Failures on the southeast Canadian margin: the Canada-COSTA focus

Piper, David J.W., Mosher, D.C., Jenner, K.A., Gauley, B.J., Morrison, M.L., and Campbell, D.C.

Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, N.S. B2Y 4A2, Canada

The Canada-COSTA community has chosen two areas of seabed failure on the southeastern Canadian margin for detailed investigation of post-glacial sediment failures: (1) the central Scotian Slope and (2) the head of Laurentian Fan (the 1929 "Grand Banks" failure).

EM300 and EM1002 multibeam bathymetric imagery of over 30 000 square kilometres on the Scotian Slope shows that the eastern Scotian Slope is deeply incised by canyons in Pliocene-Quaternary shales. The canyons were cut, probably by subglacial meltwater, when glacial ice reached the outer shelf. No failures appear to postdate the last deposition of sand sheets on canyon floors, dated at about 12 ka. Sparse failures on intercanyon areas of the lower slope are draped with late Pleistocene sediment. The central Scotian Slope is less dissected. Smooth slopes of about 0.04 have widespread shallow rotational slumps with arcuate headscarps, retrogressive rotational slumps, bedding plane slides and debris flows. In addition, lateral spreading creep has occurred on decollement planes 50-500 m below seabed. Evidence of shallow gas, including pockmarks, is widespread. Piston cores from failed areas allow a 50 m thick composite stratigraphy to be established. Failures have been dated by radiocarbon methods, Heinrich events, and correlation with upper slope till deposition. Hypotheses for triggering of failure include: excess pore pressure due to ice loading, upper slope till deposition, or high rates of sedimentation; ice-load induced seismicity; and warming of bottom waters during deglaciation causing gas hydrate dissociation. The availability of large amounts of both industry and high-resolution seismic reflection profiles and piston cores have not yet resulted in discrimination of these hypotheses.

At the head of the Laurentian Fan, around the epicentre of the 1929 Grand Banks earthquake, a similar composite stratigraphy of the upper 50 m of fine-grained sediment has been developed and allows definition of the physical properties of layers that show different styles of failure in sidescan sonar imagery. Evaluation of the role of liquefaction in sands in upper slope channels must await future multibeam bathymetry and follow up studies. The turbidity current generated by the 1929 failure reworked late glacial sands from the valleys on Laurentian Fan and transported them to the Sohm Abyssal Plain. New seismic data from the eastern Canadian margin show that large, seismically-induced failures are very rare, with a recurrence interval of hundreds of thousands of years. The reduction in frequency of large deep-water debris-flow deposits after the cutting of the canyons on the eastern Scotian Slope in the middle Pleistocene suggests that excess pore-pressures, perhaps due to gas hydrates, play an important role in large failures.