Introduction

Continental-scale glaciers had a major impact on the land west of Hudson Bay:

- They scoured the bedrock, carried debris across the landscape and shaped many landforms still visible today.
- They caused the land to sink under their weight and as they melted, the sea invaded the coastal areas.
- With the removal of their load, the land rebounded and the sea regressed, leaving the old marine sediments exposed.

Today the land is still rebounding but at a slower rate, and the sea continues to retreat and marine deposits to emerge.

A heavy ice sheet with weighty effects!

During the most recent ice age, which began about 750,000 years ago, glaciers were massive features on the landscape in and around Hudson Bay, forming a large continental ice sheet named the Laurentide Ice Sheet. We can still see evidence of the passage of this ice sheet west of Hudson Bay and it is still having a long-lasting effect on the land today.

One key effect of glaciation on the land is glacial isostatic adjustment (GIA). This is when the weight of an ice sheet pushes down the land beneath it, causing the elevation of the land to become lower compared to sea level. As the ice load is removed during deglaciation, the land bounces back.

During the last glaciation, western Hudson Bay was under some of the thickest parts of the ice sheet (e.g. the Kivalliq Dome) and therefore was compressed a great deal.

Retreat of the glaciers and invasion of the sea

After the ice sheet reached its peak about 22,000 years ago, deglaciation started. Melting glaciers had impressive effects on the landscape around Hudson Bay. The sheer quantity of water melting out of the glaciers, combined with the depressed land elevation caused by the weight of the Laurentide Ice Sheet, led to marine waters flooding low areas around the ice sheet margin and forming a large inland sea named the Tyrrell Sea. Recent research shows that the highest limit of marine inundation occurred about 10,000 years ago west of Hudson Bay and is marked by a prominent shoreline, called the marine limit. The marine limit was at times located 200 m farther inland and up to 242 m above the current shoreline along western Hudson Bay.

Rebound of the land and regression of the sea

Since deglaciation, the land has constantly adjusted to the removal of the weight of the ice sheet by rebounding, first at a rapid rate and then more gradually, until today. The land is still bouncing back, gaining elevation at an average of about 1 cm each year. As a result, the sea level along western Hudson Bay is relatively falling and the shoreline is generally moving toward the east.

Through this very important marine episode, the nearshore waves, longshore currents, and deep marine waters have left their mark on the landscape. Successive positions of the former coast are marked by series of ancient beaches, wave-cut terraces, wave-cut platforms, and drowned valleys. These structures, along with the deposits they contain, provide important indicators that we can use to understand the history of the area.

Knowledge of surface materials composition and their transport paths by moving glaciers are also very important for mineral exploration. There is research currently being done in reconstructing the directions of former glacier movements in order to trace back the sources of valuable minerals dispersed by glaciers. Knowing the highest limit of marine inundation can help to evaluate if the dispersed terrains left by glaciers were affected by reworking processes in sea waters or hidden by postglacial marine deposits.

Map of marine limit

Some of the landforms created by the postglacial Tyrrell Sea are still visible on the landscape today. Ancient beaches and terraces formed in shorelines environments, deltas deposited where meltwater and river entered the sea, and features cut by waves into rock or sediments give us clues of where the shoreline existed in the past. Marine tidal sands deposited in shallow, shallow and marine muds accumulated in areas submerged by deep seawater also provide good indicators of the presence of the ancient sea.

Recently scientists from the Geological Survey of Canada and the Manitoba Geological Survey compiled a database of these seawater indicators and recorded their elevation using measurements collected in the field or extracted from satellite imagery.

With this information, they created a detailed map of where the former sea previously existed. For example, if there is an ancient beach found in the landscape at an elevation of 110 meters above the present-day sea level, it is safe to assume that the land in the local area below the beach was underwater when the beach was formed. Using the height, it is possible to calculate the contour to which the land would have been raised around similar landforms. Then, using levels of constant elevation at various contours, the ancient shoreline can be reconstructed to give a continuous line showing the maximum limit of the seawater at the last glaciation.

The blue areas on the map to the left are thought to have been underwater at some time since deglaciation. Raised marine shorelines and marine sediments are also indicated. If an age can be determined by radiocarbon dating of organic materials found along the shoreline (e.g. seaweed, shells, or driftwood), the rate of emergence of the land from the postglacial sea can be calculated. One method of determining the age of a shoreline is to date a thin layered mud that was washed-through bedrock surface has been exposed to cosmic rays, which come to Earth from space.

The map to the right shows the location and elevations of the limit of marine invasion. Notice that the highest shoreline elevations are not constant. This is expected because the seawater invaded areas at different times following the retreating glaciers and also because the land has been rebounding at different rates in different areas.

Implications and impacts

Exposed seawater sediments are susceptible to some particular permafrost and ground ice features due to their grain-size composition. These features include ice wedge polygons that form linear fractures filled with frozen water, and thermokarst, which is where underground ice melts, releasing water and dissolved substances from permafrost. Where the sediment above the ice caves in, thermokarst lakes can form. These ice-rich features can affect the stability of the ground surface in the event of warmer temperatures.

Knowing the makeup of the soil is also important when building homes, roads, power lines, or any other kind of structure on top of it. In addition to ice-rich permafrost, the chemistry of the surface sediments and the physical structure and size of sediment grains can affect the stability of the ground and its response to climatic changes.

Retreating ice sheets can provide important indicators for geological conditions that need to be considered in modern times. For example, if there is an ancient beach found in the landscape at an elevation of 110 meters above the present-day sea level, it is safe to assume that the land in the local area below the beach was underwater when the beach was formed. Using the height, it is possible to calculate the contour to which the land would have been raised around similar landforms. Then, using levels of constant elevation at various contours, the ancient shoreline can be reconstructed to give a continuous line showing the maximum limit of the seawater at the last glaciation.

Glacial isostatic adjustment (GIA) is also a modern concern. Although today, the sea level in rising due to climate change, the uplifting of the land caused by the GIA offsets the increase in sea level around Hudson Bay. This result is that relative sea level is falling and the water readers is becoming shallow. This has important implications for the coastal community in considering building shore infrastructure or coastal navigations.

Knowledge of surface materials composition and their transport paths by moving glaciers are also very important for mineral exploration. There is research currently being done in reconstructing the directions of former glacier movements in order to trace back the sources of valuable minerals dispersed by glaciers. Knowing the highest limit of marine inundation can help to evaluate if the dispersed terrains left by glaciers were affected by reworking processes in sea waters or hidden by postglacial marine deposits.

Conclusion

The new research described here is focused on using data from many sources to determine which areas of land west of Hudson Bay were flooded by seawater since the last deglaciation. The resulting information should give us a better understanding of the most recent history of the area since the continental-size glaciers disappeared, as well as knowledge to help avoid problems in the future.

Want to know more? Check out the original research at [https://dx.doi.org/10.4296/201304](https://dx.doi.org/10.4296/201304)