Diverse microfossil assemblages characterise the Lower Jurassic deposits on Svalbard, but until recently nearly all Lower Jurassic macrofossils from this region were known only from re-deposited phosphorite pebbles in the Brentskardhaugen Bed. Here, we briefly describe a unique in situ molluscan assemblage from the lower Toarcian part of the Agardhbukta section. This assemblage is dominated by ammonites (Dactylioceras only), while belemnites and bivalves are less common.

Ammonites are typical for the Commune zone of the Arctic and belong to the new species Dactylioceras (D.) kopiki Rogov, sp. nov. and D. (Microdactylites) sp., and their findings are characteristic for a new kopiki biohorizon located in the top of this zone. Bivalves are dominated by Meleagrinella (Clathrolima) substriata providing additional evidence for the age of this assemblage. The pattern of ammonite and bivalve stratigraphical and geographical distributions in the Arctic suggest bilateral molluscan immigrations via the Greenland–Norwegian seaway during the latest early Toarcian: dactylioceratid ammonites migrated northwards, while oxytomid bivalves migrated southwards.

Introduction

Early to earliest Middle Jurassic macrofossils from Svalbard are well known and have been described in many papers (Frebold, 1929a, b, 1930; Kopik, 1968; Birkenmajer & Pugaszewska, 1975; Wierzbowski et al. 1981; Ershova & Repin, 1983; Bäckström & Nagy, 1985), but all previously reported material came from the phosphorite conglomerate located in the top of the Wilhelmøya Subgroup, the 0.2–1.2 m-thick Brentskardhaugen Bed, containing numerous phosphorite pebbles (Krajewski, 1992). These pebbles yield common...
macrofossils, mainly ammonites, and bivalves of Toarcian and Aalenian age, with a possible admixture of the Bajocian species, which permit recognising here a succession of provisional zones (Ershova & Repin, 1983). However, very few in situ findings of Early Jurassic macrofossils were reported from Svalbard until recently.

Generally, the thickness and completeness of the Lower Jurassic succession in Svalbard increase eastwards. At the western coast of Spitsbergen, the Lower Jurassic is represented by the Brentskardhaugen Bed which is underlain by a poorly fossiliferous Teistberget Member (usually 5–26 m). Successions of the Agardhbukta, Kapp Mühry and Wilhelmsøya show much more complete sections with a total thickness up to ~60–65 m (Pchelina, 1980), and farther eastwards attaining ~200 m at Svenskøya (Olausen et al., 2018). Sections exposed at Kapp Mühry and on Wilhelmsøya are crucial for our understanding of the Lower Jurassic history of Svalbard due to the significant thickness of the Lower Jurassic here. Klubov (1965) presented the first relatively detailed description of the Lower Jurassic succession on Wilhelmsøya. There, he distinguished Pliensbachian–Toarcian deposits, which in the lower part (member 28 in Klubov, 1965, represented by light-yellow weathered mudstones) yields a foraminiferal assemblage dated by Basov as Pliensbachian (see also Basov et al., 2009). Worsley (1973) erected here the Wilhelmsøya Formation which was elevated to subgroup rank by Mørk et al. (1999). The Tumlingodden Member, upper unit of this subgroup, belongs to the Lower Jurassic based on foraminifer dating (Klubov, 1965). Additional evidence for an Early Jurassic age of the upper part of the Wilhelmsøya Formation came from an analysis of dinoflagellate cyst assemblages derived from the study of the succession in Marhøgda, Sassenfjorden (Bjaerke & Dypvik, 1977). A Pliensbachian to Aalenian age of this part of the succession has recently been supported by the analysis of dinocysts from DH2 and DH4 wells (western central Spitsbergen) performed by Rismyhr et al. (2018). Pchelina (1980) summarised all available data about the uppermost Triassic and Lower Jurassic of Spitsbergen, including results of geological mapping by Soviet geologists. She provided a description of key sections and erected a set of new formations and members. Among the new paleontological findings, important for establishing the age of the Lower Jurassic part of the succession, she mentioned the occurrence of Modiolus tiungensis Petrova. 14 m above the base of the Tumlingodden Member at Kapp Mühry, i.e., from the level a little below Pliensbachian foraminifers of the same member. This bivalve species ranges from upper Pliensbachian to lower Toarcian in Northern Siberia (Kirina, 1976a, b). Thus, the age of its occurrence at Kapp Mühry is late Pliensbachian. Until now, no other in situ macrofossil records were known from the Lower Jurassic of Spitsbergen.

Material

During fieldwork in the Agardhbukta area in 2018, interesting Toarcian macrofossils were collected from a coastal section located south of Myklegardfjellet mountain (Fig. 1; coordinates 78.03945°N, 18.70837°E). A rich fossil assemblage was recorded from the topmost part of the Svenskøya Formation. In this section, a light-yellow sandstone (bed 1), containing numerous pebbles and fossil wood, is overlain by a ~2 m-thick siltstone (bed 2, Figs. 2 & 3) with numerous hard phosphorite concretions, especially common between 0.5 and 1.5 m above the base of this unit.

These concretions occurred in laterally traced levels located at 0.5–1, 1.1, 1.2 and 1.5 m above the base of bed 2. Phosphorite concretions frequently contain ammonite moulds and belemnite phragmocones, while partially dissolved belemnite guards and bivalves are less common. Small pebbles are numerous in the lower part of the bed (0.5–1 m above the base) but disappear above. The ammonite assemblage consists of micro- and macroconchs of late Dactylioceras and shows no features of re-deposition or condensation. The ammonites are generally well-preserved moulds of complete
Figure 1. Outcrops with Toarcian fossils on Svalbard mentioned in this paper. (A) General overview map of Svalbard, 1. Van Mijenfjorden; 2. Hyrnefjellet; 3. Sørkappland; 4. Dunérbukta; 5. Agardhbukta; 6. Kapp Muhry; 7. Svenskøya; 8. Wilhelmøya; 9. Marhøgda; 10. DH2, DH4 wells; (B) Map of Agardhbukta. Figure legend: 1 – Triassic, 2 – Jurassic, 3 – Cretaceous, 4 – localities on Spitsbergen (a – studied section, b – other sites).

Figure 2. Close view of the studied section (A) and details of ammonite-bearing interval (B) with clearly visible ammonite moulds embedded in phosphorite concretions.

adult specimens and their fragments, and usually rest horizontally to subhorizontally (Fig. 2B). Ammonite moulds are uncrushed (except for their body chambers in some cases) suggesting quick cementation of phosphorite concretions during the early diagenesis. Bivalves mainly belong to *Meleagrinella* (*Clathrolima*), as well as a single specimen of *Entolium*. 


It should be noted that Lower Jurassic fossils from this area are well known, and have been described or mentioned in a few publications (Frebold, 1929a; Pchelina, 1980; Ershova & Repin, 1983), but in contrast to the studied collection all these occurrences came from the Brentskardhaugen Bed, and include only younger ammonite taxa, such as diverse *Pseudolioceras*, *Porpoceras* and *Coeloceras* species.
Figure 4. Lower Toarcian (Commune zone, kopiki horizon) dactylioceratid ammonites and oxytomid bivalves. Scale bar – 1 cm (for specimens figured in natural size only; otherwise, magnification is marked as either x2 or x3). All specimens except Figs. 7 & 10 came from the Agardhbukta section. (A–C) - Dactylioceras (Microdactylites) sp., (A) – specimen ESM 146/6, 1.15–1.2 m above the base of bed 2; (B) – specimen ESM 146/21, 0.7–1 m above the base of bed 2; (C) – specimen ESM 146/17, 1.2 m above the base of bed 2; (D–F), (H) – Dactylioceras (D.) kopiki Rogov, sp. nov., (D) – specimen ESM 146/14, 1.3 m above the base of bed 2; (E) – specimen ESM 146/36, 1.2 m above the base of bed 2; (F) – specimen ESM 146/4, 1.15–1.2 m above the base of bed 2; (H) – specimen ESM 146/38, 1.2 m above the base of bed 2; (G) – Dactylioceras (D.) cf. kopiki Rogov, sp. nov., Astronomicheskaya river, section 2, bed 17 (Knyazev et al., 2003, Fig. 27), specimen ESM 146/34; (I–N). Meleagrinella (Clathrolima) substriata (Muenster, 1831), all figured with x2 magnification. (I), (K–M) – 1.5 m above the base of bed 2; (I) – specimen ESM 146/30; (K) – specimen ESM 146/29; (L) – specimen ESM 146/31; (M) – specimen ESM 146/32; (I) – the same specimen as Fig. 7; (N) – specimen ESM 146/28, 1.2 m above the base of bed 2.
The described material is stored in the collections of the Earth Science Museum, Moscow State University, Moscow, Russia (abbreviated as ESM). Ammonites were studied by M.A. Rogov, and bivalves by O.A. Lutikov.

Description of recorded species

AMMONITES (by M.A. Rogov)
Family DACTYLIOCERATIDAE Hyatt
Subfamily DACTYLIOCERATINAE Hyatt

Genus Dactylioceras Hyatt

Remarks. – Dimorphism in dactylioceratids has been distinguished since the late 60s, when Lehmann (1968) and Guex (1971, 1973) recognised micro- and macroconchs in this ammonite group. In spite of the lack of clear mature aperture modifications in dactylioceratid ammonites, dimorphs are more or less clearly recognised. Two different approaches were in use for the description of dimorphs in this group: corresponding micro- and macroconchs were either referred to different (sub)genera (e.g., Guex, 1971; Kovacz, 2014) or described under the same species name accompanied by [m] or [M] symbols (e.g., Bardin et al., 2015). Here, corresponding micro- and macroconchs are ascribed to different subgenera.

Subgenus Dactylioceras (Dactylioceras) Hyatt [M]

Dactylioceras (D.) kopiki Rogov sp. nov. [M]
Figs. 3A–B, 3D–F, 3H–I; 4D–F, and 4H

1955 Dactylioceras cf. D. commune (Sowerby): Imlay, pl. 10, fig. 10.
1955 Dactylioceras cf. D. directum (Buckman): Imlay, pl. 11, figs. 7–11, 14.
1957 Dactylioceras commune (Sowerby) var. a: Frebold, pl. 1, fig. 4.
1968 Dactylioceras sp. nov.: Kopik, p. 40, pl. 1, fig. 3 & 4, text-fig. 3 a–b.
1985 Dactylioceras toxophorum (Buckman): Bäckström & Nagy, p. 36, pl. 6, fig. 4 & 5, text-fig. 24a–b.

Holotype. – ESM 146/16 (Museum of Natural History, Moscow State University, Moscow, Russia), figs. 3.4 & 3.6.

Derivation of name. – in the memoir of Dr. Janusz Kopik (1930–2021).

Nomenclatural acts. – This published work and the nomenclatural acts it contains, have been registered in ZooBank: urn:lsid:zoobank.org:act:FA0D504E-5D44-463D-A811-E2C2B2C06E88

Type locality and horizon. – Commune Zone, kopiki biohorizon, Agardhbukta, Spitsbergen.

Material. – 21 specimens (ESM 146/1–5, 7–10, 13–14, 16, 18–20, 22–25, 36), preserved as imprints and internal moulds, from 0.7 to 1.3 m above the base of bed 2, Agardhbukta, Spitsbergen.

Diagnosis. – Semievolute coiling, subcircular whorl section, ribbing with alternating prorsiradiate simple and biplicate ribs. Terminal aperture accompanied by shallow constriction.
Description. – Semievolute coiling, with rib furcation point covered by overlying whorl. Umbilicus wide and shallow, suboval whorl-section with little flattened flanks and venter (Table 1). The peristome is simple, and in some cases accompanied by a shallow constriction and a significant decrease of rib ratio towards the aperture. Sharp and rectiradiate ribs develop a little above umbilical seam; they curved forwards in the upper third of flanks, where they split into two ribs, with secondaries which sometimes are not connected with primaries, or usually remain undivided. Ribs cross the venter either with a forward bend or remain straight. The secondary/primary rib ratio in the outer whorl is between 1.25 and 1.7. Near the terminal aperture, ribbing becomes irregular. The suture-line is unknown due to poor preservation of inner whorls.

Remarks. – The type of ribbing and shell outline of this species strongly resembles those of Zugodactylites, except for lacking tubercles in the rib furcation point throughout the ontogenesis. One doubtful specimen, though, does actually have possible tubercles (fig. 4.F). Only in some specimens, ribs in the terminal body chamber may show weak thickenings in the rib furcation point. Corresponding microconchs (see below) show a clear tuberculate stage up to a diameter of c. 1 cm. Such a mix of Dactylioceras–Zugodactylites ribbing suggests the stratigraphic position of the discussed species near to a transition between these genera, i.e., in the top of the Communis zone.

The described species strongly resembles Dactylioceras (D.) toxophorum (Buckman) (the type specimen figured in Buckman, 1928, pl. DCCCLXXVI), but differ by a little more involute coiling, lower position of rib furcation point, and more prominent ribs. D. (D.) athleticum (Simpson) also shows a close resemblance to the new species, but is characterised by more evolute coiling and a higher rib furcation point. Variability of D. (D.) kopiki sp. nov. is mainly expressed in a variation of primary rib frequency, ranging in inner whorls from ~40 to 76 per whorl, and a rib ratio ranging from 1.25 to 1.7. The position of the rib furcation point is also variable, but it usually covered by outer whorls. In some specimens (fig. 4.D) ribbing became smoother on the terminal body chamber. A closely related specimen from the Astronomicheskaya river (NE Russia) (fig. 4.G) can be referred to this species as cf.-form. A single specimen intermediate in size between D. (D.) kopiki sp. nov. and D. (Microdactylites) sp., has a rib pattern intermediate between these two taxa, with small prominent nodes in inner whorls and alternating biplicate and single ribs in the outer whorls (fig. 4.F). This ammonite specimen can be tentatively referred to as D. (D.) kopiki. Ammonites from Prince Patrick Island (Arctic Canada) referred to by Imlay (1955) as Dactylioceras cf. D. directum (Buckman) show the same rib pattern and variability as D. (D.) kopiki and could be ascribed to this species. The same is true for specimens from South Barrow test well 3 (northern Alaska) figured by Imlay (1955, pl. 10, fig. 10). These ammonites are associated with possible microconchs showing the presence of small nodes in the rib furcation points (Imlay, 1955, 1961).

<table>
<thead>
<tr>
<th>Specimen no.</th>
<th>D</th>
<th>Wh</th>
<th>Wh/D</th>
<th>Wb</th>
<th>Wb/D</th>
<th>U</th>
<th>U/D (%)</th>
<th>R/2</th>
</tr>
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<tbody>
<tr>
<td>ESM 146/9</td>
<td>48.1</td>
<td>14.2</td>
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<td>26.54</td>
<td>55%</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/16 holotype</td>
<td>50.2</td>
<td>12.6</td>
<td>25%</td>
<td>26.52</td>
<td>53%</td>
<td>32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/25</td>
<td>37.3</td>
<td>11.1</td>
<td>29.7%</td>
<td>16.6</td>
<td>44.5%</td>
<td>26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>ESM 146/4</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Measurements of D. (D.) kopiki Rogov, sp. nov. D – diameter, Wh – whorl height, Wb – whorl breadth, U – umbilical diameter, R/2 – number of primary ribs per half of whorl
pl. 10, fig. 15), as well as *D. kopiki* Rogov, sp. nov. Additional *Dactylioceras* from Prince Patrick Island figured by Frebold (1957, pl. 1) also resembles *D. (D.) kopiki*, and the figured assemblage may represent a mix of *D. commune* with *D. kopiki*.

**Distribution.** – In addition to studied specimens, this species is also known from the Brentskardhaugen Bed of Sørkappland and Hyrnefjellet, Spitsbergen (see synonymy), Prince Patrick Island (Canada), northern Alaska, and possibly from NE Russia (Astronomicheskaya river). Lower Toarcian, Commune Zone, *kopiki* biohorizon.

Subgenus *Dactylioceras* (*Microdactylites*) Buckman [m]

*Dactylioceras* (*Microdactylites*) sp. [m]

Figs. 3C, G; 4A–C


1955 *Dactylioceras* *cf.* *D. delicatum* (Buckman): Imlay, 1955, pl. 10, fig. 15.

**Material.** – 7 specimens (ESM 146/6, 11, 12, 15, 17, 21, 26) from 0.7 to 1.2 m above the base of bed 2, Agardhbukta section; one specimen from the Brentskardhaugen Bed of (ESM 146/35, collected by E.S. Ershova in 1977), Spitsbergen.

**Description.** – Evolute to semievolute coiling, umbilicus wide and shallow, suboval whorl-section (Table 2). Rib pattern is highly variable. Inner whors (in some cases up to 1 cm diameter) are covered by straight primaries, which terminate with small but prominent nodes near to ventrolateral shoulder. Later, 1 or 2 thin secondaries appear here, and nodes fade gradually.

**Remarks.** – The present material strongly resembles *Dactylioceras* sp. 2 (Guex, 1973, pl. VIII, fig. 5), which also shows the occurrence of ventrolateral nodes in its inner whors, but studied ammonites are characterised by much more distant ribs. Attribution of the described specimens to subgenus *Microdactylites* remains questionable, as the presence of ventrolateral nodes in inner whors was previously unknown for this taxon (Guex, 1971). Microconchs with such a rib pattern were supposed

### Table 2. Measurements of Dactylioceras (*Microdactylites*) sp..

<table>
<thead>
<tr>
<th>Specimen no.</th>
<th>D</th>
<th>Wh</th>
<th>Wh/D</th>
<th>Wb</th>
<th>Wb/D</th>
<th>U</th>
<th>U/D (%)</th>
<th>R/2</th>
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<tr>
<td>ESM 146/17</td>
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<td>5.6</td>
<td>26%</td>
<td>10.5</td>
<td>48%</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/15</td>
<td>22.2</td>
<td>5.7</td>
<td>26%</td>
<td>12.2</td>
<td>55%</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/12</td>
<td>15.2</td>
<td>4.1</td>
<td>27%</td>
<td>8.3</td>
<td>55%</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ESM 146/11</td>
<td>15.4</td>
<td>4.3</td>
<td>27.9%</td>
<td>7.7</td>
<td>50%</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


to be counterparts of macroconchiate *Rakusites* (Guex, 1971, p. 235), but in the Agardhbukta section they co-occur with typical *Dactylioceras (Dactylioceras)*. Intraspecific variation is expressed by different longevity of the tuberculate stage.

**Distribution.** – Spitsbergen and northern Alaska. Lower Toarcian, Commune Zone, *kopiki* biohorizon.

**BIVALVES (by O.A. Lutikov)**

Family OXYTOMIDAE Ichikawa

**Genus Meleagrinella** Whitfield
Subgenus *Meleagrinella (Clathrolima)* Cossman

*Meleagrinella (Clathrolima) substriata* (Münster)
figs. 4.9–14

1836 *Monotis substriata*: Goldfuss, p. 138, pl. CXX, fig. 7a, b.

**Lectotype.** – (chosen by Lutikov & Arp, 2020b): specimen IGPB-Goldfuss-729 a/1 from the collection by Goldfuss; Posidonienschiefer Formation, lower Toarcian, Bifrons Zone, Commune Subzone, Banz, Germany (re-figured in Lutikov & Arp, 2020b, pl.1, fig. 9).

**Material.** – 6 specimens from the Agardhbukta section (moulds and imprints, ESM 146/28–33), Spitsbergen; 1 specimen with shell preserved (ESM 146/34) from the Start Formation of the Astronomicheskaya river, and more than 20 specimens from the Suntar formation from the Tyung, Markha and Vilyui rivers.

**Revised diagnosis.** – Posterior auricle of the left valve is obtuse. The outer margin of the posterior margin of the left valve forms a S-like curve. Its curvature is either narrow or wide. The left valve is strongly convex. The posterior ligamental field of the left valve is very short.

**Discussion.** – Until recently this species has been referred to as subgenus *Arctotis (Praearctotis)* (Lutikov & Arp, 2020a, b). However, as follows from the re-examination of ligamental area of the type series of this species by Lutikov (details will be published elsewhere), it should be re-assigned to the subgenus *Meleagrinella (Clathrolima)*. Lectotype for *M. (C.) substriata* (Münster) has been chosen by Lutikov & Arp (2020b) among specimens from *Dactylioceras–Monotis*-Bed (Posidonienschiefer Formation, Hildoceras bifrons Zone, Dactylioceras commune Subzone).

Bivalves collected from other German sections (Lutikov & Arp, 2020b, pl. I, fig. 11 & 12), the Agardhbukta section, as well as from the sections in Siberia (Lutikov & Arp, 2020b, pl. I, fig. 14) and NE Asia (Lutikov & Arp, 2020b, pl. I, fig. 13) showing the same S-like curvature of the posterior wing and can be referred to the same species.
Distribution. – Range zone of *C. substriata* (Muenster) is corresponding to the lower Toarcian Bifrons ammonite zone (Lutikov & Arp, 2020a), but this species is especially common in the Commune ammonite subzone. This species is known from Spitsbergen (Agardhbukta), Northern Siberia and NE Russia (Tyung, Markha, Vilyui, Levy Kedon rivers: Lutikov & Arp, 2020b), Germany (Harries & Little, 1999; Arp & Gropengießer, 2016), the Yorkshire coast, England: (Harries & Little, 1999), Arctic Canada (Ya Ha Tinda lagerstatte: Martindale & Aberhan, 2017), Iran (Semnan area: Repin, 2000), and Japan (Okayama Prefecture: Hayami, 1961).

**Discussion**

Occurrences of Lower Toarcian macrofossils in Svalbard are relatively scarce, and all previous records came from the Brentskardhaugen Bed. These include uncommon *Dactylioceras*, *Harpoceras* and *Ovaticeras*, and more numerous younger taxa, such as *Zugodactylites*, *Porpoceras*, *Collina*, *Mucrodactylites* and *Pseudolioceras* (Wierzbowski et al., 1981; Ershova & Repin, 1983; Bäckström & Nagy, 1985). Based on this evidence, Ershova & Repin (1983) proposed a tentative zonal succession for the Toarcian of Spitsbergen. Recently, this “virtual” zonal succession has been corrected by Shurygin et al. (2011). Currently, it includes the following zones (from below to above): Harpoceras spp.; Dactylioceras commune; Zugodactylites ex gr. braunianus; Pseudolioceras rosenkrantzi.

The present work records the first in situ findings of *Dactylioceras* – *Clathrolima* association, indicating the presence of molluscan-bearing Lower Toarcian in non-reworked preservation. Its age is indicated from the integrated analysis of ammonites and bivalves. Ammonites recovered from the studied section show some features transitional from *Dactylioceras* to *Zugodactylites*. This stratigraphic interval is distinguished here as the *kopiki* biohorizon (with the studied section as the type section, with the type interval 1–1.5 m above the base of bed 2), which is correlated with topmost levels of the Commune Zone, and tentatively can be considered as the equivalent of the *athleticum* horizon, the highest horizon of this subzone in the succession of NW Europe (Page, 2004).

The bivalve family Oxytomidae is widely distributed in the Pliensbachian and Toarcian of the Northern Hemisphere. Elucidation of the geographical distribution patterns of the family is currently difficult for two reasons. First, there is insufficient information on this group from Southeast Asia, Africa, Australia and New Zealand, South America and southern North America. Secondly, the reason that complicates biogeographic studies is still our insufficient knowledge of the taxonomy of the family. The revision of the genera *Meleagrinella*, *Clathrolima* and the species “*Monotis*” *substriata* (Münster) is far from complete (Lutikov & Shurygin, 2010; Lutikov & Arp, 2020b), and the generic identity of many taxa is questionable.

The species *Meleagrinella* (*Clathrolima*) *substriata* was previously reported from all ammonite zones of the lower Toarcian of Germany (Urlichs, 1971) and Northeastern Russia (Knyazev et al., 2003). Recently, this taxon was tentatively assigned to *Arctotis* (*Praearctotis*) (Lutikov & Shurygin, 2010), and it was found that its stratigraphic range covers the Commune Zone and possibly Monestieri Zone (Lutikov & Arp, 2020a, b). However, after viewing photographs of the ligament site of type series of this species (Goldfuss, 1836, pl. CXX, fig. 7 C–D) stored in the Munich Museum, it was established that this taxon belongs to the subgenus *Meleagrinella* (*Clathrolima*). In Europe, bivalves similar to *M. (C.) substriata* are typical for the Commune subzone of Germany (Riegraf et al., 1984; Arp & Gropengießer, 2016) and England (Harries & Little, 1999), and findings of closely related bivalve specimens are also known in Iran and Japan (Fig. 5).

Early Toarcian palaeobiogeography of the Arctic remains uncertain due to the rarity of macrofossils between East Greenland and Eastern Siberia. The abundance and high diversity of Pliensbachian–Toarcian species of *Meleagrinella* (*Clathrolima*) and *M. (Praemeleagrinella)* in Northeast Russia suggest that this taxon originated in this area, and then spread widely around the world,
in the direction of Eastern and Western Siberia, farther westwards through the Barents Sea and a Greenland–Norwegian seaway (‘Viking corridor’) to Europe, and possibly through the Arctic Ocean in the direction of North America. A similar migrational pathway has recently been proposed for dinoflagellates, as some taxa first appear in Siberia and later in Europe (van de Schootbrugge et al., 2020). Importantly, mass immigration of Arctic dinoflagellates to Europe began during the Bifrons Chron, i.e., synchronous with the appearance of *Meleagrinella (Clathrolima) substriata* in the same area. However, the migration pattern of dactylioceratid ammonites appears to be different. In Europe they have a continuous record, whereas in Siberia and NE Russia there is a significant hiatus in dactylioceratid lineage (Kutygin & Knyazev, 2000; Knyazev et al., 2003; Fig. 6). This suggests repetitive invasions of this ammonite group to the Boreal seas. On the other hand, dactylioceratid successions of Arctic Canada are still insufficiently known (Imlay, 1955; Frebold, 1975) and the presence of the ‘Dactylioceras gap’ is possible here. In the southern part of Canada, such as in Alberta, the dactylioceratid succession is complete (see Them et al., 2017).

In our opinion, the discovery of the *Dactylioceras – Meleagrinella (Clathrolima)* assemblage in Spitsbergen indicates an important Arctic cross-road influenced by both westward and eastward faunal migration during the early Toarcian Bifrons Chron.
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References


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