HIGH RESOLUTION SONAR PROFILING OF EARTHQUAKE-INDUCED FAILURES IN MARINE CLAY UNDERLYING THE OTTAWA RIVER; A CONTRIBUTION TO THE OTTAWA VALLEY LANDSLIDE PROJECT

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The Ottawa Valley Landslide Project is, in part, a pioneering study of the capabilities of several geophysical techniques to provide regional-level reconnaissance surveys of critical geological controls related to landsliding in sensitive marine (Leda) clay near Ottawa. As part of this project, high-resolution, sub-bottom acoustic profiling was carried out in the Ottawa River in the Lefaivre area in order to examine the river bottom for evidence of continuation of “disturbed” ground mapped on land. The adjacent onshore area consists of 46 km^2 of very hummocky topography and severely-deformed marine sediments that have been attributed to earthquake-induced liquefaction, lateral spreading, and differential settling.

Sonar surveys were conducted in the Ottawa River using both pulsed, and “chirp” (swept frequency/de-convolved) acoustic sources working over the effective frequency range of 2 kHz and 23 kHz. Due to superior transmission and coupling characteristics in water, marine acoustic methods can yield resolutions in the decimeter range. Excellent images of features including folding, faulting and *in situ* rotation of layered Champlain Sea sediments as well as sand volcanoes were obtained, and deformation could be observed to at least a depth of 30 m below river bottom.

Faults within the bedded sediments are predominately reverse faults, with dip angles ranging from 40 to 65 degrees and displacements of up to 7 metres between up and down thrown blocks. Laterally, the larger faults diminish to smaller faults, and eventually disappear altogether. The folding and reverse faulting is consistent with a compression of the sediments, such as would have occurred when the onshore lateral spreading encroached on the river channel.

A detailed grid survey, consisting of 42 line-km of single channel sub-bottom sonar data, has mapped an *in situ* rotated block of layered sediment, 130 m by 200 m and about 25 m thick, with about 15 degrees of rotation. The bedded sediment has been folded, semi-symmetrically, and slightly faulted, but is otherwise coherent within the rotated block. Smaller rotated sections and areas of differential compaction occur along strike from this larger block. Seismic liquefaction of sediment through the development of excess pore pressure may have caused an initial failure along a single glide plane, which subsequently propagated upward in a curving path, through the overlying layers, to form a spoon-shaped slip plane. Portions of the rotated and extruded block of sediments may have originally projected above the riverbed, but have been subsequently eroded by the Ottawa River. Similar small independently rotated blocks also occur nearby. The scale of the offshore rotations is similar to the width of depressions onshore where inclined bedding has been observed, and coincides with the depth of severe deformation found in onshore borehole core.

Several sonar profiles have intersected what seems to be the remains of sand or mud blows or volcanoes. Laminated bedding has been ejected, producing a depression that was subsequently infilled, either with the ejected sediments themselves, or with later fluvial sediments. The shallow water in this reach probably allowed river ice to truncate the sand mounds.

These sonar surveys have confirmed that deformed sediments are present beneath the riverbed and are associated only with the zones of “disturbed” ground on land. The offshore deformation features are probably the result of the same catastrophic earthquake. These acoustic profiling results, with such excellent horizontal and vertical definition of disturbed features, are a significant contribution towards developing models for the process of surface disturbance onshore.

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