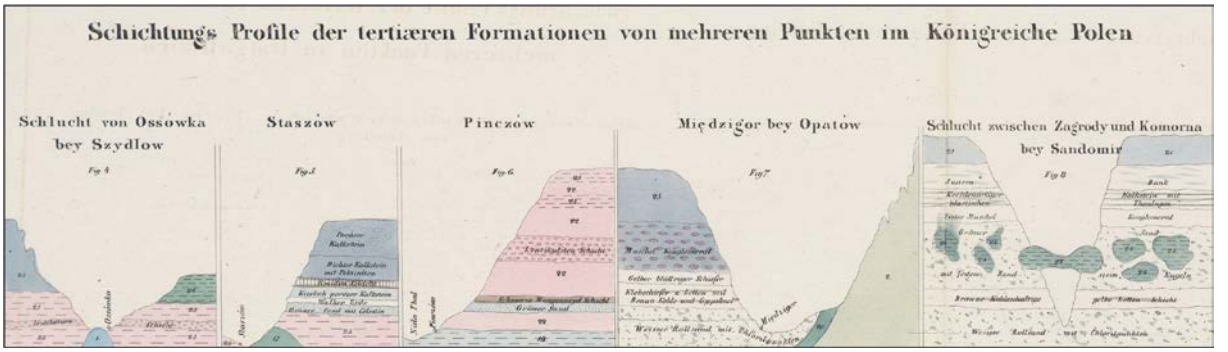
Text-fig. 12. *Gigantopecten nodosiformis* (Pusch and de Serres in Pusch, 1836). A – Articulated shell viewed from the left valve, lectotype, Skotniki; B – Lateral view of the same specimen, viewed from the posterior side; C – Interior of the right valve, Korytnica, specimen collected by Ludwig Zeuschner (A–C copied from Pusch 1837a, pl. 5, fig. 9a–c as *Pecten nodosiformis* de Serres); D – Exterior of left valve of the internal mould of shell missing a fragment of the ventral disc portion (MZ VIII Ml 4042), real length 143.0 mm; E – The same internal mould viewed from the right valve; F – Fragment of right valve (MZ VIII Ml 718/2), partly encrusted with coralline algae and traces of *Gastrochaenolites* isp., real length 71.0 mm. G – Exterior of right valve missing the posterior ear (MZ VIII Ml 718/1), real length 123.0 mm; real height 105.0 mm; H – Fragment of left valve (MZ VIII Ml 718/3), heavily bored, real length 75.0 mm. The specimens come from Skotniki (A, B), and Korytnica (C–H), Poland; Lower Badenian. Photographs by D. Nast.



Text-fig. 13. Geological map created by Georg Gottlieb Pusch titled *Geognostische Karte der Gegenden zwischen der Weichsel u. Nida* (hand-coloured lithography, J.G. Cotta, Stuttgart and Tübingen) showing the area between the Vistula and the Nida rivers, southern part of the Kingdom of Poland (original size of sheet 74 × 63 cm). Original on a scale of 1: 176 000. The first detailed map of this area, prepared in 1826 (see Kleczkowski 1980) and submitted for printing in September 1828, was published in 1837 (Pusch 1837b, pl. 5). Selective subdivision: 17 (grey-greenish, horizontal dense dashes) – Cretaceous gypsum; 22 (pale pink) – *Tertiary sandiger Grobkalk* (sandy limestones); 23 (pale pink, horizontal dashes) –*Tertiary pisolithenartiger Grobkalk* (coralline algal limestones); 24 (greenish, horizontal dashes) – *Tertiary* shelly sandstones and sand; 25 (grey-bluish) – *Tertiary* shelly conglomerate. From the collections of the Library of the Polish Geological Institute-National Research Institute, Warszawa, Poland.

of the Kingdom of Poland and Eastern Galicia with numbers 22 and 23, respectively, which were also used on a detailed map of the area between the Vistula and Nida rivers (Text-fig. 13) and profiles of the *Tertiary* strata of the Kingdom of Poland (Text-fig. 14) and Eastern Galicia (Text-fig. 15). However, supplementing the text on *Tertiary* sediments, Pusch (1836, footnote on p. 552) stated that these divisions used on the maps drawn by him in 1826 were insufficient.

According to Pusch (1829a, b, 1830b, c), the first set of Middle Miocene carbonates, represented by sandy limestones (*sandiger Grobkalk*) occasionally passing into sandstones, is characterised by an unusual palaeontological content, including bivalves and gastropods. The second set consists of very specific limestones with no sand admixture. Both the German *pisolithenartiger Grobkalk* or *Pisoliten-Kalkstein* and the Polish *grubo-wapień grochowcowy* names of these limestones derive from their dominant components, which are pea-sized grains or the size of a broad bean with a lumpy surface, entirely different from typical oolite limestones. As originally described by Pusch, these grains are mainly fragments of skeleton remains of the species *Nullipora byssoides* Lamarck, 1801 and *Nullipora racemosa* Goldfuss, 1826, which at that time were commonly considered representatives of



Text-fig. 14. The first ever drawings of the lithological sections of five selected *Tertiary* (now Middle Miocene) natural exposures from the territory of the Kingdom of Poland. For explanations of *Tertiary* units see Text-fig. 13. Copied from the *Geognostische Atlas von Polen* (Pusch 1837b, pl. 6, figs 4–8). From the collections of the Library of the Polish Geological Institute-National Research Institute, Warszawa, Poland. Descriptions of the first three exposures (from the left), i.e., a ravine in Ossówka near Szydłów, the left slope of the valley near Staszów, and the Castle hill in Pińczów were published in the *Geognostische Beschreibung von Polen* (Pusch 1836, pp. 458–460). Descriptions of the next two exposures, i.e., Międzygórze near Opatów and the ravine between Zagroda and Komorna near Sandomierz were published in the abridged Polish version of *Geognostische Beschreibung von Polen* published in the weekly magazine *Sławianin* (Pusch 1829b, p. 70; the first as Karwów SE from Opatów or the Kadłubek spring).

corals (in the then Polish language: *zwierzokrzewy*[6]). Moreover, Pusch believed that these two species of the genus *Nullipora* Lamarck, 1801[7] produce peculiar spherical nodules with the diameter of a billiard ball that may be scattered in limestones or form locally dense accumulations.

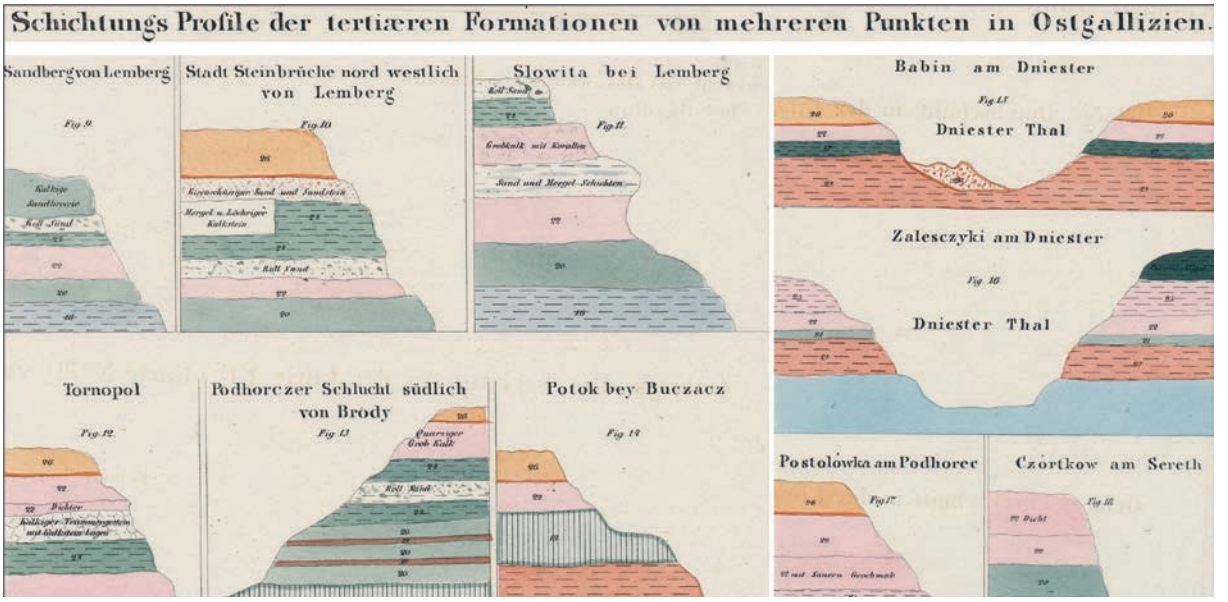
The latter was observed by Pusch in the summer of 1817 in Raków and Skotniki Quarry[8]. In his opinion, what deserved special attention was the mass occurrence in Skotniki quarry of these peculiar nodules resembling an earth embankment with cannon and rifle balls embedded in them. This comparison may seem quite unusual nowadays, but four years before visiting the Skotniki Quarry, Pusch had fought as a volunteer in the Saxon pioneer troops alongside the Napoleonic army. At the same time, he conducted geological observations in the Mainz Basin (Kleczkowski 1970, p. 104).

The accumulations of these nullipora nodules densely embedded in loose marls form a specific type of *pisolithenartiger Grobkalk*, distinguished by Pusch as *kugelig abgesonderter mürber Grobkalk*. A fairly detailed description of the latter facies, presently known as the rhodolith pavement (see Studencki 1988, pp. 4, 5; 1999, pp. 397, 398) was presented in the Polish version of the *Geognostische Beschreibung von Polen* originally published in episodes of the weekly magazine *Sławianin* (Pusch 1829b, pp. 42, 43), translated by Adam Maksymilian Kitajewski, professor of chemistry at the Royal University of Warsaw and publisher of that Polish cultural magazine, and again as a separate edition (Pusch 1830b), preceded by an introduction by Pusch, published on the occasion of Alexander von Humboldt's visit to Warsaw on the 30th of June 1830. A slightly abbreviated French version of

[6] The term *zwierzokrzewy* (Zoophyta) was introduced into Polish literature by Jan Krzysztof Kluk (1739–1796) in a textbook for national schools entitled *Zoologia* (Zoology), written in the years 1785–1789 on behalf of the Society of Elementary Books, and then, after being edited by Paweł Czenpiński (1755–1793), published in 1789 under the title *Zoologia, czyli zwierzętopismo* (Zoology, or Literature on Animals), without giving the name of the author. According to the taxonomic system used in this book, *Zwierzokrzewy* (Zoophyta) constitute one of three orders within the class *Robaki* (Vermes). Their characteristics are described on pp. 86–90, and its representatives are illustrated on pl. 3, figs 3–6 and 19.

[7] The genus *Nullipora* Lamarck, 1801 is now regarded as a *nomen ambiguum repudiandum*. In Pusch's time, however, the name *Nullipora* was considered a *valid name*. Currently, the accepted taxon for *Nullipora* Lamarck, 1801 is *Phymatolithon* Foslie, 1898. For more information, see the entry on *Phymatolithon* in the AlgaeBase database

[8] "*Po największej części ziarna te mają wielkość grochu i bobu, i niemal w massie skały pozrastane, wszakże trafiają się miéjscami takiej wielkości że 2 do 3 cali mają średnicy, i mieszczą się tuż przy sobie i nad sobą w massie wapiennéj mało co rzadszej, z której łatwo wykruszają się i wypadają. Ten osobliwy kamień wyraźniej odznacza się szczególniéj pod Rakowem. Liczne postrzeżenia przekonały mnie, że wszystkie te grochowcowe ziarna i gałki, ze zwiérzo-krzewów, a szczególniéj od rodzaju* Nullipora Lamarkii *pochodzą, a przynajmniej nié ma zapewne wątpliwości, że nérkowate wielkie gałki z pod Rakowa, od* Nullipora byssoides *Lam. i* racemosa *Goldf. wiodą swój początek, które stworzenia są, jak wiadomo, takiémi ciałami koralowemi, co już za życia same przez się na wapno się zamieniają. Na innych stanowiskach kamień ten jest w kształcie odosobnionych regularnych kul, a ściana skały z takich kamieni składająca się, wygląda jak gdyby miękka jaka massa, gęsto samemi armatniemi i karabinowemi kulmi wysadzona była. To widziéć można było przed kilka laty w łomach pod Skotnikami niedaleko Buska, w sposobie godnym wielkiego zastanowienia*" [Pusch 1829b (*Sławianin* no. 29), pp. 42, 43; 1830b, p. 35].



Text-fig. 15. The first ever drawings of the lithological sections of ten selected *Tertiary* (now Middle Miocene) natural exposures from the territory of Eastern Galicia. For explanations of *Tertiary* units see Text-fig. 13. Copied from the *Geognostische Atlas von Polen* (Pusch 1837b, pl. 6, figs 9–18). From the collections of the Library of the Polish Geological Institute-National Research Institute, Warszawa, Poland. Descriptions of the outcrops, apart from the stream slopes near Buczacz [Potok bey Buczacz; Buchach in Ukrainian] (fig. 14), were published in the *Geognostische Beschreibung von Polen* (Pusch 1836, pp. 441–463), while the description of Slowita near Lviv [bei Lemberg] was first published in its abridged Polish version in the weekly *Sławianin* (Pusch 1829b, p. 70). Moreover, Pusch (1836, pp. 458–463), based on information obtained from Professor Feliks Jarocki, presented a detailed description of a natural outcrop in Krzemieniec [Kremenets in Ukrainian], currently dated to the Lower Sarmatian.

the text published in the *Sławianin*, translated by Ami Boué, which issued in 1830, also contained the description of this peculiar facies (Pusch 1830c, p. 240).

Also, in his main work *Geognostische Beschreibung von Polen*, Pusch (1836, p. 455) again stated that the two-to-three-inch large coral nodules from Raków owe their perfect shape to *Nullipora byssoides* and *Nullipora racemosa*, but he did not provide a detailed description of them. Therefore, Eichwald (1853, p. 42), when examining specimens from Raków and the vicinity of Szydłów, concluded that the producer of such nodules was most likely *Nullipora ramosissima* Reuss, 1847, and not as suggested by Pusch *Nullipora racemosa*, a species created by Goldfuss (1826, p. 21, p. 8, fig. 2) based on Cretaceous specimens from Maastricht.

It should be noted that prior to the research by Philippi (1837), who established the genus *Lithothamnium* for the rigid limestone plant, the genus *Nullipora* Lamarck, 1801 was considered an animal. Among the five species upon which *Philippi* based the genus *Lithothamnium* was *Nullipora byssoides*. The currently accepted name of *Lithothamnium byssoides* (Lamarck) Philippi, 1837 is *Lithophyllum byssoides* (Lamarck) Foslie, 1900. However, even later, many researchers used the name *Nullipora* when introducing a new species of coralline algae. Among them was Reuss (1847) who described common fossils from Miocene limestones (Leithakalk) of the Vienna Basin as *Nullipora ramosissima* and interpreted them as corals, although he mentioned that many researchers consider *Nullipora* to be plants. Its plant nature was clearly noticed by Unger (1858), and it is known today as *Lithothamnion ramosissimum* (Reuss) Piller, 1994. More recently, studies performed by Pisera and Studencki (1989) showed that unattached nodules of coralline algae, termed rhodoliths, from the Lower Badenian in the Korytnica Basin, are multispecific, commonly constructed by five to eight coralline algae species. The monospecific rhodoliths were very rare, and of the 100 rhodoliths examined, only one was built by *Lithothamnion ramosissimum*.

According to Pusch (1829a), the *pisolithenartiger Grobkalk*, which is a type of limestone, currently referred to red-algal limestones, is widely distributed in the Kingdom of Poland and Eastern Galicia, and corresponds to the limestones of the Vienna Basin distinguished by Keferstein (1828) as *Leithakalk* and to *calcair concretioné pisolitique* described by Desnoyers (1825) from the Cotentin Peninsula

in Normandy. First, Pusch (1830b) believed that the *pisolithenartiger Grobkalk* was of the same age as the Austrian limestones, then Pusch (1836) stated that the Polish limestones are older than the Austrian ones. This interpretation is in accordance with the opinion recently presented by Harzhauser *et al*. (2020, p. 186) who considered that the Leitha Limestone Formation refers only to the Upper Badenian (lower Serravallian), while the limestones described by Pusch, now known as the Pińczów Limestones, are regarded as the Early Badenian (Langhian) in age (Alexandrowicz and Parachoniak 1956; Studencka and Studencki 1988; Chruszcz 2002).

SHORTLY ON GEOLOGICAL MAPS AND THE AGE OF GYPSUM

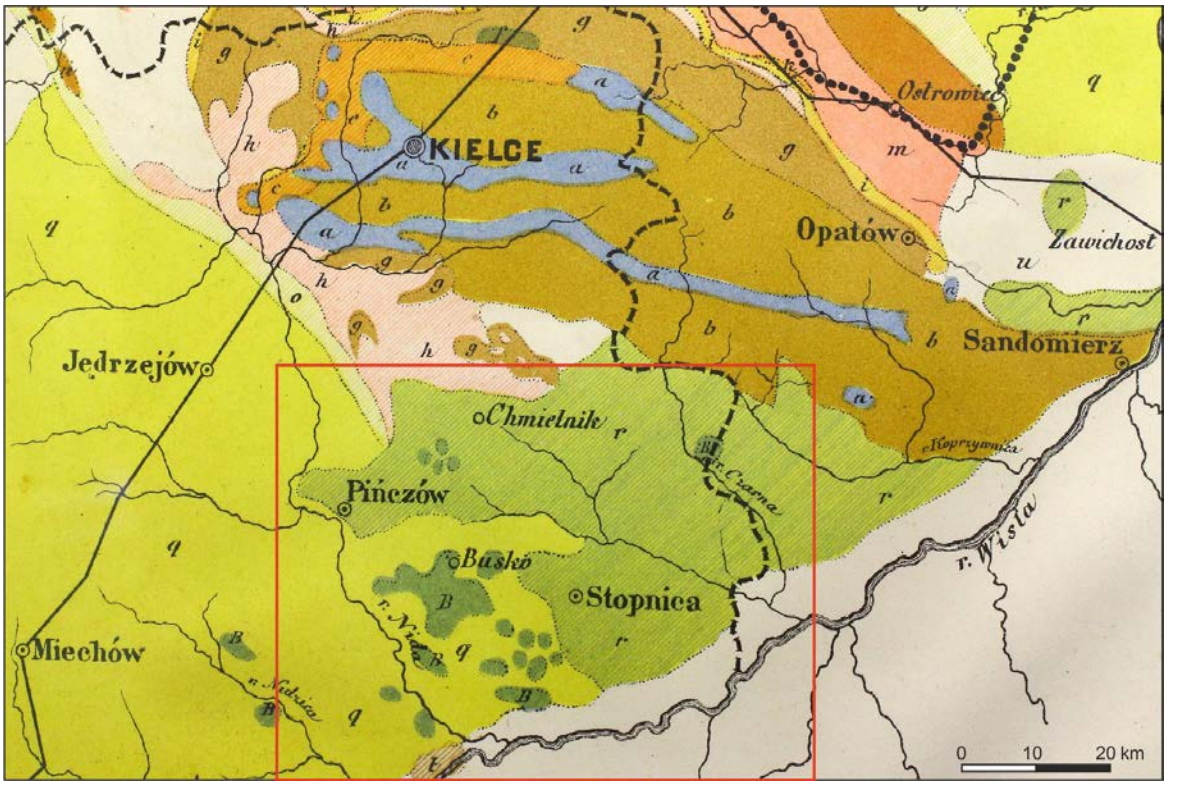
The last of the five geological maps that Pusch intended to include in the *Geognostischer Atlas von Polen* was the detailed map of the Sandomierz Mountains (*Geognostische Karte des Polnischen und Sandomirer Mittelgebirges, zwischen Sandomierz u. Malogoszcz*), now known as the Holy Cross Mountains, which he completed in 1826. Although the geological map of the Kingdom of Poland and Eastern Galicia (*Geognostische General-Karte von den Koenigreich Polen und Galizien, mit angrenzenden Theilen von Oberschlesien, Ungarn, Siedbenbürgen, Moldau und Podolien*), the first such detailed map of this part of Europe, was already prepared for printing, Pusch did not agree to share his data with Christian Kerfeistein in order to use them on the geological map of Europe. As Pusch stated in a letter to Kerfeistein from January 1828 (Kleczkowski 1980, pp. 120, 134, 135), his intention was to publish the *Geognostischer Atlas von Polen* together with the first volume of his main two-volume book entitled *Geognostische Beschreibung von Polen*. Even in 1830, Pusch was convinced that the maps he had prepared would be published in 1831, as he reported in the preface to the shortened Polish version of his *Geognostische Beschreibung von Polen* (Pusch 1830b). Moreover, this is clearly evidenced by the annotation on the title page of the copy published in 1831, which states that the work is accompanied by a geological atlas (Kleczkowski 1977, pp. 59, 60, fig. 1; Text-fig. 4). As noted by Kleczkowski (1977, p. 59), printing of the first volume began in 1830, and Pusch received 21 test sheets. It can therefore be assumed that the printing was completed by the end of 1830, but due to the political situation in the Kingdom of Poland (the outbreak of the November 1830 Uprising), it was not released for sale at that time. The first signal copies appeared in 1831, while the main edition is dated 1833 (Text-fig. 4), and on the title page there was a note that the atlas would be published together with the second volume[9]. However, this did not happen, and the second volume published in 1836 was not accompanied by an atlas.

Five maps constituting an excellent synthesis of the geological knowledge of the time, geological cross-sections and geological profiles of natural *Tertiary* outcrops (currently dated to the Middle Miocene) and salt exploration shafts (in Solec and Szczerbaków) were sent by Pusch in 1828 together with the manuscript of the first volume of the *Geognostische Beschreibung von Polen* to the J.G. Cotta publishing house in Stuttgart and Tübingen. However, due to a series of unfortunate circumstances (Kleczkowski 1977, pp. 59–62), the *Geognostischer Atlas von Polen*, which was completed in 1826, was published as late as in 1837. Only two geological cross-sections of the southern area of the Kingdom of Poland and the Carpathian chain drawn by Pusch (uncoloured lithography with explanations in Polish) were published in numbers 39 and 40 from October 1829 of the weekly magazine *Sławianin*.

These maps, illustrating the enormous contribution by Pusch to understanding the geology of the Kingdom of Poland, were not without some errors. However, field observations conducted by Pusch after 1826, i.e., after preparing a detailed map of the Holy Cross Mountains, contributed to a better understanding of the geology of the Kingdom of Poland, and resulted in a series of articles creating *Neue Beiträge zur Geognosie von Polen* (Pusch 1844; Pągowski 1847) and a new version of the map. He believed that it was the duty of every researcher to admit his mistakes and to clarify matters when new observations and a critical approach to the facts led to more appropriate views.

The German titles of all seven articles devoted to specific geological periods were mentioned by Pusch (1844) and their Polish titles were published by Pągowski (1847) in his posthumous memoir about Pusch. Apart from manuscripts, there was also a map in the legacy left by Pusch. The German title of the new map, i.e., *Geognostische Karte Königreich Polen nach neuern Beobachtungen berichtigt*, referred directly to the geological map of the Kingdom

[9] As Kleczkowski (1977b, p. 59) reported, at the very bottom of the title page of the first volume issued in 1833, on copies not trimmed during binding, there is an inscription: *N.B. Der zu disem Werk gehorende geognostische Atlas wird mit dem zweiten Band geliefert und berechnet*.



Text-fig. 16. Fragment of a geological map created by Georg Gottlieb Pusch titled *Geognostische Karte Königreich Polen nach neuern Beobachtungen berichtigt* (colour lithography, W. Główczewski, Warszawa; original size of sheet 46 × 56 cm) shows the southern part of the Kingdom of Poland. Original on a scale of 1: 1 008 000. Selected explanations: yellow, marked with *q* – Cretaceous; pale green, marked with *r* – Middle *Tertiary* formations; bottle green, marked with *B* – *Tertiary* gypsum. The red insert corresponds to the area shown in Text-fig. 13. From the collection of the Polish Academy of Sciences Museum of the Earth, Warszawa, Poland.

of Poland, corrected in accordance with new observations. The fundamental difference concerned the age of gypsum deposits of the Nida River region. Initially, Pusch (1836, pp. 343–355) considered them to be Cretaceous age, and on the new map he distinguished them as a unit of the middle *Tertiary* Formation (Text-fig. 16). Although this map was completed much earlier, in 1840 (Pusch 1844), its publication was delayed until 1881. Quite unfortunately, it was included as an insert to the first of a series of six articles, which appeared posthumously in the Polish translation of Bronisław Rejchman in the *Physiographic Memoirs* (*Pamiętnik Fizyjograficzny*). Therefore, Zejszner [Zeuschner] (1861) was responsible for the authorship of the gypsum age determination.

However, such a late printing (Pusch 1881) and the fact that the map was published as an insert to the Polish edition of an article on the Triassic *Muschelkalk* of southwestern Poland resulted in such an important map being overlooked by all researchers of *Tertiary* sediments. Neither Kontkiewicz (1882), Trejdosiewicz (1883), nor Michalski (1884, 1887, 1888) mentioned Pusch's new statement on the age of gypsum nor his map issued in 1881. Instead, they emphasised his erroneous opinion expressed in 1836. This new map of Pusch was also overlooked by the translators of the Polish version of the *Geognostische Beschreibung von Polen* published in 1903, edited by Kontkiewicz. The preface to this Polish edition highlights the main advantages that despite the passage of many decades, give value to Pusch's work, such as high accuracy of observation and diligence in their presentation, as well as the enormous abundance of factual material taken from mining and exploration works made during Pusch's times and well known to him. At the same time, it indicates that one of the three great mistakes of Pusch was to define the age of gypsum and associated sulphate-salt springs in the south-western Poland as Cretaceous. Two other errors related to the age of Jurassic sediments. Kazimierz Wójcik, a translator of the second volume of *Geognostische Beschreibung von Polen*,

also omitted Pusch's map published in 1881, not noticing that Pusch had changed his opinion on the age of gypsum deposits. Moreover, Wójcik (Pusch 1903, footnote on p. 171) reiterated the opinion that Pusch had mistakenly assigned gypsum and related marls and clays to the Late Cretaceous, while, as Zejszner [Zeuschner] (1861) claimed, they were formed in the *Late Tertiary* (Miocene), which was then presented in detail by Kontkiewicz (1882).

CONCLUSIONS

1. Among the most important results deriving from the scientific activity of George Gotlieb Pusch (1790–1846) are the *Geognostische Beschreibung von Polen* (1831–1836) and the *Geognostische Atlas von Polen* (1837b), as well as his many contributions to the knowledge of Polish palaeontology. In his treatises on geology (Pusch 1831–1836) and palaeontology (Pusch 1837a), he synthesised the general scientific approach to the study of geological and palaeontological issues on the basis of his own field experiences and extensive geological knowledge.
2. Historically, the first significant publication on the Middle Miocene fossils from Poland was the *Geognostische Beschreibung von Polen* by Pusch (1836), containing an exhaustive list of 400 species-level names and descriptions of 8 species of gastropods and 7 species of bivalves. Until the present study was conducted, this extremely important work had been omitted by all researchers of the Miocene fauna except Trejdosiewicz (1883).
3. Five species of bivalves: *Cardium gracile*, *Astarte crassatellaeformis*, *Pecten nodosiformis*, *Venericardia annulata* and *Venericardia lima* were described by Pusch (1836) as new to science, and three others, *Pecten lilli, Pecten Burdigalensis* var. *Polonica* and *Mactra biangulata*, were also recognised as new by Pusch (1837a). Currently, their taxonomic position is as follows: *Pecten nodosiformis*, *Pecten lilli* and *Cardium gracile* are considered valid and assigned to *Gigantopecten*, *Pseudamussium* and *Plicatiforma*, respectively; *Pecten Burdigalensis* var. *polonica* and *Mactra biangulata* are recognised as *nomina oblita*, *Astarte crassatellaeformis* is newly synonymised with a present-day *Venus foliaceolamellosa* Dillwyn, 1817, while the names *Venericardia annulata* and *Venericardia lima* are considered *nomina dubia*.
4. The *Geognostische Beschreibung von Polen* (Pusch 1836), the first original book on the geology of the Kingdom of Poland, was a work of fundamental and lasting importance for a long time, in which the first description of the facies presently known as the rhodolith pavement and its comparison with the Leitha-type limestone from the Leitha Mountains in Austria were given.
5. An unfortunate set of circumstances, including the November 1830 Uprising, caused the printing of the *Geognostischer Atlas von Polen*, completed by Pusch in 1826, to be significantly delayed and it was made available only in 1837. It contained not only a general geological map of the Kingdom of Poland and Eastern Galicia and four detailed maps of selected areas of the Kingdom of Poland, but also the first ever drawings of the lithological columns of natural exposures of the Middle Miocene sediments from the Kingdom of Poland (5 sections) and Eastern Galicia (10 sections) (Pusch 1837b, pl. 6, figs 4–18), reproduced herein (Text-figs 13 and 14).
6. After submitting uncoloured geological maps to the J.G. Cotta publishing house in Stuttgart and Tübingen in 1828, Pusch almost immediately started to prepare a new, improved version of the geological map of the territory of the Kingdom of Poland, which he completed in 1840. The main difference was the age of the gypsum deposits from the Nida River region. Since the map was not published until 1881, Pusch's opinion on the age of the gypsum deposits became available almost 40 years after it was made. He considered them to be *Tertiary* in age. However, this information presented on this map was ignored by both his contemporaries and later Miocene researchers.
7. Summing up, Georg Gottlieb Pusch was an outstanding geologist with an extended professional education, and while Stanisław Staszic is often nicknamed 'father of Polish geology', Pusch certainly deserves the title of 'father of Polish palaeontology'.

Acknowledgements

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