Geological Survey of Canada
Open File 8979

ICE-AGE LEGACY: A MARINE HAPPENING ALONG WESTERN HUDSON BAY, NUNAVUT AND MANITOBA

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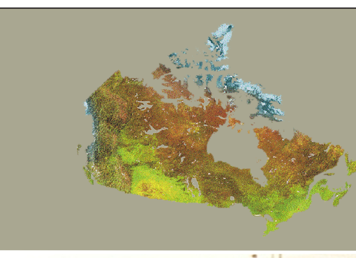


Introduction

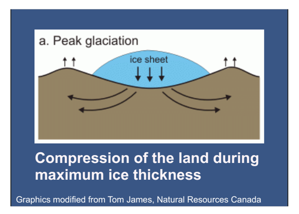
Continental-size glaciers had a major impact on the land west of Hudson Bay:

- 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 retreated, 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 75,000 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.

From Dyke et al., 2003

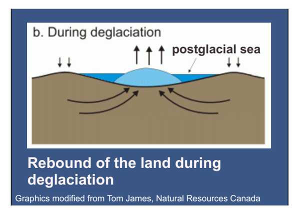


Graphics modified from Tom James, Natural Resources Canada

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 (i.e. the Keewatin 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 margins and forming a large inland sea named the Tyrrell Sea. Recent research shows that the highest level of marine inundation occurred about 8000 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 km farther inland and up to 242 m above the current shoreline along western Hudson Bay.



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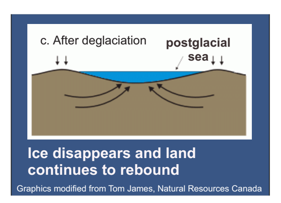
Rebound of the land and regression of the sea

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 with time. Today, the land is still bouncing back up, gaining elevation at a rate 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 towards the east.



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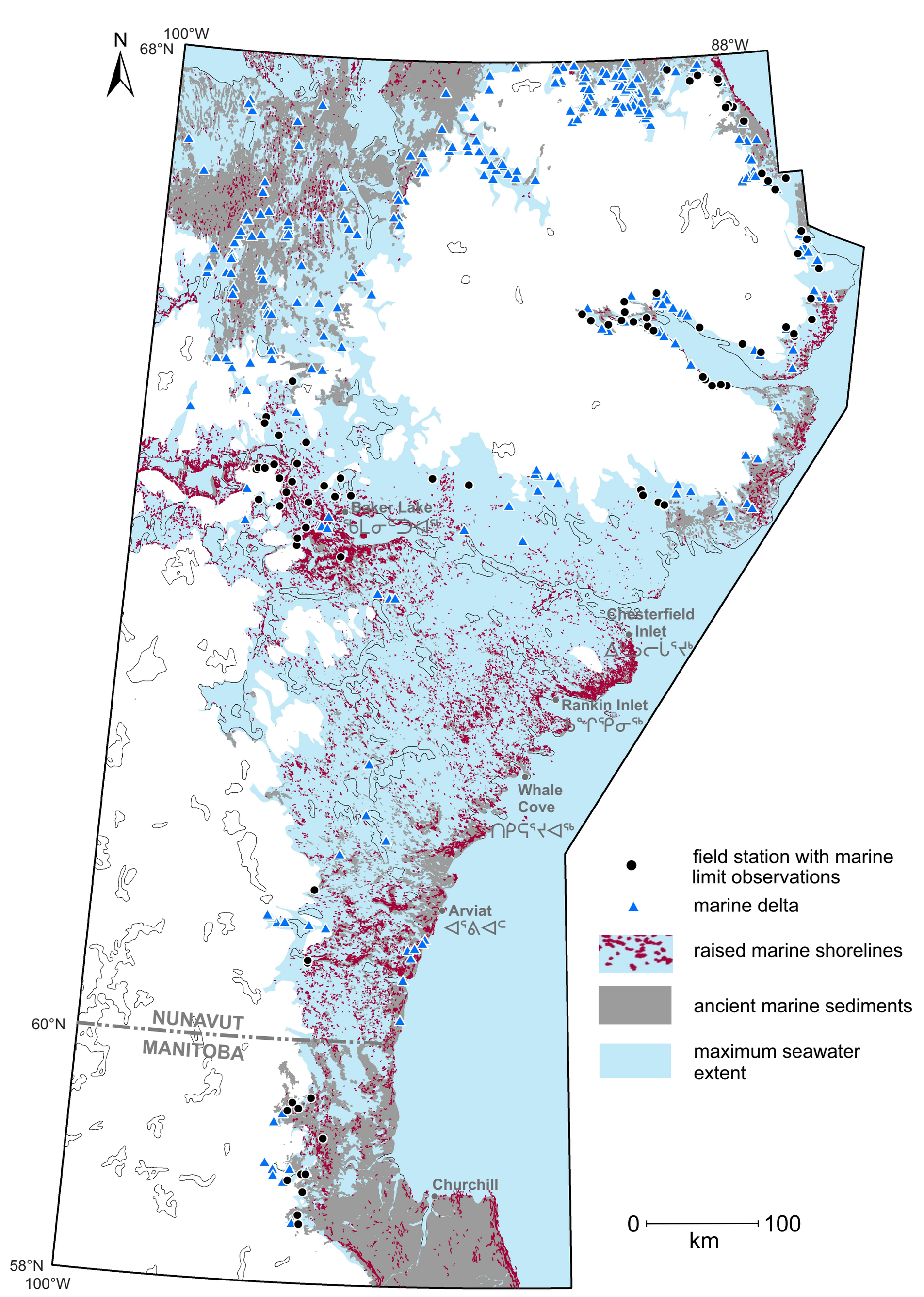
Throughout this important marine episode, the nearshore waves, longshore currents, and deep marine waters have left their mark on the landscape. Successive positions of the former coast are marked by series of ancient beaches, wave-cut notches, wave-washed bedrock surfaces, deltas, tidal flats, and various deposits of marine sediments, many containing seashells, which occur below the maximum limit of marine inundation. These features are not only interesting historically and scientifically but are also important indicators for geological conditions that need to be considered in modern times.

Map of marine indicators



Mapping the ancient sea

Some of the landforms created by the postglacial Tyrrell Sea are still visible on the landscape today. Ancient beaches and spits formed in shoreline environments, deltas deposited where meltwater and rivers 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 waters 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.

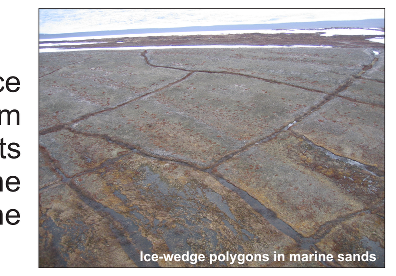
With this information, they created a detailed map of where the former sea previously existed. For example, if there is an ancient beach found in the landscape at an elevation of 150 meters above the present-day sea level, it is safe to assume that the land in the local area below the beach was underwater when the beach was formed. Using this logic, it was possible to establish the extent of the ancient Tyrrell Sea locally, around indicator landforms. Then, using lines of constant elevation (elevation contours), the various landforms were linked together to give a continuous line showing the maximum limit of the seawater after the last glaciation.

The blue areas on the map to the left are thought to have been under seawater at some time since deglaciation. Raised marine shorelines and marine sediments are also indicated. If an age can be determined from the landscape, e.g. seashells, whalebone, or driftwood, the rate of emergence of the land from the postglacial sea can be calculated. One other method of determining the age of a shoreline is by dating how long a wave-washed bedrock surface has been exposed to cosmic rays, which come to Earth from space.

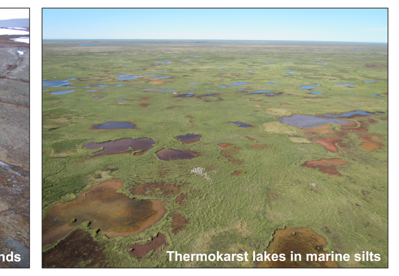
The map to the right shows the location and elevations of the limit of marine invasion. Notice that the highest shoreline elevations are not constant. This is to be expected because the seawater invaded areas at different times following the retreating glaciers and also because the land has been rebounding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

Implications and impacts

Exposed seafloor 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 away, 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.



Ice-wedge polygons in marine sands



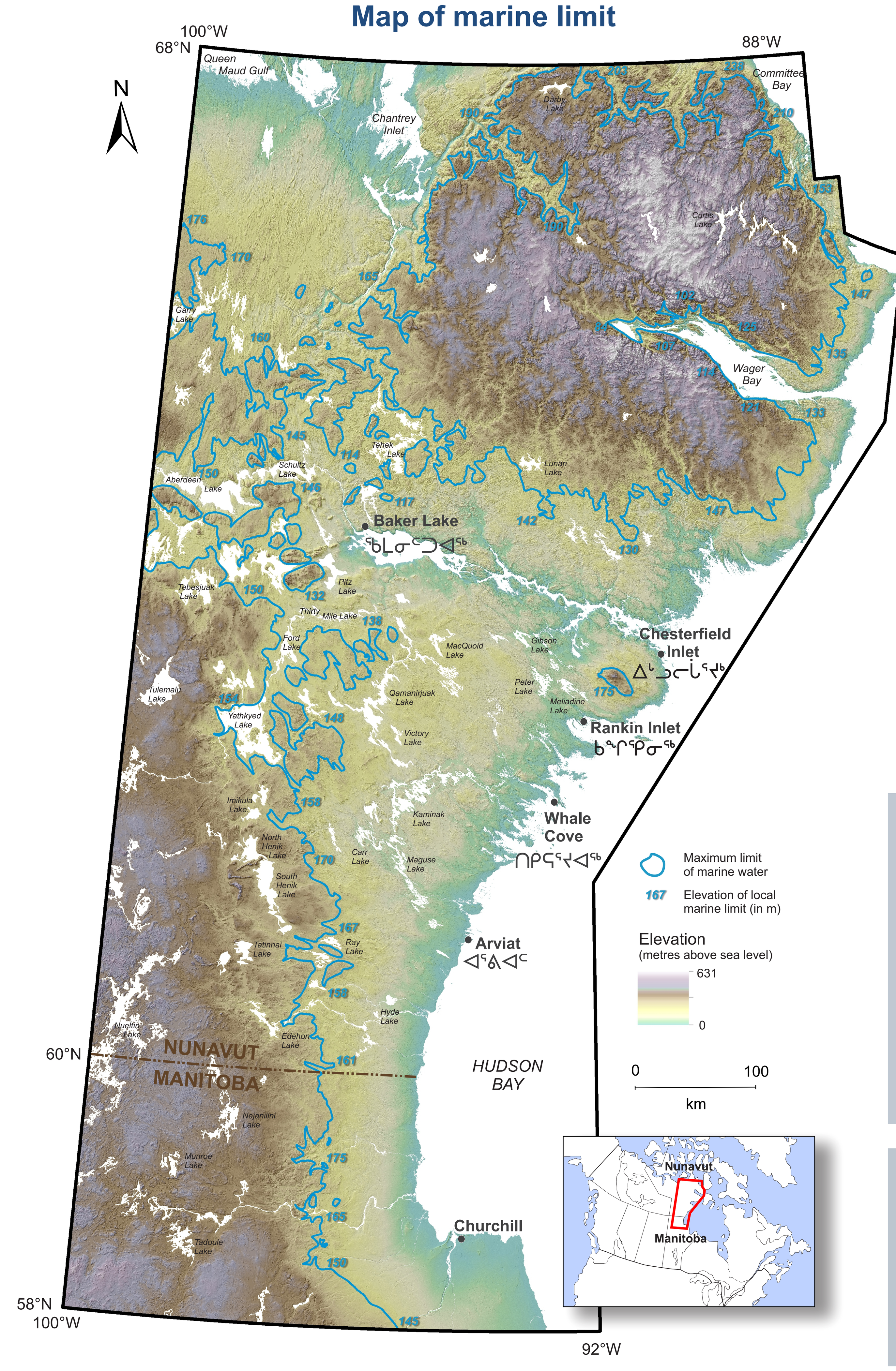
Thermokarst lakes in marine silts

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, both the chemistry of the surface sediments and the physical structure and size of sediment grains can affect the stability of the ground as a construction or foundation material.

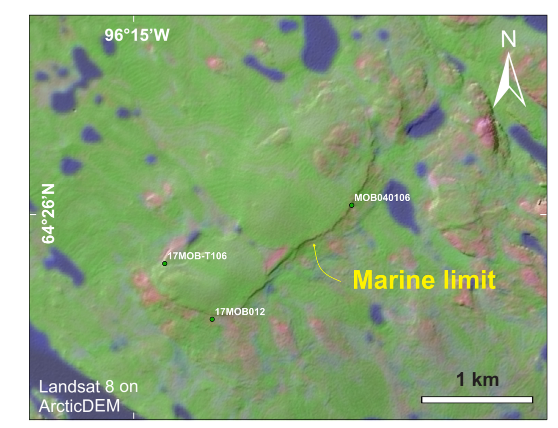
Glacial isostatic adjustment (GIA) is also a modern concern. Although today, the world sea level is rising due to climate change, the uplifting of the land caused by the GIA offsets the increase in sea level around Hudson Bay. The result is that relative sea level is falling and the water nearshore is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

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 into 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 dispersal trains left by glaciers were affected by reworking processes in sea waters or hidden by postglacial marine deposits.

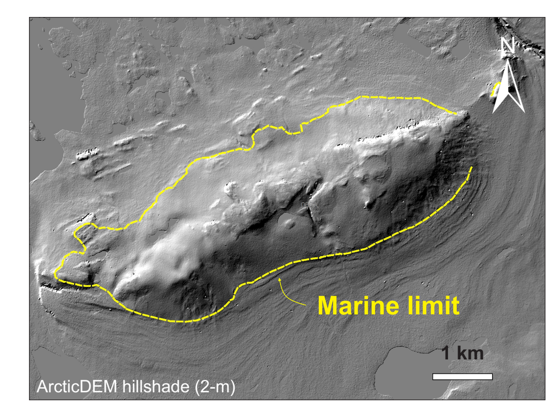
Map of marine limit



Marine limit on satellite imagery



Trimline at 118 m elevation west of Baker Lake. Thick glacial sediments are found above the marine limit; reworked sediments and bedrock outcrops occur below the limit of marine inundation.



Wave-cut notch in glacial sediments at 126 m elevation north of Pitz Lake. A series of raised marine shorelines are clearly observed below the marine limit.

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.

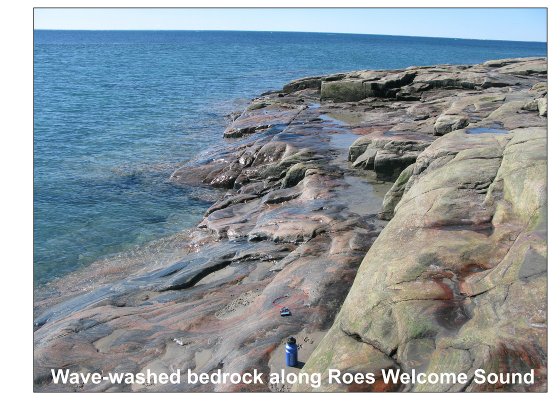
Want to know more?

Check out the original research at https://doi.org/10.4095/330940

McMartin, I., Gauthier, M.S., and Page, A.V., 2022. Updated postglacial marine limits along western Hudson Bay, central mainland Nunavut and northern Manitoba; Geological Survey of Canada, Open File 8921. https://doi.org/10.4095/330940

MODERN

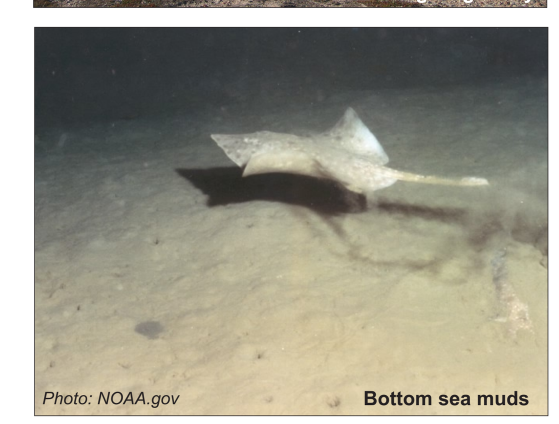
Wave-cut notch in bedrock



Wave-washed bedrock along Roes Welcome Sound

Pebbly beach along Aberdeen Lake

Tidal flats along Wager Bay

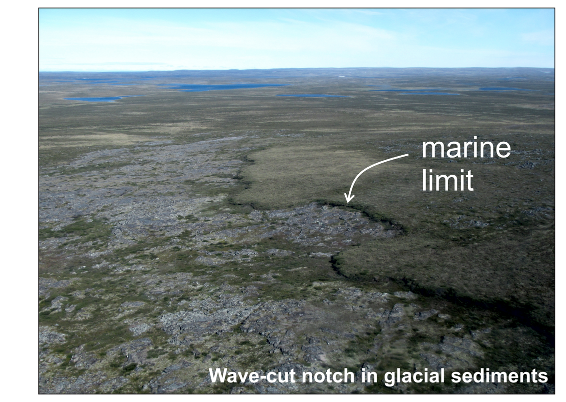


Bottom sea muds

Deltaic sands

Seashells

ANCIENT



Wave-cut notch in glacial sediments

Wave-washed bedrock

Series of raised beaches

Tidal sands and scattered boulders

Gullied marine muds

Exposed marine deltaic sands

Marine shells

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