

SUOMEN MUINAISMUISTOYHDISTYKSEN AIKAKAUSKIRJA  
FINSKA FORNMINNESFÖRENINGENS TIDSKRIFT  
XXXVI: 2

---

# EUSTATIC CHANGES OF LEVEL AND THE NEOLITHICUM

BY  
WILHELM RAMSAY

---

*Helsinki*  
K. F. PUROMIEHEN KIRJAPAINO O.Y.  
1926



## Eustatic changes of level and the neolithicum<sup>1)</sup>

by

*Wilhelm Ramsay.*

### QUATERNARY CHANGES OF LEVEL.

During the Ice Ages, great quantities of water were bound in the ice-caps and thus detracted from the sea, the level of which fell considerably in consequence. When the land ice melted again, the volume of water in the sea increased, and during the interglacial and postglacial epochs, the level of the sea rose. This view was expressed by Maclaren as early as 1842<sup>2)</sup>, and has since then been treated and developed by many authors, some of whom are mentioned in the list on page 6.

Thus, Daly has given an explanation of the shifts of level by which, according to Darwin's theory, the coral reefs grew up from great depths. And to take another example, Molengraaff sees in these shifts the cause of the low level which made the Sunda shelf in East India once a piece of land connecting Sumatra, Java and Borneo with the Malacca peninsula, as described in his interesting study. The streams of these countries joined in a common drainage system, the valleys of which have been traced by soundings (Fig. 1.). The fish fauna in the rivers of Sumatra and the western side of Borneo contains for the greater part identic species by reason of their common origin from the former general

---

<sup>1)</sup> This paper contains chiefly a translation of a lecture read before the »Nordiska arkeologmötet», in Helsingfors, July 1925, and printed in Swedish in Ymer 45 Stockholm 1925, p. 279. — Some additions are made.

<sup>2)</sup> In a former paper (1924) I have named A. Tylor (1868) as the originator of the above view.

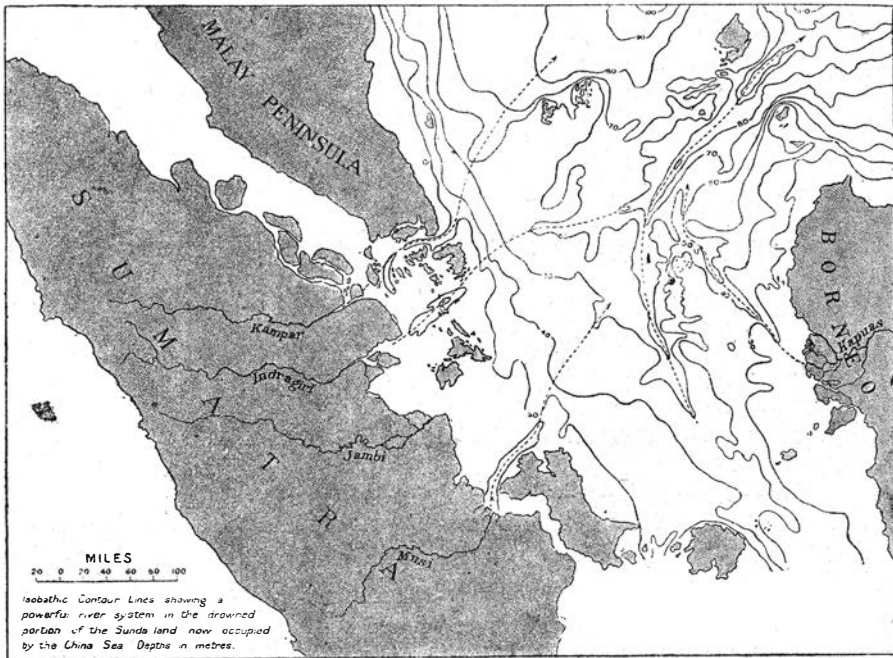


Fig. 1. The submarine river and valley system of the Sunda plateau. From G. A. F. Molengraaff.

river system, whilst a great difference exists between the fish faunas in the rivers of the western and eastern sides of Borneo as these rivers were never confluent. The tin ore bearing sand and gravel in these districts not only fill the land valleys, but the submarine valleys also. These mainland conditions occurred on the Sunda plateau at so late a time that we can very well imagine the region now submerged having been populated.

Literature gives many instances of drowned valleys, deltas, submerged forests and peatbogs off the recent coasts. Geologists have in many cases looked for local causes for these formations and thought them limited to certain regions only. A critical inquiry certainly seems to refute many of these evidences of the sea having formerly been at a lower level, but there yet remain so many undoubted instances from quite different parts of the globe that

we can hardly call in question general — «eustatic» — regressions and transgressions, in connections with the great glaciations and deglaciations of the Quaternary period. (Moreover, eustatic changes of level also occurred, especially at the beginning of that period, in consequence of displacements of continental and oceanic parts of the earth's crust).

Isostatic sinking and rising of the formerly glaciated regions have co-operated with the eustatic oscillations of the sea-level to complicate the Quaternary displacements of strand lines (Ramsay 1924). Other complications appear in districts where young mountain folding or its effects acted upon the earth's crust as lately as the Quaternary time, as for example in the Mediterranean countries (Gignoux and others). But the shifts of sea-level were less intricate in those parts of the globe which were not influenced by a late orogeny or the load of ice-caps. There we find relatively low sea-levels during the Ice Ages, and relatively high ones during the interglacial and postglacial times, higher in proportion as the climates were warmer and the more so as the ice-caps were reduced.

The complete melting of the recent land ice (about 15 million sqkm with an average thickness of 800 m) should raise the sea's surface about 30—40 m. W. B. Wright (1914) has calculated 40 m at least, Nansen (1922) 25 m or more. Raised beaches at these levels above the sea, and river plateaus and terraces formed in the valleys when the rivers flowed into the sea at a higher level than at present, are mentioned from different parts of the world which were not glaciated during the Quaternary period. They certainly belong to interglacial epochs with relatively warm climates. Palæolithic remains are found on many of them.

During the great glaciations — assuming that these were synchronous all over the globe, — the base-level sank and the river valleys deepened. During the greatest of them, the sea's surface was most lowered. Various authors have made different estimates of this sinking, as may be seen from the following list, which is given in a paper by Daly (1925):

Author	Date of estimate	Estimate in metres
C. Maclaren	1842	213
J. Croll	1866	610
A. Tylor	1872	183
T. Belt	1874	305—914
W. Upham	1878	914
A. Penck	1881	66,5 (ice of northern hemisphere alone)
E. Drygalski	1887	150
A. Penck	1894	150
W. Upham	1896	46
F. Nansen	1904	100—200
R. A. Daly	1910	46
W. B. Wright	1914	82—122
R. A. Daly	1915	50—60
W. J. Humphreys	1915	67
A. Penck	1922	40
F. Nansen	1922	130+
W. Ramsay	1924	300+
R. A. Daly	1925	50—60

Even the more moderate of these estimates show a lowering of the sea-level considerable enough to remove the coast lines far below and away from recent ones, especially in regions of broad, shallow sea shelves. The present mainlands therefore lay at a greater height above the sea than they do nowadays, and offered — during the Ice Ages — less agreeable abodes for man than the territories outside the recent coasts. These had the most genial climates and the richest vegetation. Man preferred them to the higher lands.

For the above reasons, prehistoric strand dwellings at the present shore lines or at higher levels must belong to postglacial or interglacial epochs, the strand dwellings of the Ice Ages being all submerged, and I think, therefore, that the eustatic changes of level during the glacial, interglacial and postglacial times lead to the two following consequences of archæological importance.

1. When the sea's surface was low during the Ice Ages, there were more or less extensive stretches of land, now inundated, outside the present shores, which afforded relatively most favourable cli-

mates and best conditions for human existence. Many of them may have been the home of cultures which spread later to countries within the present limits of the continents. This will be exemplified by the Persian Gulf and the Sumerian culture.

2. When the sea rose during the interglacial epochs, it reached on the continents levels more or less high above the present one according to the degree in which the land ice had diminished. In postglacial time it reached the present level. The shore lines and the river terraces formed at the limits of such a transgression are synchronous on all ocean coasts. Their positions relative to the prehistoric dwellings will probably afford the best grounds for homotaxis between archæological periods on widely separated parts of the earth. This will be exemplified by some cultures at the limit of the postglacial eustatic transgression.

#### THE SUMERIAN CULTURE AND THE PERSIAN GULF.

The oldest Sumerian culture, as it appeared on the Euphrates and the Tigris many thousands of years before Christ, must have been the outcome of a very long period of evolution, which however did not take place in the Chaldean land. All attempts to find its original home have hitherto failed, whether the search was directed to India, Central Asia or other more or less remote countries. I therefore think it most probable that the Sumerians and their culture came not from any remote land but from the immediate neighbourhood of Sumer, I mean from the bottom of the Persian gulf which must have been dry land during the last Ice Age.

This long and relatively shallow bay must have formed a broad valley extending from Shat-el-Arab to the Strait of Hormus. A mighty river with the united waters of the Tigris and the Euphrates ran down it, and with the falling and rising of the sea's surface, the mouth of this river shifted now down now up the valley, filling it with sand and silt and forming vast river plains which now make the flat bottom of the gulf with a depth of at most 80 m, according to the British Admiralty map n:o 273 (Fig. 2).

In this low-lying valley country, the climate was more genial and the disagreeable influence of the Ice Age less felt than on the upper course of the Mesopotamian rivers. The fertile land at the

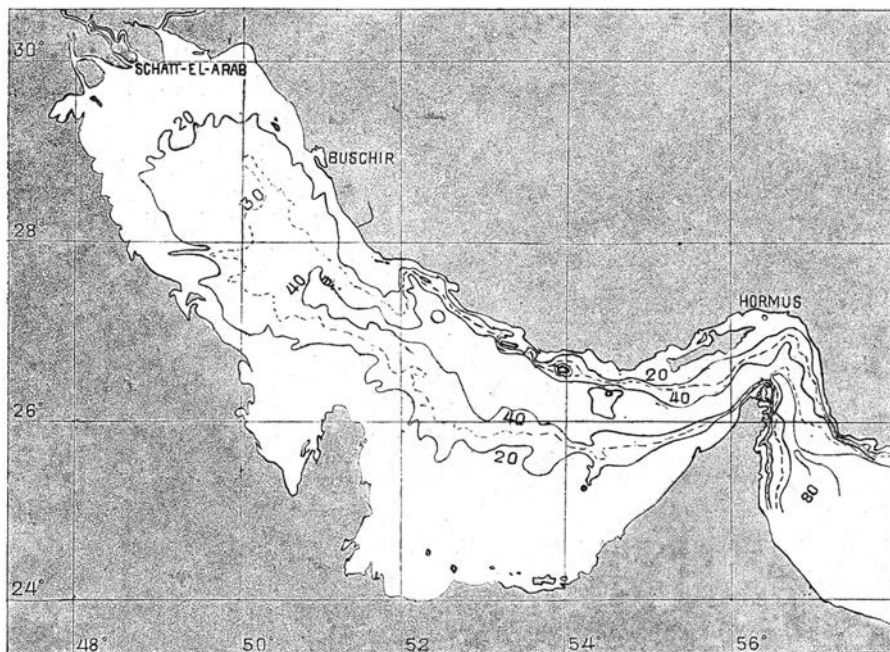


Fig. 2. The depths in fathoms of the Persian Gulf. After the British Admiralty map n:o 273.

bottom of the Persian Gulf stimulated an intelligent people to develop agriculture, and domesticate and breed cattle and other animals. The fittest plants and beasts were chosen. Fields and orchards grew up along the big river. Technical progresses were made which afterwards appeared in the oldest Sumerian culture; and here religion and social order were early developed, for valley culture and irrigation are not possible without mutually regulated human relations.

This culture could continue to evolve through the whole of the long period during which the last great Ice Age kept the sea's surface at so low a level that the floor of the gulf was land. But when the climate ameliorated and the land ice diminished, the sea rose. It gradually filled the gulf and drove the population up into the valley of the Tigris and the Euphrates, for neither Iran in the north nor Arabia in the south afforded necessary conditions for an



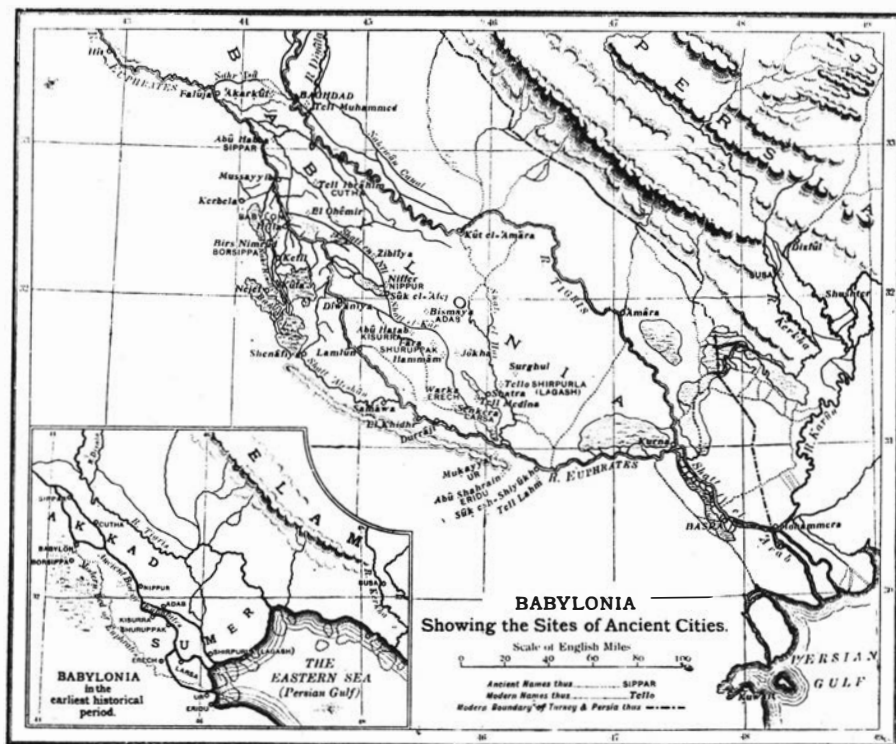


Fig. 3. Sites of ancient cities in Babylonia. From L. W. King.

agricultural life such as that to which the people were accustomed. In consequence, the oldest remains of Sumerian and Elamite villages and cities («tells») are found round the inner end of the Persian Gulf, on both sides and on the southeastern part of the delta of the Mesopotamian rivers (Fig. 3). These places lay originally near the sea or near a wide lagoon inside the Karun river delta. The Euphrates and the Tigris had thus formed a considerable delta even before the Sumerians immigrated thither.

Some of the settlements and cities were founded on the higher land on both sides of the delta, as for example Susa on the north side and Mugheir (Ur) on the south. These were never touched by the postglacial rising of the sea, and the deepest layers in them may show us prehistoric cultures even earlier than the time when the sea reached its full height. Other cities and villages were situated

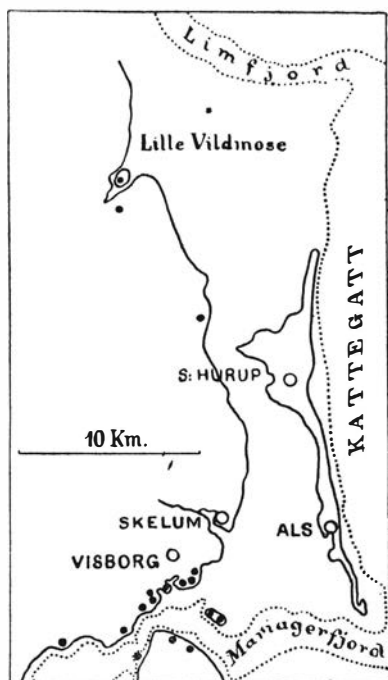


Fig. 4. Sites of «kökkenmøddings» in Denmark at the coast line of the Litorina Sea (drawn line) and the actual coast (stipled line). After A. P. Madsen and S. Müller.

on the delta plain, but these could only make a stand against sedimentation and rising of the ground water, if they raised the ground by filling up with earth or amassing offal and remains of older buildings. As long as the sea's surface rose, the delta probably grew in height faster than the culture layers, which were thus concealed beneath silt and mud even in places not directly submerged by the sea. But when transgression ceased, a certain relaxation or balance in the sedimentation made it possible for the cities to rise above the delta surface, at least in the outer part of the delta.

On all these grounds, I am inclined to think that the oldest prehistoric beds of the Sumerian «tells» on the delta may give us the date when the land ice of the last Ice Age had been diminished

to about its present volume and the ocean filled to about its borders.

This postglacial transgression being eustatic, all prehistoric cultures which appear at its close in different parts of the world have coexisted with the oldest Sumerian culture on the delta of the Euphrates and the Tigris. One among them is represented by the older «kökkenmøddings» in Denmark or the so called Ertebølle epoch of the Stone Age. These shell heaps, and other dwelling places of the same age in northern Europe, lie on raised beaches and terraces at the limits of the transgression named the Tapes or Litorina Sea by Scandinavian geologists (Fig. 4, 5 and 6). This transgression was not caused by a postglacial sinking of land, as has generally been stated, but was in my opinion (Ramsay 1924)

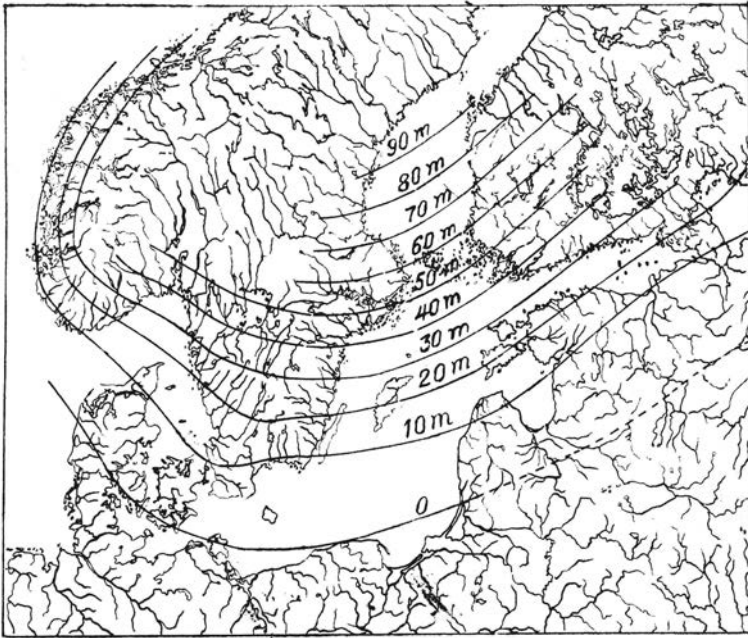


Fig. 5. Isobases showing the elevation of land in the Baltic regions since the maximum of the postglacial (Litorina) transgression.

part of the general postglacial increase of the sea, which was here in northern Europe, at a certain phase, quicker than the elevation of the land. But when the sea ceased to rise, the constant rising of the land lifted above the sea-level the shore lines formed by the transgression.

The Tapes-Litorina Sea reached its maximal extension about 4000—4500 years B. C. according to recent estimates made by Sandegren on the basis of a study of the profiles in the postglacial sediments at Ragunda in Jämtland, Sweden. The age of the oldest Sumerian culture on the delta of the Euphrates and the Tigris, as estimated by King, Langdon and others, is of the same order of magnitude.

Consequently, the peoples down by the Persian Gulf had arrived at a certain stage of agriculture, fruit cultivation and cattle-breeding, as well as considerable skill in manufacturing stone implements, textile wares and ceramics, and also already knew copper,

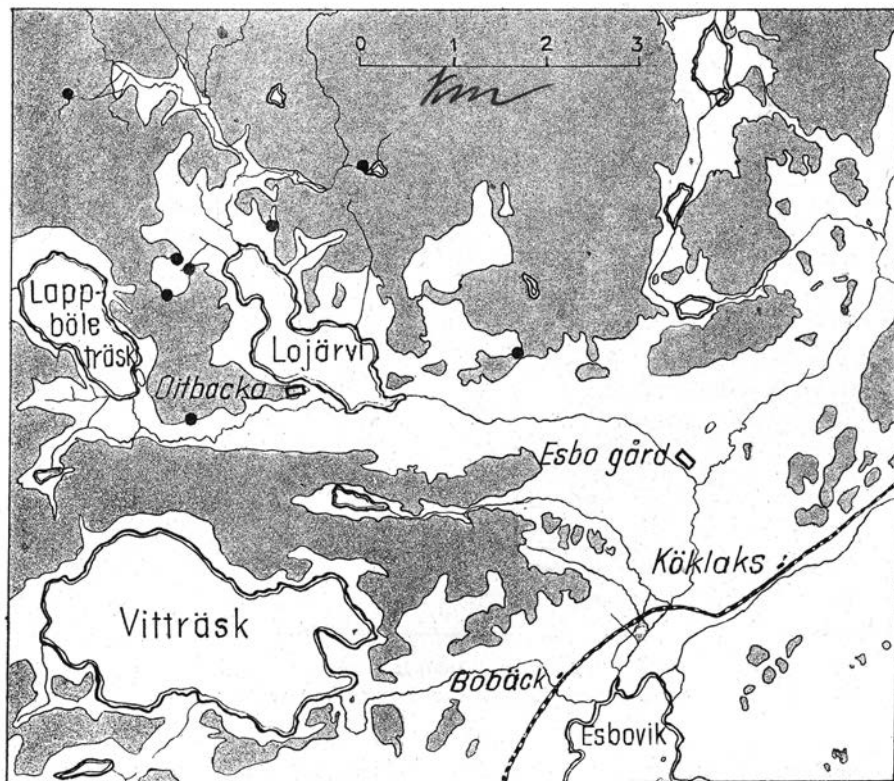


Fig. 6. The oldest Stone Age dwelling places (dots), 34 m above sea level, in the parish of Esbo in Southern Finland, on the coast of the Litorina Sea. Land gray, Litorina sea white. After A. Europaeus.

had a sort of pictography, and lived in an ordered society, whilst none but savage tribes at the stage of hunters and fishers, with very primitive tools, tried existence up in the north.

#### PREHISTORIC CULTURES COEXISTENT WITH THE CLOSE OF THE POSTGLACIAL EUSTATIC TRANSGRESSION.

I have emphasized the possibility of using the time when the postglacial eustatic transgression finished for a homotaxis of prehistoric cultures then flourishing. There are of course difficulties in adapting this method, because the postglacial changes of level

over great parts of the earth originated not only from oscillations of the sea, but also from movements of the earth's crust. It is not always easy, sometimes impossible, to decide in what degree the one or other of these factors contributed to the resulting displacement of the strand-lines. Especially where sinking of land continued to late historical time, it is difficult to fix the level (now submerged) reached by the postglacial eustatic transgression. Further, even in northern Europe and on the British Isles, where the land has risen so high that the sea shores formed at the maximum postglacial eustatic transgression, are now above the present sea-level and thus distinctly separated from it, doubt may be felt whether all these beaches are contemporary with each other and with the date when the sea ceased rising.

It is certainly supposed that the postglacial Tapes-Litorina transgression reached its maximum at the same time in all parts of Northern Europe, and this assumption forms the ground of all attempts hitherto made to find a chronology for the strand dwelling places of the Stone Age from their position relative to the raised shore-lines. But this supposition would have little likelihood if the transgression depended on the land sinking, as seems still to be the view most generally adopted among geologists in Scandinavia. For why and how should the movement of the earth's crust have turned simultaneously from sinking to rising over the whole region? On the other hand, synchronism of the raised beaches in question is very thinkable if the transgression was due the sea-level rising faster than the land. But even then, it need not necessarily have ceased at the same time everywhere in the region, for the rising land could outstrip the rising sea earlier in some zones than in others.

This question whether the postglacial transgression reached its maximum simultaneously or not in different belts of a formerly glaciated and isostatically rising district, has been answered in the negative by W. B. Wright (1925), who points to the fact that the Stone Age dwelling places at Oban belong to the Azilian, and those at Larne to the Campignian, although both lie on the shores of the postglacial transgression. For my own part, I have arrived at the opinion that the raised shore surface of the Tapes-Litorina Sea, at least in a peripheric zone from the zero isobase to that of about

30—40 m, is a synchronous one formed at the ending of the postglacial increase of the sea (Ramsay 1926).

In spite of the limitations mentioned above, the possibility of getting a homotaxis between certain Stone Age cultures from the close of the postglacial eustatic transgression seems so promising that I have been tempted to try the method.

During a certain postglacial epoch, the peripheric parts of the formerly glaciated areas of northern Europe lay at a higher level above the sea (of that time) than nowadays. In consequence, great parts of the bottom of the Cattegat, the North Sea and the English Channel were then land and connected the British Isles with the continent (Fig. 7). Land extended also off the west coast of France, as submerged forests and submarine valleys show (Welsch), and generally, as long as the glaciation and regression of the ocean lasted, the coasts of the continents lay outside the recent shores. These territories afterwards overflowed by the sea were surely inhabited, since Europe then had inhabitants, and along the shores of these now submerged countries, the forerunners of the kökkenmødding people and other coast tribes I think lived. The postglacial rising of the sea compelled them to retire to the limits of the transgression. There, we find now the remains of their peculiar cultures: in Denmark the older shell heaps (kökkenmøddings) or Ertebølle culture, on the Scandinavian peninsula and in Finland corresponding older Stone Age cultures, on the British Isles Larne and other dwelling places, from Flanders to Brittany the Campignian remains, round the Bay of Biscaya the Asturian (Obermayer) and at the mouth of the Tagus Protoneolithic shell heaps (Åberg).

Thus, from Scandinavia in the north to the Iberian peninsula in the south, the Protoneolithicum appears as peculiar coast cultures with Epipalaeolithic traits still preserved. In spite of the differences between the Ertebølle-Campignian in the north and the Asturian and the Tagus cultures in the south, we must hold them to have been coexistent. They flourished when the postglacial rising of the sea was ending.

At the same time, the first impulses of the new — the neolithic — culture came to these peoples on the coasts of the Cattegat, the North Sea and the Atlantic. The first ground and polished stone axes were then used in Scandinavia. Polished stone



Fig. 7. Land and sea in the North Sea, in late-Quaternary time.  
From K. Andrée after Cl. Reid.

implements and ceramics, cattle bones, querns and impressions of corn on the earthen vessels occur in the Campignian of France. The Asturian savages seem not to have known of these cultural advances, and it is undecided whether the small querns found in the Portuguese shell heaps were used to grind corn.

The close of the general postglacial transgression thus fixes the limit between the Palæolithicum and the Neolithicum in western Europe. It was, of course, a casual combination of events that the first influence of the neolithic culture reached these countries at the same time as the sea was filled to its borders after the last ice age. Such a coincidence of two quite different phenomena did not happen everywhere on the globe. In Sumer (see above), we met other conditions. And Italy, for example, seems to have come under the influence of neolithic culture so early that certain later stages of the Palæolithicum were passed over, at least in some

regions. Further, some reports from Egypt suggest that its culture was at a very highly advanced Neolithic, even Chalcolithic stage before the postglacial transgression ceased.

In a river land such as Egypt, a deep erosion must have taken place during the Ice Ages, because the sea-level and the base-level of the Nile were then much lowered. But accumulation went on during the interglacial epochs, because the sea-level and the base-level were then raised. Considerable remains of the sediments which filled the Nile valley during preglacial and interglacial times now form terraces and plateaus on which palæolithic implements have been found.

Blanckenhorn, and Myres with him, thinks that the terraces and plateaus in the Nile valley have their origin in pluvial times, when the action of the river and its affluents was essentially accumulative. These pluvial times were separated by interpluvial ones, during which erosion dominated and the valley deepened. The former are compared with the Ice Ages in other regions and the latter with interglacial ones. Accordingly, the palæolithic cultures on the terraces and plateaus in Egypt are regarded, by the authors quoted, as coexistent with Stone Age stages from Ice Ages in other countries. The Neolithic Age also, according to them, began with dry climate and erosion, whereafter conditions became more humid and the young alluvium was deposited. According to my above interpretation, accumulation and erosion alternated in the Nile valley and corresponded with glacial and interglacial ages in other regions in a way quite contrary to that assumed by Blanckenhorn.

When the Nile sank and the valley deepened during the glacial times, the population moved to the bottom of the valley. The remains which it left behind were overwhelmed and concealed by the accumulation of sediments as the base-level rose after an ice age.

The base-level was lowered again during the last Ice Age, the valley was excavated and deepened and the population lived on its floor beneath the present level of the river plains. When the sea's surface rose during the postglacial time, the river bed was also elevated and the valley filled with the young alluvium. In this, bones of domestic animals, fragments of earthen vessels, etc have been met with in upper Egypt more than twenty metres



below the surface of the ground. Some of the oldest cemeteries on the border of cultivation seem to dip down under the alluvial deposits, and Peet says on this matter:

»Seeing that practically all Egyptian cemeteries lie on the very edge of the cultivation, may there not be earlier predynastic cemeteries formed before the Nile mud reached its present limits, and therefore concealed beneath the cultivation? There is in itself no impossibility in this view, but it must be noted that on the whole the limits of cultivation in Upper Egypt have altered but slightly at all events in the last 5000 years, and it would be somewhat unlikely that just before Sequence Date 30 some change could have occurred to overwhelm all earlier cemeteries.»

A change in the sedimentation just before Sequence 30, or the time of the oldest known predynastic cemeteries, does not appear so unlikely to me as it does to Peet. It is the time when the post-glacial eustatic transgression was ending and the Nile reached its present base-level. The sedimentation came to a stand in upper Egypt, where as long as the mouth of the river was rising, the deposition of mud had been hitherto quicker and greater.

The Egyptian culture had advanced to a highly developed Neolithic stage before Flinders Petrie's Sequence Date 31. At the same time, people lived under Campignian conditions in northern and western Europe.

---

This short paper has in view not so much the modest essays in archæological homotaxis which are only set forth as examples of a method, as to turn the attention of archæologists to the aids in tracing a homotaxis between cultures of widely separated countries, which they may obtain from studies of the relations between prehistoric dwelling places and shore-lines formed at several stages of the eustatic quaternary shifts of level, and further to show that many of the prehistoric cultures may have grown up and developed in regions now submerged.

---

After the above lecture was read and printed in Ymer, I remarked in the Scotch Geogr. Magazine (XLI, Edinburgh 1925) an interesting paper of professor J. V. Danes, treating of the *Pleistocene Changes of Sea-Level and the Distribution of Man*.

## AUTHORITIES QUOTED.

- Åberg, N., *La civilisation énéolithique dans la péninsule Ibérique*. Uppsala 1922.
- Blanckenhorn, M., *Aegypten*. Handbuch der regionalen Geologie. Band VII. 9. Heidelberg 1921.
- Daly, R. A., *Pleistocene Glaciation and the Coral Reef Problem*. Am. Journ. Sc. XXX. 1910.
- », *The Glacial Control Theory of Coral Reefs*. Proc. Am. Acad. Arts and Sc. LI. N:o 4. Boston 1915.
- », *Pleistocene Changes of Level*. Am. Journ. Sc. X. 1925. With abundant references to the literature of the question.
- Gignoux, M., *Les formations marines pliocènes et quaternaires de l'Italie du Sud et de la Sicilie*. Lyon 1913.
- King, L. W., *A History of Sumer and Akkad*. London 1916.
- Langdon, In *The Cambridge Ancient History. I.* Cambridge 1923. Comparative Table of Sequences.
- Molengraaff, C. A. F., *Modern Deep-Sea Research in the East Indian Archipelago*. Geogr. Journ. London 1921.
- Myres, J. L., In *The Cambridge Ancient History. I.* Cambridge 1923.
- Obermayer, H., *Das Palaeolithicum und Epipalaeolithicum Spaniens*. Anthropos. XIV—XV.
- », «Asturische Stufen» in the *Reallexikon der Vorgeschichte*. 1923.
- Nansen, F., *The Strandflat and Isostasy*. Videnskabselskabets Skrifter. I. Mat.-naturv. Klasse. 1921. N:o 11. Kristiania.
- Peet, E., In *The Cambridge Ancient History. I.* Cambridge 1923.
- Petrie, Fl., *Prehistoric Egypt*. London 1924.
- Ramsay, W., *On Relations between Crustal Movements and Variations of Sea-Level during the Late Quaternary Time*. Bull. Com. Géol. Finlande. N:o 66. Helsingfors 1924.
- », *Eustatiska nivåförändringar och neolithicum*. Ymer 45. Stockholm 1925.
- », *Landhöjning och stenåldersbosättning i det baltiska området*. Fennia 49, n:o 4. Helsingfors 1926. German summary.
- Sandegren, R., *Ragundatraktens postglaciala utvecklingshistoria enligt den subfossila florans vittnesbörd*. Andra uppl. Sveriges Geol. Unders. Ser. Ca. N:o 12. Stockholm 1924. German summary.
- Welsch, J., *Les lignites du litoral et les forêts submergées de l'ouest de la France*. L'Anthropologie. XXVII. Paris 1917.
- Wright, W. B., *The Quaternary Ice Age*. London 1914.
- », *Three short Papers on Isostasy*. 3. *The Azilians at Oban*. Geol. Mag. LXII. London 1925.