Character and timing of late Quaternary earthquake-triggered submarine landslides, Orphan Basin, offshore eastern Canada

David J.W. Piper and Efthymios K. Tripsanas
Geological Survey of Canada (Atlantic), Bedford Institute of Oceanography, Dartmouth, NS, B2Y 4A2 <dpiper@nrcan.gc.ca>

The catastrophic 1929 "Grand Banks" earthquake and submarine slide off southern Newfoundland provides evidence for the style of earthquake-triggered failure offshore eastern Canada. In Orphan Basin, a widespread slope failure known as the Sheridan failure took place at about 7 ka. Like the 1929 failure, it affected several discrete drainage systems apparently simultaneously. The failure was predominantly retrogressive. It also produced a sandy-gravelly turbidity current as a result of retrogressive failure of upper slope sands and/or till. Piston cores <10 m long from Orphan Basin can be readily correlated and dated by distinctive Heinrich layers. They preserve a record

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of rare turbidites similar to that from the Sheridan failure. In some cores, there is also evidence for sediment failure at the same horizons. Although failures from the last glacial maximum and younger took place under rising sea level conditions, earlier failures appear to have occurred preferentially at times of sea level fall.

Widespread failure at discrete horizons occurs ubiquitously on the southeastern Canadian margin. Regional failures appear to be synchronous in multiple drainage systems and many cannot be accounted for by retrogression from a single point failure. Such synchronous failure over a large area probably results from earthquake triggering, although glacial meltwater discharge and consequent canyon widening is a possible mechanism in certain rare situations.

Estimating the frequency of past large earthquakes is important for assessing seismic and tsunami risk and as input into the National Building Code, which currently appears to overestimate seismic risk for coastal areas of Atlantic Canada. A crude magnitude-frequency relationship is observed, with small failures on the continental slope having a recurrence interval of perhaps $5x10^3$ yr whereas large failures have a recurrence interval of $>2x10^5$ yr. There does not appear to be a systematic relationship between failure frequency and regional gradient, although on a local scale, steeper slopes are more prone to failure, as shown by the greater abundance of small failures on active fault scarps created by salt tectonics. Failures are more common on continental slopes adjacent to glaciated continental shelves, compared with slopes of similar gradient that also receive muddy plume sedimentation far offshore, for example at Orphan Knoll. Regional failures appear no more abundant in areas of active salt tectonics than elsewhere. The decrease in frequency of failures offshore and the greatest abundance of failures during deglaciation suggests that some of the seismicity was induced by glacio-isostasy. Several factors may precondition sediments to fail more readily, including underconsolidation due to high sedimentation rates from proglacial plumes and the availability of shallow gas.