Earliest Jurassic (Hettangian) psiloceratoid ammonites from a subrosion pipe at Winterswijk, the eastern Netherlands

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Abstract

A small faunule of fragmentary Hettangian (earliest Jurassic) psiloceratoid ammonites collected from dark-coloured, clay-rich sediments in a subrosion pipe at Quarry III of the Winterswijk quarry complex is described. The genera Alsatites, Saxoceras and Schlotheimia are determined by comparison to extensive literature on coeval, north German faunas. Taphonomic features are apparent indicating condensation and reworking. Despite this, the portion of the subrosion pipe sediment fill which yielded this material can be dated as middle to late Hettangian.

Keywords: Alsatites, Ammonoidea, Lower Jurassic, Saxoceras, Schlotheimia, Winterswijk quarry

Introduction

The Winterswijkse Steen- en Kalkgroeve, located in the eastern part of the Netherlands near Winterswijk, is well known for its Middle Triassic (Muschelkalk) fossils, notably various reptilian remains such as Nothosaurus, fish, arthropods, bivalves and tracks (Oosterink, 1978, 1981; Oosterink & Poppe, 1979; Demathieu & Oosterink, 1983; Albers & Rieppel, 2003; Oosterink et al., 2003).

Only a handful of ammonites have been found in the Winterswijk quarry complex over the past few decades (Boekschoten, 1972; Dertien, 1972; Tjalkens, 1975; Oosterink, 1986), all of Middle Triassic age. Here presented is a small lot of rather poorly preserved ammonite fragments collected from dark clay-rich sediments of earliest Jurassic age.

The Winterswijk quarry complex is situated on the eastern Netherlands plateau, a high on the rim of the Münster Graben in the east and the North Sea Graben in the west (Oosterink et al., 2003). The main deposits exposed at the quarry are light-grey limestones of Middle Triassic (Muschelkalk) age (Oosterink, 1986).

The quarry complex comprises four outcrops (Fig. 1), Quarry III being in the centre. Close to the westerly face of Quarry III a subcircular plug of dark, clay-rich sediments about two metres thick and about 30 metres in diameter has recently been exposed (Oosterink et al., 2005, 2006). The origin of these clay-rich strata was long unknown until 2004 when it was determined that these were subrosion deposits that had fallen about 10 metres into lower-lying strata (Oosterink et al., 2005, 2006). Subrosion occurs when subsurface rocks become dissolved. Due to leaching of salt domes in the subsurface, a hollow pipe was formed. Eventually, the roof of this pipe collapsed and all overlying material landed in it. There are two salt domes of Röt and Zechstein age in the subsurface that could have caused this subrosion pipe to form. Bentz (1933) and Knapp (1975) determined that, in Germany, an evaporite at the base of the Röt had leached. There is no evidence of leaching of the Zechstein salt anywhere and therefore dissolution of the Röt salt plug is most likely the underlying cause of the Winterswijk subrosion pipe. Oosterink et al. (2006) noted that formation of the subrosion pipe dated back either to the Late Neogene (Miocene or Pliocene) or to a Pleistocene interstaddial.

Following discovery of these dark clay-rich sediments, the company (Winterswijksche Steen- en Kalkgroeve B.V.) exploiting the quarry transported and dumped these elsewhere in the area.
quarry, and subsequently covered them with various other material (H.W. Oosterink, pers. comm. November 2006). For this reason, the material is no longer accessible, with the exception of isolated clay-rich sediment occurrences near or at the original location of the subrosion pipe.

In view of the scarcity of Jurassic ammonites at the Winterswijk quarry complex and their biostratigraphical potential, the present fragments have been identified to the generic and/or specific level as best as possible and their zonal provenance determined.

**Systematic descriptions**

All dimensions are in millimetres. Abbreviations used are as follows: Wb = whorl breadth; Wh = whorl height; PH = phragmocone; BC = body chamber; E = evoluteness = height on symmetric plane / Wh; RGM = Nationaal Natuurhistorisch Museum (Naturalis), Leiden, the Netherlands (formerly Rijksmuseum van Geologie en Mineralogie).

Table 1 lists dimensions of specimens while Fig. 2 illustrates several whorl sections.

Table 1. Measurements (in millimetres).

<table>
<thead>
<tr>
<th>Specimen</th>
<th>PH or BC</th>
<th>Wb</th>
<th>Wh</th>
<th>Wb:Wh</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGM 542900</td>
<td>BC</td>
<td>9.0</td>
<td>7.7</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>RGM 542901</td>
<td>BC</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>RGM 542902</td>
<td>BC</td>
<td>9.0</td>
<td>10.0</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>RGM 542903</td>
<td>BC</td>
<td>20.5</td>
<td>24.9</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>RGM 542904</td>
<td>BC</td>
<td>–</td>
<td>5.0-6.0</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>RGM 542905</td>
<td>BC</td>
<td>9.1</td>
<td>10.6</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>RGM 542906</td>
<td>PH</td>
<td>10.3</td>
<td>21.6</td>
<td>0.9</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Alsatites sp.**

**Material**

RGM 542900 (Fig. 3a) is a black internal mould found in unlihified clay.

**Description**

The whorl section of this evolute body chamber is oval to rounded quadrate (Table 1; Fig. 2). Maximum whorl breadth is at about mid-flank. The venter is faintly fastigate. Ribs are approximated. The weak, rectiradiate, projected ribs weaken from the ventrolateral shoulders onwards but remain visible on the venter. Reaching the venter they curve backwards and seem to cross the venter in a wide convexity. Several unfilled burrows are observed on all sides of the former interface between shell and sediment infilling. The large burrows on the venter and flanks might be of polychaete or sipunculid origin (Rice, 1969; Bromley, 1970), although the burrow on the venter is relatively large.

**Discussion**

RGM 542900 can be assigned to *Alsatites* beyond doubt on account of its strongly evolute, serpenticone shape, the subcircular whorl section and the ribs reaching their maximum height on the flanks, only *A. laqueus* (Quenstedt, 1856) and *A. liasicus* (d’Orbigny, 1844) are possible candidates based on whorl breadth exceeding height and the faintly fastigate venter. However, differences between these two species are too minimal to determine this specimen to species level (Lange, 1941; Donovan, 1952; Schlegelmilch, 1992).

**Cf. Alsatites sp.**

**Material**

RGM 542901 (Fig. 3b) is an abraded, black internal mould found in unhithified clay.
The whorl section of this evolute body chamber is rounded as far as can be determined. The dorsal side, less heavily worn, shows a fastigate, rounded keel. Burrows are found on all sides of the former interface between shell and sediment infilling. Burrows are mostly filled with grey sediment. Again, a large burrow on the venter and smaller burrows on the flanks might be of polychaete or sipunculid origin.

**Discussion**

The overall shape of RGM 542901 is similar to RGM 542900. However, the keel on the venter more pronounced. The only genus in Lange (1941) that resembles this specimen is *Alsatites*. The rounded fastigate keel also occurs in many specimens of *Alsatites*, which is why we refer to it as cf. *Alsatites* sp.
Family Schlotheimiidae Spath, 1923
Genus Saxoceras Lange, 1924
Type species: Psiloceras costatum Lange, 1922

*Saxoceras* sp.

**Material**

RGM 542902 (Fig. 4a) is a black internal mould found in un lithified clay.

**Description**

The whorl section of this initial portion of an evolute body chamber is rectangular with rounded to slightly trapezoidal flanks (Table 1; Fig. 2). Maximum whorl breadth is at inner flank. Venter is flattened and shows a narrow furrow. Ribs are approximated. The sharp, strong, simple, rectiradiate ribs are projected and initiate on the rounded umbilical wall. Curvature of the ribs starts at the beginning of the ventrolateral shoulders. Maximum rib height is reached at the ventrolateral shoulders. Ribs efface rapidly on the venter, merging faintly the opposing ribs. The angle between the opposing ribs on the venter is approximately 90° - 100°. Only the ultimate suture line is partially visible, mainly on the venter.

Tiny crystalline pyrite crystals are present on the dorsal side. The specimen is devoid of burrows except for a possible portion of a burrow on the distal cross-section of the whorl.

**Discussion**

Ribs are too strong in comparison with *Schlotheimia amblygonia* (Lange, 1924). The ribs in *Saxoceras costatum quadratum* (Lange, 1941) are too weak and the angle between the opposing ribs on the venter is too large. *Saxoceras crassicosta* (Brandes, 1912) has gradually effacing ribs on the venter and finally also the angle between the opposing ribs on the venter is too large. Differences between *Saxoceras praecursor* (Lange, 1924)
S. Schroederi (Lange, 1922) are too small to assign this specimen to one of these confidentially. The specimen does not show (a combination of) characteristics that warrant species identification which is why this specimen is identified as Saxoceras sp.

**cf. Saxoceras sp.**

**Material**

RGM 542903 (Fig. 4b) is a black internal mould which is worn, especially ventrally and ventrolaterally. It was found in dark, clay-rich sediment aggregates.

**Description**

The body chamber represents an evolute species with a diameter of at least 80 mm. The whorl section is ellipsoid to oval (Table 1; Fig. 2). Maximum whorl breadth is at mid-flank. The venter is rounded. Ribs are approximated. Simple, rectiradiate, strong to sometimes very slightly falcoid ribs with a flattened top are projected and originate on the outer part of the umbilical rim from which they slowly grow in strength. The sharp, strong, simple, rectiradiate ribs are projected and initiate on the rounded umbilical wall. Distinct networks of burrows, which are interpreted as phoronid boreholes (compare Voigt, 1972), are mainly found on the venter. Epizoans such as an internal mould and a remineralized bivalve or brachiopod are visible dorsally.

**Discussion**

Unfortunately RGM 542903 is damaged ventrally and ventrolaterally. Maximum rib height is reached at the inner flanks which rules out Schlotheimia. As this specimen has a whorl height of about 25 mm, it is considered to be adult. The probable precursor of Saxoceras, the genus Storthoceras Lange, 1941 shows a similar whorl section and ribs which are projected as well. The ribs cross the venter (Lange, 1941). The youngest subgenus of Storthoceras, Megastomoceras Lange, 1941 would have the ribs restricted to the flanks of adult specimens which rules out Megastomoceras because this specimen has ribs connected, although barely visible. This specimen has comparable ribs to Saxoceras, showing the characteristic of ribs like Psiloceras (Hyatt, 1867) in the adult stage. So this specimen is identified as cf. Saxoceras sp.

*Genus Schlotheimia Bayle, 1878*

**Type species:** Ammonites angulus Von Schlotheim, 1820

**cf. Schlotheimia sp.**

**Material**

RGM 542904 (Fig. 5a) is a portion of a grey-coloured internal mould. It was found in dark, clay-rich sediment aggregates.

**Description**

The body chamber with slightly rounded flanks is embedded in a grey matrix. The venter shows a narrow furrow. Ribs are approximated. Simple, rectiradiate, projected, moderately sharp ribs curve forwards from the mid-flank onwards. Rib height does not change distinctly from the inner part of the flank onwards. The angle between the opposing ribs on the venter is approximately 90°. Neither burrows nor encrustations are encountered.

**Discussion**

RGM 542904 is the smallest of all specimens (Wh = 5 - 6 mm) and presumably juvenile. Juvenile specimens of Saxoceras may have ribs crossing the venter (Lange, 1941; Schlegelmilch, 1992), a feature not seen in the present specimen. It shows a narrow furrow, which is usually present in species of Schlotheimia (Lange, 1951). Therefore this specimen is referred to as cf. Schlotheimia sp.

**cf. Schlotheimia amblygonia**

**Material**

RGM 542905 (Fig. 5b) is part of a black internal mould, in particular worn on the flanks. It was found in dark, clay-rich sediment agglomerations.

**Description**

The whorl section of this evolute body chamber is rectangular with rounded flanks (Table 1; Fig. 2). Maximum whorl breadth is near mid-flank height. The venter is flattened and shows a wide furrow. The dorsal side is slightly concave and shows imprints of the previous venter and furrow. Ribs are approximated. The moderately strong, simple, sharp ribs are prorsiradiate and projected and start on outer part of the rounded umbilical wall. Curvature of the ribs starts at the beginning of the ventrolateral shoulders. The maximum rib height is on outer half of the flank as well as on the ventrolateral shoulder. The ribs remain strong and end abruptly on the venter, leaving a smooth siphonal band. The angle between opposite ribs on
Fig. 5. a. cf. Schlotheimia sp. (RGM 542904); b. cf. Schlotheimia amblygonia (RGM 542905); c. Schlotheimia angulata (RGM 542906); scale bar represents 10 mm.
the venter is approximately 90°. Small pyrite crystals are especially present on the proximal cross-section of the whorl. No burrows are found.

Discussion

The rectangular whorl section is distinctive and one of the features commonly seen in Saxoceras (Schlegelmilch, 1992). Saxoceras and Schlotheimia are distinguished by their ontogeny since adult Saxoceras shows psiloceratid-like ribs which have their maximum height on the flanks instead of on the ventrolateral shoulders as in the juvenile stages whereas the ribs of Schlotheimia reach their maximum height on the ventrolateral shoulders in both juvenile and adults stages. Unfortunately, maximum rib height this specimen is not decisive. Lange (1951) illustrated but a single species of Schlotheimia with a similar whorl section, S. amblygonia which comprises several subspecies according to Lange (1941). Budwill (1960) considered that this species could be synonymous with Schlotheimia angulata (Von Schlotheim, 1820) but failed to provide evidence for this. Therefore, we regard Schl. amblygonia as a valid species. The genus Saxoceras comprises many rounded-rectangular (sub)species (Lange, 1941) such as S. crassicosta, S. schroederi, S. costatum quadratum and S. praecursor. However, RGM 542905 cannot be identified as S. crassicosta or S. c. quadratum on account of the gradual effacing of the ribs on the ventral side compared to the abrupt ending of RGM 542905, the very blunt angle of opposing ribs being far more than 90° on the ventral side compared to the near-perpendicular angle of the ribs this specimen and the relatively narrow furrow compared to the wide furrow of this specimen. The ribs in S. praecursor and S. Schroederi are too strong in comparison. Moreover, the latter taxon possesses radial to rursiradiate ribs, in contrast to RGM 542905. The moderately strong, prorsiradiate ribs favour assignment of specimen RGM 542905 to cf. Schlotheimia amblygonia.

Schlotheimia angulata

Material

RGM 542906 (Fig. 5c) is a portion of a black internal mould found in un lithified clay.

Description

The phragmocone represents an evolute species with an estimated diameter of at least 80 mm. The whorl section is oval (Table 1; Fig. 2). Maximum whorl breadth is at mid-flank. The venter is acutely rounded and shows no furrow. The dorsal side is concave, shows suture lines as well as the imprints of the ribs from the previous inner whorl. Ribs are approximated. Simple, rectiradiate, strong, moderately sharp ribs are projected and originate on the rounded umbilical wall. Curvature of the ribs starts slightly before the beginning of the ventrolateral shoulders. Their maximum height is reached both on the flanks and ventrolaterally. All ribs drastically diminish in strength on the venter and form a chevron with a rounded top. The angle between the opposing ribs on the venter exceeds 90°. Sutures show two distinct lateral saddles and a lateral lobe (Fig. 4). Pyrite crystals are present mainly on the proximal cross-section of the whorl. Few burrows of conjectural origin (Henderson & McNamara, 1985) are present; most of them are positioned near or on the venter and are interpreted to have originated from a possible polychaete or sipunculid. Also, a network of burrows belonging to a possible phoronid is visible on the ventrolateral shoulder. An epizoan, represented by its convex dorsal side filled with grey sediment, is present on the distal cross-section.

Discussion

The oval whorl section of RGM 542906 closely resembles that of Schlotheimia angulata. This specimen is remarkably large compared to other specimens of Schl. angulata which generally have a diameter smaller than 50 mm (Lange, 1951; Blind, 1958, 1963; Budwill, 1960). On the other hand, the suture lines resemble those of Schl. angulata in detail and thus rule out Schl. germanica (Lange, 1914) which has a more complex suture. Strong ribs end abruptly on the ventrolateral shoulders at an angle of more than 90° which is also comparable to Schl. angulata as well, which is why we favour assignment to that species.
Discussion

Palaeogeography and literature

During the Early Jurassic, the Winterswijk area was flooded by an epicontinental shallow sea, which extended over large portions of today’s North Sea, the Netherlands, Denmark and Germany (Dercourt et al., 2000). The Rhenish and London-Brabant massifs as main landmasses to the south and structural highs in present-day Scandinavia and Great Britain to the north and west, respectively, acted as the continental boundaries.

The ammonites described have been compared with their north German contemporaries because these are found mainly only about 130 - 140 km east of Winterswijk near the Herforder Mulde and are supposed to be fairly similar because of direct palaeogeographical connections. Moreover, most of the north German ammonites also have been found in dark, clay-rich sediments (Lange, 1924) representing the same marine conditions (Herngreen et al., 2005a, b). The north German ammonites have been found in great numbers and described and illustrated in considerable detail (Lange, 1941, 1951).

Taphonomy and stratigraphy

At least three different preservational types can be distinguished. RGM 542900 and 522901 are black, heavily burrowed and show no pyrite crystals. This extensive burrowing suggests condensation. Markedly different are RGM 542902, 542903, 542905 and 542906: black, showing few burrows, bearing pyrite crystals and sometimes showing encrustations dorsally suggesting reworking. RGM 542903 and 542906 have grey sediment in several depressions, implying that they may have been temporarily embedded in grey sediment after having been reworked. The third preservational type is represented by the grey specimen of RGM 542904 which has none of the above features.

Reworking is apparent from several worn species. Also, the presence of lithified grey sediment in depressions in relation to the sediment in which the specimens were found frequently suggests reworking. Low sedimentation rates, often related to clay deposition, also would have enhanced the process of reworking.

All specimens are parts of ammonites and represent less than 120° of a whorl. Mechanical damage after lithification would be the likely cause.

Based on our findings, body chambers (6) are preferred for preservation over phragmocones (1) because they are relatively quickly filled with sediment compared to phragmocones (Henderson & McNamara, 1985). Complete and comparable sedimentary infill of all chambers occurs in RGM 542906. Sediment infill of chambers could be either through the sipuncle or through endolith borings in the shell of which the former would be of minor importance (Henderson & McNamara, 1985). Because of complete infilling, this species would have remained a considerable time at the sediment-water interface while endoliths might have sped up the process of infilling. The low sedimentation rate, as suggested by the clayey sediment, might be responsible for it.

Lowermost Jurassic (bio)stratigraphy for northwest and central Europe is summarised in Table 2, while Table 3 shows the present ammonite material with its inferred stratigraphic position. It appears that they can be placed either in ammonite biozones ‘he 2a’ or ‘he 2b’, equating with the middle or upper Hettangian, respectively. Saxoceras is considered to be the precursor of Schlotheimia (Lange, 1941, 1951; Blind, 1966; Guex, 1995), the evolutionary transition corresponding with the middle to upper Hettangian boundary. The present ammonites might cover biozones he 2a and he 2b wholly or in part.

Boreholes in close proximity of the Winterswijk quarry complex have penetrated Hettangian sediments as well (Gerth, 1955; Herngreen et al., 2000). Boreholes ‘Ratum’ and ‘E’, both within three kilometres distance from the quarry, have yielded pyrite crystals and sometimes showing encrustations dorsally suggesting reworking. RGM 542903 and 542906 have grey sediment with its inferred stratigraphic position. It appears that they can be placed either in ammonite biozones ‘he 2a’ or ‘he 2b’, equating with the middle or upper Hettangian, respectively. Saxoceras is considered to be the precursor of Schlotheimia (Lange, 1941, 1951; Blind, 1966; Guex, 1995), the evolutionary transition corresponding with the middle to upper Hettangian boundary. The present ammonites might cover biozones he 2a and he 2b wholly or in part.

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to the north-east of Winterswijk near the German border (see Herngreen et al., 2000). The Winterswijk quarry complex is situated a few hundreds of metres to the south of the southerly boundary of the syncline. So, Hettangian strata of the Aalburg Formation (Herngreen et al., 2000) with their fossil contents are common in the direct vicinity of Winterswijk.

The fact that only two metres were present in the subrosion pipe at the Winterswijk quarry complex might indicate that it represents only a part of the Hettangian compared with the thicknesses of two nearby boreholes, although local differences might occur. Oosterink et al. (2005) hypothesised that there must have been many metres more of these dark clay-rich sediments at the time the pipe collapsed but Hettangian thicknesses like mentioned before are not expected. The result that these ammonites originated from different layers concurs with the results of Gerth (1955), who documented the Hettangian ‘Schlotheimia Schichten’ to consist of dark clay and grey calcareous layers based on data for boreholes E and Batum. The mentioned aspects imply that the specimens are likely to have originated from a part of the middle to late Hettangian rather than covering the whole range of these substages.

It appears to date that only middle and late Hettangian ammonites have been recovered and not any early Hettangian or even Rhaetian species. This implies that Rhaetian and lower Hettangian sediments might not have been present when the subrosion pipe filled during collapse. Oosterink et al. (2005, 2006) noted that few Rhaetian sediments might have been present based on the occurrence of red spots in the lower part of the dark-coloured, clay-rich sediments at the time the pipe collapsed but Hettangian thicknesses like mentioned before are not expected. The result that these ammonites originated from different layers concurs with the results of Gerth (1955), who documented the Hettangian ‘Schlotheimia Schichten’ to consist of dark clay and grey calcareous layers based on data for boreholes E and Batum. The mentioned aspects imply that the specimens are likely to have originated from a part of the middle to late Hettangian rather than covering the whole range of these substages.

In conclusion, a hiatus covering more than 40 Ma is present between the Muschelkalk (Anisian, Bithynian) strata (Herngreen et al., 2005b) and the dark clay-rich sediments, indicated by the sudden transition from light grey to very dark-grey/black (Oosterink et al. 2006, fig. 5).

Henningsen (1989) documented that a preliminary age assessment to these dark clay-rich sediments, as based on ostracods, foraminifers and holothurians, indicated the Hettangian/Sinemurian boundary. He also stated that more material was needed to obtain a better-constrained dating. Herngreen (1989) concluded that the dark clay-rich sediments presumably were of late Hettangian age as based on sporo-morph evidence.

Our present results corroborate results of Lissenberg (1989) and Herngreen (1989) suggesting a middle to late Hettangian age for a part of the dark, clay-rich sediments from the subrosion pipe.

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References
