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THE SINKING OF GREENLAND

A CONTINUATION OF F. FRODA'S MEASUREMENTS

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For the purpose of determining the sinking of the land Captain F. Froda, R. D. N., has made some measurements in North-Greenland. The method used by Froda is based on the assumption that the balanus-stripes on the rocks at the coast are found at a rather constant distance below the mean level of high water. The sinking of the land might therefore be determined by measuring at different moments of time the position of the balanus-stripes in relation to some fixed point. In July 1897 F. Froda in Godhavn determined the vertical distance between the upper edge of 7 balanus-stripes and a fixed point[1]). In August 1923 he repeated this measurement and made similar measurements at Tipidôk and Ausiat near Egedesminde and at Prøven[2]).

At the request of the Danish Meteorological Institute the Danish Geodetic Institute in August 1946 determined the position of the balanus-stripes at Godhavn ($\varphi = 69.^{\circ}2$ N, $\lambda = 53.^{\circ}5$ W) and at Ausiat ($\varphi = 68.^{\circ}7$ N, $\lambda = 52.^{\circ}8$ W). The measurements were carried out by J. F. Chantelou, superintendent at the Danish Geodetic Institute and leader of the Geodetic Expedition to Greenland 1946. Unfortunately the stone whose top constituted the fixed point used at Tipidôk was removed, so that the measurements here were made useless.

As the height of the balanus-stripes in relation to the sea-level also depends on the qualities of the substratum and as a smaller or greater number of determinations affect the mean value of the heights measured, it has been found necessary to consider only the highest balanus-stripe for the determination of the sinking. In Table 1 all the observations made at Godhavn in the years 1897, 1923 and 1946 are given. The values stated represent the vertical distance from the upper edge of the balanus-stripes to the upper edge of a white stripe in a block of stone, described in greater detail in Froda's paper (vol. 59). The values have been entered in the same order as observed by the observer, and each of the series contains values for new stripes even if in rare cases it may happen that a stripe is measured in two consecutive series.

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[1]) Medd. om Grønland, vol. 14, p. 346, Copenhagen 1898.

[2]) Medd. om Grønland, vol. 59, p. 51—53, Copenhagen 1925.

Table 1. — Vertical distance of the balanus-stripes below the fixed point (Godhavn).

	1897	1923	1946
	84 cm	76.5 cm	45.5 cm
	103 -	86.5 -	46.5 -
	106 -	81.5 -	51.9 -
	103 -	65.5 -	31.3 -
	84 -	56.5 -	51.9 -
	85 -	87.5 -	63.9 -
	97 -	57.5 -	44.5 -
	..	66.5 -	55.8 -
	..	85.5 -	43.9 -
	..	90.5 -	40.1 -
	..	104.5 -	..
	..	85.5 -	..
	..	78.5 -	..
Smallest distance:	84 cm	56.5 cm	31.3 cm

From Table 1 it will be seen that the balanus-stripes in the course of time are rising to higher levels. On the basis hereof it is concluded that the sea-level is rising in relation to the fixed point on the shore, but as the mean sea-level all over the earth remains rather unaltered the variation is considered to be a measure for the sinking of the land.

The values for the sinking of the land in the different periods are given in Table 2.

Table 2. — The sinking of the land at Godhavn.

Period	Total sinking	Sinking per annum
1897—1923.....	27.5 cm	1.06 cm
1923—1946.....	25.2 -	1.10 -
1897—1946.....	52.7 -	1.08 -

The results of the measurements at Ausiat near Egedesminde are given in Table 3.

From the values given in Table 3 it is concluded that the sinking of the land at Ausiat in the period 1923—1946 is

25.1 cm or 1.09 cm per annum.

To the above results some remarks should be added. The errors in the determination (levelling) of the vertical distance between the balanus-stripes and the fixed points are small and without significance.

As it is not certain that the upper edge of the highest balanus-stripe reaches a level whose vertical distance from the sea-level at high water is a constant quantity, because the stratum at the place considered may be more or less suitable for the formation of a balanus-stripe, and because the mode of living of the balanus is not thoroughly

Table 3. — Vertical distance of balanus-stripes below the fixed point (Ausiat).

	1923	1946
	186 cm	171.6 cm
	193 -	168.2 -
	210 -	172.4 -
	186 -	166.4 -
	213 -	155.9 -
	209 -	164.0 -
	195 -	165.9 -
	185 -	165.8 -
	197 -	167.7 -
	192 -	161.8 -
	207 -	161.6 -
	201 -	168.4 -
	202 -	..
	214 -	..
	196 -	..
	185 -	..
	181 -	..
Smallest distance:	181 cm	155.9 cm

taken into consideration, some errors may arise in the determination of the sinking of the land.

From Tables 1 and 3 it will be seen that the smallest distance may be a value differing more or less from what should be expected when the rest of the values are considered. The error arising herefrom will certainly not exceed 3 cm.

The fact that a tidal wave with a period of 18.6 years (the revolution of the moon's nodes) exists, may also affect the above results. The amplitude of this tidal wave should according to A. F. Doodson[1]) theoretically amount to 7 per cent of the amplitude of the tidal constituent M_2. On account hereof the amplitude in the region considered should be about 5 cm. However, the tidal constituents on which the considered

[1]) A. F. Doodson: The harmonic development of the tide-generating potential. Proc. Roy. Soc. A 100, p. 305—329, 1921.

variation of the longitude of the moon's nodes has the greatest influence, are the terms O_1 and K_1, and these terms being small for the region in question, it may be expected that the amplitude of the 18.6 year wave is less than 5 cm. The maximum of this wave occured in 1894.8, 1913.4 and 1932.0 and will occur in 1950.7; the influence of the wave on the measurements of the balanus-stripes in 1897 and 1946 will therefore be of nearly the same size, so that the difference between the values for these years should be nearly unaffected.

Considering the above mentioned sources of error the resulting error of the value for the sinking of the land might not exceed 10 per cent of the value found.

In conclusion the author wishes to thank Capt. Froda who has placed the original observations from his measurements at my disposal and Superintendent J. F. Chantelou for his observations in 1946.

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