Postglacial Uplift at Tanquary Fiord, Northern Ellesmere Island, Northwest Territories

G. HATTERSLEY-SMITH[1] AND AUSTIN LONG[2]

ABSTRACT. From the radiocarbon ages of samples of marine shells and peat, a postglacial uplift curve has been constructed for the upper part of Tanquary Fiord in northern Ellesmere Island. The data show that the head of the fiord was clear of glacial ice by at least 6,500 years ago. From 6,500 to 5,000 years ago isostatic uplift was at the rate of about 3.5 m./100 yr. and subsequently at the rate of about 25 cm./100 yr.

RÉSUMÉ. On a construit, à partir d'échantillons de coquillages marins et de tourbe datés au radiocarbone, une courbe du relèvement postglaciaire pour la partie supérieure du fiord de Tanquary, dans le nord de l'île d'Ellesmere. Les données montrent que la partie amont du fiord était libre de glace il y a moins de 6,500 ans. Entre 6,500 et 5,000 av.p., le relèvement isostatique s'est produit au rythme d'environ 3,5 m par siècle: par la suite, le rythme a été d'environ 25 cm/siècle.

РЕЗЮМЕ. **Пост-ледниковое поднятие в районе Танкуэри-фьорда в северной части о. Элсмира (Северо-Западные Территории).** График пост-ледникового поднятия был построен для верхней части Танкуэри-фьорда на севере о. Элсмира на основании датировки морских раковин и торфа радиоуглеродным методом. Результаты показывают, что верхняя часть фьорда очистилась от льда по крайней мере 6 500 лет тому назад. В последующие 1500 лет скорость изостатического поднятия составила приблизительно 3,5 м/100 лет и позднее приблизительно 25 см /100 лет.

INTRODUCTION

At the head of Tanquary Fiord four major valleys converge. These valleys, flanked by mountains rising as high as 1,500 m., carry major rivers in summer. Three of the rivers have a common flood plain at the head of the fiord, while the fourth, the Macdonald River, has formed an elaborate delta system on the southeast side of the fiord, 8 km. from its head. The complexity of both these outflow systems, with their associated terraces at several levels, indicates a complicated postglacial history. We are concerned here mainly with the Macdonald River delta, and with shell samples collected from its periphery. From radiocarbon dating, an attempt is made to elucidate the recent history of the delta in relation to land emergence during the last few thousand years. The radiocarbon dates have been provided by the radiocarbon laboratories of Isotopes Incorporated, the Geological Survey of Canada, and the Smithsonian Institution from samples submitted by the first author.

THE MACDONALD RIVER DELTA

At the mouth of the Macdonald River three main delta terraces are situated at elevations of 11-19 m. (1), 28-41 m. (2), and 77-86 m. (3) (Fig. 1). There is a still higher terrace reaching a maximum height of about 100 m., which is interpreted as a kame terrace, as it shows marked kettle topography (including a large kettle lake) and falls away at an angle of about 40 min. in an up-valley

[1]Defence Research Telecommunications Establishment, Ottawa.
[2]Radiation Biology Laboratory, Smithsonian Institution, Washington, D.C.

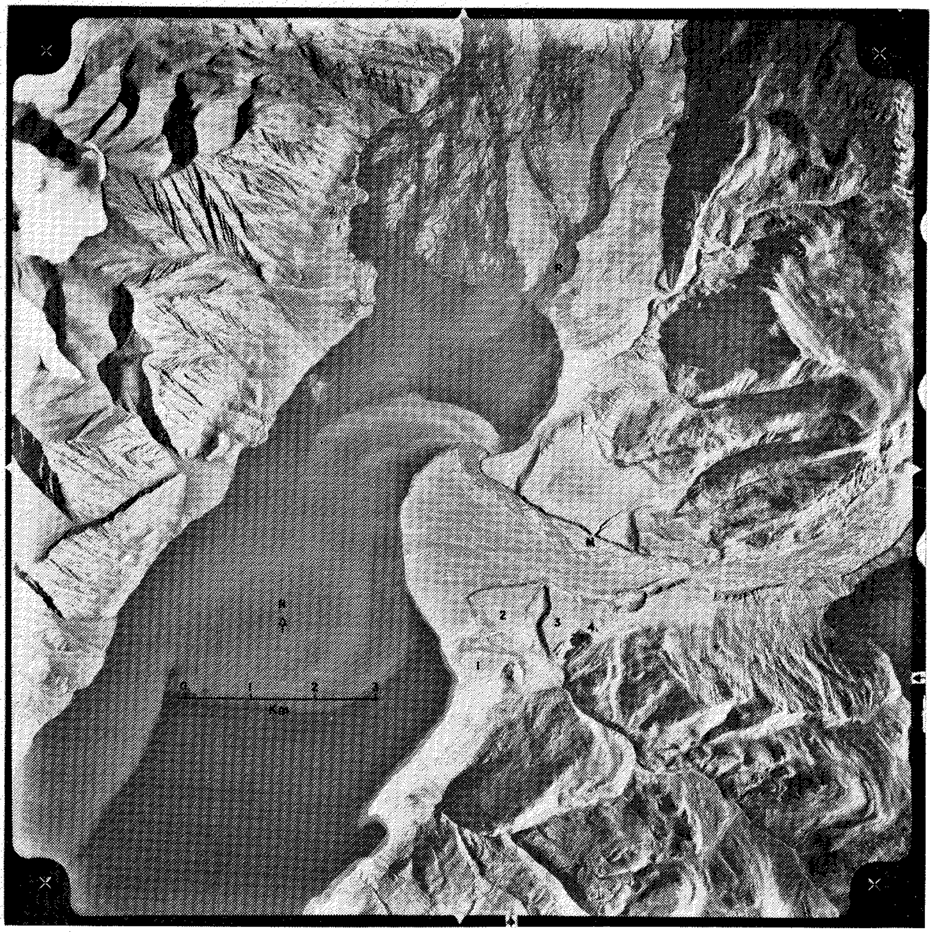

FIG. 1. Head of Tanquary Fiord from the air, showing the Macdonald (M) and Rollrock (R) rivers. Note delta terraces (1,2,3) and kame terrace with kettle lake (4). The small outlier of terrace 3 is indicated by marginal arrows. Vertical air photograph from 30,000 ft. (9,140 m.), 29 July 1959 (Courtesy of National Air Photographic Library, Canada, Department of Energy, Mines, and Resources).

direction. However, terraces 1, 2, and 3 are believed to be marine features, since three terraces at similar levels characterize the mouths of all the main rivers in the Greely Fiord-Nansen Sound area, indicating a common control. In its southwestern part, near Tanquary Camp, terrace 3 has been cut through by the stream which drains the small ice cap that lies 5 km. to the southeast at an elevation up to 1,500 m. A level survey showed that the steep forward slope of terrace 3 could not have been stream-cut, and is presumably due to original foreset delta-bedding. A small outlier of the terrace, rising to 77 m., has been left about 400 m. from the main body of the terrace. Whereas the main terrace appears to be composed almost entirely of shingle, gravel, and sand, the outlier lying on the periphery of the old delta contains considerable amounts of silt. No shells have been found on the surface of the terraces or on the modern delta, but shells occur sparsely on the terrace outlier and on the exposed marine silts southwest of the outlier. It appears that the predominating shingle and gravel on the deltas were inimical to shell environment and preservation, and that the melt-stream from the small ice cap has worked across parts of terraces 1 and 2, removing any possible shells. However, careful search in sand or silt layers in exposed sections of the terraces may yet reveal shells.

An excellent series of marine beaches runs across the forward slope of the terrace outlier (Fig. 2) up to a height of 50 m. The lower beaches in this series are represented on the forward slope of terrace 2 at heights of 20 to 25 m., where strandlines and ice-pushed gravel ridges are clearly visible, but the higher beaches are assumed to have been erased by the stream as it shifted its course across terrace 2, or to have been covered by loess at the front of terrace 3. It is evident both from air photographs and from ground observations that the stream swung past its present course as far southwest as the limit of the outwash gravels and shingle which mask the marine silts (Fig. 1). The probable former extent of the third terrace before land emergence and erosion by the stream is easily seen in Fig. 1. The ability of a river to build up such a delta system in the sea implies quiet waters and the absence of surf action, conditions which in fact obtain today when the open-water or partial open-water season lasts less than two months. In other words, we suggest that protection by sea ice was necessary for such regular delta-building.

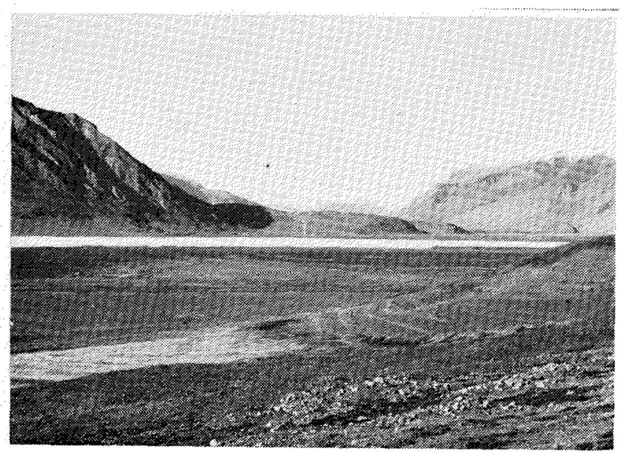

FIG. 2. Outlier of terrace 3 showing raised beaches, 16 August 1964 (Photo: G. R. Brassard).

SAMPLE LOCATIONS

Five of the 6 shell samples were collected from the terrace outlier and from the slopes on marine silts leading up to it. The sixth sample was collected from Flora Island, at the mouth of Tanquary Fiord. The samples are listed in Table 1, which also includes data on a peat sample from the Rollrock River valley. All heights of shells above sea level were measured with a Wallace and Tiernan surveying altimeter; the height of the peat was measured by theodolite. The estimated errors have been indicated. Since the mean tidal range is only 30 cm. (Hattersley-Smith, *ed.*, 1966, p. 20), no correction was necessary for the tidal phase during observations.

TABLE 1. Radiocarbon Ages of Shells and Peat from the Tanquary Fiord area, northern Ellesmere Island, N.W.T.

No.	*Locality*	*Species*	*Field altitude (m.)*	*Altitude (m.) corrected for eustatic rise above sea level*	*C-14 age (yr. B.P.)*	*C-14 Age with shell corrections (yr. B.P.)*
SI-468	Bank of Rollrock River. From bottom of 4-m. peat section.	(Peat)	72 ± ½	76 ± ½	6480 ± 200	6480 ± 200
GSC-373	Macdonald River delta. At surface of sandy silt and gravel.	*Hiatella arctica* L	55-58 ± 1	62-65 ± 1	6820 ± 140	6320 ± 140
I-1125	Flora Island. At surface of till-like deposit.	*Hiatella arctica* L	24-27 ± 2	27-30 ± 2	6285 ± 250	5785 ± 250
I-1126	Near Macdonald River delta. At surface of marine silts.	*Hiatella arctica* L	22-33 ± 2	25-36 ± 2	6340 ± 200	5840 ± 200
GSC-745	Near Macdonald River delta. At surface of marine silts.	*Hiatella arctica* L *Mya truncata* L	12-14 ± 1	12-14 ± 1	5700 ± 140	5200 ± 140
SI-393	Near Macdonald River delta. Embedded in grey marine silts, 55 cm. below surface.	*Echinoidea*	9 ± ½	9 ± ½	4220 ± 100	3720 ± 100
SI-407	Near Macdonald River delta. Embedded in grey marine silts, 55 cm. below surface.	(Random gathering of shells)	9 ± ½	9 ± ½	4360 ± 500	3860 ± 500

RATE OF ISOSTATIC UPLIFT

Figure 3 shows an uplift curve plotted from these limited data, including a correction for eustatic sea-level rise on the elevation of 0.9 m./100 yr. for the period prior to 6,000 years B.P. (Washburn and Stuiver 1962). Although we cannot make direct corrections for C-14 deficiency in shells grown on the Macdonald River delta, we have assumed a deficiency equivalent to 500 years, as did Müller and Barr (1966). The resulting curve is similar to those of other high latitude arctic areas as summarized by Müller and Barr (1966, p. 267), and as found by Lasca (1966) in northeast Greenland. At Tanquary Fiord, the highest recognized marine level is at about 60 m. above present sea level.

That the land has not emerged at a uniform rate in the 7,000 years represented on the curve is suggested by the distinct delta-terrace levels, although supply of

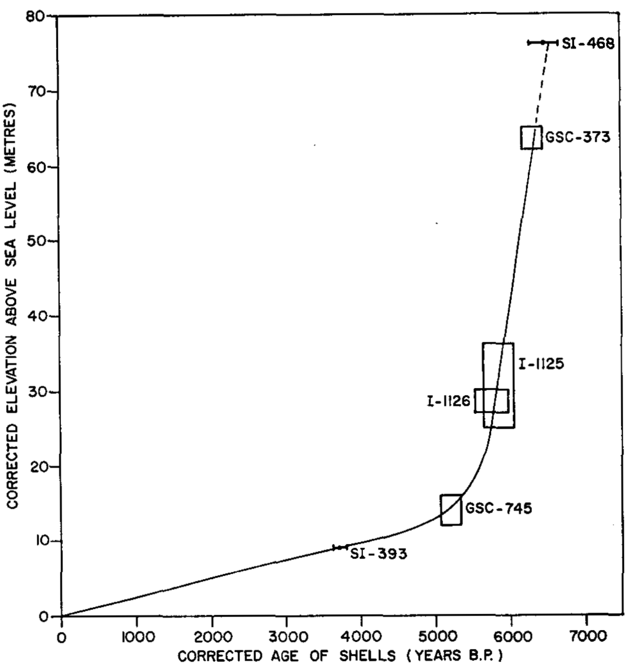

FIG. 3. Curve of postglacial uplift, Tanquary Fiord.

material was no doubt the most important factor determining these levels. Similar emergence has been reported from Axel Heiberg Island, where marine shells at the 60 m. level were dated at 7,000 ± 100 years B.P. (L647E; Müller 1966). On the other hand, shells from a raised beach in M'Clintock Inlet on the north coast of Ellesmere Island at an elevation of 38 m. have been assigned a radiocarbon age of 7,200 ± 250 years B.P. (L248B; Christie 1967); evidently, isostatic recovery was less rapid on the north coast of the island. In any case, from the massive fault system running through the line of Lake Hazen-Tanquary Fiord (R. L. Christie, personal communication), a different rate of isostatic recovery might well be expected to the north.

Comparing the present curve with that produced by Müller and Barr (1966) for Devon Island, we note a sharp decrease in the rate of land emergence at approximately 5,000 years B.P. in the former and at 7,500 years B.P. in the latter. The implication is that the main deglaciation took place about 2,500 years later in the Tanquary Fiord area, which is not surprising in view of the difference in latitude.

The age of the peat from the Rollrock River section indicates that 6,500 years ago the sea was below the present 72 m. level of the peat. Archaeological sites found by the first author at the 23 m. level near Tanquary Camp are believed to be about 4,000 years old. This estimate is based on the similarity of both the sites and the associated microblades to those of the Independence I culture on terrace 3, which were recognized by Count Eigil Knuth in 1965 (personal communication, 1967). The sites at the 23 m. level clearly date from a time when the stream had shifted more or less to its present course.

CONCLUSIONS

Radiocarbon ages of organic material enable the construction of a tentative uplift curve for the area of the Macdonald River delta. They indicate that the head of Tanquary Fiord was free of glacial ice by at least 6,500 years ago, and that by 5,000 years ago isostatic recovery of the area was 80 per cent complete.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to Dr. J. G. Fyles of the Geological Survey of Canada who arranged for the analysis of two shell samples (GSC-373 and GSC-745). Our thanks are also due to Mr. K. C. Arnold of the Water Research Branch, Department of Energy, Mines, and Resources, for assistance with levelling, and to Mr. U. Embacher of McGill University for collecting shell sample No. SI-393. Partial support for the investigations was provided by the Smithsonian Fluid Research Fund.

REFERENCES

CHRISTIE, R. L., 1967. Surficial geology of northwestern Ellesmere Island, District of Franklin. *Geological Survey of Canada, Bulletin 138.* 50 pp., map.

HATTERSLEY-SMITH, G., ed., 1966. Operation Tanquary: preliminary report, 1964. *Defence Research Board, Ottawa: Report D Phys R(G) Hazen 25.* 50 pp.

LASCA, N. P., 1966. Postglacial delevelling in Skeldal, Northeast Greenland. *Arctic,* 19: 349-53.

MÜLLER, F., 1966. Evidence of climatic fluctuations on Axel Heiberg Island, Canadian Arctic Archipelago, in *Proceedings of the Symposium on the Arctic Heat Budget and Atmospheric Circulation,* J. O. Fletcher, *ed.* The Rand Corporation, Memorandum RM-5233-NSF, pp. 135-58.

MÜLLER, F., and W. BARR, 1966. Postglacial isostatic movement in northeastern Devon Island, Canadian Arctic Archipelago. *Arctic,* 19: 263-69.

WASHBURN, A. L., and M. STUIVER, 1962. Radiocarbon-dated postglacial delevelling in northeast Greenland and its implications. *Arctic,* 15: 66-73.