Supplementary Table 1 Assessment of possible aseismic mechanisms in glacial Lake Ojibway for event horizons H, G, and E.

Mechanism	Comments	Assessment
Grounding icebergs	– Could mechanically trigger failures from higher surfaces of lake bottom. – Iceberg scour marks are present on bed of glacial Lake Ojibway, but are located over 90 km north of the study area (Dionne, 1977; Veillette and Paradis, 1996). – Near absence of ice-rafted debris in varve deposits in study area implies that few icebergs were present during interval of Dasserat varve record.	May have caused isolated failures in study area, but unlikely to account for the multi-landslide signatures of horizons H, G, and E.
Overloading or oversteepening of slopes	– Failures could result from high sedimentation rates on the undulating slopes within general location of study area. – Depositional setting is in deep water and distal with respect to sediment source implying that there are no pockets of high localized sedimentation in study area. – Difficult to account for the shift in the locations of failures between horizons H and G, and then the widespread failures occurring in horizon E, with this mechanism. – An obvious increase in the regional sedimentation rate occurred in the glacial lake beginning at varve 1528, but this change post-dates horizons H, G, and E and there is no multi-landslide horizon in the study area until after varve sedimentation began to wane (horizon B).	May have caused isolated failures in study area, but unlikely to account for the multi-landslide signatures of horizons H, G, and E.

Wind-generated waves	– Storms on glacial Lake Ojibway generated large waves during the interval of Dasserat varve record. – Deep water conditions (minimum 30 to 50 m deep) over study area probably minimized influence of wave actions on lake bed. – Waves might have triggered failures along an eroding shoreline, however, the nearest paleoshoreline in relevant period was located ~1.5 km to the south-southwest along the northeastern tip of a narrow, elevated bedrock ridge. – If wind-generated waves are an important mechanism, then there should be a greater number of event horizons with a relatively low rather than high number of landslide deposits, reflecting the higher frequency of lower magnitude storm events, but this opposite to what is observed. – Periods of 40 to 119 varve years between horizons H, G, F and E without any failures in study area further suggest this is not an important mechanism because significant storms almost certainly occurred more frequently than the duration of these periods.	Unlikely to account for the multi-landslide signatures of horizons H, G, and E.
Rapid drawdown of lake level	– Could trigger failures due to generation of high pore pressure in poorly-draining, clay-silt deposits and loss of stabilizing influence of water pressure on slopes. – No known rapid drawdown events of glacial Lake Ojibway during interval of Dasserat varve record.	Unlikely to account for the multi-landslide signatures of horizons H, G, and E.

Dionne, J.C., 1977. Relict iceberg furrows on the floor of glacial Lake Ojibway, Québec and Ontario. Atlantic Geology 13, 79-81.

Veillette, J.J., Paradis, S.J., 1996. Iceberg furrows as paleowind indicators and icebergs as erosion and sedimentation agents in Glacial Lake Ojibway, Abitibi, Québec. Open File 3031. Geological Survey of Canada, Ottawa. doi: 10.4095/205754.