FORUM

U.S. Passive Margins: Are We Missing an Important Opportunity?

Understanding passive margins—thick accumulations of sediments built above the juncture between continental and oceanic crusts—has far-reaching economic and societal implications. Passive margins underlie the coastal regions of most of the conterminous United States, extending continuously from Texas eastward to Florida and northward to Maine. They hide most of the undiscovered hydrocarbon reserves of the United States, and they are excellent sites for sequestering carbon dioxide. Natural hazards of hurricanes, tsunamis, sea level rise, and rapid subsidence, and concerns related to the United Nations Law of the Sea, also make it imperative to better understand passive margins, and how they form and evolve.

Economic and societal concerns provide natural avenues for explaining the importance of this and other hypothesis-driven geoscientific research efforts to U.S. taxpayers and political leaders, especially because much of the U.S. population lives on or near our passive margins. Linkages between fundamental geoscientific research and societal issues are relatively visible and easy to explain to residents of the tectonically active western United States, and comprehensive studies of U.S. passive margins present a similar opportunity to reach and teach residents of the eastern and southern United States. Furthermore, the economic potential of passive margins invites joint study and sharing of data by industrial and academic scientists.

Existing National Science Foundation Programs and Existing Targets

Despite compelling reasons for studying passive margins, the U.S. scientific community is missing the unique opportunity presented by the U.S. National Science Foundation's (NSF) EarthScope initiative to study these important geologic features. EarthScope is an NSF Earth science program to explore the four-dimensional (4-D) structure of the North American continent. EarthScope provides a framework for integrated studies across the Earth sciences, built around the EarthScope Facility, which consists of the Plate Boundary Observatory (PBO), the San Andreas Fault Observatory at Depth (SAFOD), and the USArray of transportable seismometers (www.earthscope.org). The USArray—the most important potential tool for studying passive margins—is being incrementally deployed from west to east across the United States to image mantle structure, and it is scheduled to reach the Texas coast in 2010 and Maine in 2013.

The GeoSwath initiative is an EarthScope effort linked to the USArray to integrate geology and geophysical imaging to better

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understand the 4-D evolution of the continental United States. GeoSwath emphasizes a continuous coast-to-coast perspective across the continent's major geologic provinces (*Tikoff et al.* [2006]; see also http://www.globalchange.umich.edu/ben/geoswath/). We support the GeoSwath initiative and recognize the need to concentrate effort in a few sites (currently seven focus regions plus a xenolith database). However, USArray and GeoSwath, in their present design, stop at the waterline, ignoring the opportunity to study passive margins. Fully 30% of North American continental crust lies beyond the shoreline [*Cogley*, 1984].

The continental United States is located mostly on the North American tectonic plate. The western boundary of the continental United States and this plate mostly correspond. In contrast, passive margins occur in plate interiors, but they are just as important as plate boundaries for understanding continental evolution. Passive margins are built above broad transitional zones, several hundred kilometers across, between distinct continental and oceanic lithospheres.

Only by studying passive margins can we understand how oceanic and continental crust and mantle merge. This lithospheric transition is buried beneath many kilometers of sediments, and it is impossible to study except with the sorts of geophysical tools that USArray and GeoSwath will use. We should not pretend to understand the nature and evolution of the North American continent if we do not understand the passive margin lithospheric transition.

As presently envisioned, Earthscope will not study U.S. passive margins. The GeoSwath initiative addresses passive margin development only indirectly, by studying—within the proposed on-land Appalachian focus site—an ancient passive margin disrupted by younger deformation, magmatism, and uplift. This entails reconstructing deformed and incomplete crustal sections, and it will provide few new insights about how the transition between continental and oceanic lithosphere occurs.

Understanding U.S. passive margins is too important to remain a secondary objective of Earthscope and GeoSwath; it deserves to be a high priority of both. We suggest that two additional focus regions be designed to similarly study the U.S. continental margins along the Atlantic and Gulf of Mexico coasts (Figure 1).

We may also be able to use existing NSF programs in addition to Earthscope to study passive margins; the NSF-MARGINS initiative recognizes the importance of understanding incipient passive margins through its Rupturing Continental Lithosphere (RCL) experiment (http://www.nsf-margins.org/RCL/RCL.html). RCL focuses on active examples of continental breakup, especially in the Gulf of California focus site (a second focus site in the Red Sea was surrendered because of security concerns in the Middle East). Mature passive margins like those of the eastern and southern United States will not be studied by RCL as presently articulated. Another NSF program that could beneficially link to Earthscope and MARGINS is the nascent NSF Ocean Observatories Initiative (http://www.orionprogram.org/OOI/).

It will not be easy to study the deeply buried lithospheric structure beneath passive margins. We also appreciate that USArray and GeoSwath are focused on land studies, and that the shoreline has traditionally marked an operational boundary between land and marine geoscientific efforts. Whatever these obstacles, the fact remains that much of the U.S. continent lies beyond the shoreline and that better understanding the transition between continent and ocean is of paramount importance to the U.S. geoscientific community and broader society.

A Call to Action

We call on the U.S. geoscientific community to discuss how best to reconfigure existing geoscientific initiatives to help Earthscope study passive margins. Perhaps the EarthScope science plan could be modified so that submerged continental lithosphere and the transition to true oceanic lithosphere is included. Or perhaps the MARGINS science plan, specifically RCL, could be modified to include mature passive margins as a research priority.

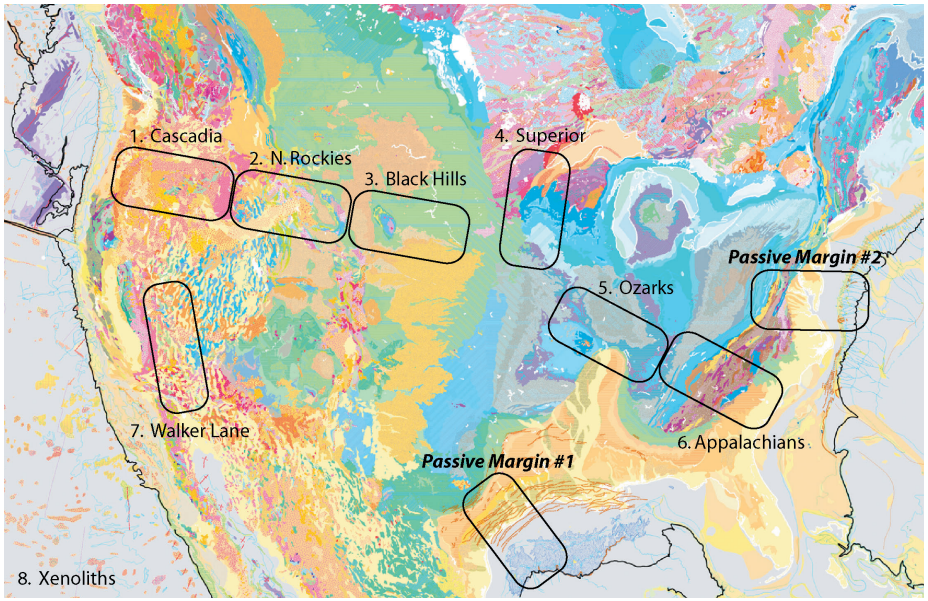

*Fig. 1. The GeoSwath focus areas numbered 1–7 plus xenolith database [*Tikoff et al.*, 2006] placed on the 2005 Geologic Map of North America [*Reed et al.*, 2005]. We have deleted the coastline and emboldened the 3000-meter isobath to stress the point that continental geology does not stop at the coastline. Additional boxes labeled Passive Margin #1 and Passive Margin #2 are just two of many possible candidate focus areas where the U.S. passive continental margins could be studied. Figure modifications thanks to E. A. Hinz.*

Another possibility is for EarthScope and MARGINS-RCL to jointly study passive margins. A first step was made at the second national EarthScope meeting in Monterey, Calif. (March 2007), when two joint GeoSwath/MARGINS workshops separately evaluated possibilities for collaboration at the active continental margin in the Pacific Northwest and across the actively forming passive margin from the Gulf of California to the Salton Trough. MARGINS is contemplating a second decade of its mission and could expand its mission to study passive margins. GeoSwath and Earthscope should look to a future in which funding has grown to allow for the incorporation of target areas that bestride our passive margins, and for USArray-type deployments that extend offshore to the true continental boundary—not limited by the shoreline that is a cartographic irrelevance to our scientific community's scientific goals.

Only if such creativity fails need we consider developing a new geoscientific initiative specifically to study U.S. passive margins. We invite readers to share their ideas for the future synergistic development and enhancement of the Earthscope, GeoSwath, and MARGINS programs to include study of this critical component of our nation.

References

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