

Seismic Hazard in Passive Margin Frontier Basins: Geological Estimates of the Frequency of Large Earthquake-Triggered Submarine Landslides in Orphan Basin, Offshore Canada

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Seismic hazard assessment for engineering design is important but challenging in frontier basins with low seismicity, such as the Canadian east coast offshore. Here the instrumental record of past earthquakes is short and seismological estimates of recurrence suggest a $M_w > 7$ earthquake every 3 ka per 100 km length of continental slope, an estimate incorporated in the 2005 Building Code of Canada. Such estimates appear much higher than the frequency of slope failure in the same area. For example, near the 1929 $M_w=7.2$ Grand Banks earthquake and landslide, submarine landslides of similar size have occurred every 150-200 ka. Order of magnitude differences in estimates of seismic hazard are a cause for concern.

Ultra-high resolution seismic reflection profiles from the continental slope in the highly prospective Orphan Basin, off Newfoundland, reveal a stratigraphic record of large submarine slope failures back to 0.1 Ma. C-14 dating of Heinrich and ash layers in many piston cores provided chronology of seismic markers at ~ 3 ka resolution after 40 ka and ~ 5 ka resolution prior to 40 ka. Slump-generated turbidites on the basin floor have a distinctive petrology, sedimentology and distribution, with ~ 1 ka chronologic resolution. Large slope failures occurred synchronously over margin lengths of 50-330 km. In the past 0.1 Ma, 5 failures affected a >120 -km-long sector of the slope and 15 failures were large enough to be recognised in seismic and/or cores. We present arguments that the widespread failures were earthquake triggered: other mechanisms for triggering laterally extensive synchronous failure do not apply.

Triaxial shear measurements on cores from the continental slope show a c/p ratio of typical sediment of 0.48, implying considerable stability. The c/p ratio falls to as low as 0.25 at some weak layers based on shear vane measurements. Relationships between seismic acceleration and c/p are examined for the 1929 Grand Banks earthquake and compared with recent data from the US Atlantic margin. This indicates that the larger Orphan Basin slope failures represent earthquakes ranging from $M_w \sim 6.5$ to ~ 7.5 with a mean recurrence interval for "large" earthquakes of 20 ka. This compares with the seismological estimate of a 1.5 ka recurrence interval for a $M_w = 7$ earthquake somewhere in this sector of the continental margin. This study demonstrates a methodology for seismic hazard assessment in other passive margin petroleum basins.