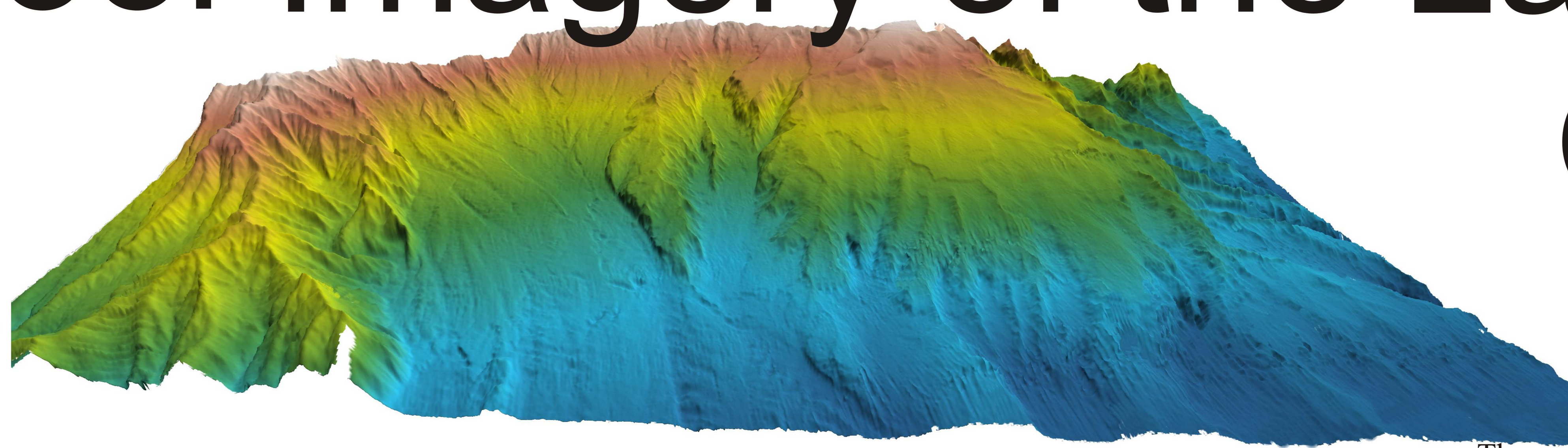
Multibeam Seafloor Imagery of the Laurentian Fan and the 1929 Grand Banks Landslide Area



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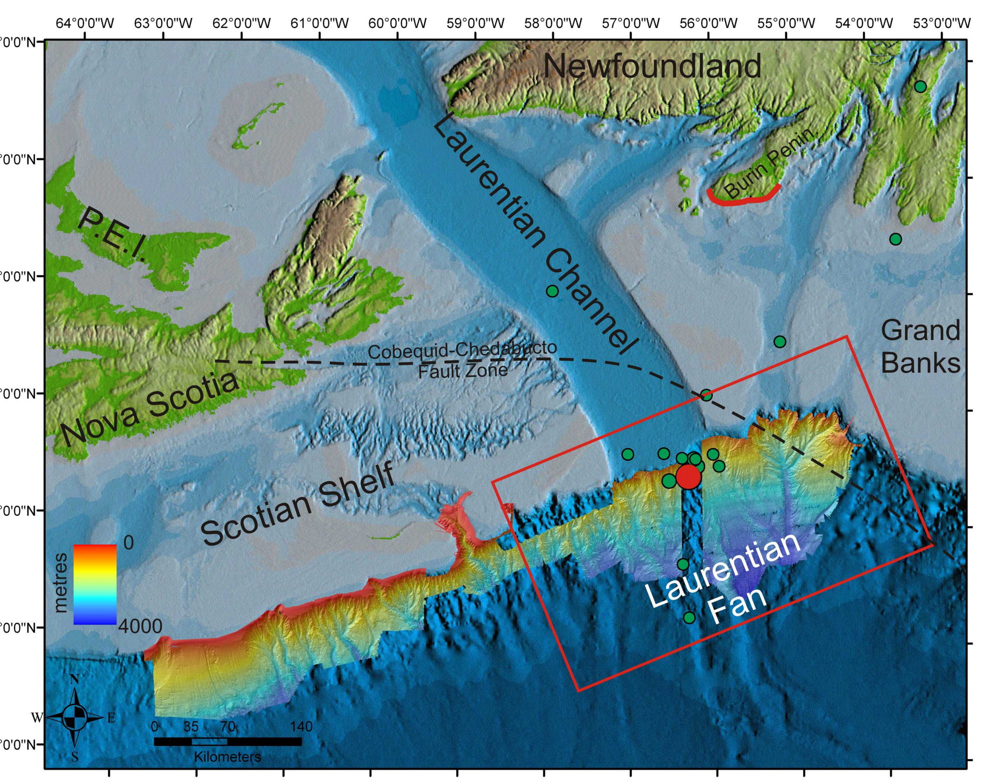
Introduction

On November 18, 1929, a M7.2 earthquake under the Laurentian Channel created a submarine landslide that severed 12 undersea trans-Atlantic communication cables. Within two hours of the earthquake a devastating tsunami struck the Burin Peninsula of the south coast of Newfoundland claiming 28 lives. Multibeam bathymetric data, acquired in September 2006, show no evidence of a single major headwall scarp and massive slump region. Instead, the 1929 Grand Banks landslide was relatively thin (< 80 m) but distributed over a large area. Resulting failed sediment quickly entered and was confined by canyons and gullies and evolved rapidly into sustained turbidity currents.

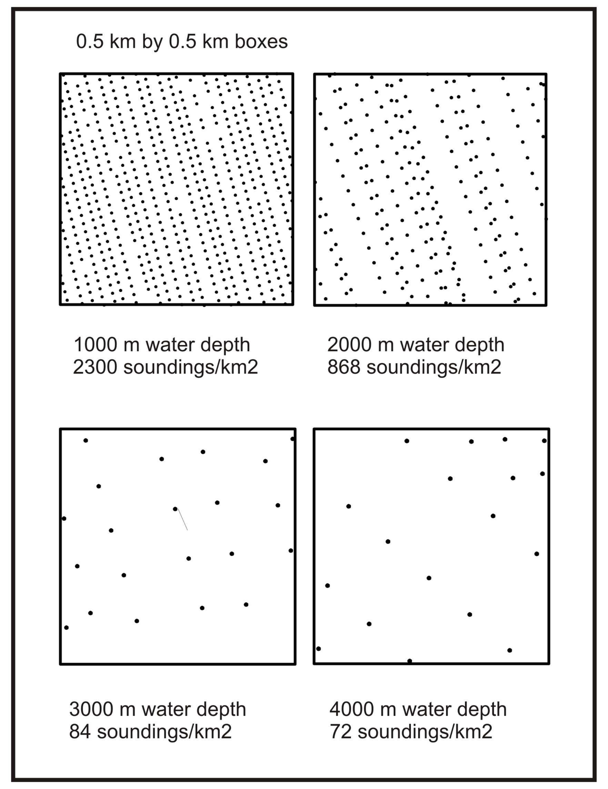


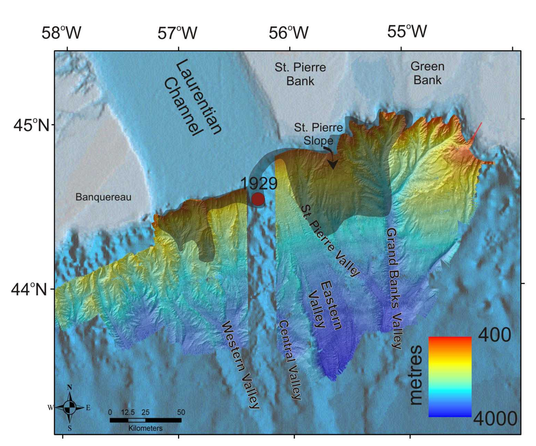
Regional Geology

The Laurentian Channel is a major Pleistocene ice outlet corridor that extends across the continental shelf from the Gulf of St. Lawrence. At the channel's termination is the Laurentian Fan; a major ice margin depo-centre throughout the Pleistocene. It is the largest deep-sea fan on the Atlantic margin of Canada and merges seaward with the Sohm Abyssal Plain. The shelf break lies in about 400 m water depth and the transition to the abyssal plain is in about 5000 m water depth. A Mesozoic transform fault (the Cobequid-Chedabucto fault) forms the southwestern edge of the Grand Banks and sweeps beneath the Laurentian Channel. It is probably on this structure that ongoing low-grade seismicity occurs.

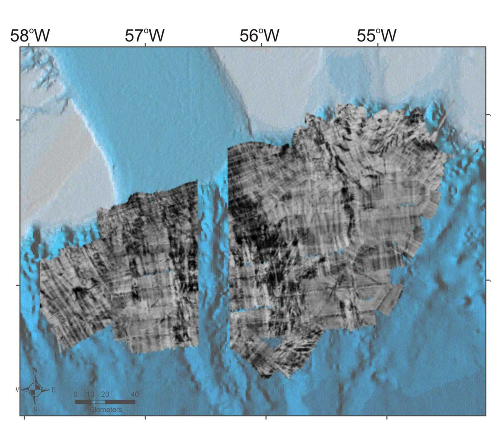
Methods

A multibeam bathymetric data set covering 32,150 km^2 of the upper Laurentian Fan was acquired in September, 2006 with the vessel *Kommandor Jack*. Data were collected by Fugro Jacques GeoSurveys Inc. of St. John's, Newfoundland. The vessel was equipped with a Kongsberg Simrad EM120 multibeam system that operates at a nominal frequency of 12 kHz, with 191 receive beams covering an ideal swath width of 150°. Maximum swath widths of about 10 km were achieved. Data density is the greatest restriction on multibeam sonar resolution in deep water. In this study, data density is on the order of 2300 soundings per km^2 in 1000 m of water and 84 soundings per km^2 in 3000 m. These values imply that horizontal resolution is nominally about 40 m at the shallower depth and 400 m in the deep.

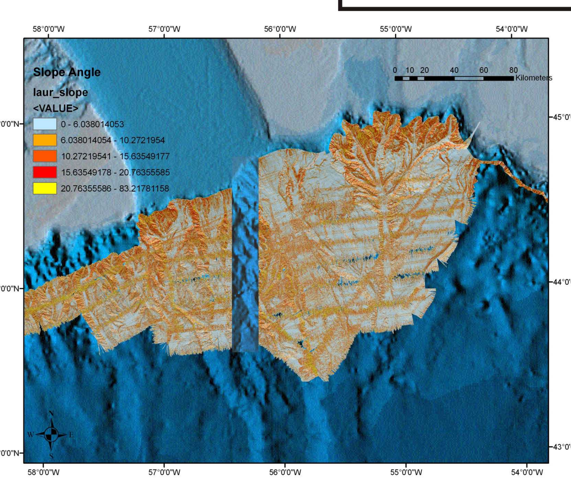




Multibeam



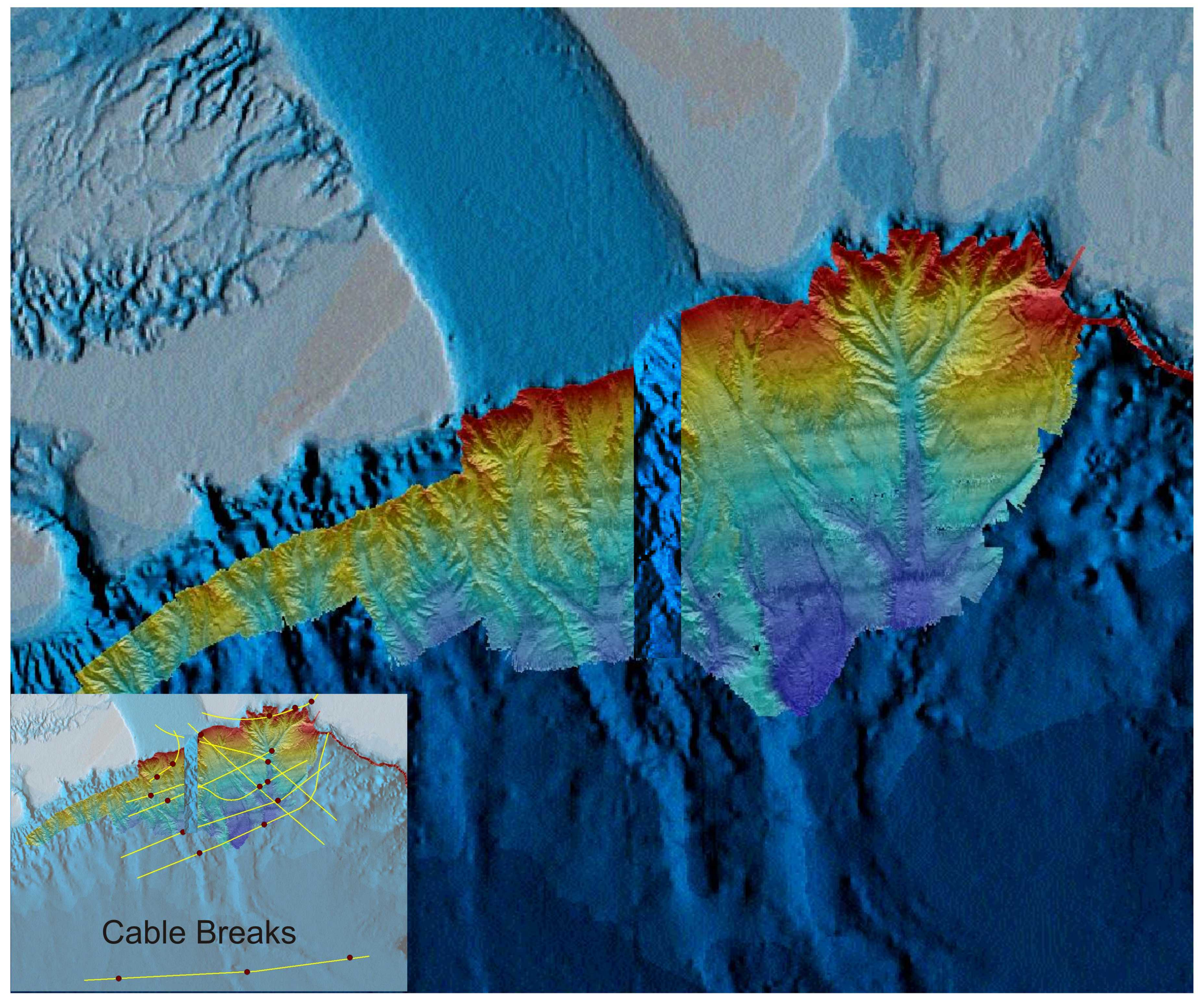
Backscatter

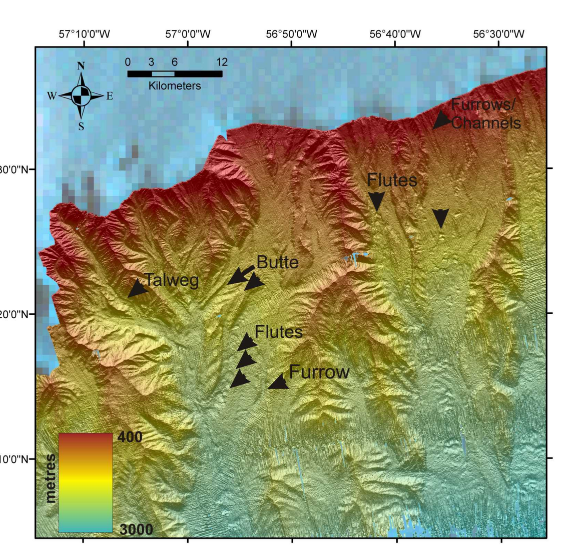


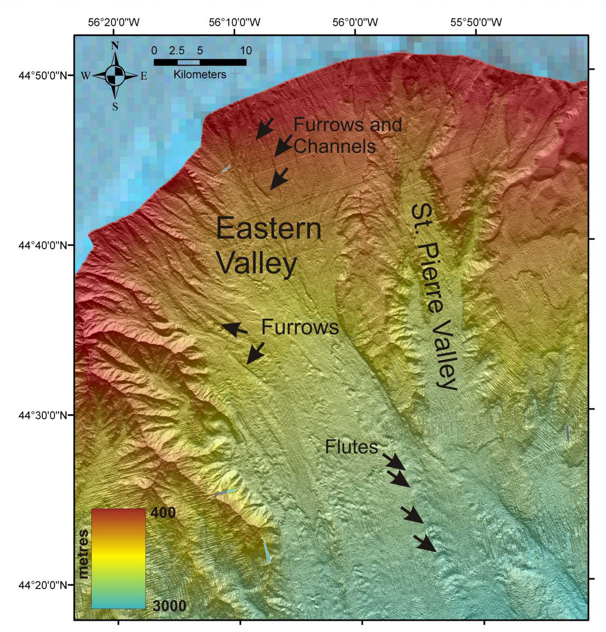
Slope Angle

Results and Discussion

The Laurentian Fan is characterized by a seafloor heavily dissected by canyons, valleys and channels, with pinnate ridges and gullies, seafloor scours and escarpments. High backscatter in low areas suggests coarse material (sand and gravel) floors the valleys. Slope angles are less than 6° and typically less than 3°, except along canyon and valley walls, where angles can reach 40°.



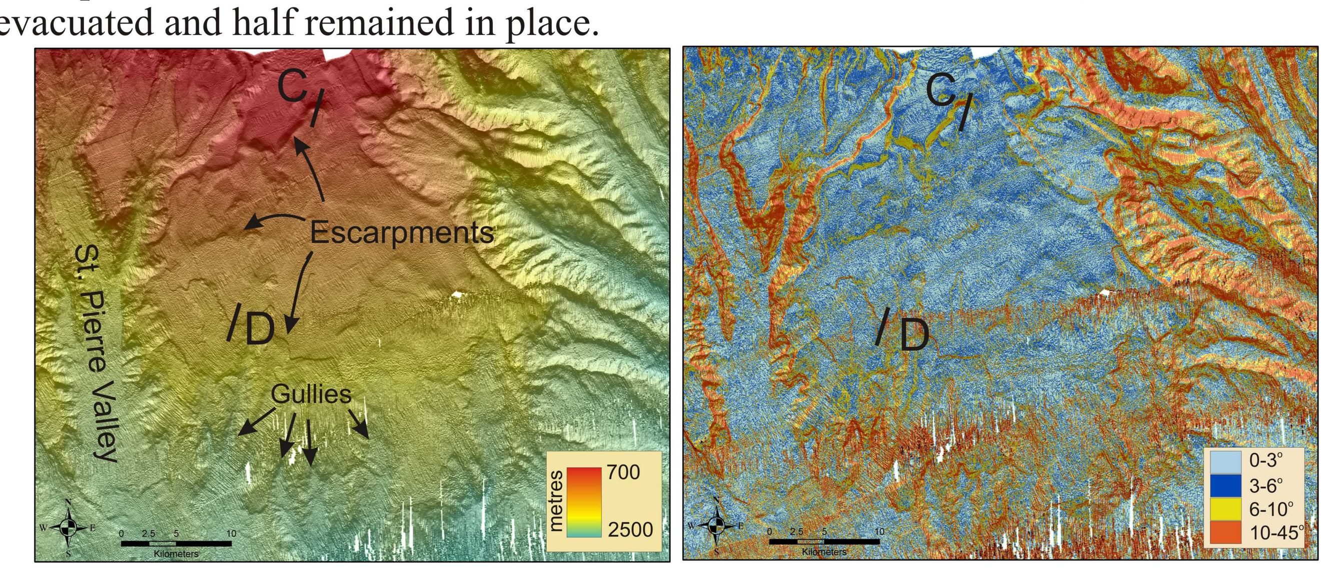


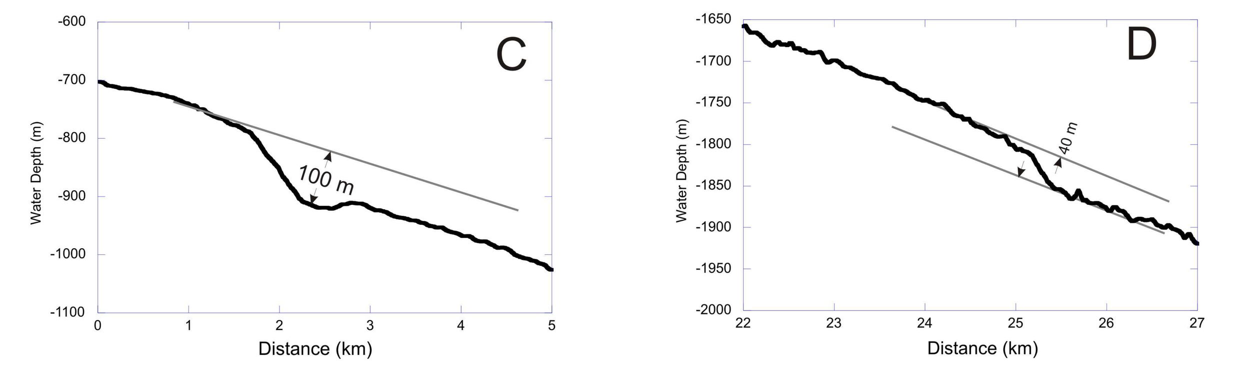


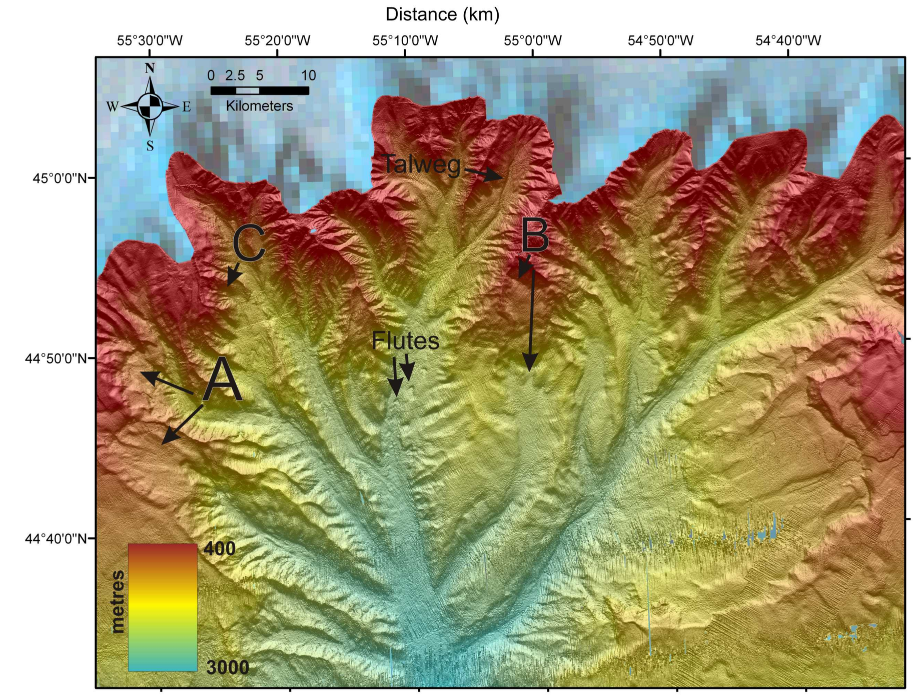
Seaward of the western part of Laurentian Channel, several broad straight valleys coalesce near the 3400 m isobath to form Western Valley (above left). Erosional furrows in these valleys extend all the way to the 600 m isobath. Upper parts of intervalley ridges have a mature dendritic pattern, with a few exceptions. Several sites on these ridges show a muted morphology, without intense gullying, that is interpreted as evidence for recent sediment mass-failure.

Eastern Valley of Laurentian Fan (upper right) is well-known from previous sidescan and submersible observations. It is unusually wide for a slope valley, has erosional furrows and residual buttes, and is floored by a 1-3 m-thick conglomerate deposited by a major sub-glacial meltwater discharge at 19.5 cal ka , as shown by the high backscatter values from the valley floor (centre left). Retrogressive failure of upper slope muds took place in 1929 and large blocks of indurated mudstone are observed overlying a broken cable near the 1200 m isobath.

The eastern St. Pierre Slope (below) is a broad flat area of relatively low gradients (3-6°) seaward of the eastern part of St. Pierre Bank. It broadens seaward with a regional increase in gradient between the 2000 and 2500 m isobaths. Between 500 and 2000 m water depth, the predominant morphological features are sinuous escarpments presumably formed by retrogressive failure. Escarpment may have slope angles in excess of 10° and 100 m relief. The steeper area between the 2000 and 2500 m isobaths is incised by a series of 100-150 m deep sub-parallel gullies interpreted as retrogressive headwall failure. Failure in this area is interpreted to have been widespread (shaded area in the figure to the lower left of this poster). It is estimated that the total amount of failed sediment in the area of St. Pierre Valley and St. Pierre Slope, between the 500 and 2000 m isobaths, was about 93.5 km^3, of which about half was evacuated and half remained in place.







A dendritic series of slope canyons is developed seaward of Halibut Channel, Green Bank and Haddock Channel, which lead downslope to the Grand Banks Valley (left). Seismic profiles and cores indicate widespread failure in 1929 at the western edge of this drainage system . Elsewhere, cores suggest that there were local failures on some canyon walls and a turbidity current flow in 1929, confirmed by the distribution of cable breaks. Again, areas where the dendritic pattern is muted probably represent areas of failure (e.g. labelled A, B, C)

Conclusions

Newly acquired 12 kHz multibeam bathymetric sonar data from the Laurentian Fan and St. Pierre Slope region of the east coast of Canada lend significant new detail to existing knowledge of the terrain in this region. Specific to the 1929 Grand Banks earthquake landslide and tsunami, these data show sites on canyon walls that appear to have failed recently, based on geomorphologic criteria, and they show numerous fresh escarpments ranging from 5 to 100 m in height on the St. Pierre Slope. They show no evidence of a single large slump, with headscarp, slump and debris lobe. These data, therefore, support earlier interpretations that the landslide was relatively thin-skinned (5-100 m thick but averages about 20 m) and dispersed over a relatively large area (~7,200 km^2). The series of escarpments suggests a retrogressive style of failure. This terrain is similar to the morphology seen everywhere on the Scotian Slope, particularly on broad flat intercanyon regions. This fact raises the issue as to whether even thin-skinned mass-transport events including large turbidity currents in deep water are tsunamigenic. If so, then the tsunami-hazard potential of the Canadian East Coast margin and likely most continental margins throughout the globe increases significantly.

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2007: Multibeam seafloor imagery of the Laurentian Fan and the 1929 Grand Banks landslide area; Geological Survey of Canada, Open File 5638, POSTER.

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