

# Cretaceous Ophiuroidea from Germany, Sweden, Spain and New Jersey.

By

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## Abstract.

Two different publications concerning the Senonian Ophiuroidea from Rügen appeared in 1950. A brief review of the species and the synonyms which have arisen is given. The results of combining single ossicles on a statistical basis to form species are shown to be wrong. In only a few cases has it been possible to refer Cretaceous species of Ophiuroidea to genus. A criticism of the use of isolated vertebrae as a basis for species and genera is given. One new species is established. Species known from Denmark and North Germany are also recorded from Sweden, Spain and New Jersey.

A number of years ago Professor JAEKEL investigated the Brittle Stars in the Upper Senonian White Chalk on Rügen. He found exclusively isolated ossicles. On the basis of those types of vertebrae which he could distinguish he divided his material into eight new species belonging to seven new genera. JAEKEL presented examples of his species to Dr. TH. MORTENSEN who, however, drew his attention to the fact that vertebrae differ according to their position in the arm, so that one could establish several genera on the basis of the vertebrae from one and the same arm. JAEKEL never published his investigation.

The author published an investigation of Cretaceous Asteroidea and Ophiuroidea in October 1950. The investigation of the Ophiuroidea comprised connected individuals and arm-fragments, and associated ossicles from single individuals, as well as numerous single ossicles. The investigation included material from Rügen, where it was possible to demonstrate six species which were also known from other localities. It could furthermore be shown that the method of combining isolated ossicles on the basis of their relative abundance in the deposit, introduced by C. BERRY, must inevitably lead to incorrect results. It became apparent that, even when one was concerned with finds of associated ossicles from single individuals, the smallest ossicles were, in nearly all cases, unrecognizable because of crystallization. This was especially marked in the case of the vertebrae of *Ophiomusium* whose lateral arm plates and radial shields are large and well preserved (W. RASMUSSEN 1950, p. 99). The Danish material originates from collections made in the field over a period of many years,

as well as from the washing of chalk samples. Many of the plates found cannot be identified with certainty. I have not found such a material suitable for statistical treatment, and I have therefore not given any statement of the frequency of occurrence of the individual types of ossicles in Denmark.

A publication by A. H. MÜLLER: "Die Ophiuroideenreste aus dem Mucronatensenon von Rügen" appeared in December 1950<sup>1</sup>). In this are established eight new species referred to three recent and three new genera. The species are all based on single vertebrae. Five of the species and one of the genera bear the previously unpublished names employed by JAEKEL.

Although MÜLLER has not had connected ossicles at his disposal, he has yet been able in large part to divide his vertebrae into groups corresponding to species. Only in one case may it be possible that two of his types of vertebrae may belong to the same species. On the other hand, it is likely that one or more of the types into which he divided his vertebrae are, in fact, common to more than one species. This is confirmed, as will be mentioned later, by the relative abundance of the ossicles. It will in my opinion, for the greater part, not be possible with certainty to identify these vertebrae as species at other localities; they are not sufficiently characteristic for this to be done.

MÜLLER also discusses other ossicles than vertebrae, which he provisionally combines with the vertebrae on a statistical basis. He has thereby unwittingly confirmed my opinion of the uselessness of this method, since all his combinations—which he, himself accepts with reserve—prove to be incorrect. MÜLLER's material is divided into eight types of vertebrae, but only five types of lateral arm plates, four types of radial shields, and four types of jaws. Although also other types are included in the material from Rügen which I have examined, and although the determination of distal vertebrae is very difficult, there is no group of undetermined ossicles included in his statistics. It is certain that a simple uniting of ossicles into species on such a basis is indefensible.

It will therefore be reasonable, in the following, to investigate:

1. Which Ophiuroids, which are known from other localities, can be demonstrated on Rügen.
2. How one must combine the ossicles found on Rügen into species on the basis of the knowledge of connected remains of individuals (from other localities), and with which frequency these ossicles are identified in the deposit.
3. Which criteria there are for referring the Cretaceous species to recent or fossil genera.
4. Whether vertebral morphology is acceptable as a basis for the division of Ophiuroids into genera.

1. In my investigation of the Cretaceous Ophiuroids (1950) I name the occurrence of the following species on Rügen:

<sup>1</sup>) Dr. A. H. MÜLLER has kindly informed me of the date.

*Ophiomusium subcylindricum* (HAGENOW)  
*Amphiura? senonensis* (VALETTE)  
*Ophiura? serrata* (ROEMER)  
*Ophiura? hagenowi* W. RASMUSSEN  
*Ophiura? substriata* W. RASMUSSEN  
*Asteronyx? ornatus* W. RASMUSSEN

The first five species named above are established on the basis of connected arm-fragments. They are identified on Rügen by the characteristic covering plates, especially the lateral arm plates. The vertebrae are difficult to identify with certainty, and only in one case, *Asteronyx? ornatus*, have I found it justified to establish a species on the basis of its vertebra. I refer to my publication for description of the individual species.

2. The single ossicles described by A. H. MÜLLER and their affinities:

A. H. MÜLLER 1950	correct names
<i>Asteronyx granulatus</i> vertebrae "H" 299. (Type). lateral arm plates "N" 468. jaws "T" 5.	<i>Asteronyx? ornatus</i> W. RASMUSSEN <i>Ophiura? hagenowi</i> W. RASMUSSEN (not determinable)
<i>Ophiura tener</i> vertebrae "B" 296. (Type). lateral arm plates "O" 617. radial shields "K" 15. jaws "S" 4.	<i>Ophiura? serrata</i> (ROEMER) <i>Ophiura? hagenowi</i> W. RASMUSSEN <i>Ophiomusium subcylindricum</i> (HAGENOW) (not determinable)
<i>Ophioderma arkonensis</i> vertebrae "C" 227. (Type). lateral arm plates "P" 111. jaws "V" 3.	<i>Ophiura? hagenowi</i> W. RASMUSSEN <i>Ophiura? serrata</i> (ROEMER) (not determinable)
<i>Transspandylus bubnoffi</i> vertebrae "E" 70. (Type) lateral arm plates "R" 74. radial shields "L" 10. jaws "U" 2.	<i>Transspandylus bubnoffi</i> A. H. MÜLLER <i>Ophiomusium subcylindricum</i> (HAGENOW) cf. <i>Ophiura? serrata</i> (ROEMER) (not determinable)
<i>Ophioderma rugensis</i> vertebrae "A" 56. (Type).	(invalid)
<i>Asteronyx simplex</i> vertebrae "G" 52. (Type).	<i>Asteronyx? simplex</i> (A. H. MÜLLER)
<i>Ophiaxina intercarinata</i> vertebrae "F" 17. (Type).	<i>Ophiaxina intercarinata</i> A. H. MÜLLER
<i>Schizospondylus jasmundiana</i> vertebrae "D" 13. (Type).	<i>Schizospondylus jasmundiana</i> A. H. MÜLLER
Not determinated: lateral arm plates "Q" 19. radial shields "M" 6. radial shields "J" 5.	<i>Ophiacantha? danica</i> n. sp. (not determinable) cf. <i>Ophiomusium subcylindricum</i> (HAGENOW)

Review of the species found on Rügen:

*Ophiomusium subcylindricum* (HAGENOW).

MÜLLER: 74 lateral arm plates "R" *Transspondylus bubnoffi*.  
 15 radial shields "K" *Ophiura tener*.  
 ? 5 radial shields "J".

The robust lateral arm plates and radial shields of this species are suitable for preservation as fossils. On the other hand the vertebrae are small over almost the whole length of the arm, and are not known with certainty. In finds of *Ophiomusium* from Denmark the vertebrae are badly preserved and usually quite unrecognizable. However, a few single vertebrae are known from Mön and Rügen which, by their saddle-shaped appearance when seen from the side, are like the vertebrae of the genus *Ophiomusium*. The variation of the species is not known with certainty. Several ossicles, with a granulation which can vary from a few hardly visible granulae to a very powerful granulation, have been found. Some of these ossicles may well have belonged to the same species. Interradial marginal plates are not present in the little material from Rügen which I have had available.

*Amphiura? senonensis* (VALETTE).

This species is characterized by its ventral arm plates, and especially by its lateral arm plates. The vertebrae are, as a rule, to be identified by their breadth and their appearance from the dorsal side. All three types of ossicles are present in the material from Rügen in the Mineralogical Museum. None of them is referred to by MÜLLER. This species has hitherto only been known from the Senonian, but it is now also demonstrated in the Lower Danian Bryozoan limestone of Nyvang Gaard in Jutland, Denmark (coll. J. WIND), and the Upper Danian of Limhamn in Sweden.

*Ophiura? serrata* (ROEMER).

MÜLLER: 296 vertebrae "B" *Ophiura tener* (type).  
 111 lateral arm plates "P" *Ophioderma arkonensis*.  
 ? 10 radial shields "L" *Transspondylus bubnoffi*.

The lateral arm plates of this species are characteristic and easily recognizable. They are common in the White Chalk on Rügen. MÜLLER includes 111 lateral arm plates of this species in his material. The vertebrae are not particularly characteristic. They are referred to by MÜLLER as *Ophiura tener*. MÜLLER states that he has 296 of these vertebrae in his material. If the statistical method was applicable there should only be half as many vertebrae as lateral arm plates, i. e., 55. The error may in part be caused by the incomplete representation of the thin and rather delicate lateral arm plates. This is, however, not sufficient to explain the whole of the error, and it must be assumed that MÜLLER's group "B" also includes vertebrae of other species, such as *Ophiura? substriata*. The radial shield lettered "L" by MÜLLER reminds one of the radial shield of the individual of this species figured by SPENCER, 1907, pl. 27, fig. 3.

*Ophiura? hagenowi* W. RASMUSSEN.

MÜLLER: 227 vertebrae "C" *Ophioderma arkonensis* (type).  
 468 lateral arm plates "N" *Asteronyx granulosis*.  
 617 lateral arm plates "O" *Ophiura tener*.

The lateral arm plates of this species are among the most commonly occurring lateral arm plates on Rügen. The ornamentation can vary

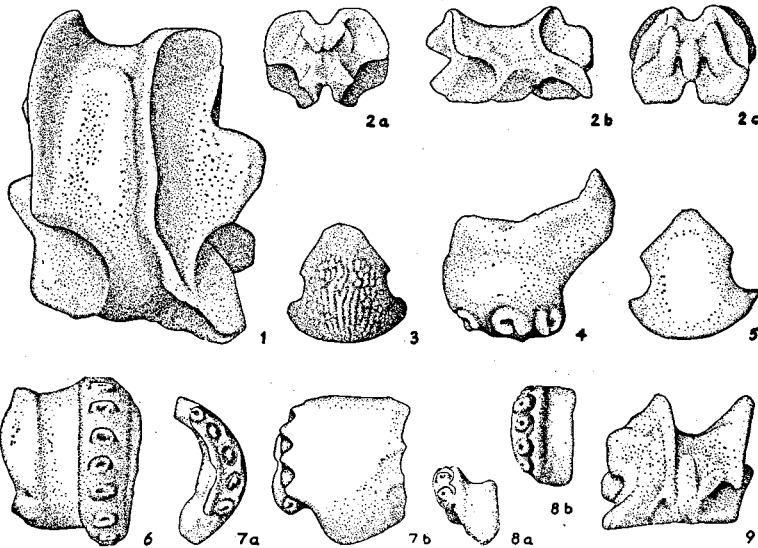


Fig. 1—5. Ophiuroidea. Single ossicles. Upper Senonian. Rügen.  $\times 15$ . 1. Vertebra from proximal end of an arm. Possibly of *Ophiomusium*. — 2. Vertebra from distal part of an arm. Possibly of *Ophiomusium*. — a, proximal end; b, lateral; c, distal end. — 3. *Ophiura? substriata*. Ventral arm plate. — 4. *Amphiuira? senonensis*. Lateral arm plate. — 5. *Amphiuira? senonensis*. Ventral arm plate. — 6. *Ophiacantha? danica* n. sp. Holotype. Upper Senonian. Rørdal, Aalborg, Denmark.  $\times 15$ . 7—9. Ophiuroidea. Single ossicles. Danian? Vincentown limesand. New Jersey.  $\times 15$ . 7. *Ophiura? cf. serrata*. Lateral arm plate. a, distal end; b, lateral. — 8. *Ophiacantha?* sp. Lateral arm plate. a, ventral; b, lateral. — 9. *Ophiomusium stephensoni*. Vertebra.

exceptionally much in coarseness, but it has not been possible for me, up to the present, to distinguish more than one species in the material which I have had available, in spite of the fact that this has included both single ossicles and a number of arm-fragments, the latter particularly from English collections. The lateral arm plates can be difficult to distinguish from *Ophiura? substriata*. The vertebrae must, in consideration of their size, and the frequency of occurrence of the lateral arm plates, be present in MÜLLER's material. The vertebra is, unfortunately, only poorly known, as only a couple of incomplete vertebrae are visible in the arm fragments which I have figured. It seems most likely that, because of their shape, the vertebrae which MÜLLER has lettered "C" belong

to this species. The ossicles "N" and "O"<sup>1)</sup> represent coarsely and finely granulous lateral arm plates of this species. Their number is however far too great in comparison with the number of vertebrae. This can in part be explained if the greater part of the coarsely granulous ossicles in group "N" have belonged to the next following species, *Ophiura? substriata*. *O.? hagenowi* has previously only been known from the Senonian, but it is now also demonstrated in the Lower Danian Bryozoan limestone of Nyvang Gaard, Jutland, Denmark (coll. J. WIND).

*Ophiura? substriata* W. RASMUSSEN.

This species is not uncommon in the material from Rügen. Especially the ventral arm plates are easily recognizable. Ossicles of this species are not mentioned by MÜLLER, which is supposedly due to the fact that the lateral arm plates can be confused with plates of *Ophiura? hagenowi*, and the vertebrae with vertebrae of *Ophiura? serrata*.

*Asteronyx? ornatus* W. RASMUSSEN.

MÜLLER: 299 vertebrae "H" *Asteronyx granulosis* (type).

Only the vertebrae of this species are known. On the basis of our knowledge of recent species of this genus, it must be assumed that the remaining arm ossicles are so small and slightly characteristic that it has not been possible to identify them among the fossil remains in the deposit. The granulation varies in detail from ossicle to ossicle. The appearance of the vertebrae is, however, so characteristic that it seems justified to make this vertebra the basis of a species.

*Asteronyx? simplex* (A. H. MÜLLER).

MÜLLER: 52 vertebrae "G" *Asteronyx simplex* (type).

This species is assumedly identical with the *Asteronyx? sp.* which I have described. There is, as mentioned below, no certainty that the generic determination is correct. There is, as always, a certain variation in the appearance of the individual ossicles, but a number of those ossicles which are to be found in Danish collections agree closely with MÜLLER's figure. The appearance of the ossicle is but slightly characteristic, and the value of the species is therefore doubtful.

*Ophiacantha? danica* n. sp.

1950 *Ophiacantha? sp.* W. RASMUSSEN, p. 120, pl. 18, fig. 10.

1950 Lateral arm plate "Q" A. H. MÜLLER, pl. 3, fig. Q.

Diagnosis.—The lateral arm plates are short and strongly arched. They have met each other proximally both in the dorsal and ventral side of the arm. The distal part of the plate is sharply demarcated from the constricted proximal part and has seven or eight powerful bosses which have formed the points of attachment of projecting spines.

<sup>1)</sup> Dr. A. H. MÜLLER has kindly sent me specimens of "O" for identification.

Type.—The specimen figured by the author 1950, pl. 18, fig. 10, and here fig. 6, is the holotype. Collection of the Mineralogical Museum, Copenhagen.

Occurrence.—Senonian of Rügen. Senonian and Danian of Denmark. Danian of Sweden.

Remarks.—All that has previously been known of this species has been a few lateral arm plates from the Senonian and Danian of Denmark. As the species seems to be identical with the ossicles lettered "Q" by MÜLLER, of which MÜLLER has 19 specimens from Rügen, and as these ossicles have now been found in large numbers in the Upper Danian of Limhamn in Sweden, it will supposedly be appropriate to attach a name to the species. Other types of ossicles belonging to this species are as yet unknown.

*"Ophioderma rugensis* A. H. MÜLLER".

MÜLLER: 56 vertebrae "A" *Ophioderma rugensis* (type).

MÜLLER states fig. A 1-5 as the type for this species. It is therefore unfortunate that figs. A 2a and A 2b must, according to the drawing, originate from other specimens than the remainder. Thus the species does not seem to be adequately and validly established. The vertebrae resemble the vertebrae of *Ophiopeza* figured by LYMAN (1882, pl. XLI, figs. 2-3).

*Transspondylus bubnoffi* A. H. MÜLLER.

MÜLLER: 70 vertebrae "E" *Transspondylus bubnoffi* (type).

The species is established on the basis of a vertebra. No other ossicles belonging to this species are known.

*Ophiaxina intercarinata* A. H. MÜLLER.

MÜLLER: 17 vertebrae "F" *Ophiaxina intercarinata* (type).

The species is established on the basis of a vertebra. This type of vertebrae can also be identified in the Danish material from Rügen. No other ossicles belonging to this species are known. The vertebrae are somewhat similar to the vertebrae of the recent genus *Ophiomyxa*.

*Schizospondylus jasmundiana* A. H. MÜLLER.

MÜLLER: 13 vertebrae "D" *Schizospondylus jasmundiana* (type).

The species is established on the basis of a vertebra. Other ossicle types belonging to this species are not known. These rather large vertebrae are only present in small numbers. They are apparently very different from *Transspondylus bubnoffi*, but there are however such important characters in common that, without knowledge of the variation, it cannot be excluded that they are proximal ossicles of this species. In the material left by JAEKEL these two types of ossicles were not separated. The vertebrae are also rather similar to the vertebrae of *Ophiocamax* figured by LYMAN (1882, pl. XLI, fig. 10-11).

3. It has so far only been possible to identify a single recent genus of Brittle Star from Cretaceous deposits. This is the genus *Ophiomusium*, whose arm has a particularly characteristic structure. The generic determination in all other previously described cases must be accepted with greatest reserve; this should also be apparent in the naming of these animals by—in agreement with the Rules of Nomenclature—placing a “?” after the generic name. It seems, on the whole, to be reasonable in the treatment of so difficult a group of fossils widely to employ “nomenclatura aperta”. Some special genera have been established for Cretaceous species. For example *Ophycoma* D’ORBIGNY, which is identical with *Ophiomusium* (W. RASMUSSEN, 1950, p. 106), and *Ophiotitanos* SPENCER. The establishment of vaguely defined fossil genera is unfortunate, since better finds can make the genus more restricted and well defined, with the result that the remaining species are again excluded from the genus.

4. BERRY and MÜLLER have established a number of Cretaceous genera on the basis of single vertebrae. This method is also unfortunate, as the vertebrae are often only slightly characteristic, and those investigations of the vertebrae in recent species which are available at present have not confirmed the assumed taxonomic importance of the vertebrae.

No monographic treatment of the vertebrae of Ophiuroids is to be found. Figures of the vertebrae of a number of Ophiuroid genera are found in LYMAN’s Report on the Ophiuroidea of the Challenger Expedition, 1882. TH. MORTENSEN published in 1913 an investigation of the vertebrae of a few recent genera of Ophiuroids. In 1917 H. MATSUMOTO published a monograph of Japanese Ophiuroidea. This publication is based on a thorough investigation of the skeleton. Lastly I. LIEBERKIND has undertaken an unpublished investigation of the vertebrae of Brittle Stars. He has kindly lent me the illustrations from his work. It is apparent from these works that the vertebrae can have a characteristic shape within some individual families and subfamilies, but that within other groups there seem to be no characteristic features which can be employed taxonomically. As an example I can mention the Y-shaped dorsal side of the vertebrae of the Ophiotrichidæ. Not even the old distinction of the two main groups, the Euryalæ and the Ophiuræ, on the basis of the articulatory bosses of the vertebrae holds true, since both streptospondylic and zygospondylic vertebrae are found in the family Ophiacanthidæ.

The vertebrae from the Senonian and Danian in Denmark, and the Senonian of Rügen which are referred to the genus *Asteronyx*? can, on the basis of MATSUMOTO’s information, be referred either to the Trichasteridæ (including *Asteronyx*) or the Gorgonocephalidæ, due to the appearance of the articulatory bosses and the relation between the size of the upper and lower muscle attachments. The last mentioned family can presumably be excluded, since no vertebrae showing arm bifurcation have been found.

Both BERRY and MÜLLER express surprise at the small number of species of Brittle Stars which are known from the Upper Cretaceous



and Tertiary. Considering how few workers have concerned themselves with fossil Ophiuroids, how difficult is the determination of these animals, and how few localities and facies-types have been investigated, I find nothing remarkable in the poverty of Ophiuroids in the Cretaceous-Tertiary seas, when compared with the Ophiuroid faunas in all recent seas—including the epifaunas of coral reefs and deep-sea faunas, of which we have no parallel in fossil deposits. I do not therefore believe that a direct statistical comparison has any value. An evaluation of the species- and individual-frequency of fossil faunas must be effected by a very careful counting and weighing of the different groups of fossils in a definite volume of the deposit. The result of such an investigation would be comparable with those investigations which are at the present day effected by means of bottom-samples corresponding to a definite area of the sea-floor. It must, however, also be taken into consideration that the absolute results of such investigations will be partly conditioned by the average life-cycle of the individual animal groups, the rate of inorganic sedimentation, the conditions for the preservation of fossils, etc. Such investigations are not as yet published in respect of Danish deposits, and are unknown to me from other regions.

### Cretaceous Ophiuroidea found in Sweden, Spain and New Jersey.

A few specimens of Brittle Stars from the Swedish Cretaceous are to be found in the collections of the Mineralogical Museum, Copenhagen.

The remains of Ophiuroids from Spain have been obtained by J. WIND from samples of Maastrichtian from Olazagutia in Navarra. The samples have been sent to J. WIND by M. RUIZ DE GAONA. Investigation of this material has given the striking result that most of the ossicles are shown to be identical with species which are known from the Senonian of northern Europe. These species seem thus to have a wide distribution both stratigraphically and regionally. Apart from the species, shown below, from the Spanish material, there were to be found a few ossicles of an unknown species. With the exception of *Asteronyx*, the species were identified by the lateral arm plates.

The American specimens of Brittle Stars were picked from samples of Vincentown limesand which J. WIND received from Professor E. VOIGT, Hamburg and from State Geologist MEREDITH E. JOHNSON, Trenton, New Jersey. On the basis of material from this locality BERRY (1942) described a new species, *Ophiomusium stephensoni*. The author showed (1950) that ossicles from more than one species were united in this species. The new material clearly shows numerous plates of two species and a few plates of two other species. The following numbers of plates were recognized in the sample:

<i>Ophiomusium stephensoni</i> : Radial shield.....	15
Interradial marginal plate.....	6
Lateral arm plate.....	325
Vertebral ossicle.....	1

<i>Ophiura? cf. serrata:</i>	Dorsal arm plate.....	44
	Ventral arm plate.....	1
	Lateral arm plate.....	725
	Vertebral ossicle.....	58
<i>Amphiura? senonensis:</i>	Lateral arm plate.....	14
<i>Ophiacantha? sp.:</i>	Lateral arm plate.....	65

The close affinity of *O. stephensoni* with *O. danicum* stressed by the author (1950) is confirmed by the study of the present material. The small amount of material seems, however, to indicate that *O. stephensoni* may be distinguished from the Danish species by the following small differences: The interradiial marginal plates are less tumid and have a more distinct flexure. On a few well-preserved lateral arm plates it is to be seen that there are only four small bosses on the inner surface near the distal margin. The lowermost of these bosses is larger than the remainder.

There is a number of lateral arm plates which seem to be identical with, or closely similar to the plates of *Ophiura? serrata*. The identity cannot be established with this material since the majority of the plates are a little more short and stout, and have a shorter distal margin than plates of *O. serrata* with the same number of spines. Four or five spines have been present on the lateral arm plates. The vertebra, dorsal and ventral arm plates figures by BERRY (1942, pl. 60) belong assumedly to this species.

Apart from these two species there are a few lateral arm plates of *Amphiura? senonensis* and of an unknown species similar to *Ophiacantha? danica*. The distal parts of these lateral arm plates project, and bear five or six strong bosses, which have formed the points of attachment of projecting spines, on the outer side near the edge.

	<i>Amphiura? senonensis</i>	<i>Ophiura? serrata</i>	<i>Ophiura? hagenowi</i>	<i>Ophiacantha? danica</i>	<i>Ophiomusium danicum</i>	<i>Ophiomusium stephensoni</i>	<i>Asteronyx? sp.</i>
Puerto de Olazagutia, Maastrichtian.							
Marl with Orbitoides.....	×	×	×	.	.	.	.
Puerto de Olazagutia, Maastrichtian.							
Upper part of the marl.....	×	×	×	.	.	.	.
Båstad, Sweden. Campanian .....	.	.	.	.	.	.	×
Östra Torp, Sweden. Danian .....	.	.	.	.	×	.	.
Limhamn, Sweden. Danian .....	×	×	.	×	.	.	.
Vincentown limesand, New Jersey. Danian?.....	×	?	.	?	.	×	.

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