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Construction of morphological profiles of raised marine beaches in Spitsbergen

ABSTRACT: The most popular field methods of measurements of raised marine beach altitudes used by geomorphologists are presented. Compared data from clisimeter routes, altimeter routes and from readings from a photogeological map and directly from air photos compose the profiles. Advantages and disavantages of each method are discussed.

Key words: Arctic, Spitsbergen, raised marine beach measurements.

Introduction

In studies of the Quaternary relief evolution of Spitsbergen investigations of age, extent and altitude of raised marine beaches are very important (Jahn 1959, Birkenmajer 1960, Marcinkiewicz 1961, Feyling-Hanssen 1965, Grosswald *et al.* 1967, Birkenmajer and Olsson 1970, Karczewski, Kostrzewski and Marks 1981, Kłysz and Lindner 1981, Salvigsen 1981, Salvigsen and Österholm 1982, Landvik, Mangerud and Salvigsen 1987, Forman, Mann and Miller 1987, and many others). Growing and disappearing of local ice caps caused oscillations of the lithosphere loading and thus intensive isostatic land movements. Land uplift or subsidence together with global fluctuations of sea level, changed configuration of a shoreline. During intensive land uplift steep cliffs were formed. They are distinct as steps, sometimes high on mountain slopes (Pl. 1, Fig. 1). During periods of isostatic equilibrium extensive, flat terraces were arisen (Pl. 2, Fig. 1).

In studies of the raised marine beaches, the measurements of their altitudes are necessary. These measurements could be made with a use of different methods. The most rigorously but at the same time the most labour-consuming is geodetic precise levelling. According to Marcinkiewicz (1961) only the application of this method allows to compare differences of isostatic movements on the whole Spitsbergen. Whereas during the geomorphological fieldworks more inaccurate measurements, but faster and to be done by a single person are used. The most popular are clisimeter routes (Birkenmajer 1960) and altimeter routes (Szupryczyński 1968).

For verification of these methods the authors made profiles of raised marine beaches along the same routes (Fig. 1) and compared the results (Figs 2

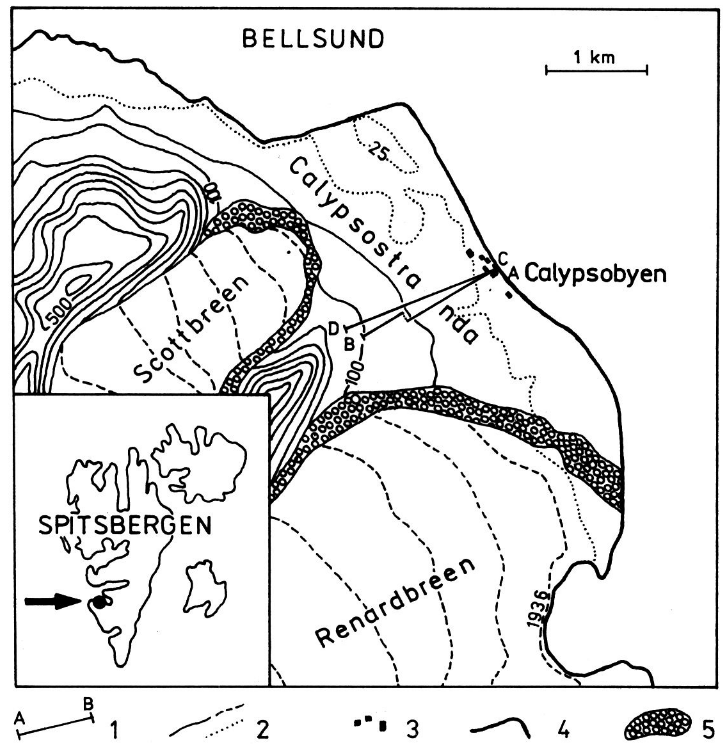

Fig. 1. Sketch of the investigated area. 1 — profile lines, 2 — contour lines, 3 — huts, 4 — sea coast, 5 — moraines

and 3). These profiles were compared with two other ones prepared on the basis of a photogeological map at a scale of 1:10.000 (Szczęsny *et al.* 1989) and readings from Norwegian air photos at a scale of 1:50.000 with a use of interpretoscope and stereomicrometer (both produced by VEB Carl Zeiss Jena).

The Calypsostranda strandflat on the southern coast of Bellsund, formed testing ground with several distinct marine beaches at 1—6, 20—35, 35—50, 50—70, 70—80 and 100—150 m a.s.l. (Pl. 1, Fig. 1, 2; Pl. 2, Fig. 1).

Compiled profiles through the Calypsostranda (Figs 2 and 3) satisfactorily show a character of the relief, however distances and altitudes along individual profiles differ from several to a dozen of meters. These divergences are due to inaccuracy of applied measuring methods.

Every altitude measurement is compared with a mean, sea level while sea level changes due to tidal oscillations are equal to 1.5 m inside the fiords. These changes have not been taken into consideration.

Clisimeter routes

During realization of clisimeter routes, systematic distance errors caused by changes of step length on surfaces of different inclination, lithology and

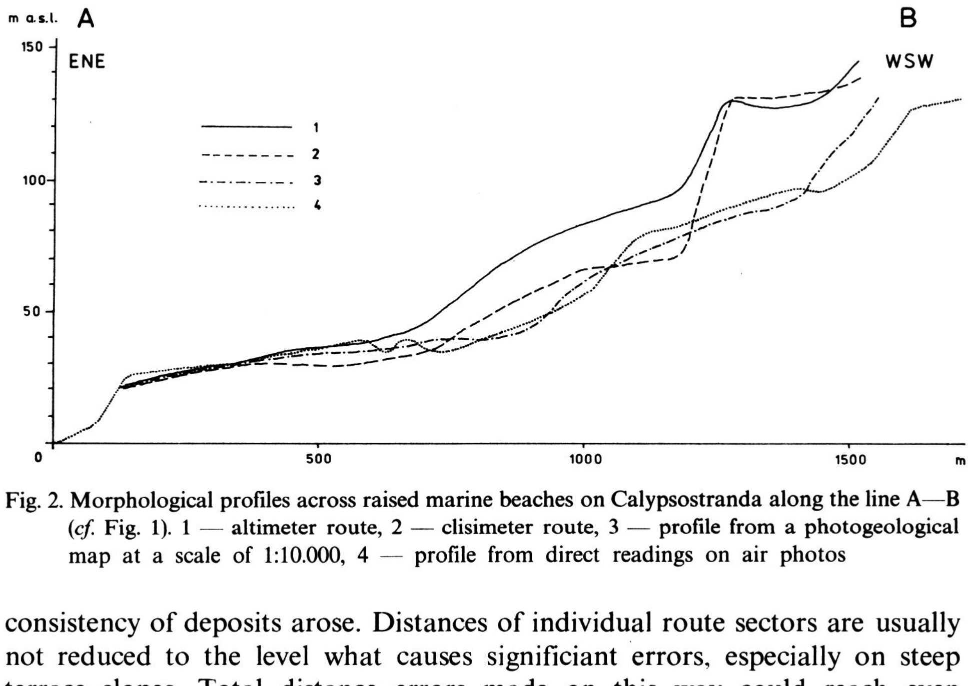

Fig. 2. Morphological profiles across raised marine beaches on Calypsostranda along the line A—B (*cf.* Fig. 1). 1 — altimeter route, 2 — clisimeter route, 3 — profile from a photogeological map at a scale of 1:10.000, 4 — profile from direct readings on air photos

consistency of deposits arose. Distances of individual route sectors are usually not reduced to the level what causes significiant errors, especially on steep terrace slopes. Total distance errors made on this way could reach even a dozen of meters along the 2 km long measured distance (Fig. 2). However altitude inaccuracies are due to systematic errors of measurements of terrain inclination. These errors seem to reach the extreme values for gently inclined widespread areas like raised marine beaches (Figs 2 and 3).

Altimeter routes

Precision of altimeter routes, except of above mentioned errors of distance measurements, depend on stability of atmospheric pressure. Sudden oscillations of pressure are typical for Spitsbergen climate (Pereyma 1983, Gluza 1988). In the middle of the exampled altimeter route (Fig. 2) a profile line suddenly rises tens of meters in comparison with other profiles. Such elevation seems to result from a sudden drop of atmospheric pressure. In another case (Fig. 3) such changes do not occur because of stabilized weather conditions during measurements.

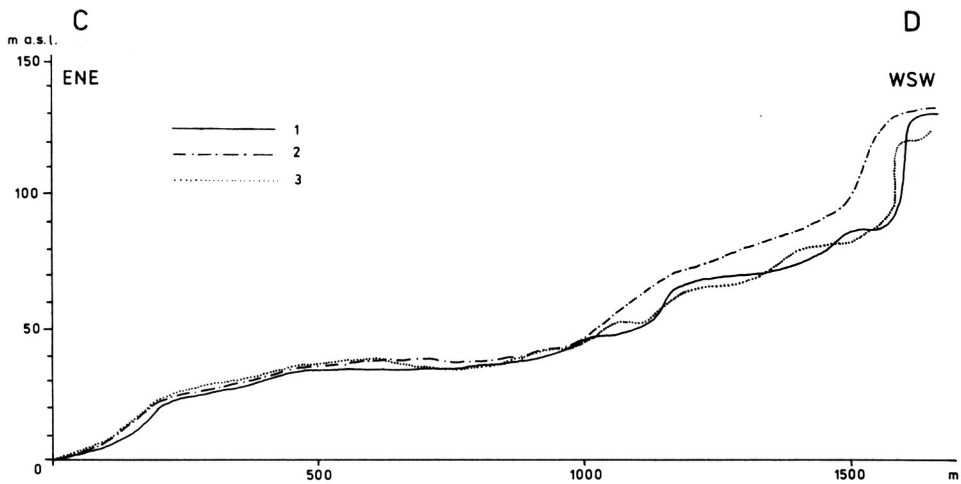

Fig. 3. Morphological profiles across raised marine beaches on Calypsostranda along the line C—D (*cf.* Fig. 1). For explanations see Fig. 2

Equalization of altimeter measurements is difficult due to sudden changes of atmospheric pressure, so confrontation of measurement results and barograph record is neccessary.

In both field methods the inaccuracies could be also caused by wrong location of measuring points on flat and monotonous terrace surfaces covered with tundra only (Pl. 2, Fig. 2).

Photogeological maps

Profiles drawn from a photogeological map (Szczęsny *et al.* 1989) do not indicate the presence of small but sometimes important landforms. It is due to the interval of contour lines equal 10 m. Distance deformations are however much more smaller than in field methods and readings directly on air photos. The autograph used for a preparation of a photogeological map allows to eliminate deformations of a stereoscopic model which forms the basis for further elaboration. These deformations are caused by non-

-parallel and non-vertical position of optical axes of air photos, as well as by approximate scale of the photos. A detailed analysis of distance and altitude deformations on photogeological maps is presented by Lindner *et al.* (1985).

The insufficient number of photogeological maps at a scale of 1:10,000 limited their usability for preparation of profiles of raised marine beaches in the other parts of Spitsbergen.

Stereoscopic air photos

A quality of profiles prepared directly from air photos with a use of the interpretoscope with a stereomicrometer, depends on image deformations while photographing. If axes of photos are vertical, these deformations become insignificant. Relief details are drawn with precision dependent on possible evaluation of changes of longitudinal parallaxes and therefore, differences in altitude. Measuring accuracy is also conditioned by precision of the apparatus and for stereomicrometers the accuracy of parallaxes measurements is equal from 0.01 to 0.02 mm.

But the observer's practice, a precision of readings is effected by the scale of air photos. If profiles are to be constructed at scales much greater than the one of air photos, then the drawings have to be enlarged. Irrespective of the applied method, errors made during interpretation are enlarged too.

Additionally the air photos, especially paper prints are very sensitive to changes in humidity, and are subjected to deformations. Evaluation of these deformations is extremely difficult, so during the studies of the stereoscopic model deformed in this way, additional errors of distance and altitudes are commited (Jania 1987). Deformations caused by paper shrinking are also varied in time.

Discussion and conclusions

Nevertheless, while all the presented methods are inquestionably imperfect, they are used because of easy measurements and immediate results in comparsion with geodetic levelling. Results are also effected by errors but seem to be sufficient for geomorphologic studies. Measurements from air photos are especially recommendable. Quick results cannot be obtained from any other method and if observer has a good experience, then their precision is quite satisfactory. The profiles of interest can be also prepared before field investigations.

The authors postulate a consequent use of only the single measuring method amongst the above described and a clear statement which of them has been chosen. A consciousness of reasons for inaccuracy allows to make an attempt for minimalization of the commited errors. A comparsion of altitudes of raised marine beaches from data of different authors should be prudent, especially if a measuring method is unknown.

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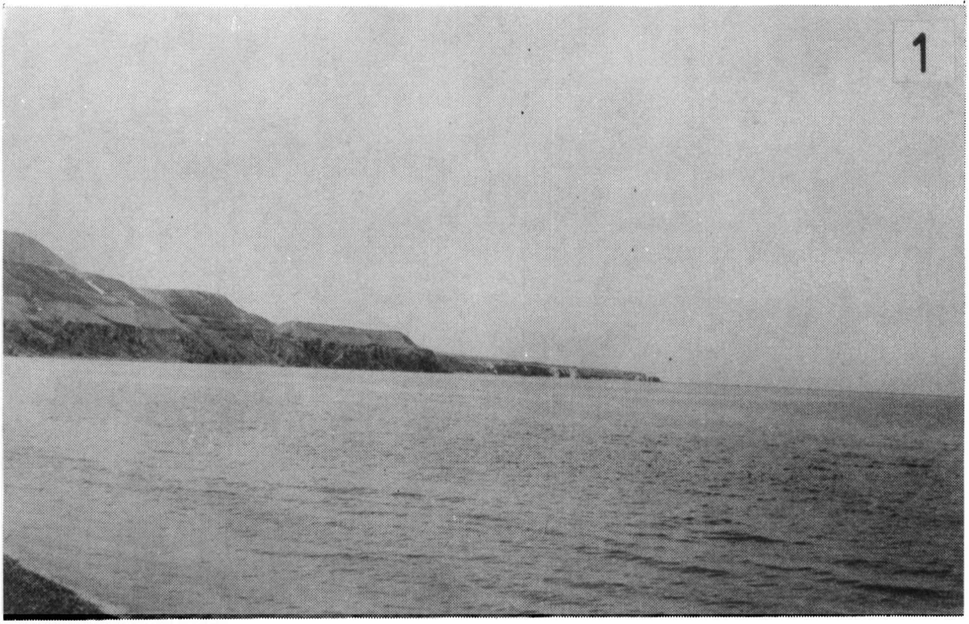
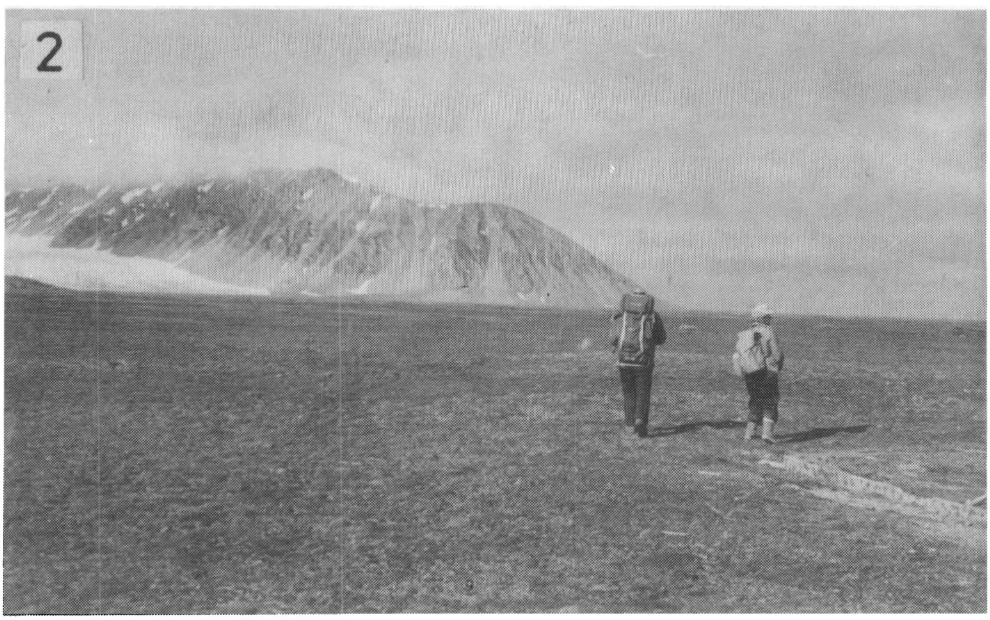
Streszczenie

Praca poświęcona jest prezentacji najpowszechniej stosowanych w praktyce geomorfologicznej metod pomiaru wysokości wyniesionych tarasów morskich (pl. 1). Porównano profile morfologiczne przez równinę nadmorską Calypsostranda (fig. 1; pl. 2), wykonane na podstawie pomiarów terenowych i fotointerpretacyjnych. Zinterpretowano zróżnicowanie profili uzyskanych w oparciu o ciągi krokowo-altymetrowe, krokowo-klizymetrowe oraz mapy fotogeologiczne i pomiary bezpośrednio ze zdjęć lotniczych (fig. 2—3). Przedyskutowano możliwości i ograniczenia każdej z metod. Pomiary wysokości tarasów bezpośrednio ze zdjęć lotniczych powinny być szerzej stosowane z racji na szybkość wykonania i wystarczającą do badań geomorfologicznych dokładność.

Praca została wykonana w ramach CPBP 03.03. B.7.



1. Complex of raised marine beaches on the southern coast of Bellsund. July 1986
2. Slope of the raised marine beach 20—35 m a.s.l. to the west of Calysobyen. July 1986



1. Testing area for fieled measurements on Calypsostranda. July 1986
2. Surface of a raised marine beach in a forefield of the Scott Glacier. July 1986