Sedimentation in Canada Basin, Western Arctic

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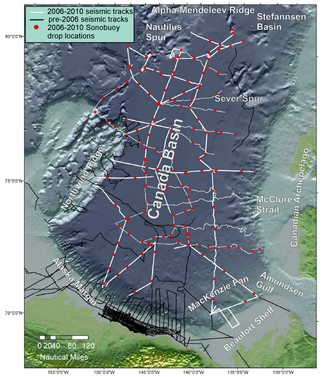
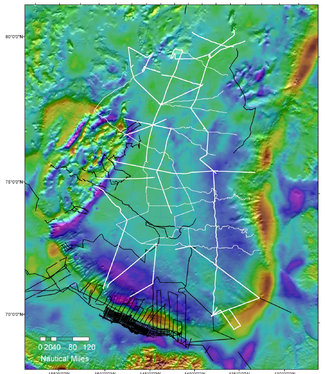
ABSTRACT

Canada Basin of the western Arctic Ocean is the least studied ocean basin in the World. Marine seismic field programs were conducted during the past 5 years in order to study the geology, sedimentary history and geomorphology of the region. As part of this program, five annual icebreaker expeditions acquired bathymetric, seismic reflection and seismic refraction data on a regional scale. More than 12,000 line-km of multi-channel seismic reflection data and 120 sonobuoy seismic refraction records over abyssal plain and continental rise regions of Canada Basin, Northwind Ridge and Alpha Ridge were acquired. The success of these programs was achieved through novel technical modifications to seismic equipment to permit towing in heavy ice conditions and through collaboration between multiple Canadian and US agencies and institutions, enabling utilization of two ice breakers during seismic and multibeam data acquisition in heavy ice.

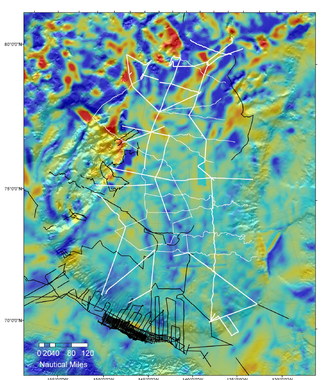
The seafloor of Canada Basin is remarkably flat-lying in its central region, with little bathymetric change over most of its extent. The sedimentary succession is generally flat lying with reflections extending over 100's of km. These reflections infill basement topography and onlap bathymetric highs, such as Alpha and Northwind ridges. The sedimentary succession is thickest in the Beaufort Sea region, reaching more than 10 km, and generally thins to the north and west. Reflection characteristics suggest that sediment volume input to the Arctic Ocean has been high and dominated by turbidity current deposition, similar to Amundsen and Nansen Basins of the Eurasian Basin. These turbidites originate from the eastern and southern continental margins. There is no evidence of contemporaneous or post-depositional reworking by bottom currents. Additionally, there is little evidence of tectonic deformation after primary basin-forming events except in the NE quadrant, nearer Alpha Ridge.



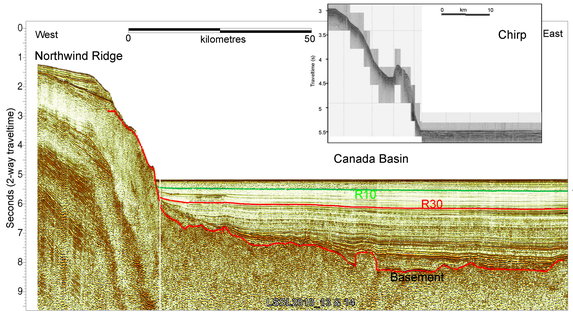
Bathymetry with seismic tracks



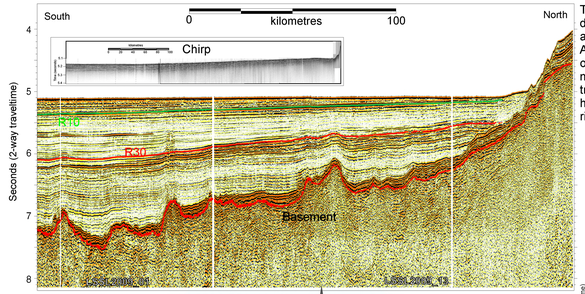
Free Air Gravity Anomaly



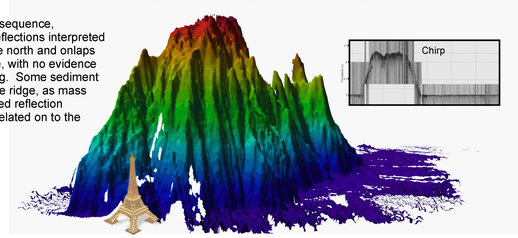
Magnetic Anomaly

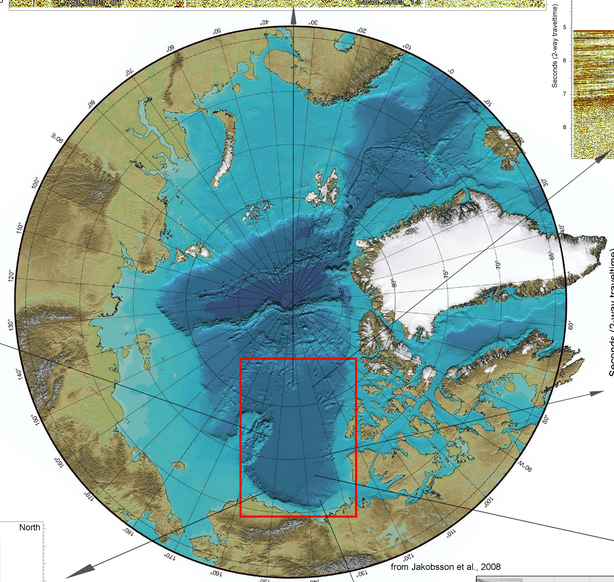


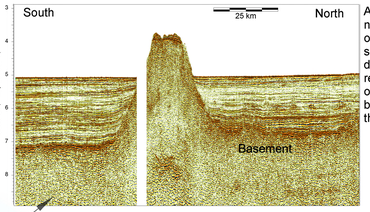
Flat-lying reflections of Canada Basin are interpreted as largely representing turbidites. They truncate against Northwind Ridge, initially with onlap but latest horizons terminate abruptly with no evidence of contour-flowing current reworking or mass transport from the ridge.



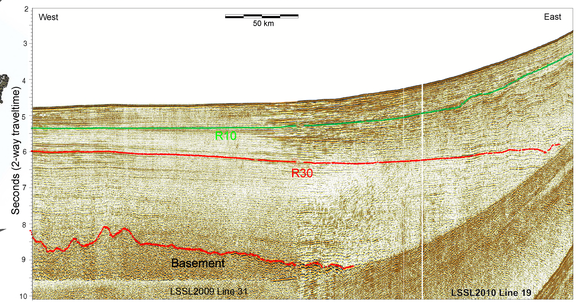
The entire sedimentary sequence, dominated by parallel reflections interpreted as turbidites, thins to the north and onlaps Alpha-Mendeleev Ridge, with no evidence of depositional reworking. Some sediment may be sourced from the ridge, as mass transport deposits. Picked reflection horizons cannot be correlated on to the ridge.



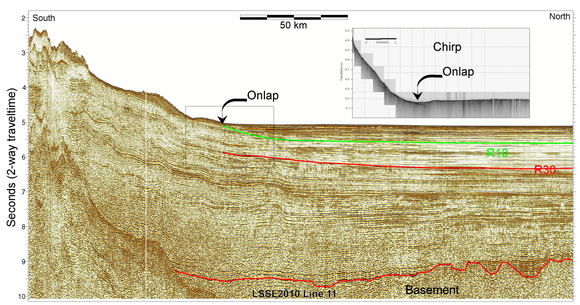




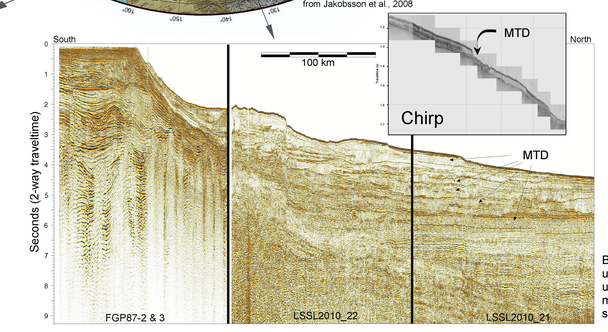
A seamount was discovered in the northern portion of Canada Basin. It is over 1000 m high above the surrounding seafloor, and is about 12 by 5 km in dimension. Note how the parallel reflections, characteristic of turbidites, onlap and truncate against the bathymetric high. No moat occurs around the seamount.



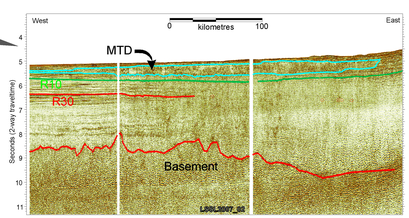
The Canadian Archepelago margin has the thickest and toughest ice conditions, making surveying in this region difficult. The R30 to R10 interval thickens substantially against this margin, suggesting sediment was sourced from this region during this period. Mass transport deposits are common and appear to evolve into turbidites downslope and throughout the basin .



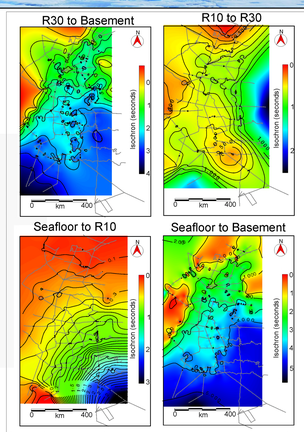
The Alaska Beaufort margin is characterized by a gullied/canyoned morphology. Basement to the R30 reflection event thickens slightly inboard, but the R30 to R10 interval thins slightly. The R10 to seafloor interval appears to onlap existing sediments in this region, thus is interpreted as MacKenzie River sediments sourced to the east and deposited as distal turbidites.



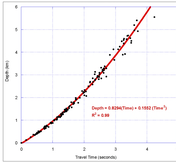
Beneath the Mackenzie-Beaufort shelf, reflections show a progradational sequence set underlain by folded and faulted reflections. The slope contains a sediment pile of unknown thickness (basement is not imaged) that is characterised by successive stacked mass transport deposits. These MTDs make it impossible to correlate the basin stratigraphy inboard.



Within Canada Basin, in the distal regions of the MacKenzie River fan, a giant mass transport deposit measuring at least 132,000 km^2 in area underlies much of the southern portion of the basin. The deposit is outlined by the light blue polygon above.

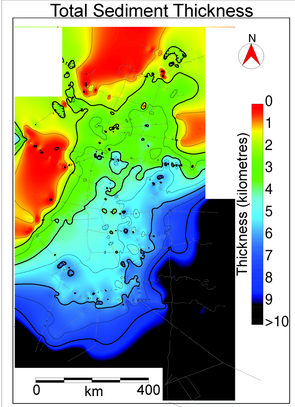


The sedimentary seismic sequence within Canada Basin was divided into four units based on correlation of the Basement, Seafloor and two regionally traceable reflection horizons, R10 and R30. Four isochron maps were generated as a result. The R30 to Basement interval shows infilling of basement topography and thinning from south to north. Anomalous patterns in the southern half correspond with the central basin gravity low and reflect a ridge-valley-ridge system. R10 to R30 shows thinning largely from east to west, with sediments sourced from the Canadian Archepelago. The seafloor to R10 interval shows thinning from SE to NW, sourcing from MacKenzie River and spreading rather symmetrically throughout Canada Basin.



Velocities derived from sonobuoy wide angle reflection and refraction results were used to convert seismic traveltimes to depth. Regression of these traveltime-depth pairs provides the equation to calculate depths of the correlated horizons and subsequent sediment thicknesses.

Total Sediment Thickness



The total sediment thickness shows that the sediment section thins from south to north (>10 km thick in the south). Sediments truncate relatively abruptly against bathymetric highs, such as Northwind Ridge, Nautilus Spur and Sever Spur, with little to no sediment on top of these features. Reflection patterns suggests mass transport processes along the margins supplied a significant amount of sediment to the basin. Mass failures evolved into unconfined turbidity current flows, resulting in thick accumulations of turbidites within the basin. There is no evidence of post-depositional reworking along the flanks of ridges and margins, suggesting little to no deep water current acitivity.

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