GEOLOGICAL SURVEY OF CANADA
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Preliminary notes on the marine geology off southwest Newfoundland, based on a merged multibeam/LiDAR data set

J. Shaw

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SUMMARY

1) For purposes of description the area is divided into three areas (1-3). In the absence of seismics, grab samples, and photographs, estimates of sediment type and thickness are based on bathymetric cross-sections and backscatter. Backscatter data were extracted but there are levelling differences between backscatter collected by CCGS *Matthew* and that collected by launches.

2) The coastline consists of coastal bluffs composed of glacial sediments, resting on bedrock that is generally exposed at or above sea level.

3) Generally speaking the inner shelf is wave-dominated area in which bedrock is exposed at the sea floor adjacent to the coast. Two main types of bedrock occur: 1) Carboniferous sedimentary bedrock in the north, recognized by numerous parallel ridges 1-2 m high; and 2) older, more-resistant bedrock with complex patterns of joints in the south. These two types are separated by the offshore extension of a major structural lineation, the Cabot Fault. This runs southwest from the vicinity of Little Codroy.

4) Several large sand sheets are present on the inner shelf, usually above a depth of 50 m. These sand bodies are mostly thin (2-3 m at most) and, with two exceptions, do not reach the modern coast, are not linked with modern sediment sources, and can be considered relict.

5) In the north of the mapped area, crescentic bars on the barrier beach at Little Codroy (vicinity of site 7) connect with offshore sand bodies. The bars are mobile during storm conditions. In the extreme south (near site 1) the large nearshore bar immediately offshore from a large barrier beach connects with a sand sheet that runs many kilometres offshore. This bar also is mobile in response to changing wave conditions.

6) Farther offshore from the sand/bedrock zone the topography is muted, and bedrock disappears below a cover of Quaternary sediment, probably till. This is characterised by high backscatter. Till in the extreme northwest of Area 1 is marked by relict iceberg furrows.

7) Areas of low backscatter between the inner shelf bedrock/sand zone and the outer glacial sediment zone probably comprise postglacial sandy mud of unknown thickness.

8) A dominant feature in the survey area is a previously unrecognized submarine canyon, hereby informally named the Cape Ray Submarine Canyon. It comprises a headwall area, and a series of shallow (~5 m) channels that continue into deeper water. This feature adjoins one of the large sand sheets. The sand sheet shows signs of sediment starvation where it adjoins the canyon. Based on published information on canyons on the outer continental shelves, it is suspected that this canyon was created by resuspension of sediment near the shelf edge by oceanographic processes. There is no information on modern activity in this canyon. The hazard potential of canyons on the outer continental shelves with respect to submarine pipelines has been discussed by Campbell and MacDonald (2006).

INTRODUCTION

Multibeam sonar and LIDAR surveys were conducted offshore from the southwest coast of Newfoundland in early 2011. The multibeam surveys were conducted using CCGS *Matthew* and launches. This report is a brief summary of the surficial geology of this region. Backscatter information from multibeam surveys was extracted using in-house tools. The backscatter information was derived from two differing systems (CCGS *Matthew* and launches), and since these systems are not calibrated it contains some levelling errors.

No geophysical or ground-truthing data were available, so the report is very preliminary. In particular, estimates of sand thickness quoted need to be validated by ground-truthing. Examination of these new data has resulted in the discovery of a large submarine canyon whose existence was unsuspected. It has some parallels with canyons of the outer continental shelves, but also with small canyon-fan systems in nearby St. Georges Bay. The outer-self canyons have been discussed in terms of the hazard they might pose to pipelines by Campbell and Macdonald (2006).

SURFICIAL GEOLOGY OF AREA 1

This area is depicted on Figures 1-7. Figure 4 is a preliminary interpretation of surficial geology. In depths shallower than ~ 50 m, much of the area is sedimentary bedrock, with well developed ridges that have relief of 1-2 m. Several large sand bodies extend offshore. In the absence of geophysical data, their thickness is estimated at 1-2 m. The sand is probably mobilized by wave action. The depth of mobility is uncertain, but large sandy bedforms that could be resolved by the multibeam system are absent, suggesting mobility to perhaps 0.5 – 1.0 m. Close to the coast the offshore sand bodies connect with systems of nearshore bars 1-2 m thick (Figure 5). The bars have a crescentic form. They probably change position in response to changing wave conditions. The seafloor between the bars and the shore is probably coarser material, perhaps gravel.

Farther offshore, in depths >~50 m, the sand sheets are absent and the bedrock disappears below a cover of Quaternary unconsolidated sediment, probably till (see Fig. 4). These sediments have high backscatter, indicating gravel at the sea floor. In the extreme northwest these sediments are marked by relict iceberg furrows. A large area of smooth sea floor in deep water has low backscatter (Fig. 3) and is interpreted as postglacial sandy mud that overlies the glacial deposits (see Fig. 4).

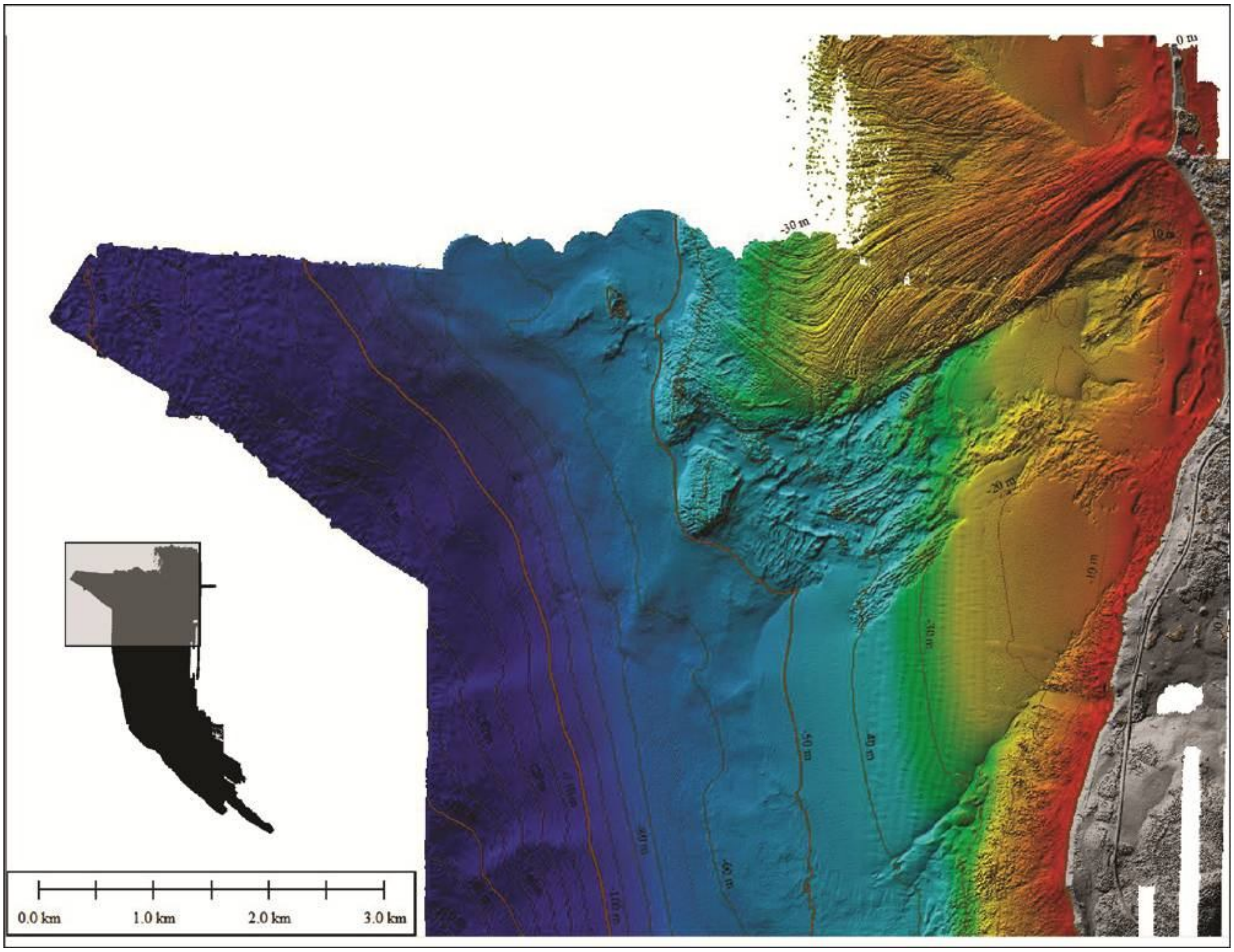

Figure 1: Coloured shaded relief map of Area 1, with isobaths.

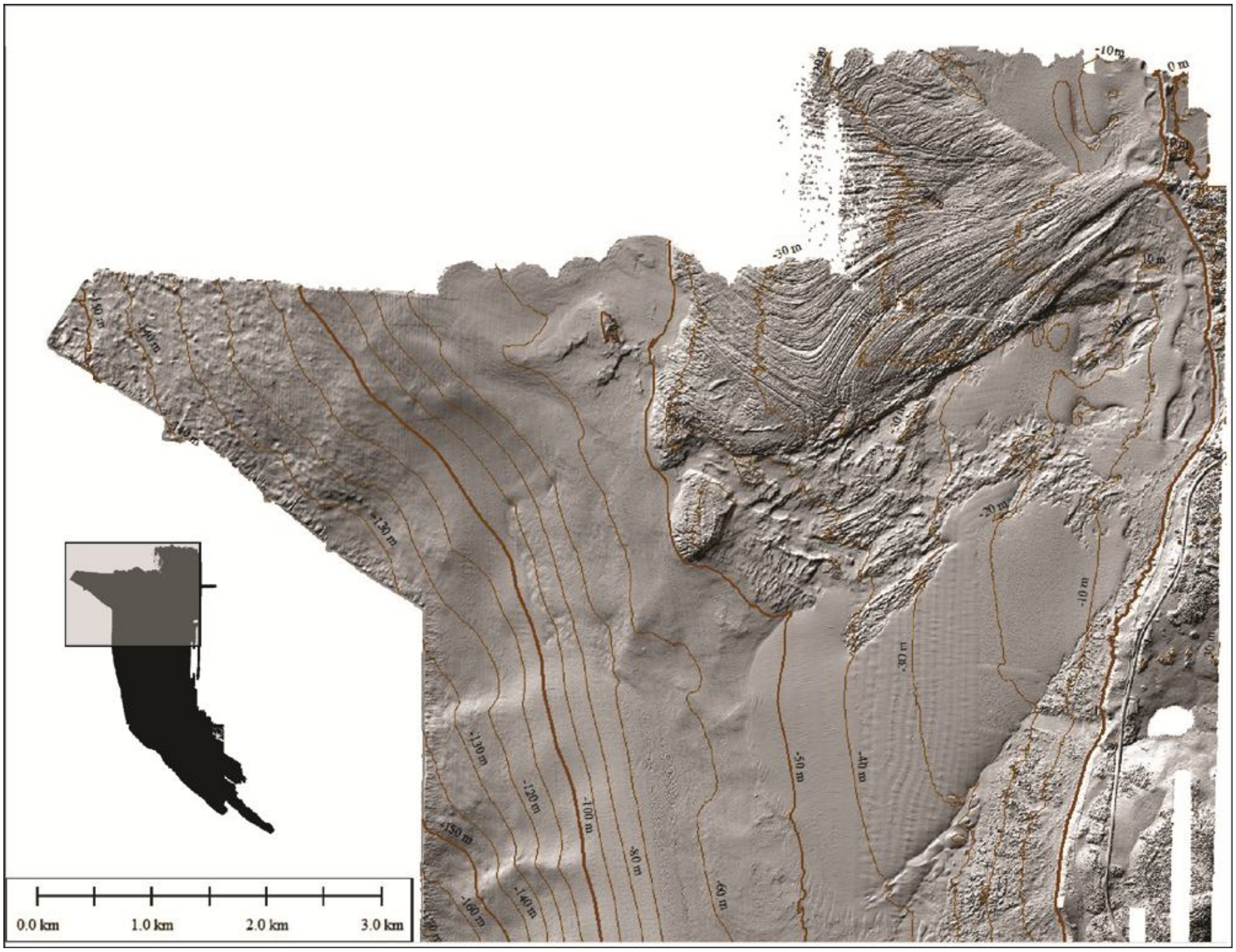

Figure 2: Gray scale shaded relief map of Area 1, with isobaths.

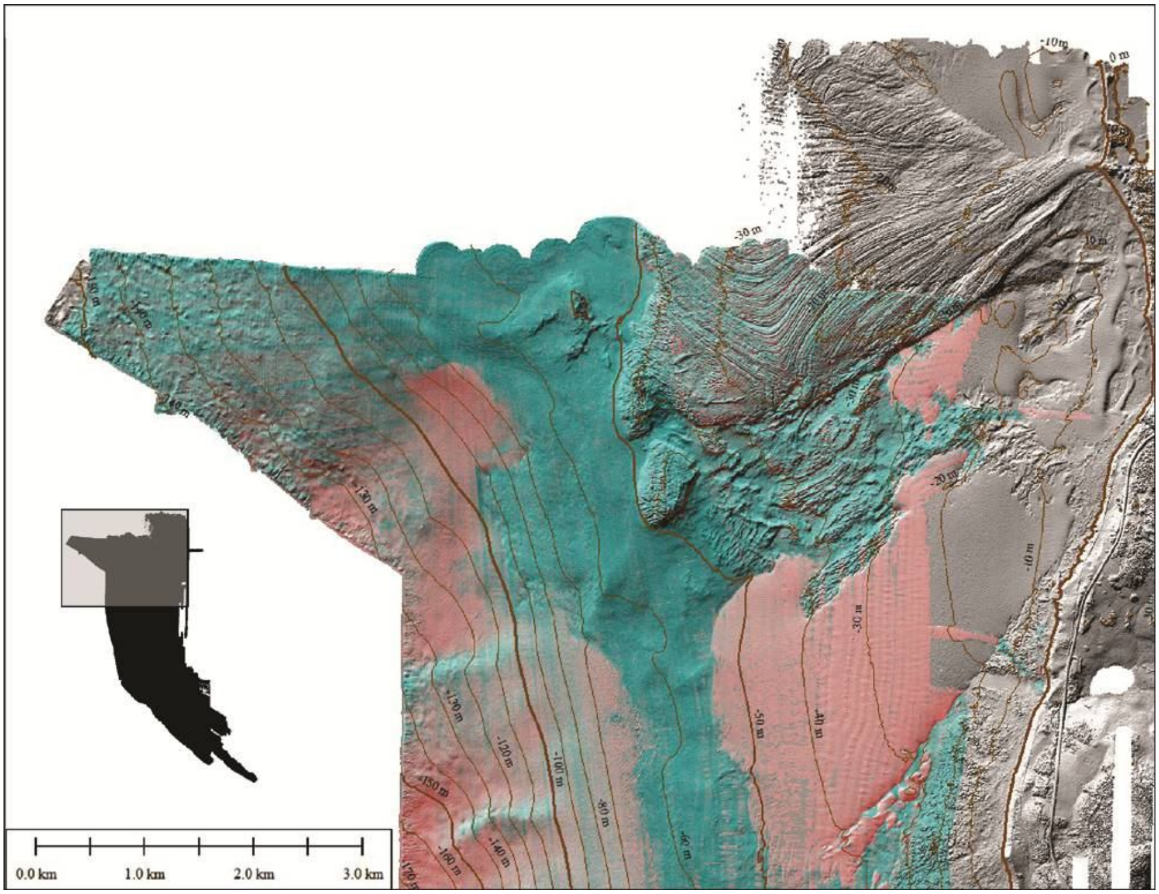

Figure 3: Area 1, backscatter draped over relief. Pink areas have low backscatter (typically sand or muddy sand) while gray-green areas have high backscatter (bedrock or glacial deposits with gravel at the sea floor). Backscatter was extracted only from multibeam data, and are not available for areas mapped with LIDAR.

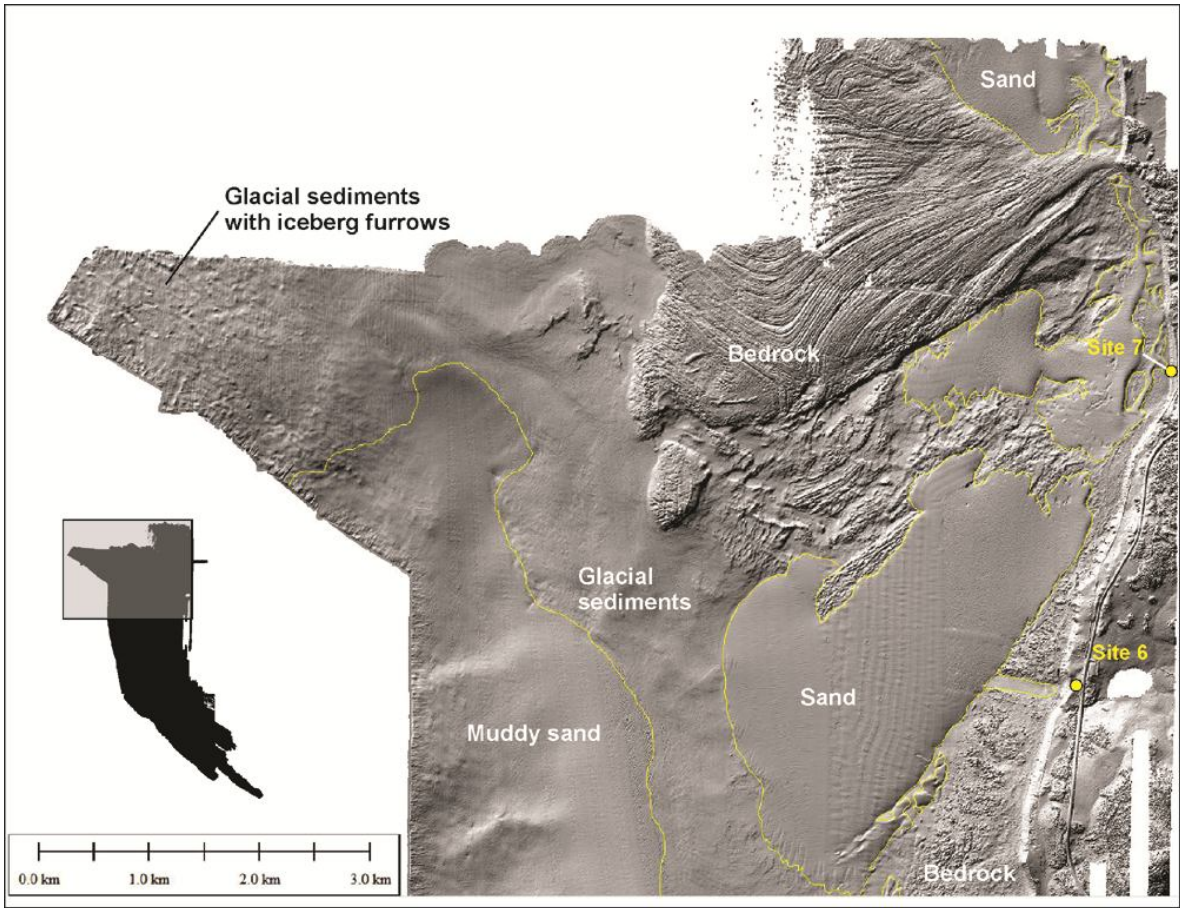

Figure 4: a provisional interpretation of the surficial geology of Area 1.

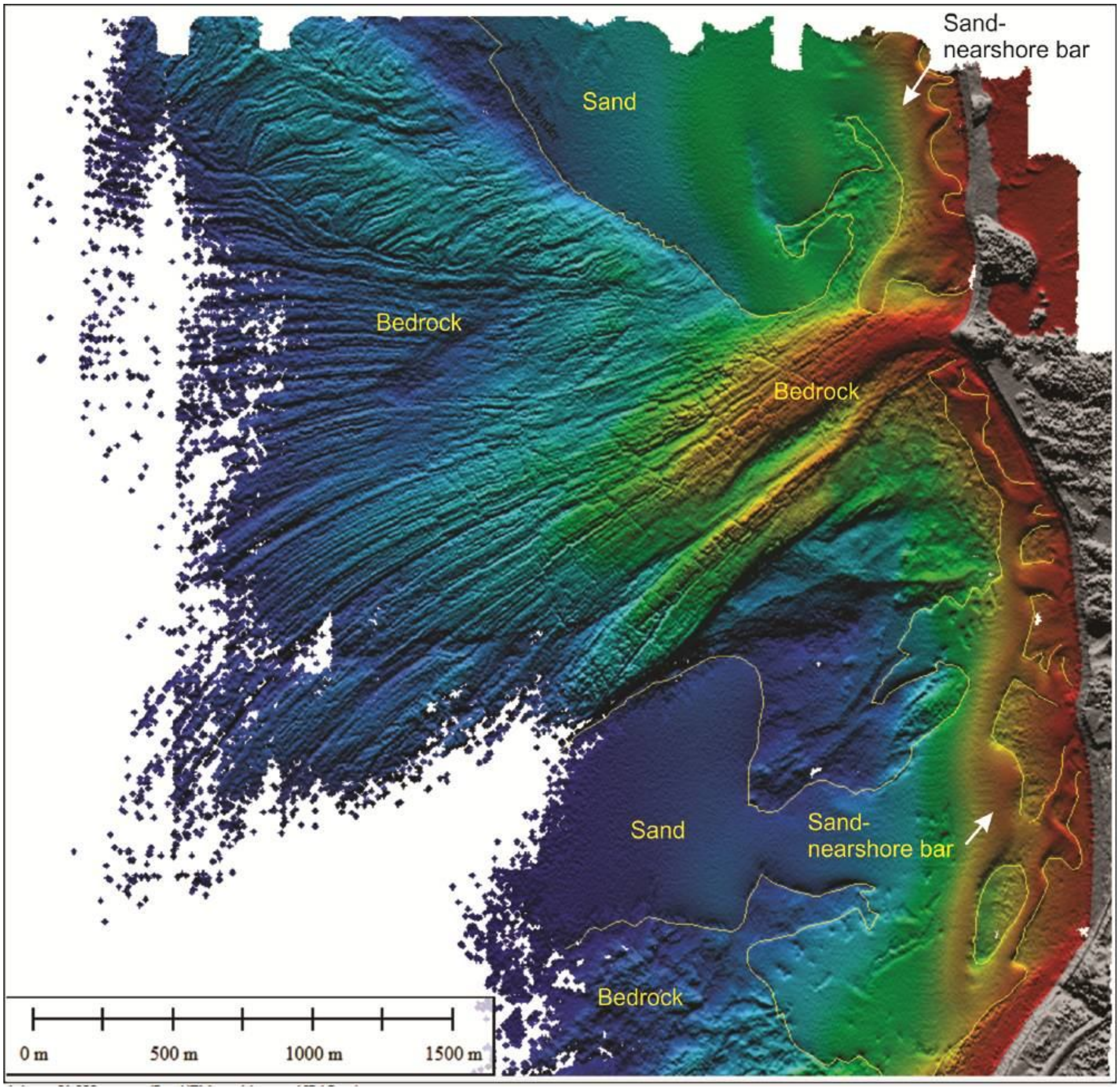

Figure 5: enlarged view of the northernmost area, close to the coast, showing the nearshore bar systems. Site # 7 is located in this area.

Half way down the coast a valley extends to the coast, crossing the bedrock zone (Figs. 6 & 7). This valley may have been formed by glacial meltwater, and almost certainly was occupied by a stream in the early Holocene (c. 9000 yrs ago), when sea level stood about 30 m lower than now. The smooth floor of the valley is probably underlain by unconsolidated sediments, perhaps glacial and or fluvial gravels and sands. The bedrock base of the valley may lie a further 5 m below these sediments. The valley vanishes beneath the large offshore sand sheet (point A on Figure 7). It may therefore continue some distance offshore, underneath the sand sheet.

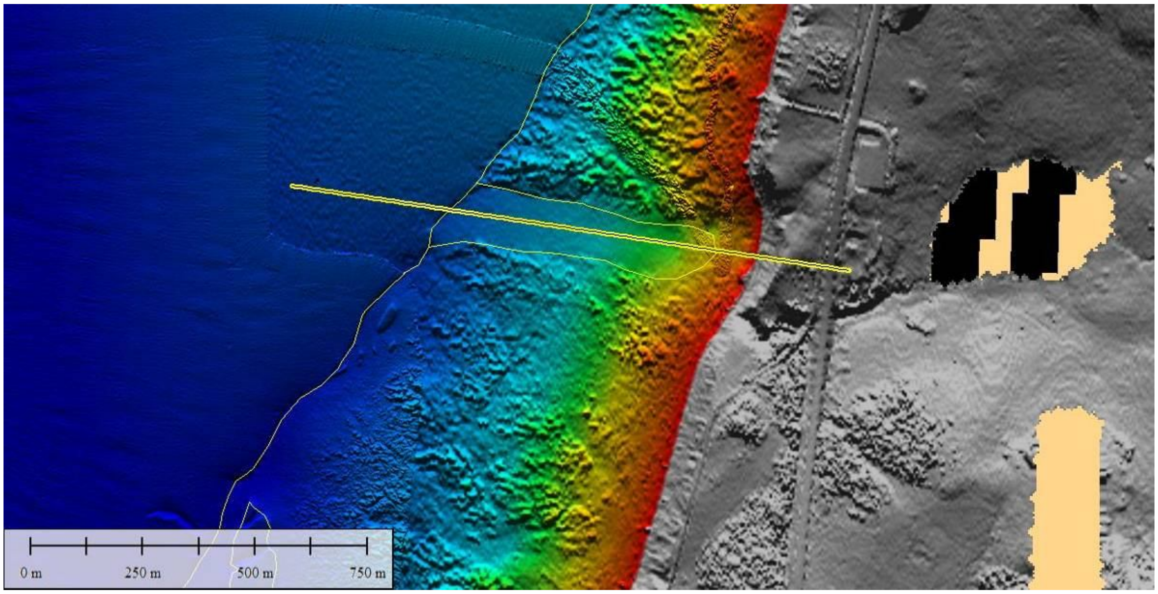

Figure 6: Valley crossing the bedrock zone, with location of profile. This is the vicinity of site 6.

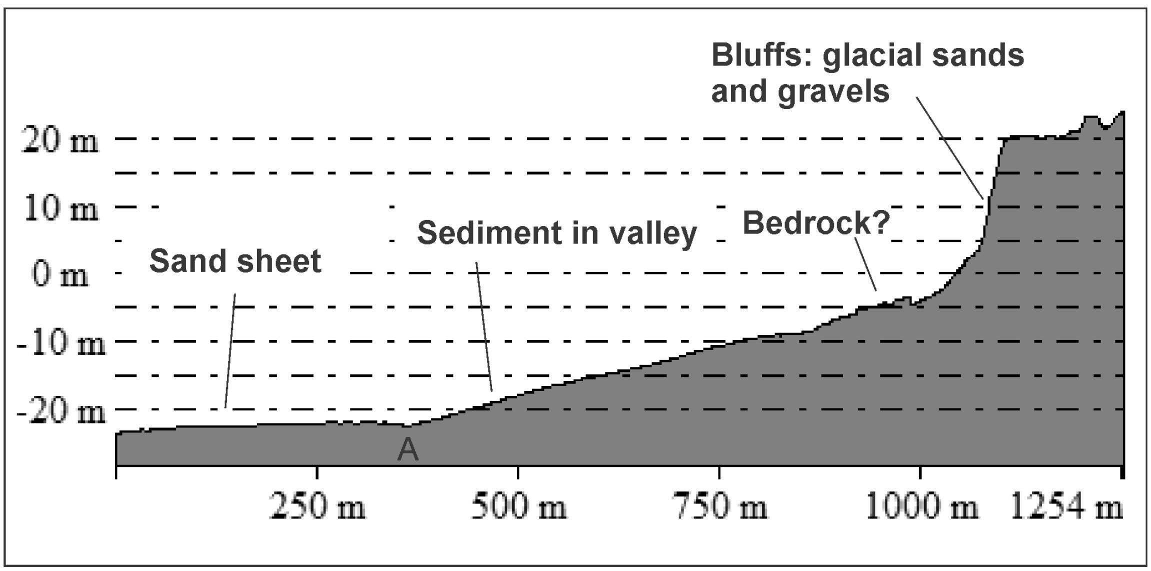

Figure 7: Profile up the valley. The edge of the offshore sand sheet can be seen as a sharp break in slope (A).

SURFICIAL GEOLOGY OF AREA 2.

In this area bedrock extends offshore for distances of 2-3 km, except where a large bedrock ridge extends much farther. In the southern half of this area, however, a large offshore sand body approaches to within 100 m of the coast at site 4 (Fig. 11). This sand sheet is estimated to be generally 2 m thick. About 1 km offshore it thins, and forms a series of 'fingers' of sand separated by a gravel sea floor. This area of uneven topography extends into deeper water, and connects with a submarine canyon, hereby informally called the Cape Ray Submarine Canyon. This feature is discussed in more detail below.

Farther offshore the smooth seafloor indicates either glacial sediment (high backscatter) or postglacial sandy mud/muddy sand (low backscatter) (Figs. 10 & 11).

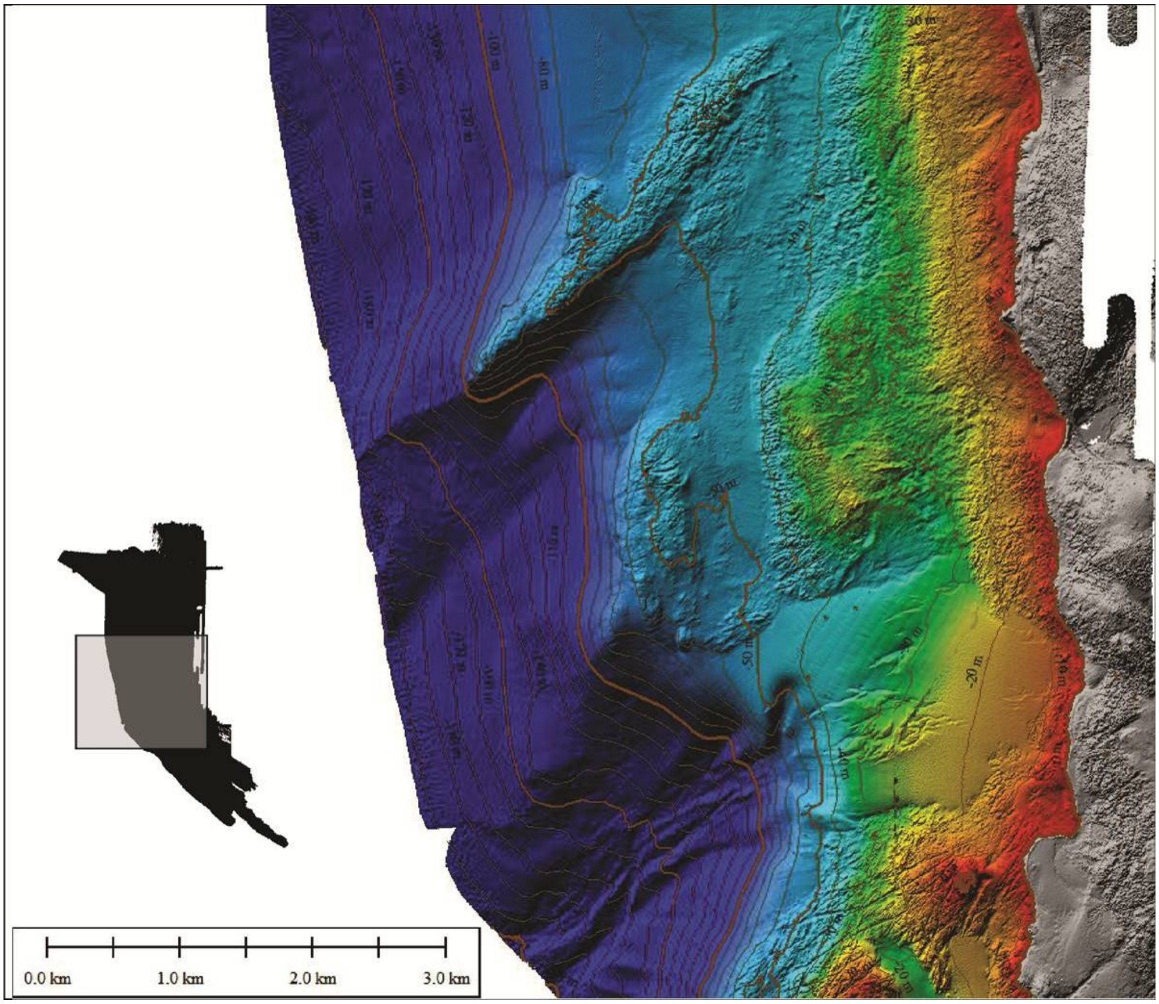

Figure 8: Coloured shaded relief map of Area 2, with isobaths.

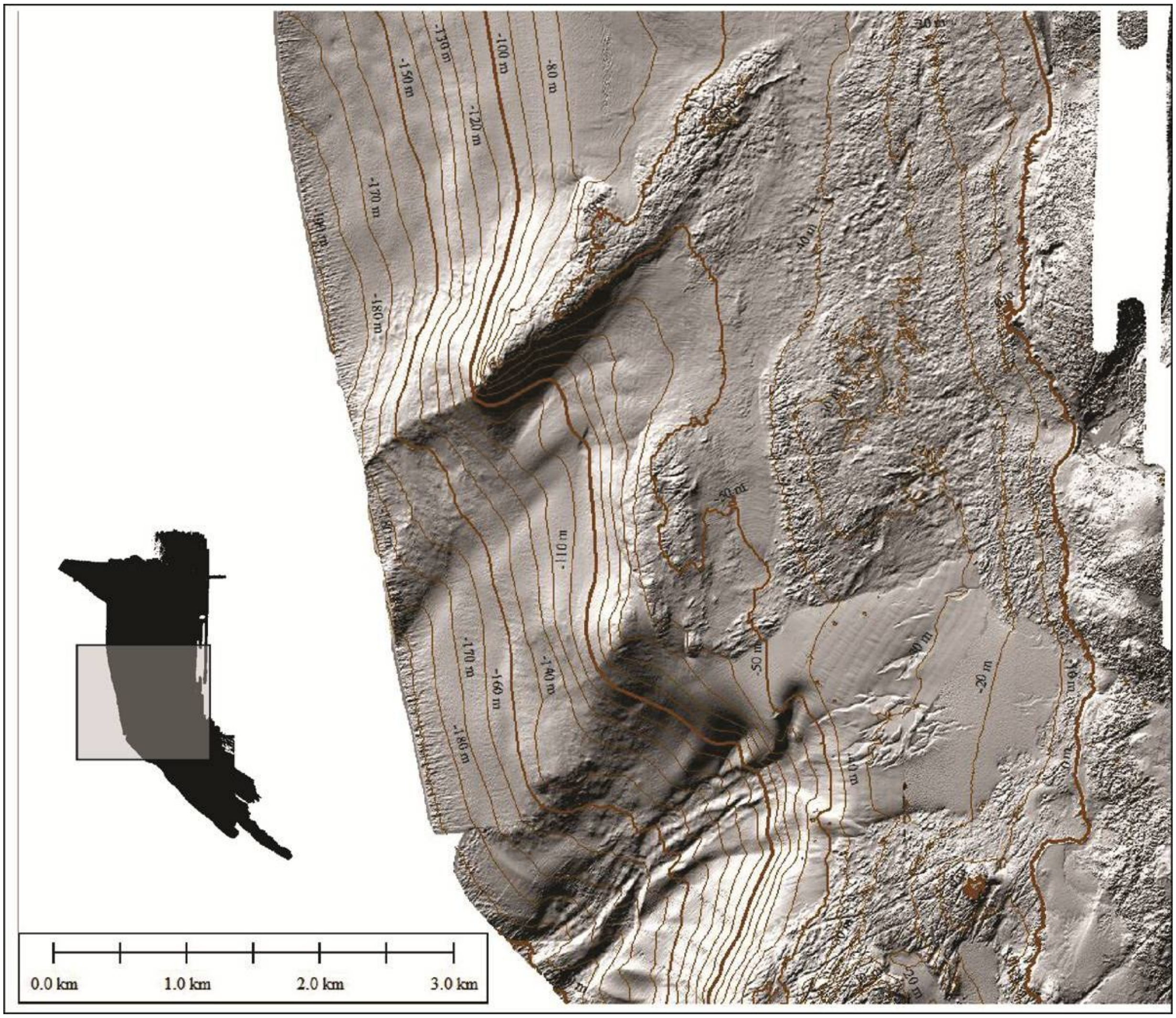

Figure 9: Gray scale shaded relief map of Area 2, with isobaths.

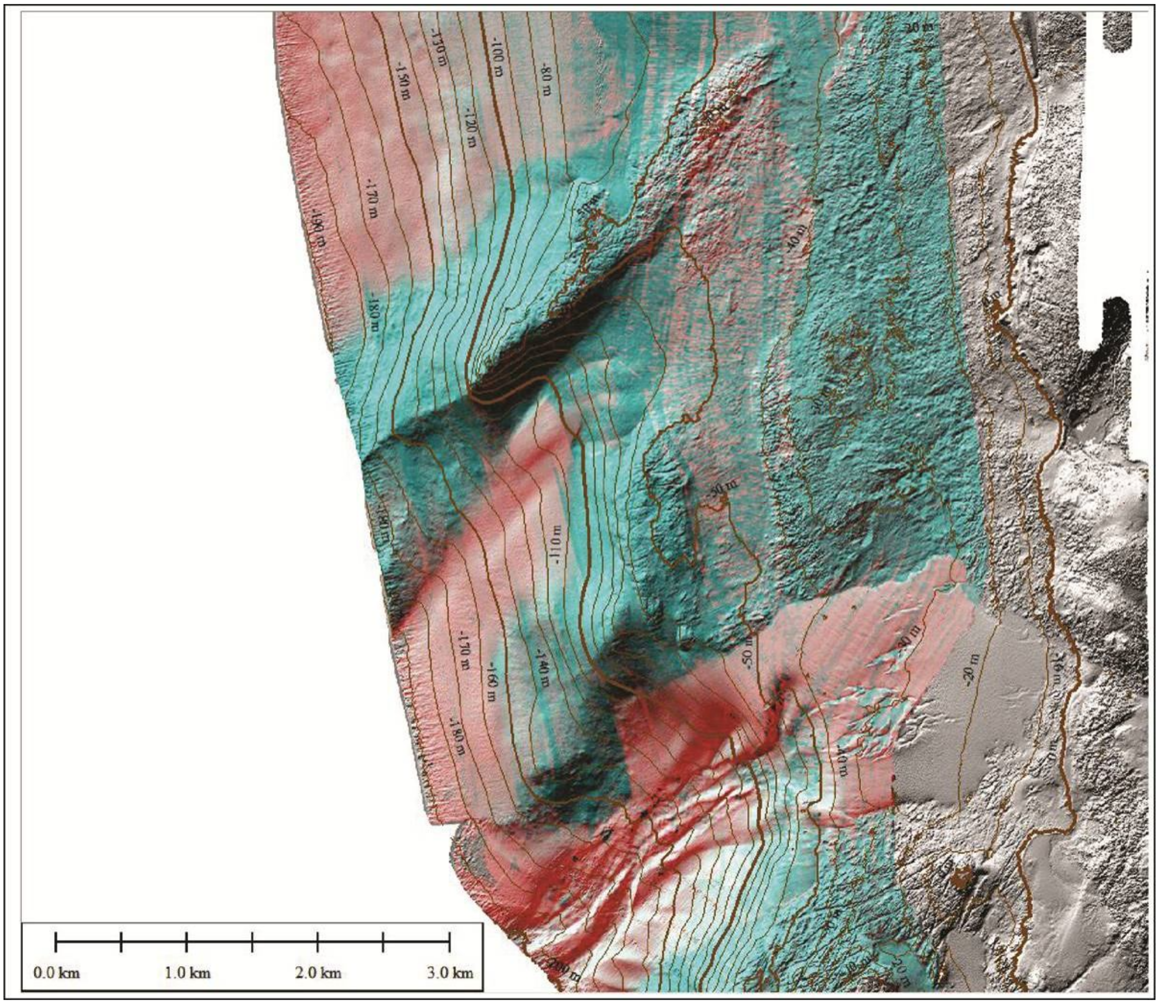

Figure 10: Area 2, backscatter draped over relief. Pink areas have low backscatter (typically sand or muddy sand) while gray-green areas have high backscatter (bedrock or glacial deposits with gravel at the sea floor). Backscatter was extracted only from multibeam data, and are not available for areas mapped with LIDAR.

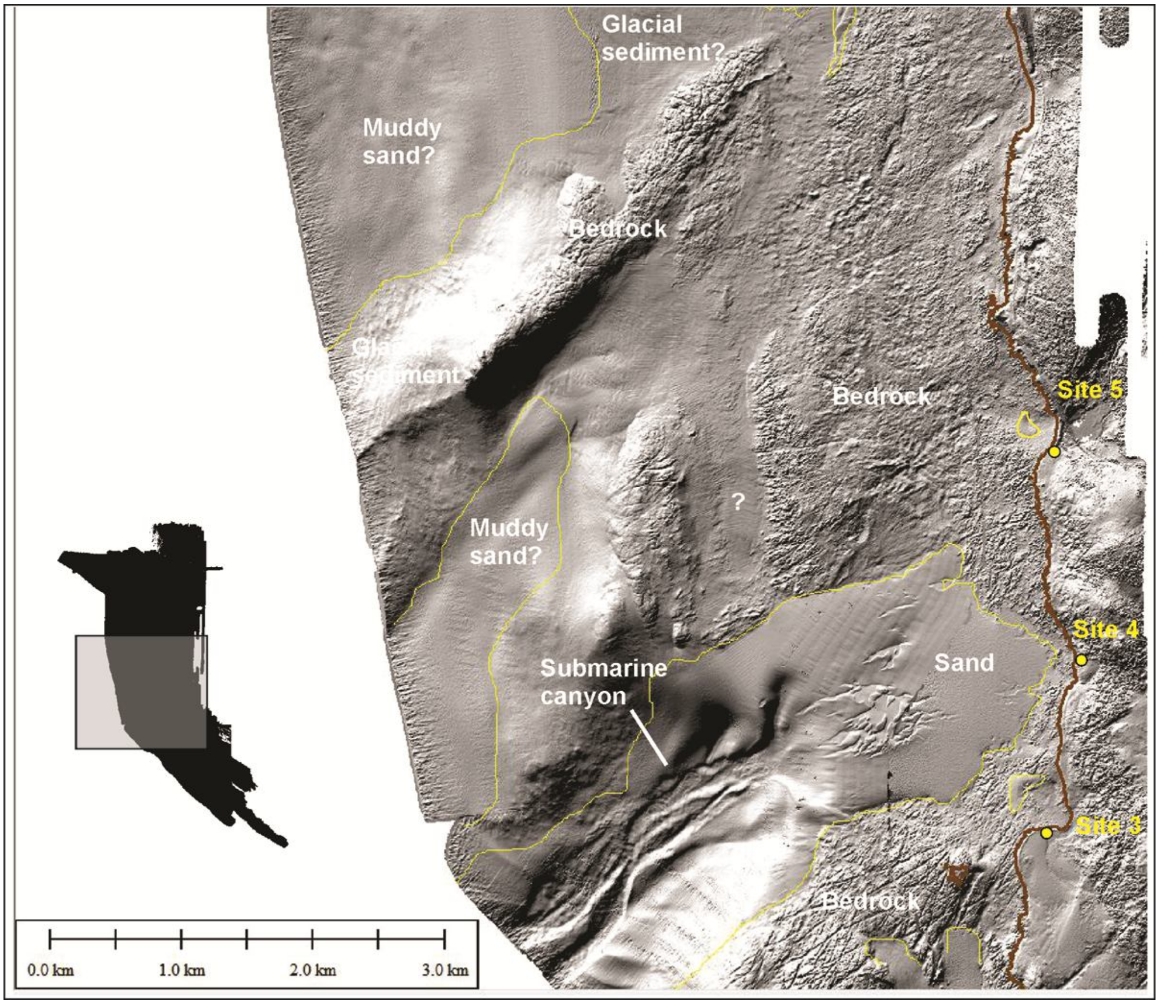

Figure 11: a provisional interpretation of the surficial geology of Area 2. Coastline is the brown line. Positions of sites 3, 4, and 5 indicated.

Cape Ray Submarine Canyon

The submarine Canyon (Figure 12) extends across the inner shelf, with a break of slope at -40 m. The Canyon appears to connect with the large (but thin) sand sheet that extends to near the coast at site 4. In the vicinity of the Canyon headwall the sand sheet thins into a series of 'fingers' of sand, and isolated small sand bodies, that are separated by a lag gravel. The topography gives the appearance of sediment starvation. A large headwall area connects with a series of channels that extend downslope. There is some possibility that a submarine fan is developed in the deeper water, off the coverage.

Several questions arise: 1) is this an active canyon; and 2) does it constitute a hazard for seabed infrastructure (cables, pipelines, etc.). The discovery of this canyon on the continental shelf is of interest, because hitherto the best analogs occur on the edge of the continental shelves of Atlantic Canada. Piper and Normark (2009) recognized three major initiation processes on submarine canyons: transformation of failed sediment, hyperpycnal flows from rivers or ice margins, and resuspension of sediment near the shelf edge by oceanographic processes. The third mechanism seems most likely here (Piper and Normark, 2009, p. 353).

The recurrence interval for sand moving down the canyon is unknown. Possibly the sand body adjacent to the canyon head has been these source of sediment moving down the canyon. This sand body is not presently connected to any sediment source, and may have been depleted. Similar canyons on a smaller scale have been located and mapped in nearby St. George's Bay, on the flanks of a submarine platform (Shaw et al., 2006a,b,c). The initial survey of these fans was in 1995. No changes were detected by a repeat survey in 2010.

With regard to whether or not this canyon might pose a hazard, a similar question was considered by Campbell and MacDonald (2006) with regard to canyons on the Scotian continental slope.

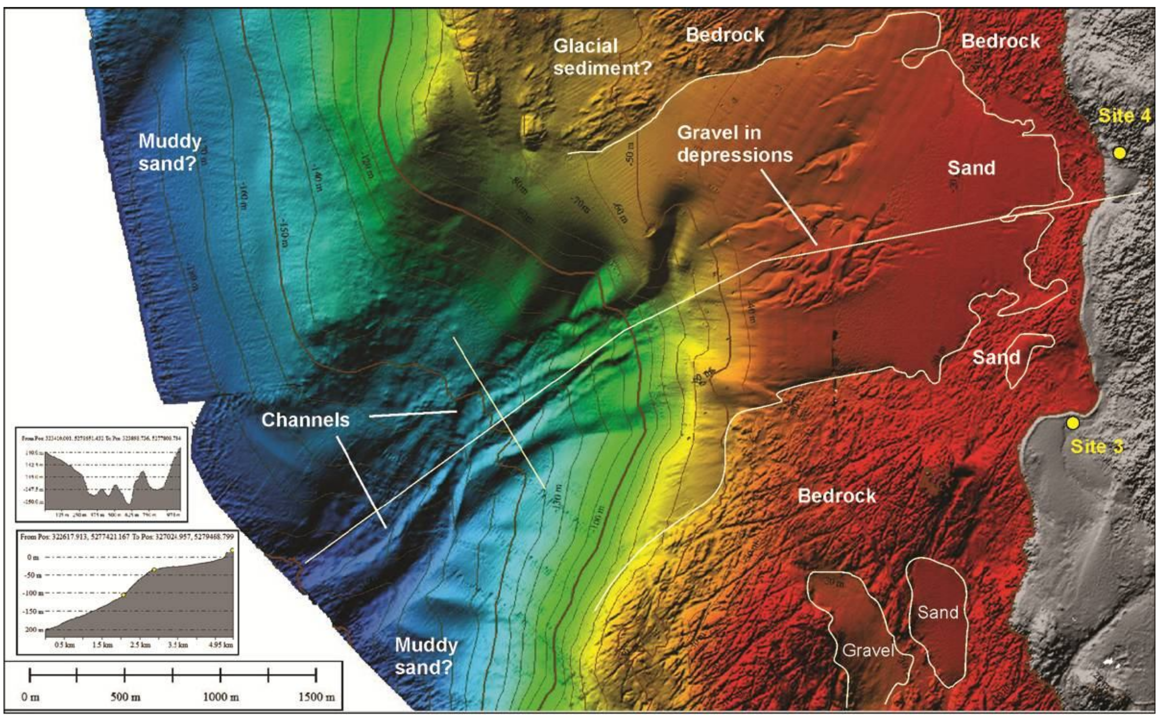

Figure 12: The Cape Ray Submarine Canyon, showing the location of the two cross-sections (not to same scale).

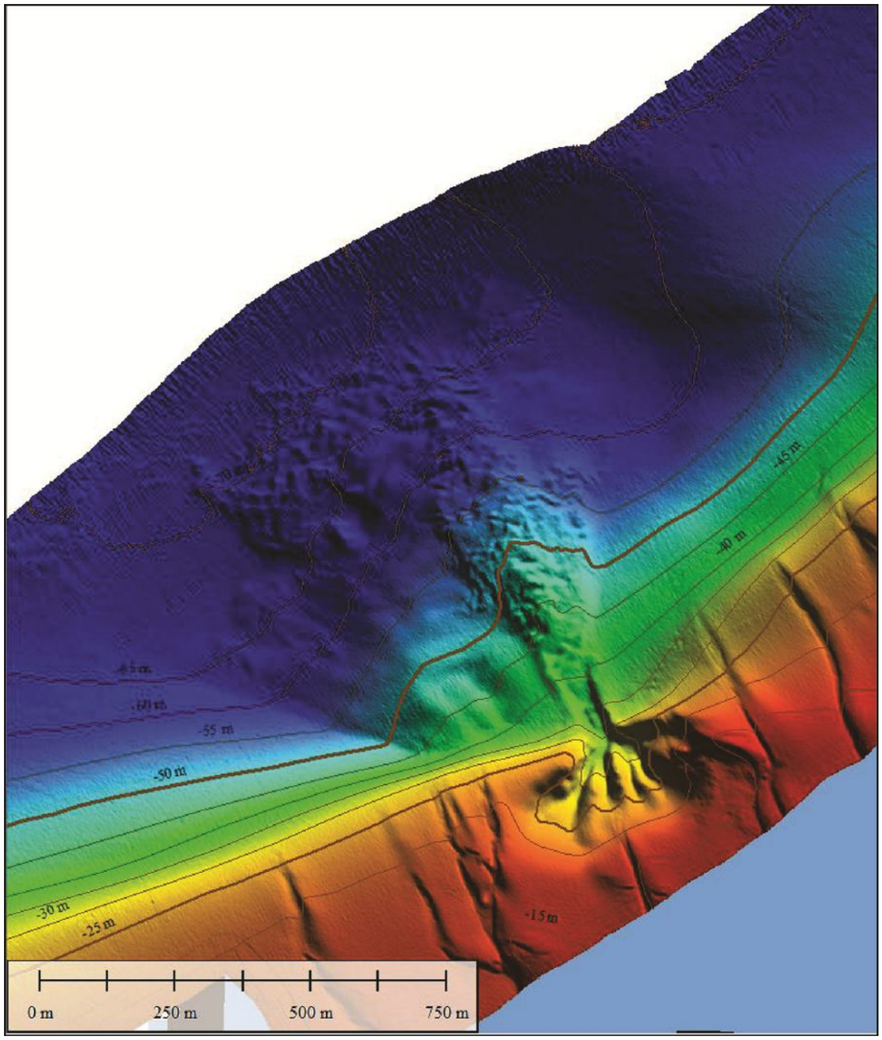

Figure 13: Small submarine fans on the flanks of a barrier platform in St. George's Bay, southwest Newfoundland. By analogy we might expect that the Cape Ray Submarine Canon will link with a depositional fan in deeper water.

SURFICIAL GEOLOGY OF AREA 3

In this region large volumes of sediment are present onshore, in coastal dunes, beaches, inlets, etc. The new multibeam and LIDAR imagery shows large volumes of sand offshore also. East of Cape Ray is a sandy barrier beach, enclosing a large lagoon that connects to the ocean via a channel at the west end of the beach (Site 1). Channels sometimes migrate back and forth along a beach, but this one may have existed in the same location for some time. It is possible, however, that the outlet can temporarily close. The beach appears to be overwashed regularly, most likely when major storm waves approach from the southwest. Over the long term the beach is probably slowly migrating landwards.

Offshore from the barrier beach is a sandy nearshore bar that is 1.5 m high. The sand continues offshore as a prism perhaps more than 10 m thick, and maybe as much as 20 m – a geophysical survey could delineate the exact thickness. The sand in the offshore in this area, therefore, appears to be greater in volume and thickness than in areas farther north.

Bedrock predominates offshore just west of Cape Ray and also to the southeast of the study area. An offshore sand body comes within 250 m of the coast at site 2, but is limited in extent.

Two kilometres south of Cape Ray the nearshore sand prism thins rapidly. The seafloor steepens (see cross section), with a break of slope at 45 m depth. Seaward of here the seafloor is irregular: numerous bedrock pinnacles come close to the surface, and are separated by a smooth sea floor probably comprising sand overlying glacial sediments.

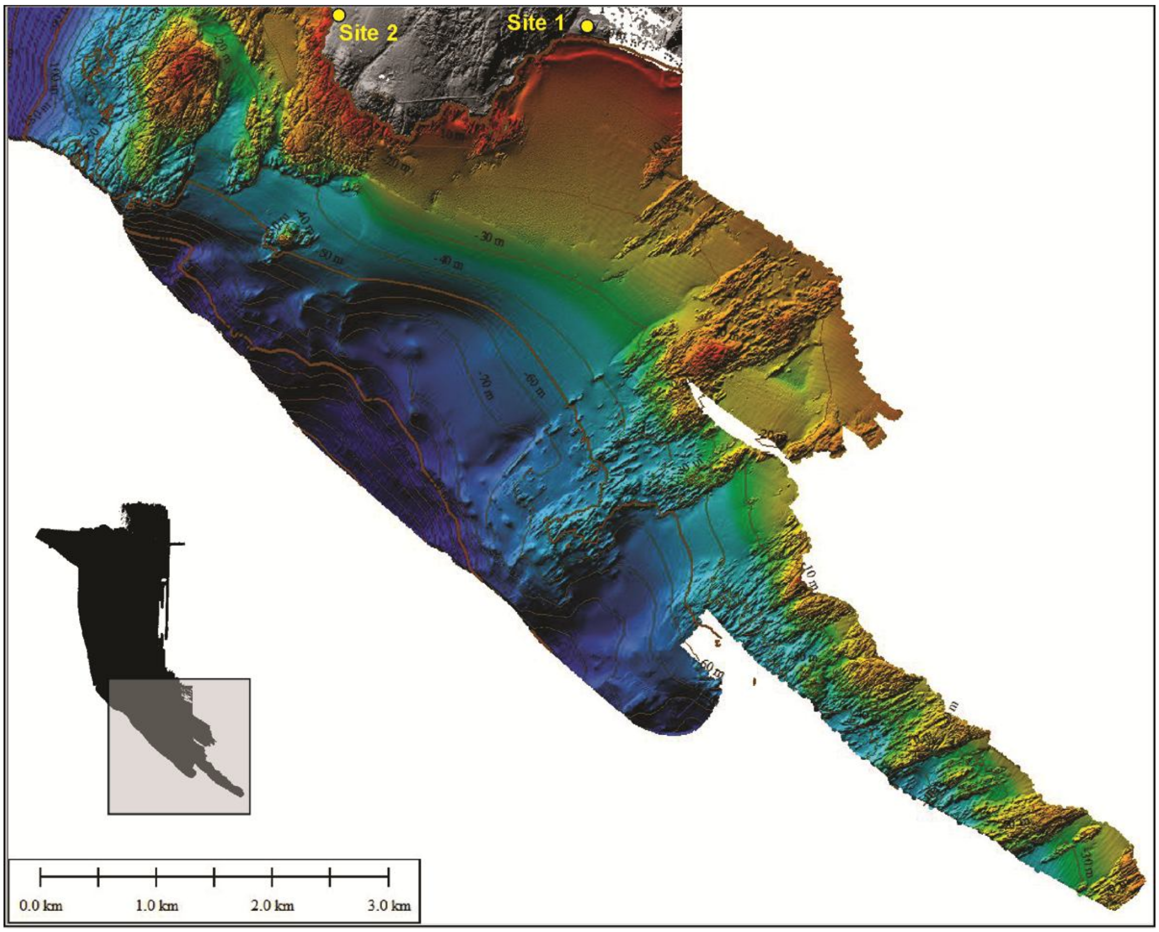

Figure 14: Coloured shaded relief map of Area 3, with isobaths.

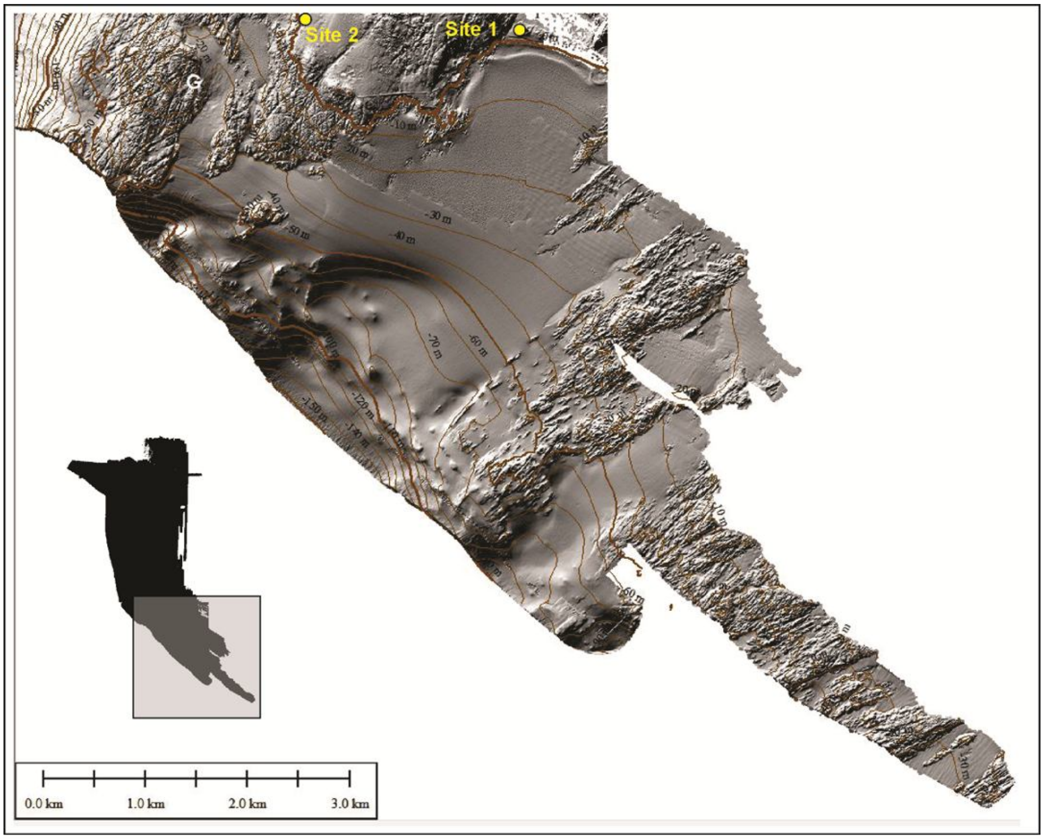

Figure 15: Gray scale shaded relief map of Area 3, with isobaths.

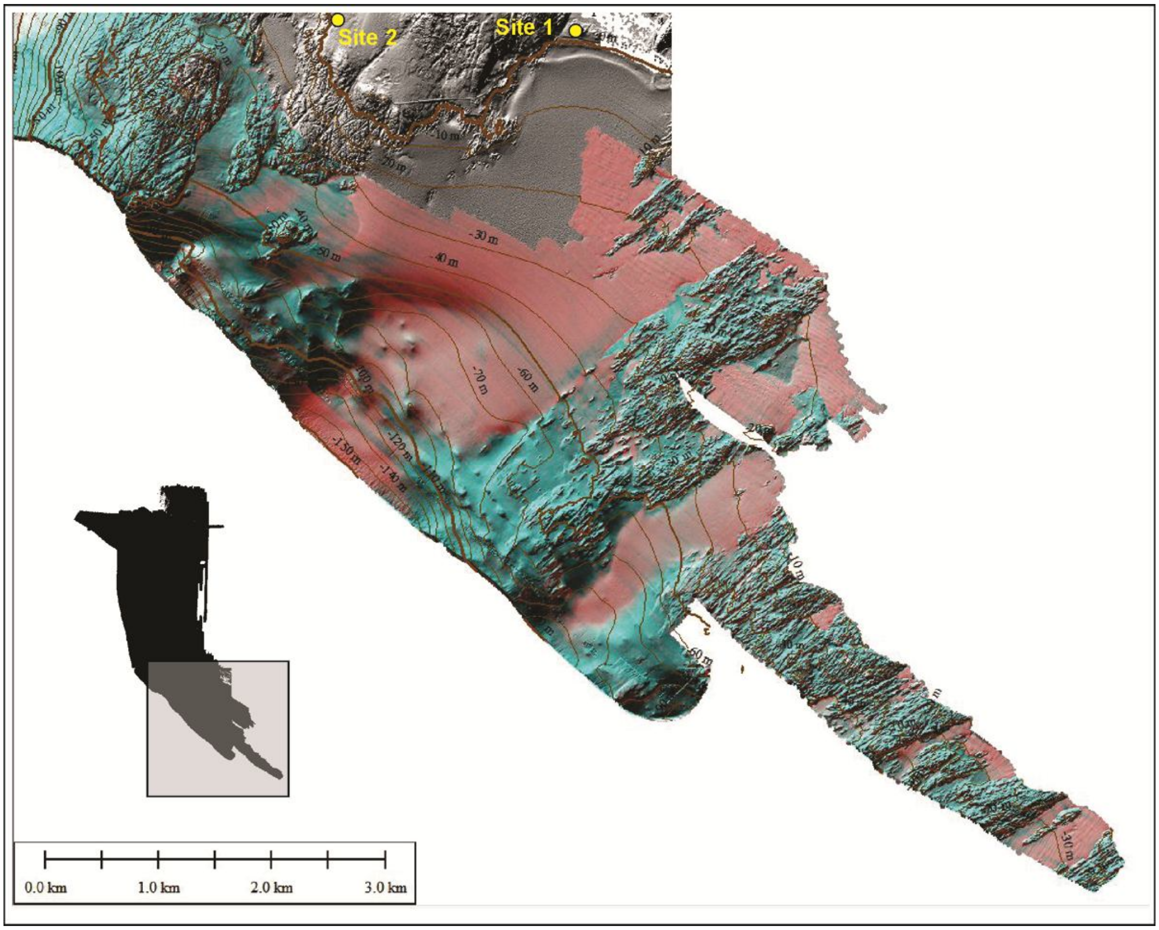

Figure 16: Area 3, backscatter draped over relief. Pink areas have low backscatter (typically sand or muddy sand) while gray-green areas have high backscatter (bedrock or glacial deposits with gravel at the sea floor). Backscatter was extracted only from multibeam data, and are not available for areas mapped with LIDAR.

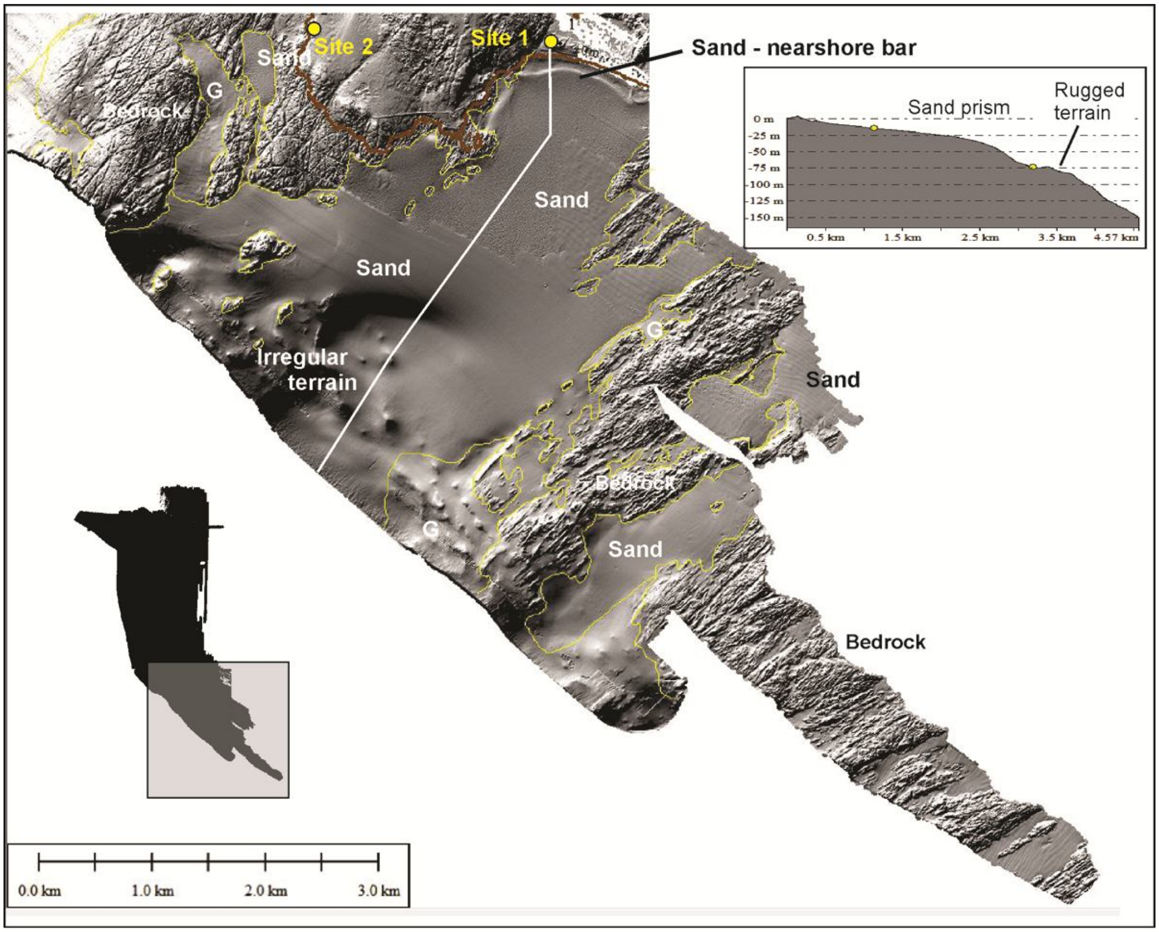

Figure 17: a provisional interpretation of the surficial geology of area 3. Coastline is the brown line. Positions of sites 1 and 2 indicated. G= gravel. White line indicates profile (inset).

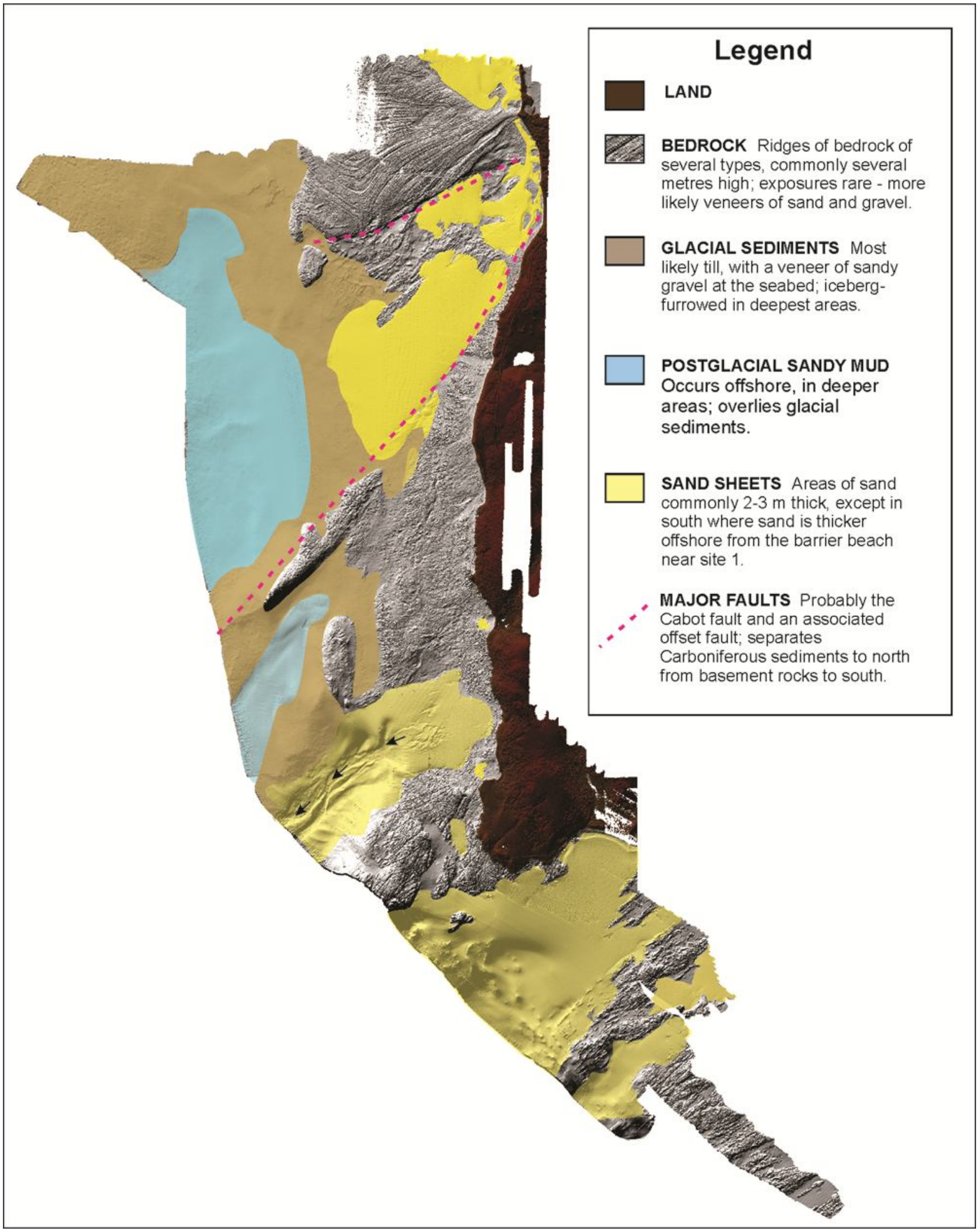

Figure 18: A summary of the main features of the surficial geology. This figure illustrates the bedrock zone close to the coast, and the five principal sand sheets. Only in the north and south do these sand sheets link with the shore. The sand sheets are for the most part thin (up to 2-3 metres) although deeper sections may occur. Also, some areas of high backscatter, indicative of gravel, occur in the areas shaded yellow here, but are not distinguished for simplicity. The postglacial sandy mud unit is conjectural. Arrows indicate possible transport pathway for sand moving down the Cape Ray Submarine Canyon.

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