

# C-14 chronology of Late- and Post-glacial marine deposits in North Jutland

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C-14 dates of mollusc shells from marine Late- and Post-glacial deposits, mainly from Vendsyssel, North Jutland, are presented. The *Zirphaea* beds, which were formerly referred to the Allerød oscillation, are now correlated with the Bölling oscillation, and the beach deposits from Borgbakke and from Råholt are included in the *Zirphaea* beds. The dates of the *Dosinia* beds fall within the first half of the Sub-boreal, pollen zone VIII, and perhaps the end of the Atlantic, pollen zone VII. A number of recent shell samples were measured as a control.

Series of mollusc shells from marine deposits in North Jutland, especially in Vendsyssel, and from the island of Læsø have been collected and dated in an attempt to establish a chronology of the most important events in the Late- and Post-glacial marine sequence of the area. Special emphasis was placed on getting as broad a representation as possible from the different Late-glacial marine deposits and from the Post-glacial *Dosinia* beds, but no effort was made to cover the whole Post-glacial sequence.

Our knowledge of the marine deposits of the area is based mainly on investigations and observations made at the end of the last and the beginning of this century (Jessen 1899; Nordmann 1904). As several of the sites from that time are no longer accessible, a few samples have been taken from shells collected at that time and kept since then in the specimen collections of the Geological Survey. The rest of the fossil samples originates from new field collections made from 1962 to 1968 by Sigurd Hansen and Harald Krog from the Geological Survey, partly assisted by Ib Marcussen and Erna Nordmann. The recent control samples, K-330 to K-339, were kindly placed at our disposal from the specimen collections at the Zoological Museum. A number of the dates have previously been published in date lists (Tauber 1966 a, 1966 b). A list of the samples dated after the 1966 lists is found at the end of this paper.

A survey of the shell dates in the present date list and in the lists of

1966 is given in Table 1. Stratigraphical divisions and the terminology applied in the table and in the date lists are mainly those used by Jessen (1936) and followed by Hansen (1965) and Krog (1968). The shell layers from Borgbakke and from Råholt have, however, been placed in a stratigraphically uncertain group, Upper *Saxicava* sand/*Zirphaea* beds, because opinions have differed as to the proper stratigraphical position of these deposits. The Post-glacial deposits are only divided into two groups, *Tapes* deposits *s.l.* and *Dosinia* deposits, because the material presented here is too sparse to allow a more detailed subdivision. Two samples, K-1248 and K-1469, have not been included in the table because of uncertainties as to what is actually represented by the sample material.

The samples in the first two groups in Table 1, Lower *Saxicava* sand and Late-glacial *Yoldia* clay, have all been collected from layers in a supposed primary position and are considered reliable. The samples in the two groups thus date deposits from the Late-glacial *Yoldia* sea and are chronologically correlated with Daniglacial time and pollen zone I a.

It has not been possible to get shell samples from stratigraphically certain deposits of Upper *Saxicava* sand, which is usually supposed to represent the end phase of the Late-glacial *Yoldia* sea.

The shell layers at Borgbakke and Råholt, here placed in the uncertain group Upper *Saxicava* sand/*Zirphaea* beds, have previously been referred to the *Zirphaea* beds (Jessen 1899), to Upper *Saxicava* sand (Jessen 1936), and to a separate transgression between the *Yoldia* sea and the *Zirphaea* sea (Hansen 1965). It follows from Table 1 that the three samples chronologically fall within the age range of the true *Zirphaea* beds. On the basis of the C-14 dates they should therefore be referred to the *Zirphaea* beds, as was tentatively done by Krog (1968).

The samples representing *Zirphaea* beds were collected partly from shells in reliable primary positions, partly from shell banks and similar deposits where redeposition is likely to occur. It should be noted, however, that all species dated are members of the *Zirphaea* fauna and are not represented in deposits from the previous periods. They are therefore reliable as time markers for the *Zirphaea* beds, even when found in rebedded positions. The dates in this group are spread relatively evenly over about 800 years and hardly allow any subdivision into different stages as was done by Mörner (1969, p. 174). Pollen analytically the *Zirphaea* beds have previously been referred to the Alleröd oscillation (Iversen 1947). However, all the C-14 dates, except three that are older, fall within the range of dates for the Bölling oscillation. The present dates therefore very strongly indicate that the *Zirphaea* beds should be correlated with the Bölling oscillation, as was also accepted by Iversen (1967, 1973). The three some-

what older dates, among these one made directly on shells of *Zirphaea crispata*, may suggest that the climatic amelioration that is reflected both by the *Zirphaea* fauna and by the terrestrial Bölling oscillation was registered slightly earlier in the sea than by the terrestrial plant communities.

Opinions have differed somewhat as to the chronological position of the Post-glacial *Dosinia* beds. Hansen (1965) has correlated them with the Sub-boreal, pollen zone VIII. The dates presented here suggest that the correlation should rather be with the first half of the Sub-boreal, perhaps with a beginning already at the end of the Atlantic as suggested by K-1237 and K-1238. However, as stated in the sample descriptions, these two samples are not considered fully reliable as they originate from a shell bank. However, the fact that the two dates, from the upper and the lower part of the shell bank respectively, are almost identical supports the idea that all shells in the bank, and among these are shells of *Dosinia exoleta*, are likely to be of the same age. It should be emphasized that the number of samples and dates from *Dosinia* beds is too small for an exact chronological delimitation of this group.

The samples referred to *Tapes* deposits *s.l.* have not been systematically collected to give a broad representation and need only little comment. The samples from Melholt must all be considered to belong to the same beach deposit, and the age differences between the dates for these samples may perhaps be explained as due to contamination from rebedded older shells. The youngest date in Table 1, K-1246, grouped under *Tapes* deposits *s.l.*, is interesting because it refers to a deposit found only 300 m from a *Dosinia* bed and at the same level as this, but stratigraphically it deviates from the *Dosinia* beds by not being deposited on the stony surface of Older *Yoldia* clay like these, but in marine sand. Deposits similar to the one represented by K-1246 are rather common within the area of the *Dosinia* beds, but their chronological position is uncertain.

C-14 dating of marine shells poses some special problems. While the atmosphere of each hemisphere is well mixed within months and thus ensures a uniform C-14 activity of contemporary terrestrial plant material, the turnover of water masses in the oceans is a slow process that gives rise to considerable differences in C-14 activity within the oceans. The mean residence time of water masses in the deep oceans, i.e. below the thermocline, varies from ocean to ocean. In the Atlantic it is of the order of 600 to 700 years (Broecker *et al.* 1960). During this time C-14 atoms in the deep oceanic bicarbonate will gradually decay. In areas of upwelling of deep ocean water, i.e. around the Antarctic and in restricted areas with divergent surface currents, oceanic bicarbonate is therefore depleted in C-14 activity relative to equilibrium conditions. Due to exchange of carbon dioxide be-

tween the atmosphere and the oceans the C-14 activity of upwelling deep water will gradually increase again as the water masses are mixed into the upper mixed layers, and on the rate of exchange of carbon dioxide between way an equilibrium, mainly depending on the rate of turn-over between the deep ocean and the upper mixed ocean, on the mean residence time in the upper mixed layers, and on the rate of exchange of carbon dioxide between the atmosphere and the oceans, tends to be established. With the present circulation pattern a fairly constant C-14 activity, corresponding to a depletion in C-14 activity of about 4-5 % or an apparent age of surface water bicarbonate of about 300-400 years, is attained in areas well away from the centres of upwelling. In the Atlantic sector this relative constancy prevails in the North Atlantic and the adjacent seas (Broecker *et al.* 1961, Mangerud 1972), perhaps with the exception of the East Greenland Current where outflow of water from the icecovered Arctic ocean may give a local depression in C-14 activity corresponding to about 100-200 years (Östlund and Fonselius 1959; Hjort 1973).

Another effect also influences the age calculations. When atmospheric carbon dioxide is absorbed in the oceans an isotopic fractionation takes place and, under equilibrium conditions, gives rise to an enrichment of 4-6 % in the C-14 activity of oceanic bicarbonate relative to that of terrestrial plant material. At the present rate of ocean circulation the enrichment in C-14 due to fractionation and the depletion in C-14 due to ocean circulation almost cancel. In the upper mixed layers of the North Atlantic, and in the adjacent seas with a pronounced marine influence, the C-14 activity of ocean bicarbonate, and of marine shells, therefore broadly equals the C-14 activity of contemporary organic terrestrial material.

The uniformity or near-uniformity in C-14 activity of terrestrial plant material and of marine shells is shown in the measurements of the recent shell samples K-433, K-892, and K-893 (Tauber 1966a, 1966b), and the series K-330 to K-339 in the list below. The molluscs in the last mentioned series had been collected as live animals between 1840 and 1934. The C-14 activity of the shells has been corrected for decay between the time of collection and 1950, and expressed in percentage of the international modern standard (0.95 times the activity of the NBS oxalic acid standard), which is also used as a standard in age calculations of organic terrestrial material. The average activity of 11 recent samples that were living before large-scale nuclear testing began is 99.9 % of the modern terrestrial value, with a scatter slightly exceeding what is normally expected statistically.

Calculated with this standard and with no correction for isotopic fractionation, dates of marine shells are thus directly comparable with C-14

dates of organic terrestrial material, provided that the circulation pattern in the oceans has not changed significantly. No further "sea correction" should therefore be applied to these dates, as was erroneously done in a recent discussion of the Late-glacial (Mörner 1969, pp. 174, 380, and 385; cf. Tauber 1970, p. 180). In this connection it may be noted that two Scandinavian C-14 stations, Uppsala and Lund, in the age calculations of marine shells apply a correction for the isotopic fractionation that occurs in the absorption of carbon dioxide in ocean water, and disregard the effect of ocean circulation. In this way they arrive at dates for shell material that are about 400 years older than those presented below.

Shell material is liable to post-depositional contamination due to exchange with bicarbonate of marine water or of percolating ground water. To avoid errors from this effect the surface layers of the shell samples, or about 10-20 % of the total sample weight, were removed with acid prior to dating. Finally it should be noted that the shell dates listed below are given in "conventional" C-14 years B.P. (before 1950). Dates in approximately absolute years may be obtained, at least as far back as 7300 B.P., by a calibration with the American bristlecone pine chronology (Suess 1970; Damon *et al.* 1973). In the middle of the Post-glacial this calibration amounts to a correction of the conventional C-14 dates by about 800 years. In the Late-glacial and the early Post-glacial conventional C-14 dates approximate the revised Swedish varve chronology and therefore, perhaps, may need no correction (Tauber 1970). However, this question is still disputed and will not be finally decided before the bristlecone pine chronology has been extended further back in time.

Table 1. Late- and Post-glacial shell dates from North Jutland and recent samples from the North Atlantic sector.

*Lower Saxicava sand*

K-858	Lönstrup Klint	<i>Saxicava arctica</i>	13,900±220 B.P.
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*Late-glacial Yoldia clay*

K-1051	Gölstrup	<i>Saxicava arctica</i>	14,280±240 B.P.
K-1052	-	-	14,080±240 --
K-1049	Læsö	-	13,770±130 --
K-1053	Skeen Möllebæk	-	13,610±220 --
K-887	Dybvad	-	13,180±200 --
K-903	-	-	13,010±190 --
K-894	Læsö	-	12,910±180 --
K-1050	-	-	12,850±210 --
K-891	Bindslev	<i>Mya tr., Sax., Mac. calc.</i>	12,650±180 --

*Upper Saxicava sand/Zirphaea beds*

K-1688	Råholt	<i>Mytilus edulis</i>	12,400±180	B.P.
K-859	Borgbakke	- -	12,030±130	--
K-1687	-	- -	12,020±180	--

*Zirphaea beds*

K-1468	Vangen	<i>Zirphaea crispata</i>	12,770±190	B.P.
K-898	Skeen Møllebæk	<i>Mya truncata</i>	12,770±160	--
K-897	- -	<i>Mytilus edulis</i>	12,520±180	--
K-1318	Kjul Å	<i>Zirphaea crispata</i>	12,460±190	--
K-1357	- -	<i>Macoma baltica</i>	12,370±190	--
K-862	Skeen Møllebæk	- <i>calcareo</i>	12,360±150	--
K-899	- -	<i>Mytilus edulis</i>	12,240±180	--
K-860	- -	<i>Mya truncata</i>	12,230±170	--
K-861	- -	- -	12,190±170	--
K-1681	- -	<i>Mytilus edulis</i>	12,120±180	--
K-1320	Kjul Å	<i>Mac. bal., Zir., Cypr.</i>	12,130±190	--
K-1470	Tværsted Å	<i>Cyprina islandica</i>	11,980±190	--
K-1471	- -	<i>Zirphaea crispata</i>	11,950±190	--
K-1319	Kjul Å	<i>Mytilus edulis</i>	11,950±190	--

*Tapes (Littorina) deposits s.l.*

K-895	Tværsted Å	<i>Cardium edule</i>	8280±140	B.P.
K-1472	- -	- -	8250±130	--
K-1054	- -	- -	7820±140	--
K-906	Melholt	<i>Ostrea edulis</i>	6110±120	--
K-890	-	<i>Card. ed., Ost., Cypr.</i>	6090±120	--
K-907	-	<i>Cardium edule</i>	5940±140	--
K-888	-	<i>Ostrea edulis</i>	5620±140	--
K-889	-	<i>Cardium edule</i>	5560±140	--
K-902	-	-	5550±140	--
K-866	Lille Vildmose	<i>Ostrea edulis</i>	5580±150	--
K-864	Gettrup	<i>Ostrea ed., Myt. ed., etc.</i>	4150±140	--
K-865	-	<i>Littorina litt.</i>	4010±120	--
K-1241	Glomstrup Vig	<i>Ostrea edulis</i>	3050±100	--
K-1246	Frederikshavn	<i>Cardium edule</i>	2440±100	--

*Dosinia deposits*

K-1237	Frederikshavn	<i>Ostrea edulis</i>	5240±120	B.P.
K-1238	-	- -	5180±150	--
K-900	Strandby	<i>Dosinia exoleta</i>	4470±140	--
K-1039	-	<i>Ostrea edulis</i>	4290±130	--
K-1038	-	<i>Dosinia exoleta</i>	3990±130	--
K-1236	Frederikshavn	<i>Ostrea edulis</i>	3980±140	--

Recent samples			% of modern
K-331	Middelfart, Denmark, 1861	<i>Mytilus ed.</i>	101.8±0.8 %
K-332	Horsens Fj., Denmark, 1934	— —	100.5±0.8 %
K-333	Limfjorden, Denmark, 1886	— —	99.0±0.6 %
K-334	Sörvåg, Faroe Isl., 1905	— —	99.6±0.8 %
K-330	Faxebugt, Iceland, 1840	— —	101.0±0.6 %
K-335	Thorshöfn, Iceland, 1913	— —	98.0±0.6 %
K-336	Godthåb, Greenland, 1887	— —	98.3±0.6 %
K-337	Jacobshavn, Greenland, 1898	— —	100.3±0.8 %
K-338	Disco, Greenland, 1902	— —	101.1±0.8 %
K-339	Disco, Greenland, 1906	— —	98.9±0.6 %
K-433	Limfjorden, Denmark, 1952	<i>Ostrea ed.</i>	100.7±0.5 %
K-892	Kujegrund, Denmark, 1962	<i>Cardium ed.</i>	100.8±0.5 %
K-893	Sæby, Denmark, 1962	<i>Mya aren.</i>	101.9±0.5 %

## Sample descriptions

		14,280±240 B.P.
K-1051.	Gölstrup, DGU 291	12,330 B.C.
Shells ( <i>Saxicava arctica</i> ) from clay pit at the brick-works Gölstrup Teglværk (57°25'N Lat, 9°49'E Long), Vendsyssel. Found in Late-glacial <i>Yoldia</i> clay, ca. 3 m below ground level.		
		14,080±240 B.P.
K-1052.	Skeen Møllebæk, DGU 292	12,130 B.C.
Shells ( <i>Saxicava arctica</i> ) from Skeen Møllebæk, E of Skeen Møllegård (57°33'N Lat, 10°07'E Long), Vendsyssel. Found in Late-glacial <i>Yoldia</i> clay, 3 m below the top of the clay.		
		13,610±220 B.P.
K-1053.	Skeen Møllebæk, DGU 293	11,660 B.C.
Shells ( <i>Saxicava arctica</i> ) from same locality as K-1052. Found in the uppermost 30 cm of the Late-glacial <i>Yoldia</i> clay, just below shell-free <i>Zirphaea</i> sand, 3 m above sample K-1052.		
		13,770±230 B.P.
K-1049.	Læsø, Byrum, DGU 289	11,820 B.C.
Shells ( <i>Saxicava arctica</i> ) from Late-glacial <i>Yoldia</i> clay, Byrum, Læsø, S of the farm Storehave (57°15'N Lat, 10°59'E Long). Found ca. 1½ m below ground level, ca. ½ m below the clay surface.		
		12,850±210 B.P.
K-1050.	Læsø, Byrum, DGU 290	10,900 B.C.
Shells ( <i>Saxicava arctica</i> ) from Late-glacial <i>Yoldia</i> clay, Byrum, Læsø, just N of the farm Storehave (57°15'N Lat, 10°58'E Long). Found ca. 1½ m below ground level in the top part of the clay.		
		13,250±160 B.P.
K-1469.	Vangen, DGU 386	11,300 B.C.
Shells ( <i>Macoma calcarea</i> ) from clay pit ca. 200 m W of Vangen Bro abt. ½–1 km SSW of Nr. Bindslev (57°32'N Lat, 10°12'E Long), Vendsyssel. Found in lower part		

of clayey sand on top of Late-glacial *Yoldia* clay, altitude ca. + 15 m. The layer was clearly referred to the *Zirphaea* beds, but it was evidently disturbed by solifluction processes and already when taking the samples we had a suspicion that part of the shells might be reworked from the underlying shell-rich *Yoldia* clay. From the results of the date it is concluded that the shells originate from the *Yoldia* clay. Date is average of two measurements: 13,490±200 and 13,010±200.

K-1468. Vangen, DGU 385 12,770±190 B.P.  
10,820 B.C.

Shells (*Zirphaea crispata*) from same locality as K-1469. Most of the shells were found in the same sand layer (*Zirphaea* bed) as the shells from K-1469, but a few of them were found in their burrows in the upper 10-15 cm of the *Yoldia* clay. Altitude ca. + 15 m.

K-1318. Kjul Å, DGU 343 12,460±190 B.P.  
10,510 B.C.

Shells (*Zirphaea crispata*) from *Zirphaea* bed, Kjul Å, abt. 150 m N of Helligkilde (57°35'N Lat, 10°01'E Long), Vendsyssel. Found partly in a small shell bank, 1-5 cm thick, on top of Older *Yoldia* clay, partly in their burrows in the upper 10-15 cm of the *Yoldia* clay below the shell bank. Altitude ca. + 6½- + 7 m.

K-1357. Kjul Å, DGU 348 b 12,370±190 B.P.  
10,420 B.C.

Shells (*Macoma baltica*) from *Zirphaea* bed, same locality and same layer as K-1318.

K-1319. Kjul Å, DGU 344 11,950±190 B.P.  
10,000 B.C.

Shells (*Mytilus edulis*) from *Zirphaea* bed, Kjul Å, ca. 130-140 m N of Helligkilde (57°35'N Lat, 10°01'E Long), Vendsyssel. Found in shell rich silt layer, 10-30 cm thick, on top of Older *Yoldia* clay. Almost all shells were juvenile. Altitude ca. + 5½ m.

K-1320. Kjul Å, DGU 345 12,130±190 B.P.  
10,180 B.C.

Shells (*Macoma baltica*, *Zirphaea crispata*, and *Cyprina islandica*) from *Zirphaea* bed, same locality as K-1319. Found in a small shell bank, ca. 5 cm thick, ca. ½ m above surface of Older *Yoldia* clay, and separated from K-1319 by shell-free sand layer. Altitude ca. + 6 m.

K-1248. Kjul Å, DGU 330 11,710±180 B.P.  
9760 B.C.

Shells (*Mytilus edulis*) from Kjul Å, abt. 200 m S of Helligkilde (57°35'N Lat, 10°01'E Long), Vendsyssel. Found in sand layer ca. 75 cm above surface of Older *Yoldia* clay. Altitude ca. + 6½ - + 7 m. The sequence above the *Yoldia* clay consists of Late- and Post-glacial marine gravel and sand layers without any distinguishable limit. The layer from which the shells are collected was originally believed to be a *Zirphaea* bed. The same layer contained lumps of organic material which by pollen analysis proved to be of very young Post-glacial age. Thus the shells may be of mixed origin.

- K-1470. Tværsted Å, DGU 387  
11,980±190 B.P.  
10,030 B.C.  
Shells (*Cyprina islandica*) from *Zirphaea* bed, Tværsted Å, W of Nr. Tværsted (57°35'N Lat, 10°11'E Long), Vendsyssel. From gravel layer rich in fragmented shells. Altitude ca. + 3 m.
- K-1471. Tværsted Å, DGU 388  
11,950±190 B.P.  
10,000 B.C.  
Shells (*Zirphaea crispata*) from *Zirphaea* bed, same locality and same layer as K-1470.
- K-1689. Skeen Mølle, DGU 414  
12,120±180 B.P.  
10,170 B.C.  
Shells (*Mytilus edulis*) from clay pit N of Skeen Mølle (57°33'N Lat, 10°07'E Long), Vendsyssel. Type site for *Zirphaea* beds. Found in gravel layer on top of Late-glacial *Yoldia* clay, covered by 3–5 m of stratified sand. Coll. V. Nordmann 1904.
- K-1688. Råholt, DGU 415  
12,400±180 B.P.  
10,450 B.C.  
Shells (*Mytilus edulis*) from Råholt (57°27'N Lat, 10°31'E Long), Frederikshavn, Vendsyssel. From gravel rich in shell fragments. In the literature this deposit has been referred both to the Upper *Saxicava* sand and the *Zirphaea* beds. Altitude ca. + 25 m. Coll. V. Nordmann 1904.
- K-1687. Borgbakke, DGU 416  
12,020±180 B.P.  
10,070 B.C.  
Shells (*Mytilus edulis*) from Borgbakke (57°27'N Lat, 10°31'E Long), Frederikshavn, Vendsyssel. From gravel rich in shell fragments. Like K-1688 this deposit has been referred to both the Upper *Saxicava* sand and the *Zirphaea* beds. Altitude ca. + 20 m. Coll. V. Nordmann 1904.
- K-1054. Tværsted Å, DGU 294  
7820±140 B.P.  
5870 B.C.  
Shells (*Cardium edule*) from cliff at the river Tværsted Å (57°35'N Lat, 10°11'E Long), Vendsyssel. Found in Post-glacial marine sand below *Cardium* clay. See comment to K-1472.
- K-1472. Tværsted Å, DGU 389  
8250±130 B.P.  
6300 B.C.  
Shells (*Cardium edule*) from cliff at the river Tværsted Å, same locality as K-1054. From sand layer in lower part of marine series on top of thin peat layer. The Post-glacial marine transgression is marked in the profile by transition from peat to marine clay gyttja and by pollen analysis it is dated at the transition between pollen zones V and VI. Altitude of shell layer + 6.0 m. Samples K-1054 and K-895 (see Table 1) must be referred to this layer too.
- K-1237. Frederikshavn, DGU 318  
5240±120 B.P.  
3290 B.C.  
Shells (*Ostrea edulis*) from Skippergade in Frederikshavn (57°27'N Lat, 10°32'E Long), Vendsyssel. From uppermost part of a more than 1 m thick shell bank. Surface of

shell bank (and sample level) ca. 40 cm below ground level, altitude ca. + 1.3 m. Referred to *Dosinia* beds as shells of *Dosinia exoleta* were present, but not enough for a date. Most of the shells in the shell bank were fragmented. Date is average of two measurements:  $5380 \pm 150$  and  $5100 \pm 150$ .

K-1238. Frederikshavn, DGU 319  $5180 \pm 150$  B.P.  
2320 B.C.

Shells (*Ostrea edulis*) from lower part of same shell bank as K-1237. Altitude ca. + 0.3 m. Two fragmented shells of *Dosinia exoleta* were found in this layer. As it must be assumed that the shells in the shell bank have been redeposited, the shells of *Dosinia* and of *Ostrea* may be of different origin and age. Accordingly it is uncertain if K-1237 and K-1238 really date *Dosinia* beds.

K-1038. Strandby, DGU 287  $3990 \pm 130$  B.P.  
2040 B.C.

Shells (*Dosinia exoleta*) from Strandby ( $57^{\circ}29'N$  Lat,  $10^{\circ}30'E$  Long), Vendsyssel. Found in layer of clayey shell gravel, ca. 25 cm thick, on top of Older *Yoldia* clay. Altitude ca. + 4 m.

K-1039. Strandby, DGU 288  $4290 \pm 130$  B.P.  
2340 B.C.

Shells (*Ostrea edulis*) from same layer as K-1038. *Dosinia* bed.

K-1236. Frederikshavn, DGU 317  $3980 \pm 140$  B.P.  
2030 B.C.

Shells (*Ostrea edulis*) from *Dosinia* bed, near Flade Engvej N of Frederikshavn ( $57^{\circ}28'N$  Lat,  $10^{\circ}31'E$  Long), Vendsyssel. Found in thin shell-rich sand layer on top of Older *Yoldia* clay. Altitude ca. + 4 m. Shells of *Dosinia exoleta* were present but not sufficient for a date.

K-1246. Frederikshavn, DGU 328  $2440 \pm 100$  B.P.  
490 B.C.

Shells (*Cardium edule*) from place ca. 300 m N of K-1236, near Flade Engvej N of Frederikshavn ( $57^{\circ}28'N$  Lat,  $10^{\circ}31'E$  Long), Vendsyssel. From small shell bank of *Cardium* shells in otherwise shell-free sand, at approximately same level (+ 4 m) as K-1236. Date is average of two measurements:  $2480 \pm 110$  and  $2400 \pm 110$ .

K-1241. Glomstrup Vig, DGU 322  $3050 \pm 100$  B.P.  
1100 B.C.

Shells (*Ostrea edulis*) from shell bank near Glomstrup Vig S of Tissing Huse ( $56^{\circ}43'N$  Lat,  $8^{\circ}38'E$  Long), island of Mors, North Jutland. From fossil "oyster bank" covered by marine mud. In the layer were found 3 different species of *Tapes* which during *Tapes* time (*Littorina* time) lived in Danish waters. Coll. V. Nordmann 1903. Date is average of two dates:  $2920 \pm 120$  and  $3180 \pm 120$ .

K-330 Faxe Bugt  $101.0 \pm 0.6$  %  
of modern

Shells (*Mytilus edulis*) from Faxe Bugt (ca.  $64^{\circ}20'N$  Lat, ca.  $22^{\circ}00'W$  Long), Iceland. Collected in 1861 as live animals and preserved in the Zoological Museum, Copenhagen.

- 101.8±0.8 %  
of modern
- K-331 Middelfart Sund  
Shells (*Mytilus edulis*) from Middelfart Sund (55°31'N Lat, 9°42'E Long), Denmark. Collected in 1861 as live animals and preserved in the Zoological Museum, Copenhagen.
- 100.5±0.8 %  
of modern
- K-332 Vorsø, Horsens Fjord  
Shells (*Mytilus edulis*) from Vorsø, Horsens Fjord (55°52'N Lat, 10°01'E Long), Denmark. Collected in 1934 as live animals and preserved in the Zoological Museum, Copenhagen.
- 99.0±0.6 %  
of modern
- K-333 Fur Sund, Limfjorden  
Shells (*Mytilus edulis*) from Fur Sund, Limfjorden (56°48'N Lat, 9°00'E Long), Denmark. Collected in 1886 as live animals and preserved in the Zoological Museum, Copenhagen.
- 99.6±0.8 %  
of modern
- K-334 Sørvåg, Vågø  
Shells (*Mytilus edulis*) from the beach at Sørvåg, Vågø (62°04'N Lat, 7°20'W Long), Faroe Islands. Collected in 1905 as live animals and preserved in the Zoological Museum, Copenhagen.
- 98.0±0.6 %  
of modern
- K-335 Thorshöfn  
Shells (*Mytilus edulis*) from Thorshöfn (66°15'N Lat, 15°19'W Long), Iceland. Collected in 1913 as live animals at a depth of 0-6 m and preserved in the Zoological Museum, Copenhagen.
- 98.3±0.6 %  
of modern
- K-336 Godthåb  
Shells (*Mytilus edulis*) from Godthåb (64°12'N Lat, 51°45'W Long), Greenland. Collected in 1887 as live animals at a depth of 4-9 m and preserved in the Zoological Museum, Copenhagen.
- 100.3±0.8 %  
of modern
- K-337 Jacobshavn  
Shells (*Mytilus edulis*) from Jacobshavn (69°13'N Lat, 51°08'W Long), Greenland. Collected in 1898 as live animals and preserved in the Zoological Museum, Copenhagen.
- 101.1±0.8 %  
of modern
- K-338 Disco  
Shells (*Mytilus edulis*) from Disco (ca. 69°15'N Lat, ca. 53°30'W Long), Greenland. Collected in 1902 as live animals and preserved in the Zoological Museum, Copenhagen.

98.9±0.6 %  
of modern

K-339 Mudderbugten, Disco

Shells (*Mytilus edulis*) from Mudderbugten, Disco (69°41'N Lat, 52°00'W Long), Greenland. Collected in 1906 as live animals and preserved in the Zoological Museum, Copenhagen.

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## Dansk sammendrag

En række C-14 bestemmelser på molluskskaller fra sen- og postglaciale marine aflejringer, hovedsagelig fra Vendsyssel, fremlægges. De fleste prøver er indsamlet 1962-1968, men enkelte stammer fra indsamlinger foretaget i begyndelsen af dette århundrede. En del af dateringerne er tidligere publiceret i dateringslister (Tauber 1966a, 1966b), de øvrige findes i slutningen af denne afhandling. Dateringerne er oversigtligt samlet i Table 1, opdelt i stratigrafiske grupper efter A. Jessens terminologi (Jessen 1899, 1936). Som vigtigste resultater skal fremhæves, at *Zirphaea*-lagene, der tidligere var henregnet til Allerødtid, ifølge disse dateringer tilhører Böllingoscillationen. Stranddannelserne fra Borgbakke og Råholt har hidtil været stratigrafisk usikkert placeret, men må ifølge C-14 dateringerne henregnes til *Zirphaea*-lagene, og dermed Böllingoscillationen. Dateringerne af skaller fra *Dosinia*-lagene falder inden for første halvdel af subborealtid og måske i slutningen af atlantisk tid. En række recente skalprøver er blevet målt til kontrol af de ovennævnte dateringer.

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