AGGLUTINATED FORAMINIFERA FROM THE CAMPANIAN OF THE KRISTIANSTAD BASIN, SOUTHERN SWEDEN

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In samples consisting mainly of Campanian biocalcarenite from Maltesholm and Ullstorp 23 foraminifera species were identified. The number of species lies within the range for a normal marine environment according to Fisher α-diagrams and triangular diagrams. It is concluded that Maltesholm represents a more shallow marine environment than Ullstorp.

A systematic description is included for the agglutinated species.

Kristianstad basin, Maltesholm, Ullstorp, Campanian, biocalcarenite, foraminifera, shallow marine environment.

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The Kristianstad basin is situated in the NE-part of Scania (southern Sweden) (Fig. 1). The Hanö bay-Kristianstad Basin subsided along the Christiansö-, the Linderödsåsen- and the Nävlingeåsen faults during Santonian to Maastrichtian and was later tilted to the southwest (Norling & Bergström 1987). During late Cretaceous the basin was covered by a warm-temperate sea.

The basement consists of Precambrian, crystalline, partly kaolinite weathered rocks, followed by a sedimentary sequence of kaoline, quartzitic sandstone and limestone.

A somewhat different lithology dominates in the SW-part of the Kristianstad area, where the studied localities are situated. The main lithologies in this area are calcareous arenites with conglomerates (Erlström & Gabrielson 1986). The above mentioned succession, in large, represent a marine environment characterized by fluctuating sea level.

Two localities (Fig. 1) of Campanian age have been studied in order to classify the foraminifera, mainly emphasizing on the agglutinated species, and to evaluate a probable variation in occurrences between species. Variations in

Fig. 1. The map shows the position of the Kristianstad basin with the localities written with capital letters and marked with squares.
the fauna between the different levels have also been examined in order to interpret possible environmental changes during the deposition of the sediments in Maltesholm and Ullstorp.

**Localities and methods**

**Maltesholm**

This locality comprises of an abandoned quarry, and was originally described by Grönwall (1915). He described the lithology as a loosely packed biocalcarenite and also briefly listed some of the fossils found there. Lundegren (1934) described two localities, called the old and the new Maltesholm quarries, but no more precise location was given, thus making their identification difficult. However, he concluded that the localities were of Early late Campanian age, based on some fragments of *Belemnellocomax mammillatus*. Christensen (1975) studied the belemnites from Maltesholm in order to do a stratigraphical interpretation on the Kristianstad area (Fig. 2). Siverson (1992) noted the rarity of lamniform sharks, which could be explained by the rarity of belemnites in comparison with other localities of *Belemnellocomax mammillatus* age.

The sampled section (Fig. 3) from this quarry consists of 0.40 m thick layers of biocalcarenite interlayered with clayey, more fine-grained limestone. The section is fairly homogeneous in terms of sedimentary development, i.e. it lacks distinct horizons and contacts. The reference level is put at the quarry floor. Rudists occur in the first metre above the reference level. Belemnites and ostracodes are common throughout the sequence. Samples were taken
from three different levels. Sample M1 was taken at 1.4 m, sample M2 was taken at 4.4 m and finally sample M3 was taken at 5.7 m. Quaternary deposits cover the sequence 5.8 m above the reference level.

**Ullstorp**

This locality consists of five quarries (Fig. 4), of which only one is used industrially today. Some of these quarries have been described by Lundegren (1934), Christensen (1975), Erlström & Gabrielson (1986) and Gabrielson (1991).

The sampled locality in this paper is called Ullstorp 3 (see Erlström & Gabrielson 1986, p. 242, fig. 1). The lithologies in the sampled section (Fig. 5) are biocalcarenite, conglomeratic biocalcarenite and conglomerate. Unit $a$ consists of 4.3 m biocalcarenite, unit $b$ begins with a 0.30 m thick conglomerate horizon which grades into a conglomeratic biocalcarenite with hummocky cross-bedding structures in the upper part and finally unit $c$ consists of 1.70 m fine-grained biocalcarenite, however more finegrained than that in the lower part of the section. The reference level is put at the quarry floor. Sample U1 was taken at 0.85 m, sample U2 was taken at 4.0 m, sample U3 was taken at 6.05 m and finally sample U4 was taken at 6.75 m. Quaternary deposits covers the sequence 6.95 m above the reference level.

**Methods**

Of each sample, 200 g were wet sieved into the fractions 63 μm-125 μm, 0.125-0.250 mm, 0.25-0.50 mm, 0.50 mm-1.00 mm and >1.00 mm. The 0.125-0.250 mm fraction was picked for foraminifera until 400 specimens were found. The picked material was weighed. The comparable weights were splitted from the 0.25-0.50 mm and 0.50-1.00 mm fractions, and the material was picked for foraminifera. This method is used when sorting out in which fractions foraminifera occur in. Depending on what fraction is prevailing one can decide whether the specimens are juvenile or adult (Phleger 1960). However, one must take into consideration that
Fig. 6. A. The triangular diagram is showing the distribution of the different environments (redrawn from Murray 1973). B. represents the distribution of the samples from Ullstorp plotted in a triangular diagram. C. represents the distribution of the samples from Maltesholm.
the a- and b- generations have different test-size.

The foraminiferal population in the samples was used in order to interpret the depositional environment at the localities with the aid of Fisher α- and triangular diagrams following the recommendations in Murray (1973). In Fisher α-diagrams the number of species are plotted on the Y-axis against the number of individuals plotted on the X-axis (see Murray 1973, fig. 101). When sample values are plotted in the diagram, the α-index is read. Different environments have different α-values. High values indicate normal marine environments, and when the α-index < 5 it points to a restricted environment. In short, a Fisher α-diagram is a useful tool when determining the environment. (It is constructed so you do not need to calculate the α-value. This value is found to be constant in a logarithmical scale). The agglutinated, hyaline and porcellaneous ratios were plotted in triangular diagrams following Murray (1973, fig.102). In a triangular diagram the three corners represent agglutinated, hyaline and porcellaneous foraminifera. Empirical analyses of foraminiferal populations in different environments have revealed the possible variations in the foraminiferal population within a specific environment. Therefore, when sample values are plotted some environments can be dismissed.

Qualitative analysis was performed with a scanning electron microscope (SEM) on some agglutinated foraminifera in order to determine the minerals that were preferred in test construction.

Fig. 7. A Fisher α-diagram showing the environmental possibilities based on the number of species versus the number of specimens. When α equals or is larger than 5, the environment is normal (redrawn from Murray 1973).

- Shelf seas of normal salinity.
- Hypersaline and nearshore shelf seas.

Fig. 8. The Fisher α-diagram with the samples from Maltesholm plotted.

Fig. 9. The Fisher α-diagram with the samples from Ullstorp plotted.
Systematic descriptions
In the descriptions below, short remarks are made for the agglutinated species. At the suprageneric levels the present classification follows the scheme presented by Loeblich & Tappan (1964, 1988). As the original descriptions were unaccessible, references are made to Franke (1928), Brotzen (1936), the Catalogue of Foraminifera by Ellis and Messina (1940 et seq.), Cushman (1946) and Loeblich & Tappan (1988).

Class Rhizopodea, von Siebold 1845
Order Foraminiferida, Eichwald 1830
Suborder Textulariina, Delage and Hérouard 1896

Superfamily Litulacea, de Blainville 1825
Family Textulariidae, Ehrenberg 1838

Subfamily Spiroplectamminae, Cushman 1927
Genus Spiroplectamina, Cushman 1927

Spiroplectamina baudoiniana (D’Orbigny) Pl. 1, Fig. A

☐ 1928 Textularia baudoiniana Franke, Pl. 12, Figs. 12A- B.

Remarks: Of the characters described in Franke (1928) the following could be observed on the specimens. The test is biserial lanceolate, i.e. that the chamber-size becomes larger at the last chambers and each chamber is rounded at the suture but sharply wedge-shaped at the outer margin. The aperture is a crescentic arch at the inner margin of the last chamber.

Subfamily Textulariinae, Ehrenberg 1838
Genus Textularia, Defrance 1824

Textularia subconica, Franke 1928 Pl. 1, Fig. B

Remarks: The studied specimens showed the characters mentioned here. The test is sagittate-shaped, with chambers that are rounded at the inner margin and ellipsoidal-shaped towards the outer margin. The chambers become larger towards the terminal face. The aperture is a crescentformed slit and placed subterminally on the last chambers inner margin.

Superfamily Textulariacea, Ehrenberg 1838
Family Eggerellidae, Cushman 1937

Subfamily Dorothinae, Balakhmatova 1972
Genus Marssonella, Cushman 1933

Marssonella oxycona (Reuss) Pl. 1, Fig. C

☐ 1928 Gaudryina oxycona Franke, Pl. 13, Figs. 8A- B. ☐ 1988 Marssonella oxycona Loeblich & Tappan, Pl. 188, Figs. 1- 3.

Remarks: Of the characters described by Franke (1928) and Loeblich & Tappan (1988), the following are the most dominant ones on the specimens. The test is almost conical in cross-section, with the initial chambers forming a point. The chambers increase rapidly in size. The test becomes biserial in the upper part. The aperture is a short arch subterminally placed at the inner margin of the last chamber. The terminal face is slightly concave.

Superfamily Verneuilinacea, Cushman 1911
Family Prolixoplectidae, Loeblich & Tappan 1985

Genus Plectina, Marsson 1878

Plectina? sp. Pl. 4, Fig. A

Remarks: The rarity of specimens makes a classification on species-level difficult, and even the generic classification is somewhat uncertain. The test is elongate. The chambers are globular and the early chambers form a trochospiral in the otherwise biserial conical test, when seen from above. The aperture is loop-shaped and subterminally placed. However, when the listed characters, which are the most dominant in the specimens, are compared to the description in Ellis & Messina (1940 et seq.) they indicate that the specimens belong to the genus Plectina.
Superfamily Ataxophragniaceae, Schwager 1877

Family Ataxophragmoiidae, Schwager 1877

Subfamily Ataxophragninae, Schwager 1877
Genus *Ataxophragnium*, Reuss 1860

*Ataxophragnium* sp. Pl. 4, Fig. B

Remarks: Due to poor preservation, the indicative characters are too few to classify the specimens on species-level. However, the following characters could be noted: the test is trochospiral subcircular in which the early whorls are not visible. The chamber-size seems to increase rapidly. The aperture is loop-shaped and placed peripherically.

Superfamily Ammodiscacea, Reuss 1862
Family Ammodiscidae, Reuss 1862

Subfamily Ammodiscinae, Reuss 1862
Genus *Ammodiscus*, Reuss 1862

*Ammodiscus* sp.

Remarks: Since too few specimens were found to confirm the actual species, the specimens were only classified to generic level. These are the characteristics found in the specimens: the test is a planispirally evolute tub that is slightly concave on both sides. The hooded aperture is subterminally placed.

Results

Additional foraminiferal fauna

Besides the agglutinated species, the following species were identified: *Quinqueloculina antiqua*, Pl. 1, Fig. D; *Cibicides ribbingi*, Pl. 2, Fig. A; *Gavelinella sandigei*, Pl. 2, Figs. B-C; *Heterohelix striata*, Pl. 2, Fig. D; *Rugoglobigerina* sp., Pl. 2, Fig. E; *Rugoglobigerina rugosa*; *Hedbergella* sp.; *Globigerinelloides multispira*; *Bolivinoides* sp., Pl. 3, Fig. A; *Lagena isabella*, Pl. 3, Fig. B; *Lagena hexagona*, Pl. 3, Fig. C; *Nonionella warburgi*, Pl. 3, Fig. D; *Nonionella extensa*, Pl. 3, Fig. E; *Guttulina adhaerens*, Pl. 4, Fig. D; *Globorotalites multi-

*septa*, Pl. 4, Fig. E; *Conorbina martini*; *Nodosaria* sp., *Praebulimina* sp.

Quantitative analysis

The calculated number of identified and unidentifiable specimens per 50g is for Maltesholm in M1: 40000 specimens, in M2: 13900 specimens, in M3: 13600 specimens, and for Ullstorp in U1: 22500 specimens, in U2: 35700 specimens, in U3: 14900 specimens and finally in U4: 28600 specimens. The values given above are approximated.

Since the results obtained from the triangular diagrams and the Fisher α-diagrams are not accurate enough, a division into five groups, with different morphological features and ecological preferences as characteristics, is made in order to establish the environment with more preciseness. The groups are as follows: the agglutinated group, the planktic group, the benthics, the attached mobiles and immobiles group, and the miscellaneous group which includes the other foraminifera present in the material but are excluded herein due to the fact that these have a cosmopolitan distribution and ability to live in different environments. Thus, these groups are of minor use in paleoenvironmental reconstructions. The following observations are made, when the differences between the groups are taken into consideration:

In Maltesholm (Fig. 10) the attached mobiles and immobiles group dominates the foraminifer fauna throughout the sequence reaching its maximum abundance in M2 with 51 per cent. In the lowermost part of the section (M1) the attached mobiles and immobiles group have almost 47 per cent of the foraminifer fauna, the benthics are the second largest group with a maximum abundance of almost 16 per cent for the section, followed by the agglutinated group with 8 per cent.

Further up (M2) (Fig. 10), the agglutinated group, in this order *Spiroplectammina baudouini*, *Ataxophragnium* sp., *Ammodiscus* sp., *Marssonella oxycon* and last *Plectina* ? sp., increases from the previous level and is the second largest group with 16 per cent. The benthic group decreases from the previous level and reaches 10 per cent while the abundance for the planktic group is unaltered.
Fig. 10. The lithology of the Maltesholm section with the composition of the foraminifer fauna in the different samples.

At the top (M3) (Fig. 10) the agglutinated group is the second largest group and still increasing and reaching a maximum abundance with 20 per cent with Spiroplectammina baudouini ana constituting the larger portion of that group, and also the benthics increase and reach 11 per cent. The attached mobiles and immobiles group decreases to 42 per cent, while the planktics disappear completely.

In Ullstorp in sample U1 (Fig. 11) the attached mobiles and immobiles group dominates with almost 41 per cent, while the second most abundant group in the sample is the agglutinated group with its maximum abundance of 29 per cent of which Textularia subconica constitutes the largest portion, followed by S. baudouini ansa, Plectina ? sp., Ataxomphragmium sp. and Ammodiscus sp. together with Marssonella oxyconca. Third largest group is the benthics, which reach their maximum abundance for the section with 14 per cent. The planktic group follows with almost 10 per cent.

Higherup, in sample U2 (Fig. 11), the planktic group increases from 10 per cent to 21 per cent, and reaches its maximum abundance for the section. The agglutinated group decreases compared to the previous level to 5.5 per cent with Ataxomphragmium sp. constituting approximately 2.8 per cent of these 5.5 per cent, and the attached mobiles and immobiles group has no change, that is it has still 41 per cent. The benthics decrease to almost 8 per cent.
Sample U3 (Fig. 11) is dominated by the attached mobiles and immobiles group, which make up almost 60 per cent of the total foraminiferal fauna, while the agglutinated group falls back to approximately 10 per cent of the total foraminifer fauna but is the second largest group. In the agglutinated group the *Alistrophragmium* sp. is still the dominating species, as it is in sample U2.

In sample U4 (Fig. 11) the attached mobiles and immobiles group dominates with 47 per cent, with the benthics as second largest group reaching 12 per cent. Amongst the decreasing agglutinated group which is the third largest group with almost 9 per cent, *Spiroplectammina baudoiniana* has the largest portion with 2.7 per cent.

The qualitative analysis with the SEM were performed on two specimens of *Spiroplectammina baudoiniana* and one specimen of *Marssonella oxycon*a and showed that the agglutinated foraminifera seem to have preferred calcium-feldspar- and silica- particles in their test. However, this analysis is based on too limited material, to verify the differences in the mineral composition of the test with certainty.

Regarding the agglutinated group, *Spiroplectammina baudoiniana* is the most common...
species in Maltesholm. A similar pattern with a dominance of a certain species is not distinguishable in Ullstorp, since the composition of the foraminiferal fauna varies from sample to sample.

It is worth noting that *Praebulimina* sp. has abundance values that are 10 per cent higher at Ullstorp than at Maltesholm. This genus is often the second or the third largest group in the samples, but too wide stratigraphical range and cosmolopolitic distribution make it unusable in this reconstruction.

**Analysis of foraminiferal abundance**

Strange morphological features, difficulties in identifying fragments of foraminifera and foraminifera affected by crystal growth and/or denudation, which are different between orders, are elements that can distort the results. This problem is discussed by Lipps (1988), Peebles & Lewis (1991) and Wetmore & Plotnick (1992).

**Agglutinated group**

The foraminifera within this group are geographically the most widespread group at present (Murray 1973). One of the reasons is the presence of organic cement binding the foreign particles of the wall, this allows them to flourish below the CCD, as well as in brackish, marginal marine environments with low alkalinity (Haynes 1981). According to Haynes (1981) their widespread distribution is also a result of their tolerance for lower oxygen levels, which allows them to inhabit silled basins and, apparently, to penetrate deeper into the sediments than calcareous foraminifera.

In general the agglutinated species become more abundant upwards in the sequence in Maltesholm.

*Ammodiscus* sp. occurs in all samples from Maltesholm, decreasing upwards in the sequence, while in Ullstorp only one specimen is found, i.e. in U1.

*Spiroplectammina baudouinianna* is more common in Maltesholm, becoming more abundant upwards in the sequence reaching 15 per cent in M3. In Ullstorp it decreases upwards in the sequence, except for the uppermost sample (U4), in which it increases. The highest value in Ullstorp is 6 per cent (in U1).

The occurrence of *Marssonella oxycona* (L.- U. Cretaceous) rarely exceeds 2 per cent. In Maltesholm it decreases upwards in the sequence.

*Textularia subconica* has its maximum in U1 with 16 per cent of the foraminiferal fauna. In the rest of the sequence it is rare, with values between 0.6 to 1.2 per cent. In Maltesholm it is missing in sample M1, but occurs with 1.5 per cent in M2 and 3.5 per cent in M3.

*Ataxophragmium* sp. In Ullstorp it increases upwards, but decreases at the top of the sequence (U4). It seems to be more common in Ullstorp than in Maltesholm.

*Plectina?* sp. is more common in Ullstorp than in Maltesholm, reaching almost 5 per cent in U1. The highest value for Maltesholm, at M2, is 0.7 per cent (see Tab. 1).

**Planktic group**

Regarding planktic foraminifera, keeled and smooth-shelled species live in deeper water than spinose and small-sized specimens (Gabrielson 1991). *Hedbergella* and *Rugoglobigerina* falls into the latter category.

The specimens within the planktic group are generally rare in Maltesholm, and they disappear completely in M2. They are somewhat more abundant in Ullstorp, where the frequency reaches a peak in U2, then it decreases in U3 and U4. U2 is the only sample in which all identified planktic forms occur.

*Globigerinelloides multispina* occurs only in U2 with 0.7 per cent.

*Heterohelix striata* is extremely rare in the samples, (see Tab. 1).

*Rugoglobigerina rugosa* (L. Santonian- L. Maastrichtian) is found only in U2 with certainty, with 0.3 per cent.

*Rugoglobigerina* sp. occurs only in U2- U4, with a maximum occurrence in U2 reaching 10.3 per cent, otherwise the values are less than 5 per cent. These specimens probably belong to *Rugoglobigerina rugosa*, but a positive identification is not made due to the state of preservation, therefore a distinction between *Rugoglobigerina*
rugosa and Rugoglobigerina sp. is made.

Hedbergella sp. occurs only in U2 and U3 with values reaching approximately 3 per cent.

Benthic group
Globorotalites multisepa (Turonian- Campanian) seems to be rather common throughout both Ullstorp and Maltaholm. In U1 and U4 it constitutes about 11 per cent, while being somewhat lower in U2 and U3 with 7.5 per cent and 4.1 per cent respectively. In M1 it occurs with 14.6 per cent and a bit lower 9.2 per cent and 10.2 per cent in M2 and M3 respectively.

Bolivinoides sp. is an index fossil for late Santonian to Maastrichtian. It is much more abundant in Ullstorp than in Maltaholm. In U1 it reaches a value of 3.7 per cent, otherwise the value is lower. The group is missing completely in M1.

Quinqueloculina antiqua has been described as ranging from M. Albian to M. Cenomanian. However, a longer stratigraphical range, at least into Campanian are probable, since the examined samples are of Early late Campanian age. It dominates in shallow, warm water and prefer temperate and hypersaline lagoons (Murray 1973). In Ullstorp these occur only in U4. Its frequency decreases throughout the section in Maltaholm as disappears completely in M3.

Attached immobiles and mobiles group
Attached mobiles have their largest abundance in shelf environments. Attached immobiles are commonly attached to firm substrates with a preference to algal facies (Gabrielson 1991), thereby indicating shallow water (within the photic zone. If the shell has a low trochospiral form, as these specimens have, it indicates a high energy environment (Gabrielson 1991). They increase to their maximum- abundance in U3, then they decrease in number in U4.

Gavelinella sandidgei (Coniacian-Maastrichtian) has high values in all samples. In Maltaholm the frequency increases upwards in the sequence reaching maximum abundance in M2, then decreasing in M3.

Cibicides ribbingi (M. Santonian- L. Maastrichtian) is more common in Ullstorp than in Maltaholm (Tab. 1). In Maltaholm they decrease upwards in the sequence.

Paleoenvironment
A climate equivalent to that existing in this part of Scandinavia in Campanian, is probably found at the northern Mediterranean today. Accelerating sea- floor spreading rates are assumed to have given a global transgression, which probably caused the somewhat warmer climate (Ziegler 1982).

The results obtained from the Fisher a-diagrams and the triangular diagrams indicates a shallow marine environment (Figs. 7-9). A high- energy regime is indicated by the dominance of the Gavelinella sandidgei and Cibicides ribbingi in both localities.

The increased abundance of planktic species in U2 indicates a local transgression as a part of the global transgression mentioned earlier.

In Ullstorp hummocky cross- bedding structures near U3 reveals that the sedimentation probably took place on the shelf below the depth for normal, fair- weather wave- reworking, but shallow enough to be influenced by storm waves.

In Maltaholm the planktic species are extremely rare, disappearing totally from M3. This is pointing towards a shallower environment in Maltaholm than that in Ullstorp and is possibly also reflecting a more shallow environment towards the top of the sequence.

Acknowledgements
I would like to thank Jan Gabrielson, my supervisor, for the support and advice he gave me during the writing of this essay. I also would like to thank Leif Arndorff for helping me whenever I had problems with the computers. A thank must also be said to professor Kent Larsson and Sven Stridsberg who commented the manuscript.
Table 1. Occurrences of the taxa in the different sample levels. Samples U1-U4 are taken in Ullstorp with U1 as the lowermost sample and U4 as the uppermost sample. Samples M1-M3 are taken in Maltesholm with M1 as the lowermost sample and M3 as the uppermost sample.

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<th>U1</th>
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<th>U3</th>
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References


Plate 1
Fig. A: Spiroplectammina baudouiniiana, SEM 250 (459 μm).
Fig. B: Textularia subconica, SEM 230 (413 μm).
Fig. C: Marssonella oxyconia, SEM 250 (210 μm).
Fig. D: Quinqueloculina antiqua, SEM 250 (459 μm).

Plate 2
Fig. A: Cibicides ribbingi, SEM 250 (463 μm).
Figs. B- C: Gavelinella sandidgei  B: SEM 250 (274 μm),
C: SEM 170 (332 μm).
Fig. D: Heterohelix striata, SEM 250 (260 μm).
Fig. E: Hedbergella sp., SEM 250 (238 μm).

Plate 3
Fig. A: Bolivinoides sp., SEM 250 (356 μm).
Fig. B: Lagena isabella, SEM 250 (296 μm).
Fig. C: Lagena hexagona, SEM 250 (210 μm).
Fig. D: Nonionella warburgi, SEM 170 (310 μm).
Fig. E: Nonionella extensa, SEM 170 (257 μm).

Plate 4
Fig. A: Plectina? sp., SEM 160 (566 μm).
Fig. B: Ataxophragmium sp., SEM 220 (277 μm).
Fig. C: Ammodiscus sp., SEM 220 (287 μm).
Fig. D: Guttulina adhaerens, SEM 170 (265 μm).
Fig. E: Globorotalites multisepia, SEM 250 (286 μm).
Tidigare skrifter i serien ”Examensarbeten i Geologi vid Lunds Universitet”:


22. Utgår.


