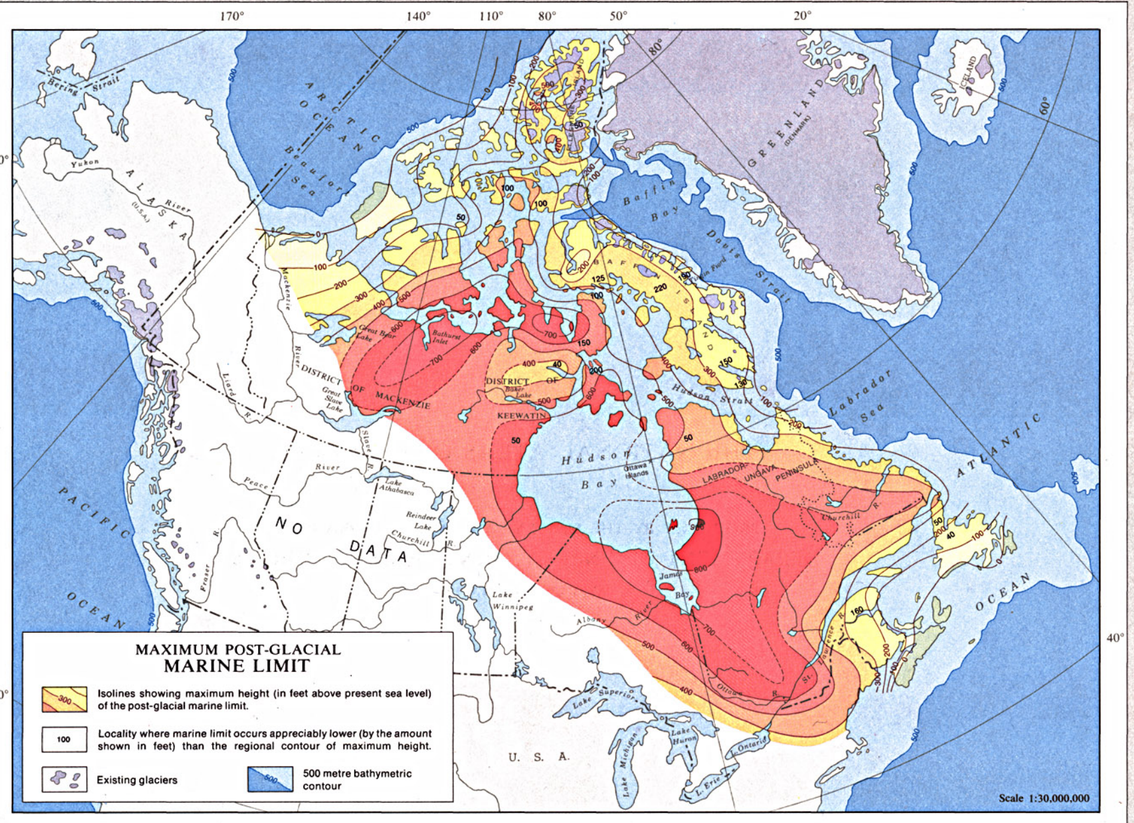
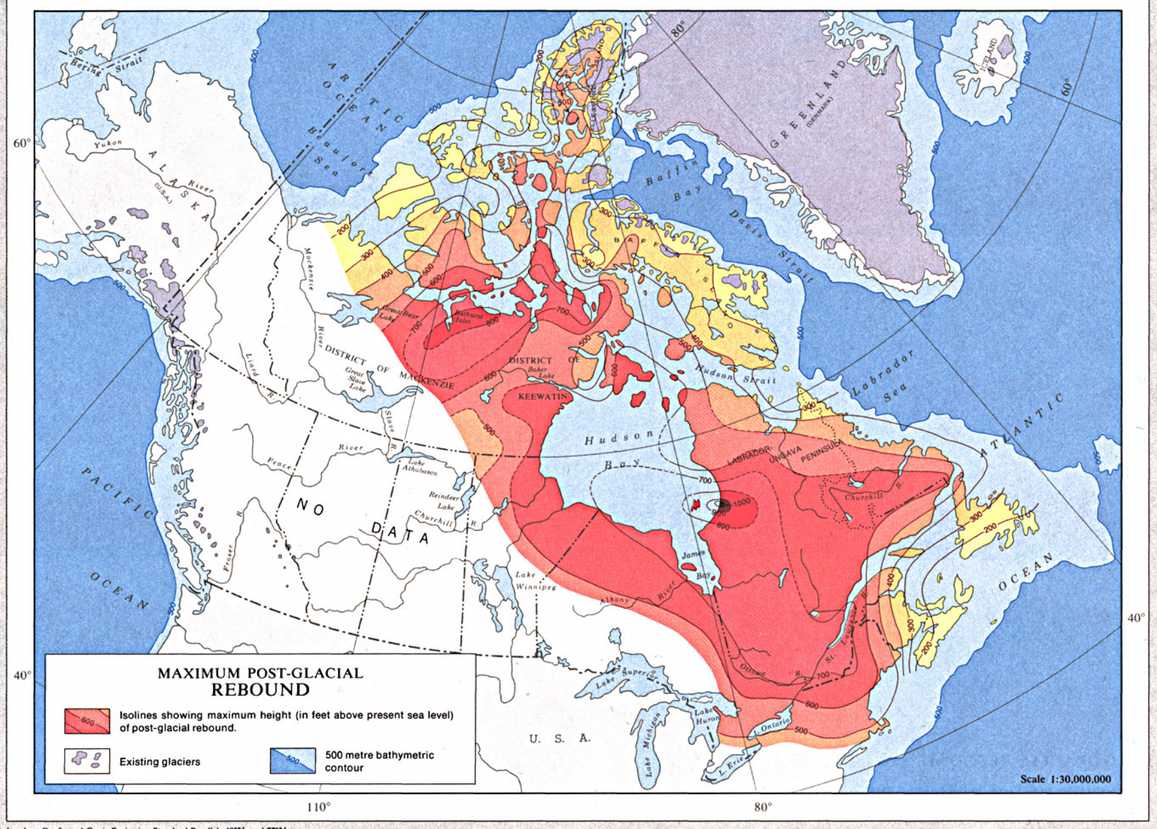
POST-GLACIAL REBOUND





Lambert Conformal Conic Projection Standard Parallels 49°N. and 77°N.

THE NATIONAL ATLAS OF CANADA

POST-GLACIAL REBOUND

It may be difficult to think of the earth's crust being sufficiently flexible that it can be depressed by a heavy load. However, there is conclusive evidence that the earth's crust does respond in this way and moreover, as the load is removed the crust rebounds. Striking results of this response are seen in coastal areas of Canada where marine shells and ancient sea beaches can be found at various heights up to 930 feet above the present sea-level. What is the cause of this movement? It is accepted that during the last glaciation a considerable area of Canada and the northern United States was covered by a large ice cap. Thus, approximately 18,000 years ago, Canada could be compared with Antarctica or Greenland today. The growth of huge ice sheets required a considerable volume of water to be removed from the oceans. It has been estimated that at the maximum of the last glaciation, world sea level was 360 feet lower than today. By comparing the size of the oceans and volume of water removed it has also been estimated that the ice sheet over Canada had an average thickness of about 8,200 feet. At the centre of the ice cap the ice may have attained a depth of 15,000 feet.

The transfer and addition of this mass was enough to cause the earth's crust to sink. Opinions vary as to the amount of depression and estimates range from one quarter to one third of the overlying ice thickness, implying that the maximum depression due to the ice load ranged between 3,750 and 5,000 feet. However, as soon as the ice cap began to thin and retreat, the earth's crust started to rebound towards a new equilibrium. Thus part of the glacially controlled rebound (or glacio-isostatic rebound) occurred while the ice still covered the coastal areas. But in some places ice retreat exposed the coasts and the sea impinged on the depressed land surface. This upper level of marine action is called the "Marine Limit". It was formed at different times at different sites, varying from 13,000 years ago to less than 5,000 years ago in parts of Arctic Canada. Between the time that each marine limit was formed and today, rebound has occurred so that the marine limit is some height above present sea-level.

The marine limit elevation reflects only part of the post-glacial uplift or rebound. During the period of glacier melting and retreat, water was transferred back to the oceans and sea-level gradually rose. Ten thousand years ago sea-level is estimated to have been 100 feet lower than today. Suppose the sea cut a marine limit 10,000 years ago and that today this feature is 200 feet above sea-level. In this time sea-level has risen 100 feet, therefore the total post-glacial rebound would be 200 plus 100 or 300 feet.

At one time it was thought that the altitude of the marine limit gradually increased towards a centre near James Bay. However, research in the last decade indicates that the elevation of the marine limit can vary greatly in a few miles. This pattern is caused by differences in the rate of glacier retreat. Where the ice has been slow to retreat, thus preventing incursion by the sea, marine limits are relatively low compared to neighbouring areas.

There are now many hundreds of observations on the elevations of the marine limit throughout Canada and the maps presented here provide a generalized depiction of the varying height of this feature. In order to produce the map of the marine limit a grid was laid over a base map on which were plotted the known heights and locations of marine limit observations. A template was placed on 125 grid intersections. Approximately 33 percent of the country was sampled in this way. At each grid intersection the maximum marine limit elevation in the area covered by the template was plotted (the template covered 94 x 94 miles). The resulting network of points was then contoured.

Data is available only for coastal sites, hence the contours over parts of the Labrador-Ungava peninsula and the Districts of Keewatin and Mackenzie are interpretations. A note was made of sites where the marine limit is appreciably lower than the maximum value (see map), thus indicating the location of late lying ice masses. The resulting surface shows the *maximum post-glacial marine limit* for part of Canada. At each of the 125 grid intersections an addition was made for the estimated amount of eustatic sea-level rise since the time of marine limit formation, and a map of *maximum post-glacial rebound* was constructed. In both cases the maps show the *highest* possible marine limit or rebound. Some areas lying along a particular contour might for various reasons lie below a regional contour value. As the peripheral areas of the ice cap were freed from ice first, they have the largest sea-level correction; therefore, the main difference in the two contoured surfaces is that the post-glacial rebound surface has a lower gradient and is higher.

The maps show three centres of post-glacial rebound. The first is located north of James Bay; the second occurs over Bathurst Inlet and the third is centred over western Ellesmere Island. Two small, low cells are located over northwest Baffin Island and in the vicinity of Baker Lake. Elsewhere, the contours on both surfaces indicate an increase in post-glacial rebound and in the elevation of the marine limit towards the two main high zones.

The maps support the concept that the crustal rebound is related to glacial loading. The amount of post-glacial rebound is least on the margins of the former ice cap and increases towards the centre where the ice thickness was greatest. After the formation of a marine limit, emergence was at first very rapid and then became progressively slower as illustrated in the graphs below.

The curve on the left is from central Hudson Bay, that on the right is from east Baffin Island. Note that in the last 7,000 years Hudson Bay has emerged approximately 425 feet whereas east Baffin Island has emerged 130 feet. Curves such as the ones below are obtained by radio-carbon dating marine shells, whalebone, peats and driftwood found at various elevations below the marine limit.

J.T. Andrews.