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Records of Emergence around Oobloyah Bay and Neil Peninsula in Connection with the Wisconsin Deglaciation Pattern, Ellesmere Island, N. W. T., Canada: A Preliminary Report

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Summary: In the neighbourhood of Oobloyah Bay various phenomena can be encountered which point to a large-scale uplift of shorelines, i. e. to an emergence of 200 m. Delta terraces, deltaic fan terraces and glacio-marine sands are regarded by the author as being the most reliable evidence of this. The marine limit documented by glacio-marine sand is to be found at ~ 170 m a. s. l. Hints of ancient shorelines located at a higher level exist only in the shape of badly preserved raised beaches. They were classified as less reliable records of past sea-levels, due to the lack of marine fossils and/or drift wood, and furthermore because those forms had been strongly influenced by periglacial processes. Deltaic deposits are of more importance in this context. The glacio-marine deltaic sands of several terrace levels contain terrestrial plant remnants which delivered C14-dates. Using these dates and the relative elevations of terraces the emergence of the area investigated could be recorded. This occured in a series of phases (and steps) which were summarized into two periods: an early period of emergence which took place from at least 25 300 years B. P. to later than 17 340 years B. P. and a later one from at least 12 870 years B. P. up to the present day. The emergence seems to represent a discontinuous but regular sequence of relative sea level movements without intermittent submergence.
Since the deltaic fans of the early emergence period were accumulated by sediments through glacio-fluvial channels of an adjacent glacier body the appropriate location of this glacial stage for one of the glaciers delivering meltwater (Nukapingwa Glacier) could be reconstructed. This stage of the glacier appears to belong to a retreating phase of the Mid-Wisconsin (?).
The later period of emergence resulted in six rather large glacio-marine delta terrace generations at the mouths of the main rivers with glacio-fluvial regimen debouching into the Oobloyah Bay. A connection of this emergence with the glacial history of the field area is discussed. If one may rely on the age determinations of land derived plant fossils and their application for the climatic history of the area investigated, it must be concluded that the Heidelberg Valley, to a large extent, was already deglaciated 25 000 years ago. The existence of a "Cockburn"-Phase in the sense of a major readvance in Late Wisconsin times appears to be doubtful, or has been developed rather weakly.

Zusammenfassung: In der Umgebung der Oobloyah Bay sind — wie in anderen arktischen Küstengebieten — eindeutige Anzeichen für eine negative Strandlinienverschiebung, also eine Emersion zu erkennen, die hier einen Betrag von 200 m Höhe über das gegenwärtige Meeresniveau erreicht: als Zeugnisse und Höhenmarken werden vom Verfasser Deltaterrassen, deltaische Schwemmfächer-Terrassen und glacio-marine Sande ausgewertet. Die marine Obergrenze wird durch eine glacio-marine Sanddecke bis ~ 170 m Höhe markiert. Hinweise auf noch höhere ehemalige Strandlinien gibt es in Form schlecht erhaltener Strandterrassen. Sie wurden als weniger sichere Zeugen des früheren Meeresspiegels betrachtet, weil marine Fossilien oder Schwemmhölzer fehlen und die in Frage kommenden Formen durch periglaziale Prozesse beeinflußt sind.
Für die Altersbestimmung des Hebungsprozesses und der jüngeren Glazialgeschichte in jenem Teil der Arktis sind die deltaischen Ablagerungen vor allem wegen ihres Fossilinhaltes von Bedeutung: Fluviomarine deltaische Sande mehrerer Ablagerungsniveaus enthalten terrestrische Pflanzenreste, die C14-Daten lieferten. Auch der Humushorizont eines fossilen Bodens brachte ein relevantes C14-Datum. Auf diese Weise konnte die phasenweise Emersion im Untersuchungsgebiet nicht nur räumlich, sondern auch zeitlich erfaßt werden: Eine ältere Emersionsperiode reicht von 25 300 J. v. h. bis mindestens 17 340 J. v. h., eine jüngere von mindestens 12 870 J. v. h. bis heute.
Insgesamt scheint es sich um einen diskontinuierlichen, aber in seinem Verlauf einheitlichen Emersionsvorgang zu handeln, der durch glazial-isostatische Hebung einerseits und durch glazial-eustatische Meeresspiegelerhöhung andererseits gesteuert wird.
Da die glacio-deltaischen Schwemmfächer der älteren Emersionsperiode durch Abflüsse ehemals benachbarter Gletscher akkumuliert wurden, konnte auf Grund des faziellen Zusammenhangs und mit Hilfe von Moränenwall-Resten u. a. der zugehörige Gletscherstand für einen der schmelzwasserliefernden Gletscher (Nukapingwa-Gletscher) rekonstruiert werden. Dieser Gletscherstand muß dem Alter nach einer Rückzugsphase des Mittleren Wisconsin, möglicherweise auch schon als Spät-Wisconsin zu bezeichnenden Periode angehören.
Falls man die aus fossilen Pflanzenresten gewonnenen Altersbestimmungen ernst nimmt, müssen die Oobloyah Bay und das sog. Heidelberg Valley im NW von Ellesmere Island bereits vor 25 000 Jahren weitgehend eisfrei gewesen sein.
Eine „Cockburn"-Phase im Sinne einer größeren „Late Wisconsin"-Vereisung scheint sich im Expeditionsgebiet nicht oder nur sehr schwach ausgeprägt zu haben.

1. INTRODUCTION

In the summer of 1978 the Heidelberg Ellesmere Island Expedition visited the area around Oobloyah Bay (Figs. 1 and 2). As a participant of this group the author's main goal was to study raised marine beaches, delta-terraces, nearshore terraces and other features which might demonstrate sea level change during the Middle or Late Wisconsinan and Holocene times. Apart from the investigations of HATTERSLEY-SMITH & LONG (1967) in the Tanquary Fiord area some 140 km miles to the east, and of MÜLLER

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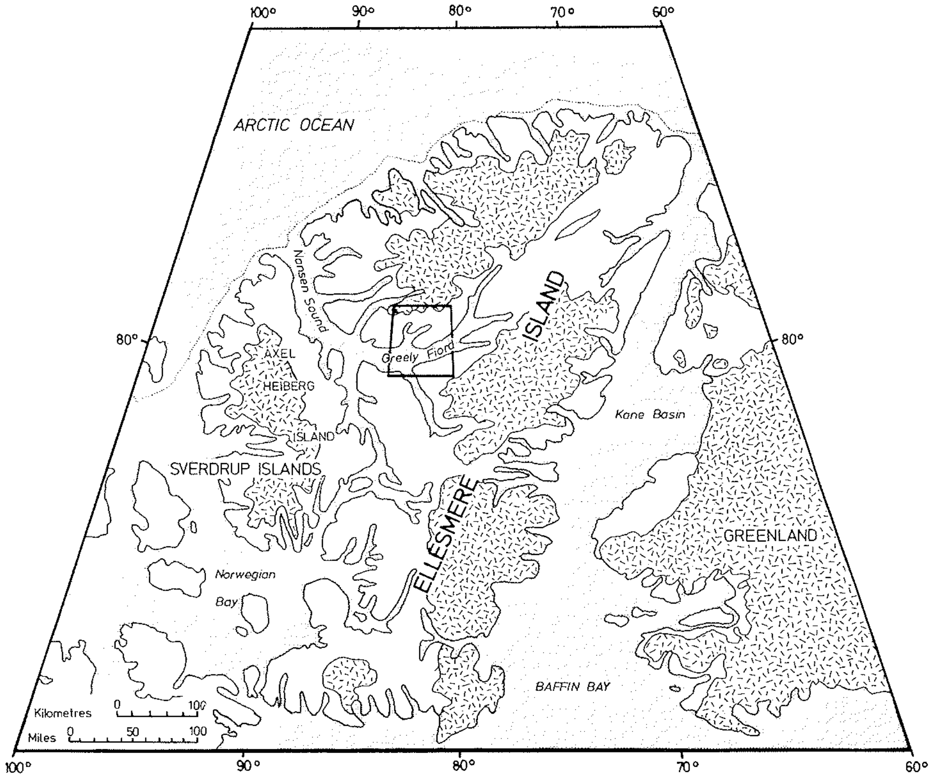

Fig. 1: Topographical map showing location of the expedition area on Ellesmere Island, N.W.T., Canada.

Abb. 1: Topograpische Übersichtskarte mit Lagebezeichnung des Expeditionsgebietes auf Ellesmere Island, N.W.T., Kanada.

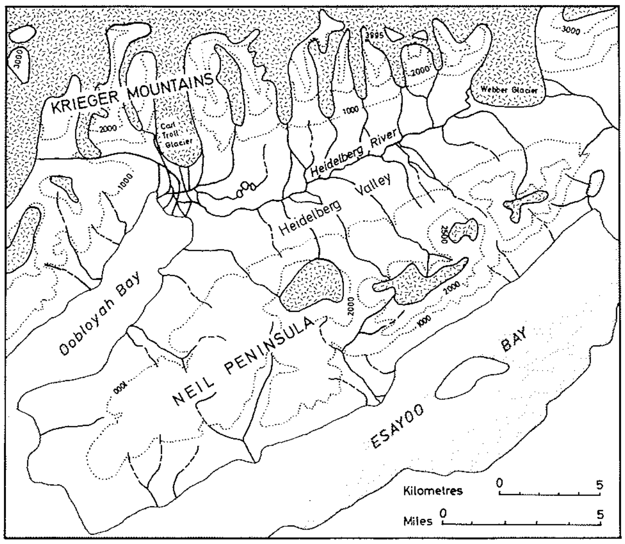

Fig. 2: Topographical sketch map of the expedition area around Oobloyah Bay and Neil Peninsula (elevations in feet).

Abb. 2: Topographische Kartenskizze des Expeditionsgebietes um Oobloyah Bay und Neil Peninsula. Höhenangaben in Fuß.

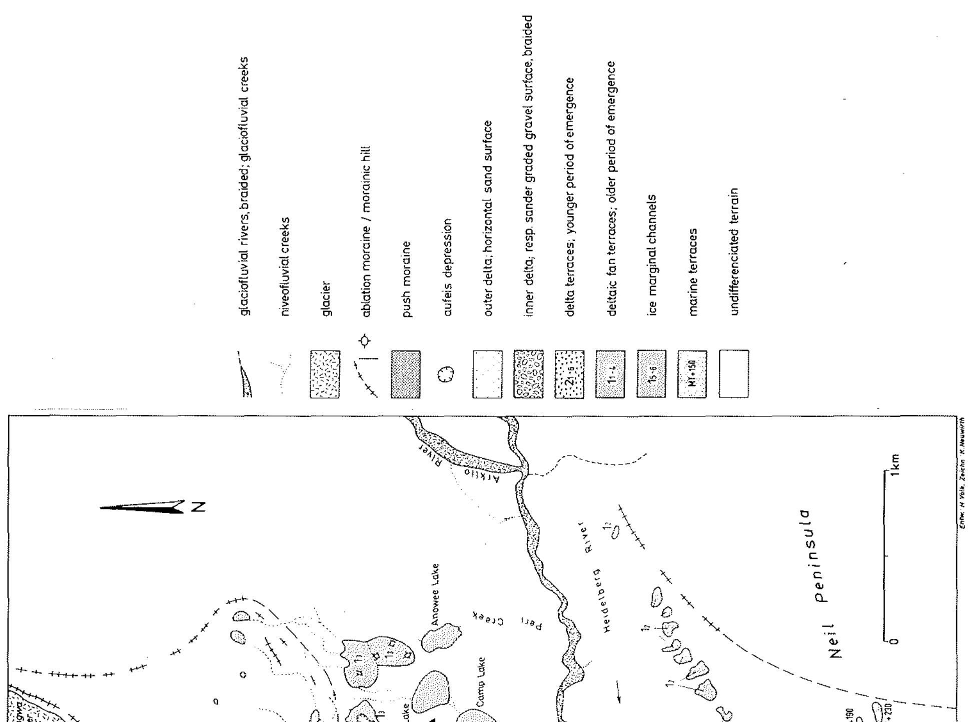

Fig. 3: Simplified map of Quaternary geology of the expedition area, indicating the distribution of deltaic fan terraces, delta terraces and marine terraces as records of emergence. In addition, the position of KING's (1981) stage III is shown.

Abb. 3: Vereinfachte Karte der Quartärgeologie des Expeditionsgebietes mit Verteilung der glacio-deltaischen Schwemmfächerterrassen, der Deltaterrassen und der Strandterrassen als Zeugen der Emersion. Ferner ist die Lage von KINGs (1981) Moränenstand III angegeben.

(1963) on the Schei Peninsula of Eastern Axel Heiberg Island virtually nothing was known of the Quaternary geology of the area near the Oobloyah Bay, apart from some general indications on the geological map of „Greely Fiord West" 1:250 000 (THORSTEINSSON, 1971). Oobloyah Bay, a fiord-like feature

Fig. 4: Upper section of the Heidelberg River canyon. View towards ENE.

Abb. 4: Obere Canyonstrecke des Heidelberg River.

trending NE-SW, ends up in the NE with a recent deltaic plain made up of well-sorted sand intermingeled with plant remnants and tiny wood branches which were certainly brought in by streams debouching there in impressive alluvial fans. The latter form large aggradations of coarse gravel on the inner side of the actual sandy deltaic plain. These fans are built up by glacial meltwater streams issuing out of canyon-like incised valleys from the eastern side of the Bay, e. g. the broad Heidelberg Valley which is shaped structurally as well as glacially in a U-form (VÖLK, 1981a) is partially fed by melt water from the large adjacent Carl Troll Glacier and a few smaller glacier bodies NW of the bay. Raised marine beaches could be observed in the area investigated at elevations of 70—230 m a. s. l. in a rather degrading state. Instead, we found nicely developed delta and fluvial terraces, fan-like remnants of coastal terraces as well as fluviomarine sand layers up to 170 m a. s. l. in height (VÖLK, 1981b).

2. DELTA AND RIVER TERRACES OF THE TRUNK STREAMS

2.1. *The NE coast of Oobloyah Bay*

Two rivers, the Heidelberg River and the Nukapingwa River, both of which are fed by glacial meltwater, reach Oobloyah Bay from the east through canyon sections in their lower courses. The canyons cut the western slope of the hanging Heidelberg Valley (Fig. 4) (BARSCH, 1981a).

Below the canyon sections at the western end of Heidelberg Valley six huge delta-terraces (2_{1-6}) are to be found [1]). These continue upstream in the shape of narrow river terraces which gradually become fewer in

[1]) Actually these six delta-terraces consist of a higher number of smaller scarps which the author reduced to six terrace-generations.

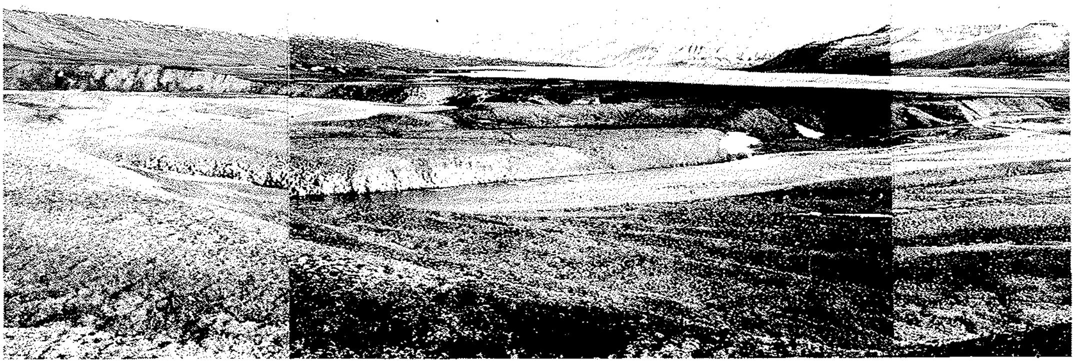

Fig. 5: View towards SW over Oobloyah Bay and delta terraces of the Heidelberg River.

Abb. 5: Blick nach SW auf Oobloyah Bay und Deltaterrassen des Heidelberg River.

number. The delta terraces (Figs. 3 and 5) can clearly be distinguished from the river terraces in so far as the first represent accumulation terraces, built up of two distinct layered sequences, where as the river terraces in the canyon sections are developed as rock-terraces with very little gravel covering. The large delta terraces always reveal a foreset-bedded sand body under a fluvial gravel cover of 3—5 m thickness; the upper meters of sand contain tundra-moss and willowstem-remnants. According to the author's opinion the sand layers are to be interpreted as fluvio-marine resp. glacio-marine delta-front-facies, with their upper surface more or less corresponding to the ancient sea-level. Caused by the seaward migration of the fluvial gravel facies on the sandy delta plain during the development of each delta generation which subsequently was raised and entrenched, the rhythmic sedimentary sequence of the various ancient delta levels was deposited and these can now be observed up to 65 m a. s. l., because of discontinous emergence and repeated incision of the delta complex. Thus each delta terrace consists of the deltaic sand facies below, and the alluvial gravel facies above. This means that the delta terraces are the result of discontinous negativ sea-level changes which acted upon the delta complex (VÖLK, 1981b).

2.2. *The north-west coast of Oobloyah Bay*

A meltwater-river, debouching from the West, also with a canyon section in its lower course, shows delta terraces which are similar to those reported above, as far as the sedimentary aspect is concerned; the terraces, however, are generally steeper and more fan-like. Four delta-terraces have developed, which reach up to 100 m a. s. l.

3. DELTAIC FAN TERRACES OF TRIBUTARIES

Searching for further evidence of earlier and possibly higher sea-levels, the author examined the slopes of Heidelberg Valley, a large synclinal valley in the north-eastern prolongation of Oobloyah Bay. In fact, terrace-like benches, made up of gravel, could be found not only on the northern, but also on the southern slope of Heidelberg Valley at different levels of elevation from 95 m up to 174 m a. s. l. (11—6). These fan-terraces are of glacio-deltaic origin and are mostly rather small, but become larger and better developed at lower levels (Fig. 6). They are comprised of very coarse sandy gravel, retain evidence of braided channel systems and were originally adjusted to the sea-level, in the author's opinion. The fan-like gravel bodies are always connected with former glacial meltwater channels, partly degraded to niveo-fluvial drainage channels today.

The largest deltaic fan terraces (I_3) can be recognized north of Access and Goose Lake and are located at 120—125 m a. s. l. [2]). One should also pay particular attention to the fan terraces on the southern side of Heidelberg Valley which occur frequently at 110 m a. s. l. where numerous slope furrows carry meltwater from the Neil Peninsula ice caps down into the main valley.

4. RAISED BEACHES

Unfortunately, nowhere in the area of Oobloyah Bay can clear-cut raised beaches be found i. e. those verified by marine fossils. Nevertheless, various terrace-like rock-benches should be mentioned at this point; these, according to the author, might be understood as poorly preserved remnants of old shorelines [3]).

4.1. *The southern slope of Heidelberg Valley*

At Neil Peninsula, i. e. the southern border of Heidelberg Valley, several rock terraces appear between 190 m and 230 m a. s. l. They all show a massive periglacial cover of debris. At most places the terrace-like benches are rather smaller and can only be observed sporadically.

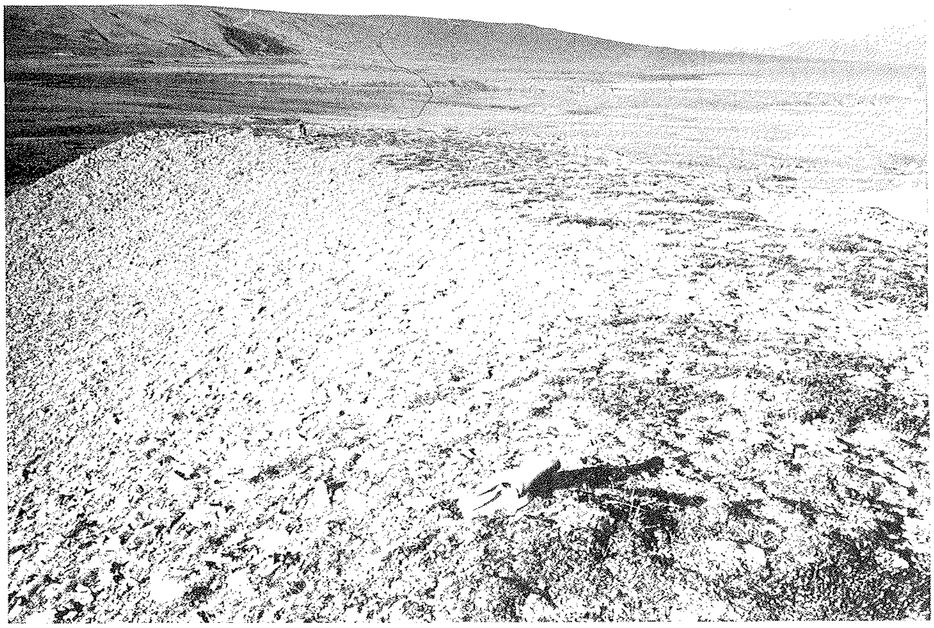

Fig. 6: View towards SW over the surface of a glacio-deltaic fan terrace (I_1) on Heidelberg Valley and Neil Peninsula (in the background).

Abb. 6: Blick nach SW über die Oberfläche einer glacio-deltaischen Schwemmfächerterrasse (I_1) auf Heidelberg Valley und Neil Peninsula (im Hintergrund).

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[2]) On one of these terraces an interesting phenomenon could be observed: a dischargeless, flat concave hollow or kettle of 1—2 m in depth, occupying an area of more than 250 m ^{2}. This phenomenon must be understood as a hollow which was filled with aufeis at the time of its origin.

[3]) The development of typical littoral features, whether in the shape of undercut notches on the cliff, or rounded beach-gravel on the shore-platform is bound to fail, simply because the dynamics of waves and breakers on the arctic beaches of closed bays is extremely low. I, myself, also noticed this fact when I investigated the present shore-platform on the western border of Oobloyah Bay. The coarse material above the sandfraction consisted almost exclusively of rock fragments between 0,03—0,6 m grain size, practically without any evidence of roundness (VÖLK, 1981a). In addition one has to consider the brittle rock of the mesozoic underground which splits up into fragmentary platy pieces and thereby provides most unfavourably structured material for the development of littoral landforms in Oobloyah Bay.

4.2. *The Western slope of Oobloyah Bay*

On this slope more rock terraces exist than along Neil Peninsula, but their altitudinal range is only 70—150 m a. s. l. The terrace surfaces are of various extension, covered by solifluction material such as that which was described above (Fig. 7). It is very interesting to notice that on one terrace level (150 m a. s. l.), rather large erratic blocks were found, the biggest of which had a volume of roughly 50 m^3. The presence of such blocks is an indication of the nature of such rock-terraces as ancient shorelines, because the erratics can only reasonably be interpreted as blocks which have been rafted by sea-ice.

Fig. 7: Badly preserved marine terrace at 150 m a. s. l. on the west side of Oobloyah Bay covered with solifluction material. In the background, towards NNE, the transverse valley of Carl Troll Glacier cuts through the Krieger Mountains.

Abb. 7: Schlecht erhaltene Strandterrasse in 150 m über NN an der Westseite der Oobloyah Bay, bedeckt mit Solifluktionsmaterial. Im Hintergrund, Richtung NNE, das quer durch die Krieger Mountains schneidende Tal des Carl Troll-Gletschers.

5. RECORDS OF PAST GLACIATIONS

As in other areas of the arctic zone present glacierization is of very limited extension compared to past glaciations and especially to the earlier ones. The extension and location of present glacierization are shown in Fig. 2 and described in detail by KING (1981).

Evidence of earlier more extensive glaciation can be recognized in the expedition area at a number of places. Glacier-shoulders and rounded rock-spurs of interfluves on the northern and southern slope of Heidelberg Valley probably represent the oldest form-elements of extensive glaciation. These rock-planations at a height of 450—650 m, located in the valley-section between the Carl Troll and Webber Glaciers (Figs. 8 and 9), show signs of strongly advanced weathering[4]). Nothing is known about the age of these glacial forms, but the degree of weathering bears resemblance to the Komaktorvik Zone of IVES

[4]) Discussing remnants of past glaciations, BARSCH (1981b) mentions the moraine walls in the Heidelberg Valley, but emphasizes the dominance of frost-shattered rock rubble on the higher slopes where the old glacio-erosional landforms are extinguished almost completely.

(1978) or Zone C of GRANT (1977), viz. the uppermost weathering zone of formerly glaciated areas in the arctic regions. Around the most westerly ice cap of Neil Peninsula at an elevation of c. 600 m a. s. l., the author and Dr. Horst Eichler found numerous small exotic moraine blocks made up of crystalline rocks certainly derived from further north of Ellesmere Island, now resting on sandstone of the Heiberg Formation.

Fig. 8: View towards NE over Carl Troll Glacier with push moraine. At the southern end of the Krieger Mountains two glacial shoulders can be seen a different elevations (c. 500 m a. s. l. and c. 250 m a. s. l.).

Abb. 8: Blick in Richtung NE über den Carl Troll-Gletscher und seine Stauchmoräne. Am Südrand der Krieger Mountains lassen sich zwei Gletscherschultern in unterschiedlicher Höhe erkennen, ca. 500 m und ca. 250 m über NN.

Moraines below the glacier-shoulders, located mainly on the slopes of the Heidelberg Valley as well as near the front of the present small glaciers, are certainly younger. In the author's opinion, an older and a younger generation of moraines can be distinguished.

5.1. *Older moraines* [5])

Along the foot of the northern slope of Heidelberg Valley huge quantities of morainic material in the shape of a large terrace-like rampart of 100—200 m in width and occupied by several morainic wall remnants can be found. Only the latter consist of young moraine-material; the large rampart itself must probably be regarded for the most part as consisting of "older" moraine. Throughout the moraine a perceptible percentage of crystalline components can be observed, although the present glaciers do not originate on crystalline rocks. In the author's opinion, this huge mass of debris represents an essentially older lateral moraine-wall, which had once accumulated at the side of a large glacier-arm which formerly filled the Heidelberg Valley. Later it was overridden by several advances of small glacier tongues from the side valleys (Fig. 9).

Obviously the suspected old glacier was a large valley glacier branching off the Webber Glacier and

[5]) Possible age relations are given in chapter 8.2.

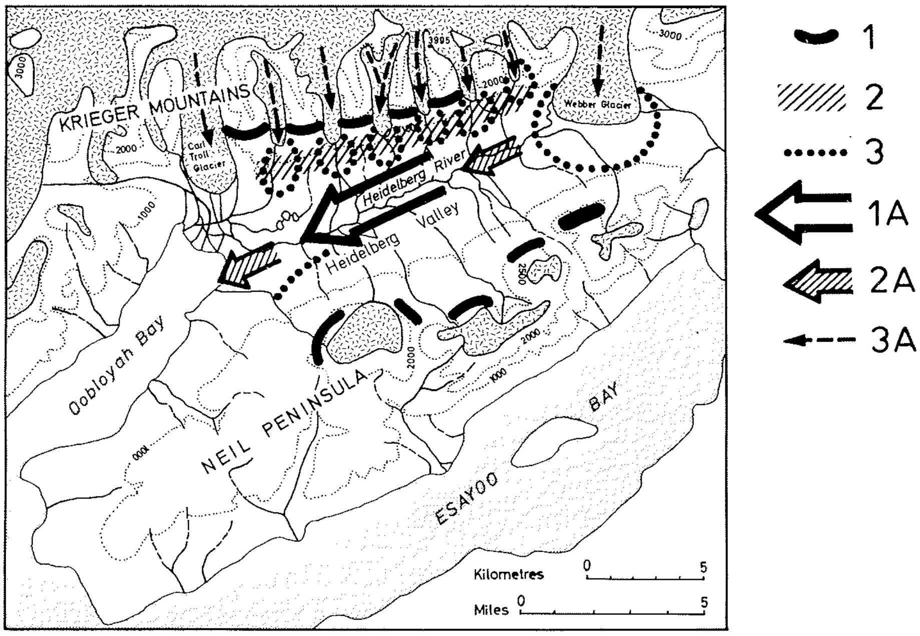

Fig. 9: Sketch map of the expedition area diagrammatically showing the paleograhic position of glacial landforms and glacier advancing directions at different elevations. 1 = glacier shoulders at elevations of 450—650 m a. s. l., oldest glacial remnants; 2 = moraine rampart at an elevation of 225—250 m a. s. l., ''older'' moraines; 3 = lobate moraine walls at elevations below 225 m a. s. l., ''younger'' moraines. 1A = glacier direction belonging to 1, 2A = glacier direction belonging to 2, 3A = glacier direction belonging to 3.

Abb. 9: Kartenskizze des Expeditionsgebietes mit schematischer Lagebezeichnung alter Glazialformen und der Bewegungsrichtung ihrer zugehörigen Gletscherströme in unterschiedlicher Höhe über NN. 1 = Gletscherschultern in 450—650 m über NN, älteste Reste; 2 = breiter Moränewall in 225—250 m über NN, ,,ältere'' Moränen; 3 = Moränenloben unterhalb 225 m NN, ,,jüngere'' Moränen. 1A = Gletscherbewegungsrichtung bei 1, 2A = Gletscherbewegungsrichtung bei 2, 3A = Gletscherbewegungsrichtung bei 3.

flowing into the longitudinal Heidelberg Valley from east to west. This former valley glacier had been heavily loaded with morainic debris by six tributary glaciers debouching from the north. One should pay particular attention to the even level of elevation of the extensive terrace-like rampart moraine. It appears over a distance of more than 6,5 km (i. e. including a glacially flattened spur between Carl Troll and Nukapingwa Glaciers in the west to the eastern end at Webber Glacier) at a remarkably regular elevation of 225—250 m a. s. l.; the relative heigth is a maximum of 170 m. The degree of weathering might be compared with the intermediate weathering zone, Koroksoak, of IVES (1978) or Zone B of GRANT (1977).

The conditions on the southern slope of Heidelberg Valley seem to confirm these findings, since there — on the slope of Neil Peninsula, below the most westerly located ice cap — the author also noticed a glacier-shoulder at a height of 225—250 m a. s. l. Below this shoulder a smooth slope without any blocks was encountered, covered by basal till overlain by sand.

5.2. *The younger moraines*[5])

Covering the terrace-like moraine rampart described above many wall-remnants can be found — as already mentioned — from which KING (1981) reconstructed several moraine lobes (stages I—IV); these, in part, can clearly be ascribed to the small glaciers of the northern tributary valleys. Some wall-remnants reach our expedition camp near the valley-center, where they encircle some small glacial lakes. All these

[6]) This situation can also be demonstrated on a infra-red photograph taken by Dr. HORST EICHLER who kindly provided this additional information.

moraine lobes belong to a relatively young glacial stade of much less glacier extension and thickness without any trace of longitudinal valley glacierization (Fig. 9). Related to the degree of weathering in the sense of IVES (1978) and GRANT (1977) all younger moraines (stages I—IV) should be classified as Saglek Zone or Zone A resp., although a further subdivision seems possible.

As will be discussed later, the innermost moraine wall lobe (KING's stage IV) might represent the maximum re-advance of the last glaciation, while all the other wall remnants (e. g. KING's stage III) should be considered as relics of glacier retreat stages, which pre-date the last re-advance.

Among other features the relative youth of glacial stage IV is revealed by the fresh-looking, unweathered surface of the area[6]) inside the moraines of stage IV which is still relatively free of vegetation. Furthermore, wall-remnants can also be recognized on the southern side of the valley. They must be regarded as traces of a younger moraine wall pertinent to a more extended ice cap.

In the present author's opinion, KING's stage III, of the Nupakingwa glacierization, however, is closely connected with the origin of the glacio-deltaic fan-terraces (1_{1-6}). They always show a well-preserved tributary-channel draining the old stage III-moraine-circle, presently degenerated to niveo-fluvial outlets. In other words, the deltaic fan-terraces were accumulated at an ice margin by meltwater riverlets whose base levels were controlled by their respective sea-level. Therefore they can be used as markers of the sea-level.

Likewise, on the southern border of Heidelberg Valley the meltwater influence of the former more extended ice caps can be noticed. Among the meltwater tributaries the NW-outlet of the western ice cap must be mentioned in the first place, even though quite a number of other radial outlets formerly accumulated deltaic fans, as can be concluded from the widely distributed fan-terrace level (1_2).

6. THE GLACIO-MARINE SAND COVER OF THE HEIDELBERG VALLEY

Walking along the broad longitudinal Heidelberg Valley which softly ascends from west to the east i. e. from 80 m a. s. l. to 175 m a. s. l. at the basis of the Webber Glacier in the east, vast plains of an almost continuous sand-cover of 1—3 m in thickness can be observed over a distance of 20 km; from these only a few wall-moraines and esker-like hill-remnants protrude. A sand-cover also lies on all the plane landforms below an altitude of 80 m, i. e. below the end of the hanging valley down to the present-day sea-level, as far as one takes the area outside the delta-terraces and river courses. The sand is well-sorted, without any gravel, thinly stratified and sporadically equipped with phytogenic intercalations of tundra-moss-remnants and willow-stalks, which can be as thick as a pencil.

In the author's view, this sand is to be considered as fluvio-marine resp. glacio-marine sediment, which was originally transported by glacial meltwater rivers and creeks from the surrounding slopes into Heidelberg Valley, then a marine bay inundated by sea water. There it was deposited in the sea in a prodeltaic environment. At that time the sea must have filled Heidelberg Valley up to Webber Glacier, i. e. at least up to 175 m above the present-day sea-level, and must have encircled Neil Peninsula as an island. Phytogenic fossils were found along the Heidelberg River up to an altitude of 150 m. Locally sand accumulation can also be observed on the slopes of Heidelberg Valley, up to 170 m a. s. l.

It must be remarked, however, that the fluvio-marine sand-cover has not been found everywhere in the field below the altitudinal level of 175 m a. s. l. This appears to be caused by the following circumstances which prevented deltaic sand sedimentation in the then inundated valley:

[7]) The denotations Early, Mid and Late Wisconsin are chosen according to ANDREWS (1974, Tab. 6A.1). ANDREWS & BARRY (1978, Fig. 2) changed the time spans of the previous subdivision a bit.

— retreating glacier ice
— dead ice
— coarse clastic fan deposition
— subsequent denudation from steep relief after emergence.
For example, no sand was discovered in the lacustrine sediments of Heidelberg Valley. Diggings made by the author in one of the flat concave kettle-like depressions presently covered by grass tundra in the area near the expedition camp revealed grey clay at a thickness of at least 17 cm (active layer) below the vegetation. It was concluded that dead ice had filled the depression at the time of sand sedimentation.

7. PALEOGEOGRAPHY AND CHRONOLOGY

For the aim of paleogeographical reconstruction we have to discuss three questions:
a) at what elevation did the marine limit resp. the maximum sea-level lie during the submergence in late Pleistocene times, and when did this maximum sea-level exist?
b) how did the emergence proceed spatially and chronologically?
c) which extent of glacierization existed during emergence?

7.1. *The maximum sea-level (marine limit)*

Landforms, which the author interpreted as marine terraces or as raised beaches, can be found at maximum elevations of 230 m a. s. l. The question as to whether these forms are reliable indicators of high sea-levels will be left to further investigations. Similar relative elevations of former sea-levels during the Wisconsin times, though, have already been described and dated by other investigators from Eastern Ellesmere Island (ENGLAND & BRADLEY, 1978).

In connection with glacio-marine sand accumulations something different appears to be the case. These sediments are exposed up to 170 m a. s. l. and are considered by the author as reliable evidence for the marine limit of the region investigated, but no marine fossils have so far been found.

7.2. *Emergence*

This process progressed in a series of stages, which, where their altitude is concerned, are marked mainly by deltaic fan and delta terraces. Regarding the terrace elevations two parts resp. periods of emergence can be distinguished.

Upper part of emergence (older period)
The older period is clearly evidenced by the existence of fluvio-marine sand between a height of 170 m and 80 m, and by the deltaic fan terraces of the Heidelberg Valley tributaries between 175 m and 95 m a. s. l. (Fig. 3). Apart from doubtful shorelines between 190 m and 230 m, badly preserved raised beaches with ice-rafted blocks on the western slope of Oobloyah Bay exist at 150 m a. s. l.

Probably simultaneous to the progressing emergence of the older period the deposition of the fluvio-marine sand cover was going on. This includes the inter-bedding of tundra plant remnants, which provide paleoclimatological, as well as paleogeographical evidence of the environment of the formerly inundated Heidelberg Valley: a sufficiently extended land surface covered by polar tundra-vegetation must have existed.

Two samples of organic material taken from the sand-cover which is very well exposed on a stoss-side of the Heidelberg River at 93—94 m a. s. l. yielded two radiocarbon dates (Tab. 1): 17 340 ± 180 years B. P. and 25 000 ± 580 years B. P.

Lower part of emergence (younger period)
The younger period is recorded by large delta terraces at the mouths of the Heidelberg and Nukapingwa Rivers, which accumulated on the glacio-erosional step of the hanging Heidelberg Valley against the overdeepened Oobloyah Bay, below 80 m a. s. l. Six terrace-generations (VÖLK, 1981b) can be recognized, 2_{1-6}, whose fluvio-marine (resp. glacio-marine) sand layers below the various fluvial terrace gravels also delivered radiocarbon dates from land-derived phytogenic intercalations (Tab. 2). For the age determination of the most recent delta terrace the dating of a fossil soil of the next, higher terrace has been useful.

Heidelberg River upper canyon	elevation (m a. s. l.)	C14-dates (years B. P.)
organic intercalations in glacio-marine sand layers	94	17 340 ± 180 (H 5622 — 5164)
	93	25 300 ± 580 (H 5725 — 5269)

Tab. 1: C14-dates of the older emergence period.

Tab. 1: C14-Daten der älteren Emersionsperiode.

7.3. *Extension of the glaciers*

Information on the extension of the glaciers at the time of emergence has been obtained for the early period. It was recognized from air-photographs and field-work that the deltaic fan terraces NW of the expedition camp had been fed by glacial meltwater channels originating from a certain positon of the Nukapingwa Glacier (stage III; KING, 1981).

During this period, between at least 25 000 and 17 300 B. P., i. e. the dated part of the fluvio-marine sand-cover of the Heidelberg Valley, the extension of the glacier corresponded to the position outlined in Fig. 3.

Heidelberg River delta terrace	elevation (m a. s. l.)	C14-dates[8]) (years B. P.)
24	40—38	9 770 ± 100 (H 5726 — 5270) 10 160 ± 100 (H 5686 — 5232) 12 870 ± 145 (H 5687 — 5233)
23	22,5—20	4 630 ± 75 (H 5727 — 5271) 7 650 ±75 (H 5706 — 5252)
21	15,5—2	2 500 ± 45 (H 5708 — 5254)

Tab. 2: C14-dates of the younger emergence period.

Tab. 2: C14-Daten der jüngeren Emersionsperiode.

[8]) The dates represent conventional C14-ages based on 1 950 B. P. and halflife T1/2 = 5 568 a. (STUIVER & POLACH, 1977).

Concerning the extension of the glaciers during the later emergence period (later than 17 300 B. P.): we must assume that the glaciers retreated relatively rapidly to their present stage. This must have happened in a rather short space of time, because the large delta terraces of the rivers at Oobloyah Bay could develop undisturbed near the big Carl Troll Glacier. At any rate, the process of emergence does not seem to have been affected isostatically on a perceptible scale.

8. HYPOTHETIC MODEL OF GLACIAL HISTORY; DISCUSSION

Before introducing a model more chronological dates which are hitherto available from the investigated area should be provided.

8.1. *Dates*

Firstly there are some "old" C-14 dates. BARSCH, KING & MÄUSBACHER (1981) have described pieces of wood, which are at present thawing out of the basal layer of the glacier tongue of Webber Glacier at the eastern end of Heidelberg Valley. The samples delivered two radio-carbon ages: 35 600 years B. P. and 37 550 years B. P. KING (1981) found drift wood adjacent to the sandur plain of Carl Troll Glacier on the eastern shore of Oobloyah Bay. The samples produced dates between 40 000 and 54 000 years B. P.

Unfortunately no dates exist for age determination of possibly Late Wisconsin moraines. But we have several younger C-14 dates. They all come from samples of organic bearing material (peat and humus rich silt) which were collected in front of actual glacier tongues at a distance of a few 100 m up to 1,5 km inside the end and lateral moraine wall system (stage III and IV; KING, 1981). These dates show a range of between 5 100 and 5 800 years B. P., whereby KING concluded that his glacial stages (including stage III and IV) must be older than the dated samples.

Still closer to the glacier (100 m from Webber Glacier) DYCK & FYLES (1963) collected a peat sample with an age of 4 190 year B. P., which did not include any basal peat. Finally, it is interesting to note that the author encountered organic-bearing silty material in basal till in front of the Carl Troll Glacier, 400—500 m away from its actual push moraine along the thermoerosional rim of its sandur plain. This material has a radiocarbon age of 2 900 years B. P. (VÖLK, 1981b). Similar in age is the peat layer underneath fossil aufeis, not far S of Webber Glacier, which was dated as 3 200 years B. P. (BARSCH, KING & MÄUSEBACHER, 1981) and the fossil humus-rich soil on the second to last fluvial terrace of Heidelberg River, with a date of 2 500 years B. P. (VÖLK, 1981b).

If one considers these dates in connection with the chronology of emergence and the observations in the field about "old" glacial records communicated by the author in this paper the following hypothetic picture of glacial history might be reconstructed for the surroundings of Oobloyah Bay.

8.2.2. Glacial stade (= Early Wisconsin?) with older moraine

Huge lateral moraines and benches of glacial erosion at a regular height of between 225 and 250 m a. s. l. (moraine rampart) along the northern rim of Heidelberg Valley and also partly on the southern slope prove the existence of a large former valley glacier of somewhat minor dimension than during the older stade.

8.2.3. Glacial interstade (= Early/Mid-Wisconsin?)

Tundra-moss thawing out from the base of actual glaciers, as well as driftwood in front of actual glaciers close to modern sea-level give an age of between 35 600 and 55 000 years B. P. and indicate an interstade of less extensive glaciation than today.

8.2.4. Glacial stade (= Mid-Wisconsin?) with younger moraines
This stade could have developed between 35 600 B. P. and 17 000 B. P., whereby KING's stage I—III might have occured towards the end of this time span. From the mapping of KING (1981) it has become quite clear that no longitudinal valley glacier existed any more. Instead a lobate glacierization can be observed, derived from tributary valleys N of Heidelberg Valley being as a whole of small dimension compared to the earlier glacial stade. Definite deglaciation — evidenced by fossiliferous glacio-marine sand layers — started at least 25 000 years B. P. and appears to have been accompanied by a long period of emergence which still seems to be in progress. The emergence is first recorded through a series of deltaic fan terraces, i. e. a period between 25 000 B. P. and 17 300 B. P., then trough larger glacio-marine delta terraces, i. e. younger period of emergence dating from 12 800 B. P. up to the present day. KING's stage III ended during the older period of emergence.

8.2.5. Glacial re-advance (= Late Wisconsin/Early Holocene?)
Rather small moraine walls of KING's stage IV represent the youngest wall remnants outside the actual end-moraines. They are, according to KING (1981), older than 5 800 years B. P. and could therefore be ascribed to the Cockburn Phase as defined by ANDREWS & IVES (1972) and ANDREWS (1974).

8.2.6. Neoglaciation (= Post-glacial event)
A climatic deterioration starting < 3 200 years B. P. caused a small glacier fluctuation of the Carl Troll Glacier at 2 900 years B. P., burried soil at 2 500 years B. P. and formed aufeis on peat in front of a glacier, dated with 3 200 years B. P.

8.3. *Discussion*
As a preliminary result one may say that some aspects of the glacial pattern during the Wisconsin and postglacial times, typical for the High Arctic Zones, are clearly recognizable in the Oobloyah area, e. g. the declining dimension of glacierization (see ANDREWS, 1974; ANDREWS & BARRY, 1978) and the occurence of relatively old organic material of the Mid-Wisconsin Interstade (ANDREWS, 1974; DYKE, 1976; HODGSON, 1973; LOWDON & BLAKE, 1978). Apparently also some observed elevations of glacial records correlate quite well with situations on northeastern Ellesmere Island around Lady Franklin Bay and Kennedy Channel (ENGLAND, 1978; ENGLAND & BRADLEY, 1978). Moreover, there is a remarkable chronological accordance with the onset of deglaciation and emergence in Mid-Wisconsin times (ENGLAND & ANDREWS, 1973; ANDREWS, 1974). The postglacial climatic deterioration at about 3 000—2 500 years B. P. is also a characteristic one and known from the Arctic (BRAY, 1970; PETERSEN & MEHRINGER, 1976; STUCKENRATH et al., 1979; SHORT & NICHOLS, 1977).

On the other hand significant differences seem to exist from the situation of neighbouring areas (MÜLLER, 1963; HATTERSLEY-SMITH & LONG, 1967; LYONS & MIELKE, 1973; HODGSON, 1973; BLAKE, 1975, 1976; ENGLAND, 1976, 1978; ENGLAND & BRADLEY, 1976, 1978), especially concerning late glacial events and postglacial emergence. While in various areas of Axel Heiberg and Ellesmere Island at about 9 500—7 500 years B. P. a clear glacial re-advance (Cockburn Phase) can be noticed, followed by final deglaciation and rapid glacio-isostatic uplift, there seems to be — apart from small moraines of KING's stage IV — no evidence of a major glacial event in the emergence pattern of the field-area investigated.

The present author is aware of the danger of having obtained wrong C14-dates because of the possibility of reworking and mixing of still older plant fossils. Caution should therefore be attended to in overestimating their accuracy at the present time.

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