Rift Architecture

What controls the structural and stratigraphic architecture of rifted continental margins during and after breakup?

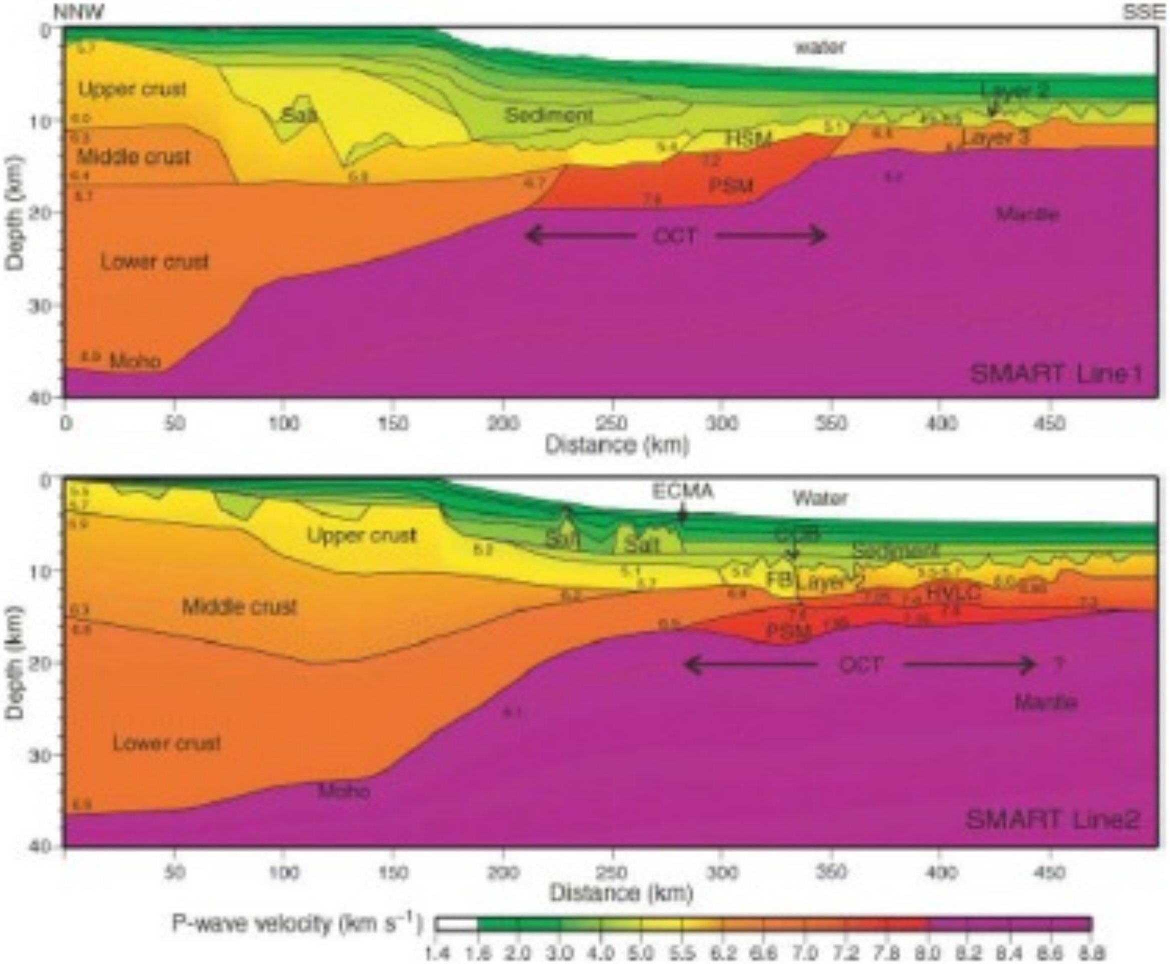


Figure 5.8. Crustal cross sections from wide-angle seismic data offshore Nova Scotia in a region of along-strike changes in the style of crustal thinning, magmatism and sedimentation [Wu et al., 2006]. Observations of along-strike changes in fundamental rift structure here and elsewhere (Gulf of California, offshore Australia, Black Sea, etc.) highlight the need for better constraints on the 3-D evolution of rifting, and the causes of such variability.

Distribution and amount of thinning, style of deformation, igneous features, vertical motions, sediment load

1: What controls the large-scale form of evolving rifted margins?

Crust and mantle lithosphere structure variability

Controlled by: Strain rate, thermal and compositional structure of the lithosphere, influence of fluids and sediment supply, lithosphere-asthenosphere interactions

1: What controls the large-scale form of evolving rifted margins?

Problem: uncertainties in interpretation of features (high velocity crustal bodies, transitional crust, etc)

1: What controls the large-scale form of evolving rifted margins?

Needed:

-Higher resolution geophysical studies at a variety of scales

-Drilling and characterization of ancient margins exposed onshore

-Comparison with syn-rift settings

-Numerical studies

2: How does evolving rift architecture modify and interact with subaerial and submarine sediment-dispersal pathways through time?

2: rift architecture & sediment dispersal pathways

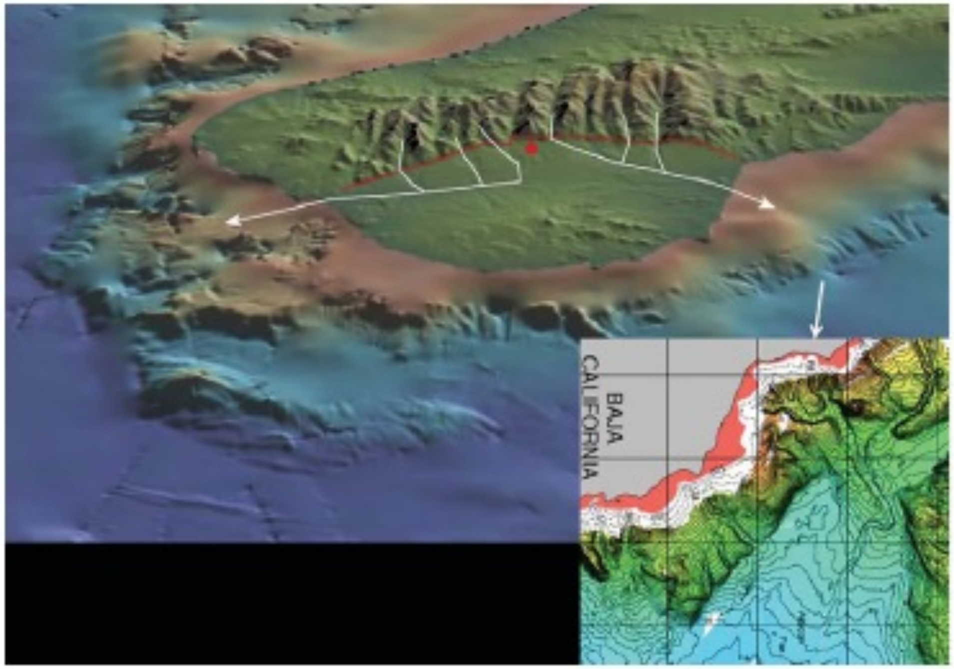


Figure 5.9. Oblique view west-northwest at bathymetry and topography of the southernmost Baja California Peninsula. Sediment is routed from the uplifting Sierra La Laguna across the active San Juan de Los Cabos fault (red) and the terrestrial piedmont into the adjacent marine system with important climate modulation in this tropical monsoonal setting [Arrowsmith et al., RCL workshop 2009; Arrowsmith, et al., 2009]. Inset bathymetry of the Alarcon Fan is unpublished data, courtesy of P. Lonsdale et al.

Sediment supply larger than capacity vs sediment starved

2: rift architecture & sediment dispersal pathways

Rifting initiates in isolated depocenters that later connect by growth and linkage of basin-bounding normal faults

Problem: differences in fault geometries & fault integration not well understood, and how sediment dispersal patterns change in response (marine and nonmarine)

2: rift architecture & sediment dispersal pathways

Needed:

-High resolution surface topography (LiDAR)

-Surface dating

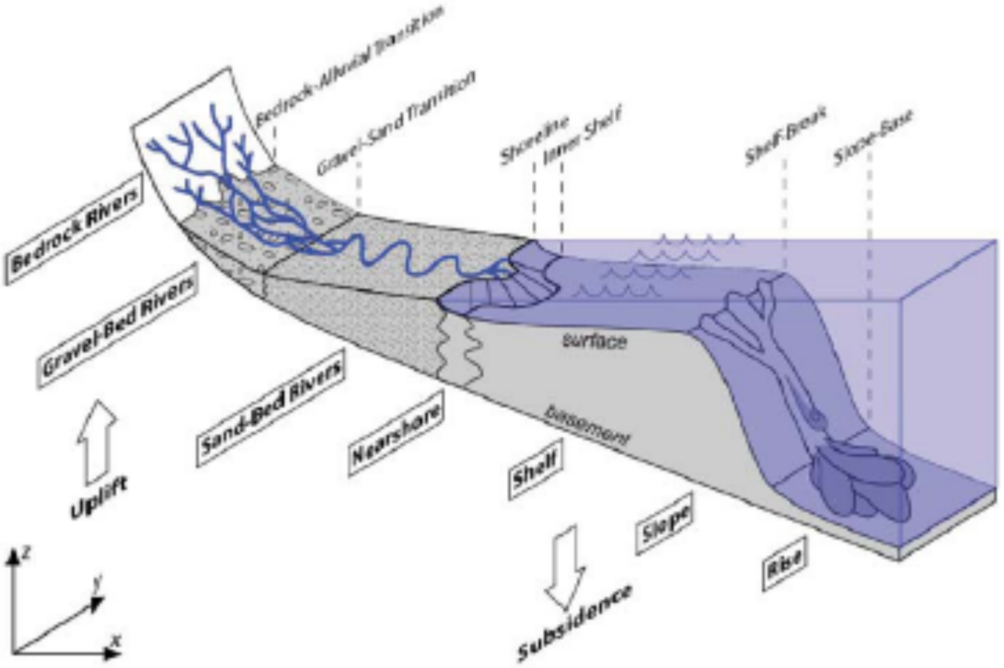
-3D seismic datasets on sedimentary sequences

-Laboratory & numerical studies on faulting & sedimentation

3:What are the rates, processes and timescales of delta transport across shelves into deep basins and how are the signals of these variations expressed in the stratigraphic record?

3: stratigraphic record

Complex interplay between processes such as lithosphere deformation and sealevel change, and sediment transport and deposition



Delta lobe progradation

3: stratigraphic record

Problem: not well understood how the time and length scales of autogenic behavior vary with rate & style of allogenic processes- sometimes overlap between time and length scales

Needed:

-field studies of exposed strata, seismic and well data of buried stratigraphy

-development of new numerical models for surface evolution of continental margins

4: What active processes influence the form of the post-rift continental margin?

The large-scale slope of the continental margin results from the balance between sediment loading, thermal subsidence, gravitational stresses, deformation of shale and salt, etc

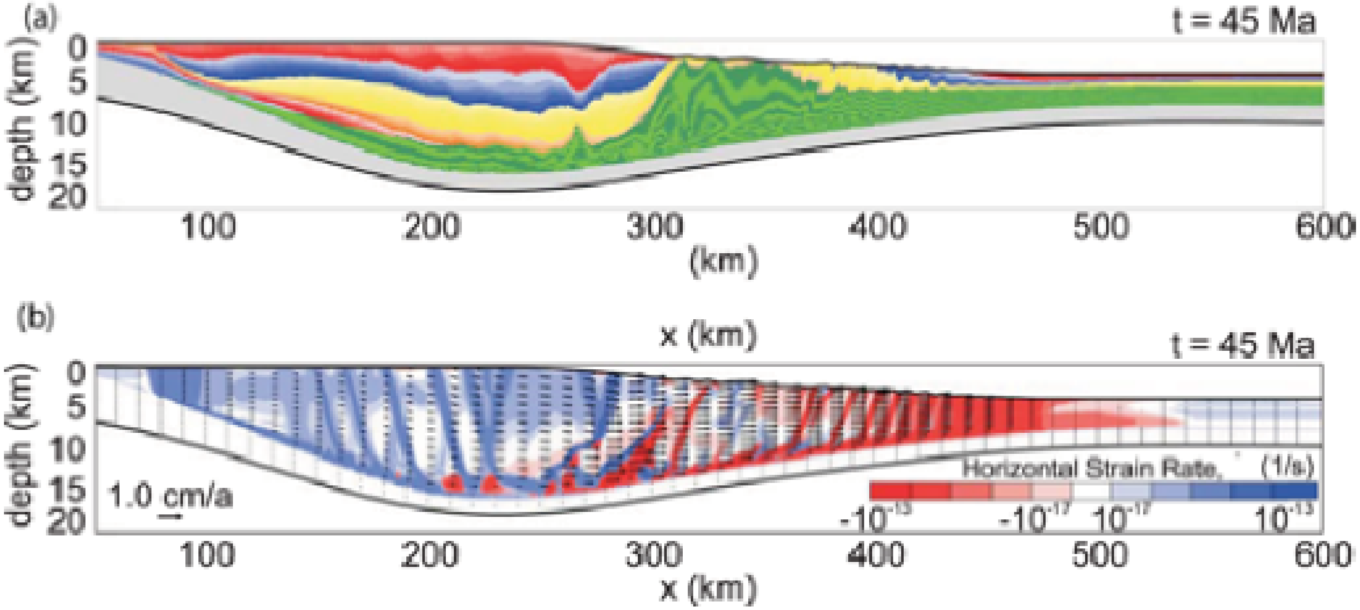


Figure 5.12. Representative numerical simulation of evolution of a passive margin in response to differential loading of thinned continental crust assuming visco-plastic sediment behavior. The combined fluid and mechanical calculations describe large deformation flows and include dynamic pore fluid pressures. Simulation of evolution of passive margin after 45 m.y. (top) Lithology: shale is shown in light and dark green and the sand-dominated

4: Post-rift continental margin

Problem: not well understood how climate cycles (glacial-interglacial) and changes in loading affect margin dynamics and stratigraphic record

Needed:

-seismic reflection to infer ongoing deformation

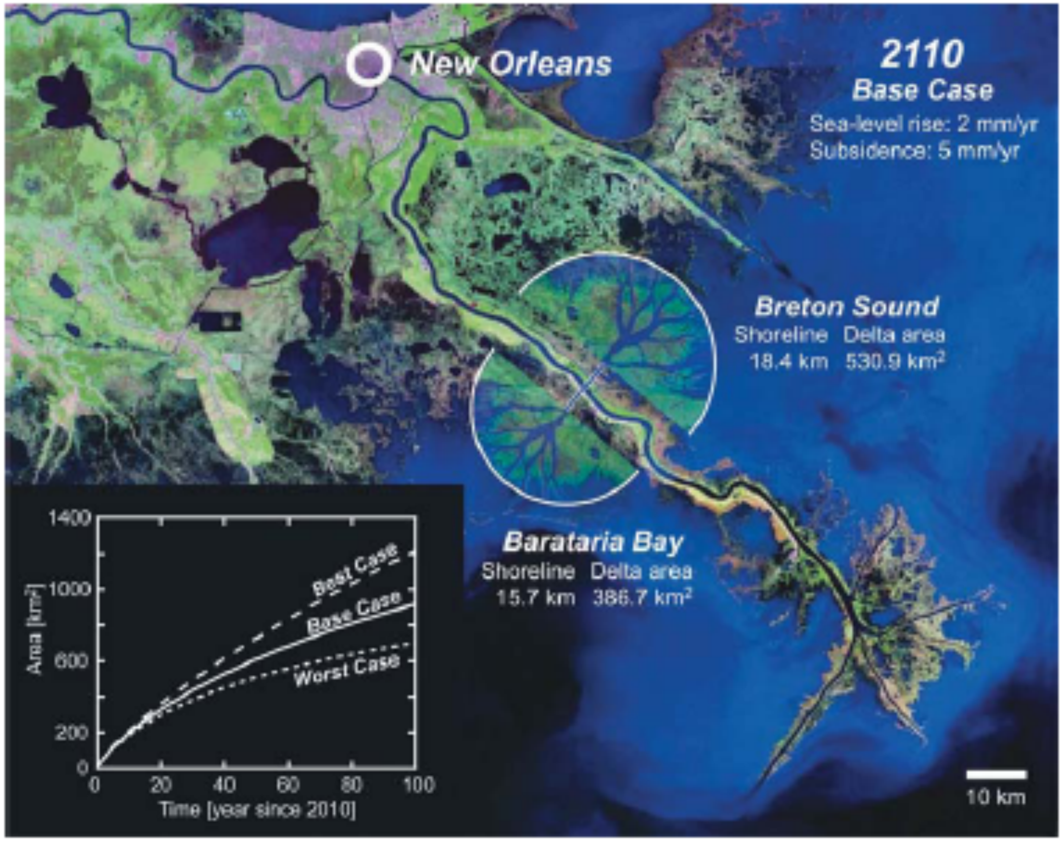
-coring to constrain in-situ conditions

-coupled mechanical and fluid flow models

5: How do fluxes of sediment to margins, and the landscapes they support, respond to changes in climate and land use? How can these insights be used to predict future changes expected for large, heavily populated, low-lying deltas?

The shoreline changes

Figure 5.13. Application of scientific understanding of balances between sedimentation, production of accommodation space, and process transitions to the prediction of future changes expected for large, heavily populated, low-lying deltas. This schematized prediction of the lower Mississippi River below New Orleans shows the predicted new land (delta surface) that could be built over the next 100 years depending on sediment flux, sea level rise, and subsidence rate [from Kim, et al., 2009a based on Kim, et al., 2009b].



5: the shoreline

Problem: not well understood how deltaic morphodynamics respond to subsidence (lithospheric), surface processes (storms), sediment load & composition changes, ecosystems, sea level changes

Needed:

-study of shoreline deposits throughout the Quaternary; shallow geophysics & wells to compare modern coastal systems with past coastal zones