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SURFICIAL GEOLOGY OF THE AMERASIAN BASIN FROM SUBBOTTOM PROFILER DATA

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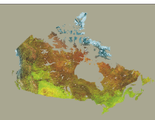


ACOUSTIC FACIES

Subbottom profiler data were characterized into acoustic facies according to the character of the bottom echo and subbottom reflections. Facies are grouped into categories that include those with chaotic/irregular bottom echo, smooth bottom echo with acoustically transparent subbottom, and coherent parallel subbottom reflections.

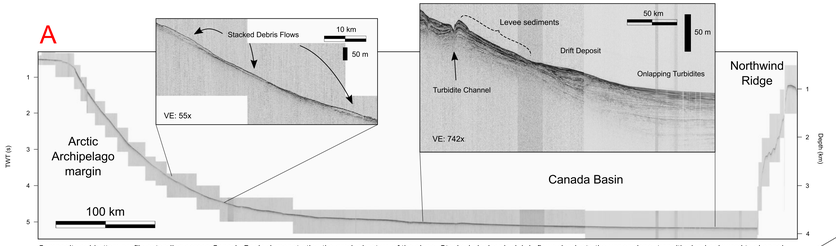
Category	Facies Name	Example	Description	Generalized Geologic Interpretation
Chaotic/Irregular Seafloor	1a		Chaotic bottom echo with amorphous or transparent sub-bottom reflections.	**Shelf**: Ice-scoured/turbated sediment or till **Shelf break**: Slump/mass transport deposit (MTD) **Slope/Abyssal Plain**: MTD
	2a		Scoured bottom echo with amorphous or transparent subbottom and semi-parallel incoherent reflections.	**Shelf/Shelf Break**: Ice-scoured sediment with turbated upper layer.
	2b		Semi-parallel coherent reflections interrupted by troughs at the seafloor surface.	**Shelf/Shelf Break**: Ice-scoured bedded sediments with minimal or no turbation.
	3a		High amplitude, irregular bottom echo with amorphous subbottom reflections.	**Shelf**: Eroded surface or till **Slope**: Eroded surface, exposed bedrock, MTD or channel thalweg **Abyssal Plain**: Exposed bedrock (seamount), channel thalweg
	3b		Varying amplitude, broad or one-sided hyperbolic bottom echo with no subbottom reflections. Occur on steep bathymetric gradients. Hyperbolae 1-2 km in width.	Fault/mass failure scarp or basement structure
	4a		Overlapping narrow hyperbolic reflections with absent or amorphous subbottom reflections occurring on flat or gently sloping seafloor. Hyperbolae 0.1-1.0 km in width.	**Shelf/Shelf Break**: Ice-scoured sediment or slump **Slope**: Slump/MTD **Abyssal Plain**: MTD
Smooth Seafloor/ Transparent	5a		Smooth bottom echo with incoherent transparent lens-shaped deposit(s).	**Shelf**: Diamict (often till from glacier retreat phase), or MTD **Slope**: Debris flow, MTD
	6a		High amplitude, smooth bottom echo with acoustically transparent subbottom.	**Shelf**: Undisturbed deglacial and post-glacial deposits **Slope**: Channel lag deposits part of MTD
Coherent subbottom reflections = Bedded/Laminated	7a		Smooth undulating, coherent parallel to subparallel reflections. Reflections pinch out, diverge, or vary in amplitude laterally.	**Shelf Break**: Current-influenced glaciomarine and post-glacial deposits **Slope**: Mixed turbidites/hemipelagites, fan **Abyssal Plain**: Undulating turbidites or contourites
	7b		Smooth, wavy coherent parallel to subparallel reflections with sediment waves. Sediment waves defined by dipping planes of pinching reflections.	**Slope**: Fan sediments, levee sediments related to deep-sea channels
	7c		Smooth bottom echo with coherent parallel reflections that experience blanking at depth.	**Shelf/Shelf Break**: Permafrost sediments, glacio-marine sediments with buried syn-sedimentary ice scours, or gas if complete blanking.
	7d		High amplitude smooth bottom echo truncating coherent, semi-parallel subbottom reflections. May experience blanking at depth.	**Shelf**: Eroded glaciomarine/periglacial or Holocene sediments. Blanking due to gas, buried margin wedges, buried ice scours
	7e		Rugose bottom echo with semi-coherent contorted parallel/sub-parallel and amorphous subbottom reflections.	**Slope**: Deformed sediments, MTD, or fan deposits with small-scale sediment waves.
	7f		Chaotic bottom echo truncating, coherent semi-parallel reflections.	**Shelf**: Eroded preglacial / glaciomarine sediments
	8a		Smooth bottom echo with coherent parallel to sub-parallel reflections that mimic bathymetry. Subbottom reflections maintain a consistent amplitude laterally.	**Shelf**: Laminated glaciomarine / Holocene hemipelagic drape deposits **Slope**: Hemipelagic drape, mixed fan sediments
	9a		Smooth, flat-lying, coherent parallel reflections. Reflections typically onlap neighboring facies or structural highs. Reflections may thicken towards depocenter.	**Abyssal Plain**: Flat-lying turbidites and interbedded hemipelagites

Compound facies were used to characterize data with a stratigraphic relationship between two or more principal facies. This nomenclature emphasizes the surficial unit while retaining stratigraphic information contained in the profile. These groups are particularly useful in describing locations where debris flows are interbedded with stratified sediments, or in shelf areas with complex ice margin histories.

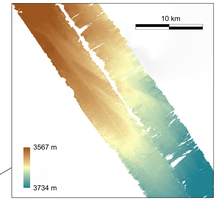
Compound Facies	Facies Name	Example	Description	Generalized Geologic Interpretation
	1a over 6a		Chaotic bottom echo with amorphous/transparent subbottom reflections overlying high amplitude smooth echo with amorphous/transparent subbottom.	**Shelf**: Ice-scoured sediment, till and/or glacimarine iceberg turbate
	1a over 1a		Chaotic bottom echo with amorphous/transparent subbottom reflections overlying chaotic subbottom reflections.	**Shelf**: Stacked ice-scoured/till deposits/till tongues
	1a truncating 8a		Chaotic bottom echo with amorphous subbottom reflections overlying chaotic subbottom reflections.	**Shelf**: Ice-scoured sediment/diamict unconformably overlying older stratified sediments
	5a over 8a		Smooth bottom echo with incoherent transparent wedge deposits overlying coherent parallel/sub-parallel subbottom reflections.	Debris flow/MTD/diamict over stratified sediment (e.g. hemipelagic/turbidites/glacimarine)
	6a over 1a		Smooth bottom echo with amorphous subbottom overlying chaotic subbottom reflection(s).	**Shelf**: Undisturbed post/de-glacial sediments over chaotic surface
	8a interbedded with 5a		Smooth bottom echo with draping coherent subbottom reflections interbedded with transparent wedge shaped deposits.	**Slope**: Hemipelagic drape interbedded with MTDs/debris flows

INTRODUCTION

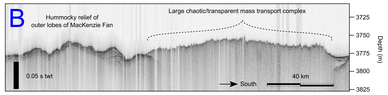
International research efforts of the past decade have led to a multi-fold increase in the quantity of marine geophysical and geological data holdings in the high Arctic. There is now sufficient subbottom profiler, multibeam and seafloor sample data in many regions to map the surficial geology and provide it as a layer to compliment the International Bathymetric Chart of the Arctic Ocean (Jakobsson et al. 2012). Such additional information provides a resource for collective analysis of the morphology and geology of the Arctic seafloor, and has a variety of applications including environmental assessment, habitat mapping, geohazard identification and oceanographic and geologic process studies. Acoustic facies derived from subbottom profiler data form the foundation of this surficial geology map. More than 140,000 km of subbottom profiler data are now interpreted and mapped in the Amerasian Basin. Additionally, gridded single beam and multibeam echosounder data help define geologic boundaries. Mapped acoustic facies reveal the distribution of sediment types and associated processes in the region, such as extensively ice-scoured shelves; debris flows and fan deposits along continental margins; and drifts, bedforms, and deep-sea channel systems in the Canada abyssal plain. Here we present the acoustic facies used for classification and the current extent of mapped surficial units in the Amerasian Basin.

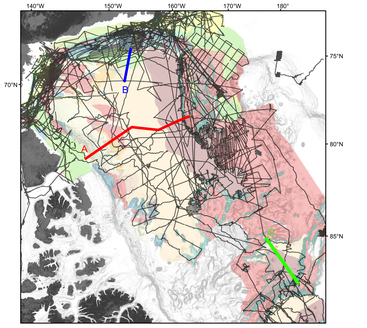


Composite subbottom profile extending across Canada Basin demonstrating the gradual nature of the slope. Stacked glacigenic debris flows dominate the upper slope, transitioning basinward to channel-levee turbidite systems, contourite drift deposits, and flat/featureless abyssal plain sediments that abut Northwind Ridge. Profile location shown in trackplot (right). All depths plotted assume a uniform water velocity of 1500 m/s.

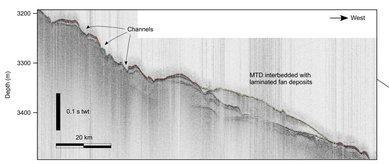


Multibeam bathymetry showing distribution channel forms and fan lobes of the outer MacKenzie Fan (data from Flinders et al., 2014).

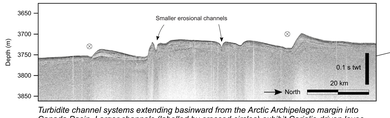




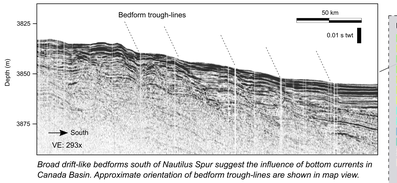
Trackplot showing the locations of subbottom profiler data used to map acoustic facies. Position of profiles "A", "B" and "C" shown in colour.



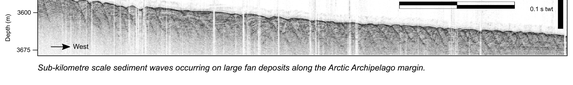
Mixed assemblages of laminated fan deposits and associated slope channels interbedded with debris flows, demonstrated by transparent lenses.



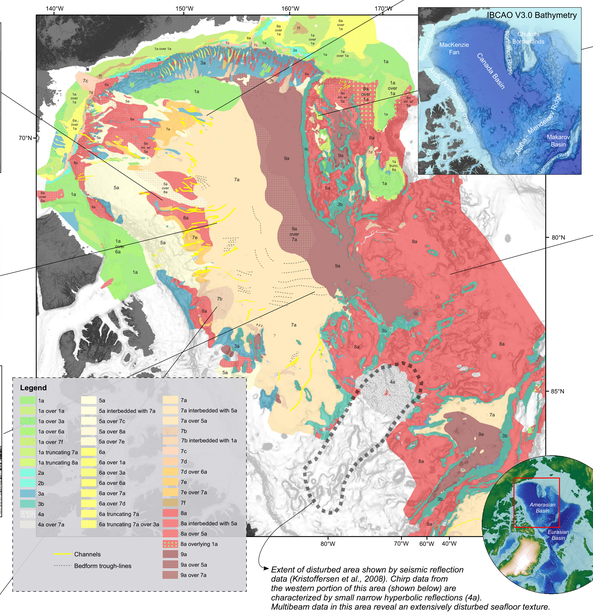
Turbidite channel systems extending basinward from the Arctic Archipelago margin into Canada Basin. Larger channels (labelled by crossed circles) exhibit Coriolis-driven levee asymmetries. Profile is oriented looking down-slope.



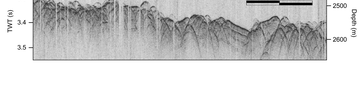
Broad drift-like bedforms south of Nautilus Spur suggest the influence of bottom currents in Canada Basin. Approximate orientation of bedform trough-lines are shown in map view.



Sub-kilometre scale sediment waves occurring on large fan deposits along the Arctic Archipelago margin.



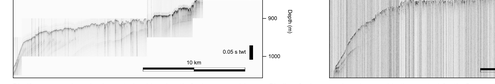
Extent of disturbed area shown by seismic reflection data (Kristoffersen et al., 2008). Chirp data from the western portion of this area (shown below) are characterized by small narrow hyperbolic reflections (4a). Multibeam data in this area reveal an extensively disturbed seafloor texture.



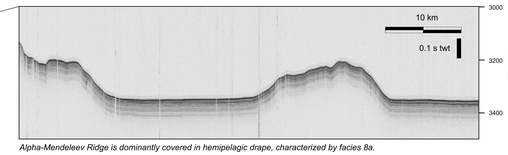
RESULTS

The map presented here reveals the distribution of acoustic facies in the Amerasian Basin. This map facilitates several regional observations concerning the surficial geology and sedimentary processes in the basin. These include:

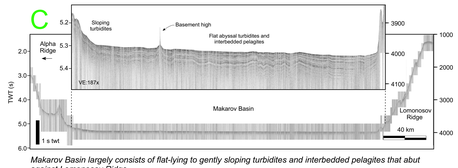
- An overall basin-ward transition in Canada Basin from mixed mass transport and glaciomarine processes near the shelf break, to turbidite and contourite dominated sedimentation towards the Canada abyssal plain. This transition largely corroborates modelled surficial sediment velocities derived from seismic refraction records (Shimeld et al., 2016) which predict a general fining of sediments towards the northwest of the basin.
- Shelf areas are extensively scoured by ice and are largely characterized by chaotic acoustic facies assemblages. Similar facies assemblages occur at various locations shallower than ~1000 m in the central Arctic Ocean (e.g. Chukchi Borderlands and Lomonosov Ridge) where they are likely to be the result of grounding of a regional ice shelf (e.g. Jakobsson et al., 2016). Distributions of acoustic facies can be used to inform the mapping of grounding depths for paleo-ice sheets in the region.
- Mass transport deposits (e.g. GDFs) and channels suggest gravity flow processes dominate the continental slope of the Canadian Arctic Archipelago margin.
- Bedforms and drift deposits in central Canada Basin suggest reworking by bottom currents.
- Makarov Basin is largely characterized by flat-lying turbidites and interbedded pelagites.
- Alpha-Mendeleev Ridge is dominantly draped in hemipelagic sediments, with an extensively disturbed central portion characterized by narrow, overlapping hyperbolic seafloor reflections.



Shelf areas are largely characterized by chaotic facies assemblages. Similar facies are also observed in the central Arctic Ocean, including portions of the Chukchi Borderlands and Lomonosov Ridge.



Alpha-Mendeleev Ridge is dominantly covered in hemipelagic drape, characterized by facies 8a.



Makarov Basin largely consists of flat-lying to gently sloping turbidites and interbedded pelagites that abut against Lomonosov Ridge.

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