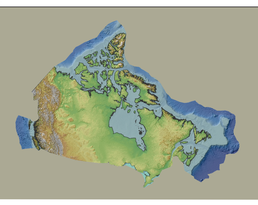
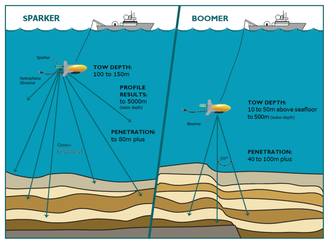
Geological Survey of Canada
Open File 8497

ULTRA-HIGH-RESOLUTION IMAGING OF SUBMARINE LANDSLIDES: THE GEOFORCE GROUP LIMITED BOOMER AND/OR SPARKER SUBBOTTOM PROFILER

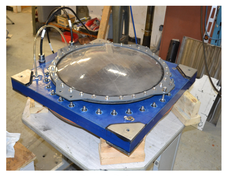
D.C. Mosher[1], G. Standen[2], and D.C. Campbell[1]

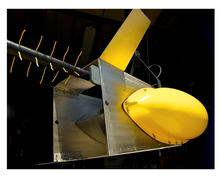


An ideal subbottom profiler has a broad frequency band, high energy, rapid trigger rate, and highly repeatable source characteristics. These elements provide for maximum vertical and horizontal resolving capacity, subbottom penetration even in hard and gas-bearing sediments, shot-to-shot coherency and phase and amplitude information to facilitate interpretation. In addition, directional source characteristics limit incidental environmental noise. The Geoforce DTS optimizes these characteristics to the physical limits of modern technologies, utilizing two modes of operation: sparker and boomer.

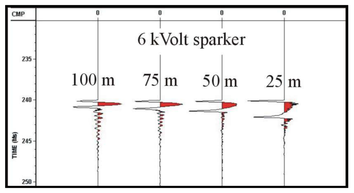


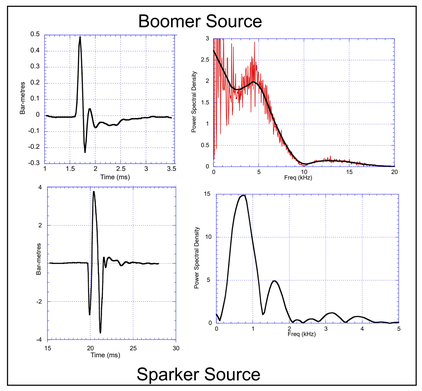
Depending on operational water depths and survey demands, either mode can be chosen “on the fly”. Deep tow of the system removes surface and vessel motion (heave, pitch and roll), eliminates the surface ghost, and stabilizes source characteristics. Digitization of received signals within the tow body eliminates cable and EM noise interference. The result is an ideal tool for resolving complex structures such as are present in mass transport deposits.

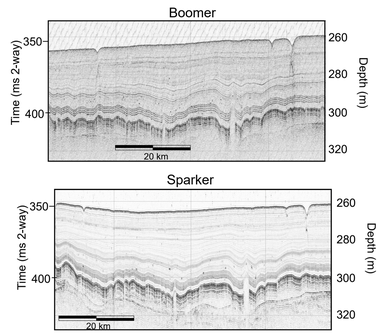

Boomer Plates


Sparker Tip

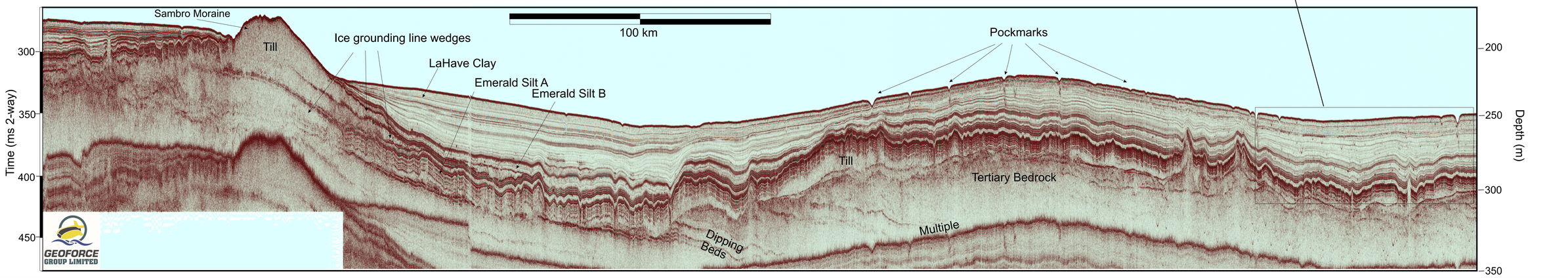
On the far left is a picture of the housing of the boomer plates that fits within the towed fish. Rapid expansion of the boomer plates accelerates a cylindrical plug of water mass that creates a highly directional and highly repeatable pressure wave. On the immediate left is the sparker tail protruding from the rear of the tow body. In this case, discharge of energy through the wire tips within a conducting fluid (salt water) creates a spark that vapourizes a surrounding water mass. The vapour bubble collapses rapidly under ambient water pressure, creating an implosion as the impulsive sound source. Variations in ambient pressure (i.e. tow depths) can create different source wavelets, as shown in the figure above.



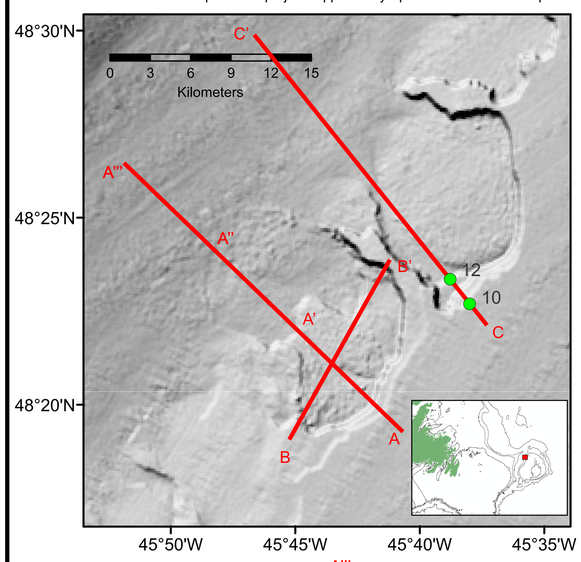




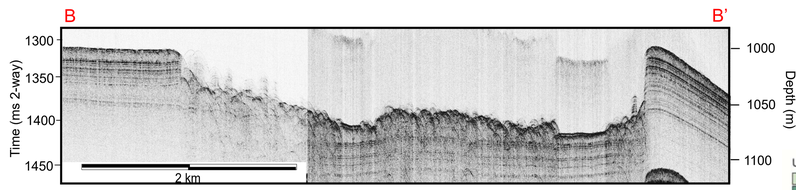
Below is a Geofroce DTS profile from Emerald Basin on the Scotian Shelf. The data were filtered and migrated and displayed here in full phase. The profile shows a variety of glacigenic geologic features including till, stacked ice-margin wedges and subbottom ice-rafted debris. Dipping beds of Tertiary bedrock can be seen below the glacial section. Two subbottom profiles of approximately the same ground from this profile are shown to the left; the top panel shows boomer data acquired with an internal, single element hydrophone and displayed as full phase. The bottom panel shows data collected in sparker mode and received on an external hydrophone streamer (a 12-element array towed behind the tow-fish).

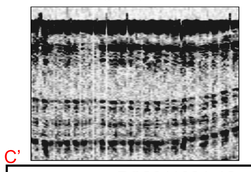


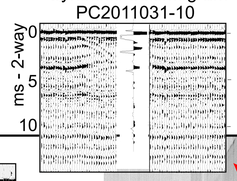
Flemish Pass, off of the Grand Banks of Newfoundland, is dominated by contourite deposits. These are subjected to submarine landsliding as apparent on the surface (multibeam image to the left) and in the subsurface). Geoforce DTS Sparker profiles show that these failures occurred retrogressively. Coring the headscarps allows development of the stratigraphy and creation of synthetic seismograms. Comparison of the seismograms with full phase Geoforce sparker data shows that Heinrich layers produce a strong correlateable horizon. Mutlibeam data are compliments of the Nerieida program; A NAFO sponsored project supported by Spain and Canada to map the outer banks of the Grand Banks of Newfoundland. Huntec data were acquired by Campbell et al. (2011) on Hudson expedition 2011031.

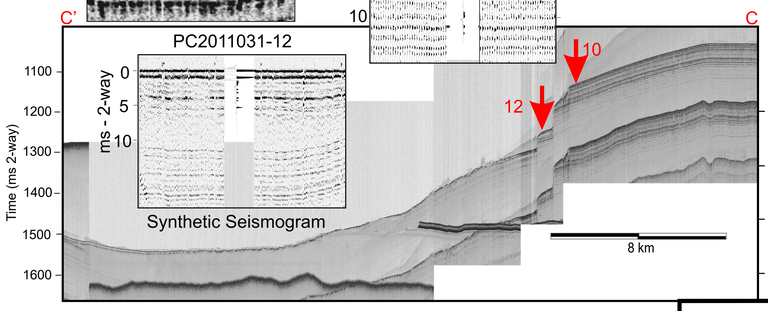


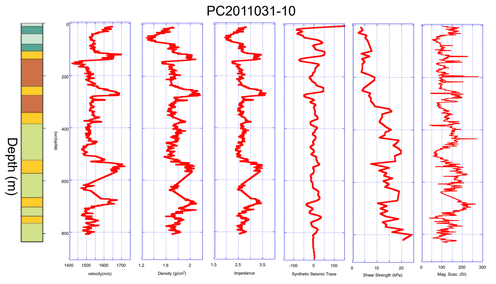
Below are two profiles of the same data crossing core site Pc2011031-12. One is displayed as envelope of the trace and the other as full phase. Controlled source subbottom systems, such as Chirps, record data as envelope (or average energy) as they do not recover useable phase information. The loss in resolution is readily apparent and comparison with core stratigraphy is much less certain. Full phase data allow comparison with detailed core stratigraphy, as shown below and to the right.

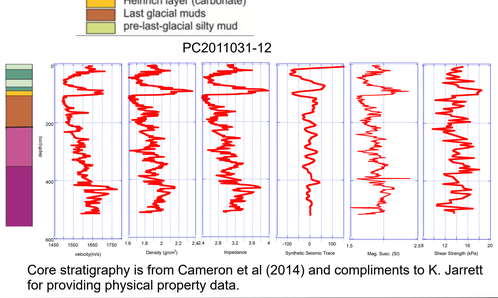




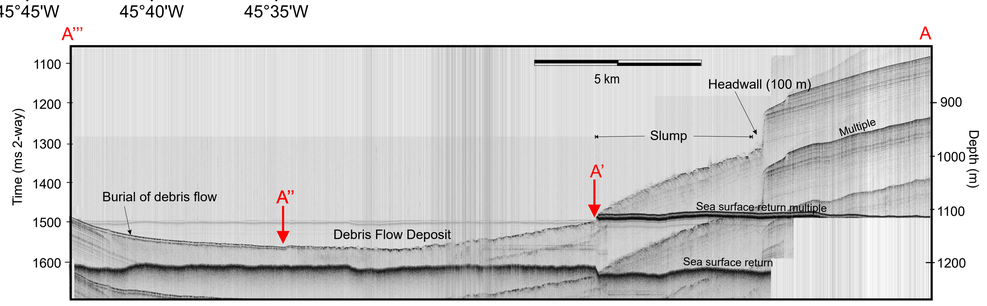


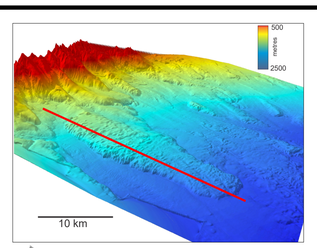


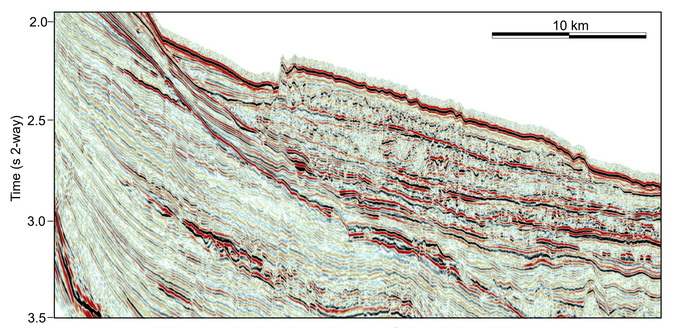




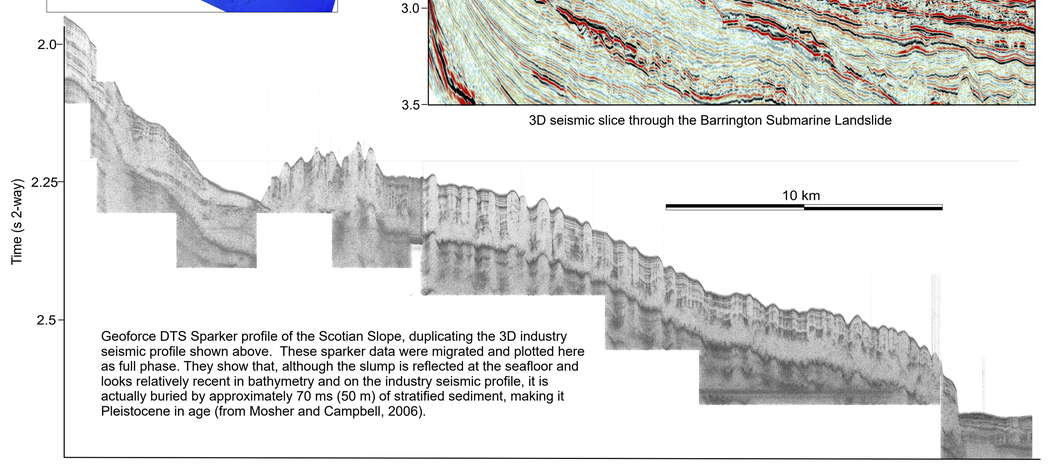
Core stratigraphy is from Cameron et al (2014) and compliments to K. Jarrett for providing physical property data.



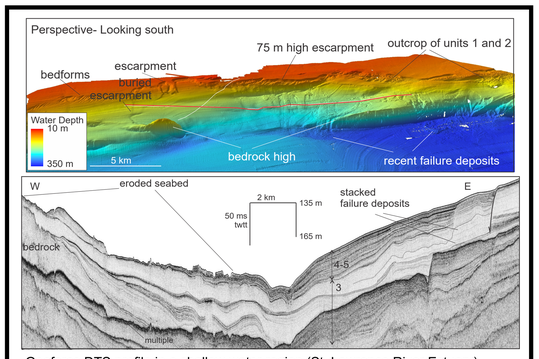




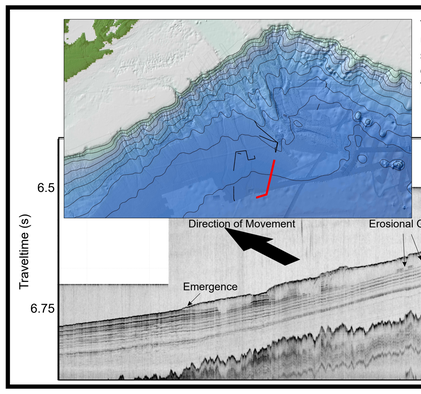
3D seismic slice through the Barrington Submarine Landslide



Geoforce DTS Sparker profile of the Scotian Slope, duplicating the 3D industry seismic profile shown above. These sparker data were migrated and plotted here as full phase. They show that, although the slump is reflected at the seafloor and looks relatively recent in bathymetry and on the industry seismic profile, it is actually buried by approximately 70 ms (50 m) of stratified sediment, making it Pleistocene in age (from Mosher and Campbell, 2006).



Geoforce DTS profile in a shallow water region (St. Lawrence River Estuary), showing multiple stacked MTDs (from Campbell et al., 2008)



This Geoforce DTS Sparker profile was acquired in ultra deep water off of the Laruentian Fan. It shows how the fan levees consist of MTD deposits, even on the very surface and shows details of the failure, even on its lower bounding surface (from Normandeau et al., this conference volume).

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