TITLE: Transition from magma dominant to magma poor rifting along the Nova Scotia Continental Margin

AUTHORS: Mladen R. Nedimović[1,2], Keith E. Louden[3], Ka Wai Helen Lau[3], Louise Watremez[3], Donna S. Shillington[2], James B. Gaherty[2], Suzanne S. Carbotte[2], Harm Van Avendonk[4], Sonya A Dehler[5]

INSTITUTIONS: 1. Department of Earth Sciences, Dalhousie University, Halifax, NS, Canada 2. Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, USA 3. Department of Oceanography, Dalhousie University, Halifax, NS, Canada 4. University of Texas Institute for Geophysics, Austin, TX, USA 5. Geological Survey of Canada - Atlantic, Halifax, NS, Canada.

WHITE PAPER: Passive margins have been characterized as magma-dominant (volcanic) or magma-poor (non-volcanic). However, the conditions under which margins might switch states are not well understood as they typically have been studied as end member examples in isolation to each other. The Nova Scotia (NS) continental margin, however, offers an opportunity to study the nature of such a transition between the magma-dominant US East Coast margin to the south and the magma-poor Newfoundland margin to the north within a single rift segment. This transition is evidenced by a clear along-strike reduction in features characteristic of syn-rift volcanism from south-to-north along the NS margin, such as the weakening of the East Coast Magnetic Anomaly (ECMA) and the coincident disappearance of seaward dipping reflector sequences (SDRS) on multichannel seismic (MCS) reflection profiles.

Results from recent industry MCS profiles along and across the margin (Figure 1) suggest a potentially narrow magma-dominant to magma-poor along-strike transition between the southern and the central NS margin. Such a transition is broadly consistent with results of several widely-spaced, across-strike ocean bottom seismometer (OBS) wide-angle profiles (Figure 1). In the southern region, the crustal structure exhibits a narrow (~120-km wide) ocean-continent transition (OCT) with a high velocity (7.2 km/s) lower crust, interpreted as a gabbro-rich underplated melt, beneath the SDRS and the ECMA, similar to crustal models across the US East Coast. In contrast, profiles across the central and northern margin contain a much wider OCT (150-200-km wide) underlain by a low velocity mantle layer (7.3-7.9 km/s), interpreted as partially serpentinized continental mantle, which is similar to the magma-poor Newfoundland margin to the north. However, the central-to-northern OBS profiles also exhibit significant variations within the OCT and the along-strike continuity of these OCT structures is not yet clear. Preliminary analysis of 2010 wide-angle seismic data from the 240 km-long 20 OBS OCTOPUS margin parallel profile, which extends from the central to the northern margin segments along an existing industry MCS profile (Ion/GX Technology NovaSPAN 5100), indicates that the cross-strike structures are continuous within the OCT. However, a substantial anisotropy in velocity (~8% lower parallel to the margin) is observed within the OCT. This result is consistent with an interpretation of partially serpentinized mantle that flowed perpendicular to the margin during its extension. In addition, along strike variations are also observed along the profile, which suggest a higher degree of volcanism and a thinner layer of serpentinized mantle to the southwest.

The results already generated at the Nova Scotia margin provide a framework for future studies to, for example, investigate questions such as:

1. What are the characteristics and causes of a single-rift-segment transition from a magma-poor to a magma-dominant margin regime? Can variations in magma underplating within the magma-rich to magma-poor transition be related to along-strike differences in mantle temperature?

2. What is the nature of along-strike variability in magmatism between magma-dominant rift segments?
3. Is there a correlation between variations in magmatic addition to the crust and mantle structure?
4. Did magmatism facilitate continental breakup? Comparison of the OBS lines suggests that sea-floor spreading began more abruptly and more robustly (i.e., greater crustal thickness) offshore southern Nova Scotia, relative to offshore central and northern Nova Scotia, where the oceanic crust thins and layer 3 has a lower velocity on the seaward end of the profiles. But the gap between lines in the south is too great to know if there is a direct correlation.
5. Can changes in the transition and characteristics of post-breakup sea-floor spreading be related to variations in magmatism along the margin?

The existence of high quality 2D crustal profiles opens the door for a more 3D approach to examining crustal structure and a framework for looking deeper into the mantle.

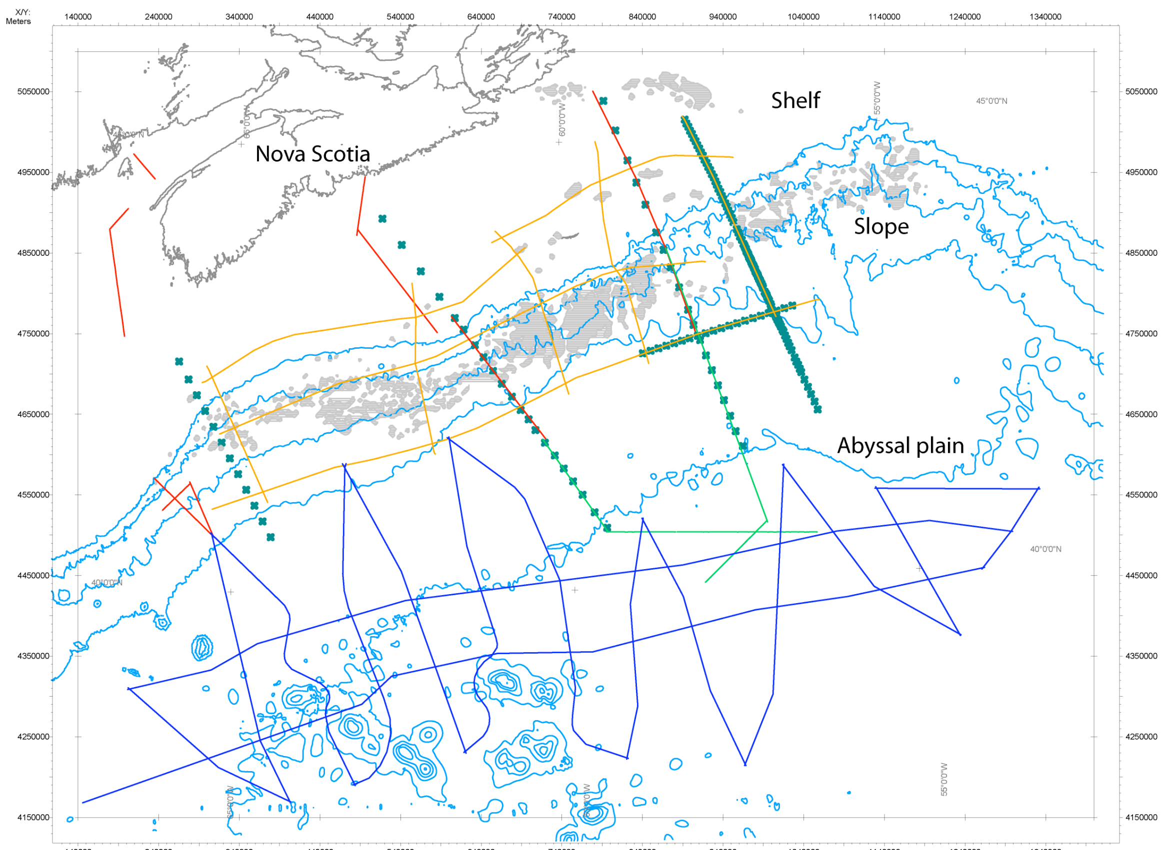

Figure 1. Offshore Nova Scotia region. Earlier MCS profiles available as raw data and processed images: Lithoprobe lines (red, 3-4 km-long streamer); BGR lines (green, 3-4 km -long streamer). Modern MCS profiles available as raw data and processed images: NovaSpan 2003 lines (orange, 9 km-long streamer); UNCLOS 2007 lines (blue, 4-km-long streamer). Green crosses mark OBS locations: Three long margin-normal profiles are from SMART project, one 100 OBS profile is the 2009 OETR profile, and the one margin-parallel profile is from the 2010 OCTOPUS project. Gray areas are salt dominated regions of the slope. Blue lines are bathymetry at 1000, 2000, 3000, 4000 and 5000 m depth. Coast is outlined in gray.