Continental Margins - Where the Action Is

For geologists, continental margins are where the action is. Along margins great rivers dump their sediments, coral reefs form, volcanoes erupt, and colliding plates build mountains. The rocks that form along continental margins thus record many of the significant events in Earth's history.

VIMS geologist Dr. Steven Kuehl and colleagues at VIMS and around the world have now established an interdisciplinary program to systematically study these margins.

The objectives of the 10-year MARGINS program, funded by the U.S. National Science Foundation, are ambitious. Says Kuehl, "the stated goals are to rewrite the book when it comes to understanding the processes that operate on continental margins, from mountain top to abyssal plain."

A more thorough understanding of these physical, chemical, and biological processes will help geologists better decipher the record of past changes in climate, landscape, and human activity that are preserved in marine sediments.

MARGINS research will also allow policy makers to better manage how humans interact with the margin environment. The importance of that environment is clear. Continental margins provide many of humanity's mineral and fossil-fuel resources, and hold an ever-increasing percentage of the human population. Nearly two-thirds of humanity—more than 3.5 billion people—now live within 150 kilometers of a coastline. Within three decades, that figure is likely to reach 75 percent.

To achieve its goals, the MARGINS program needs to address the obstacles that have hindered past margin research. These include the sheer size of the margin environment, the wide range of time and space scales on which margin processes operate, and the parochial nature of much past margin research.

The very feature that defines a continental margin—its position at the boundary between land and sea—has traditionally hindered efforts to understand the processes by which margins form and evolve. That's because the physical boundary that defines a margin has also acted as a disciplinary boundary between land-based and marine geologists.

The "Source to Sink" initiative, one of the four main components of the MARGINS science plan, is specifically designed to help break down some of these disciplinary barriers. As its name implies, the initiative encourages researchers from many different fields to collaboratively view rivers, their tributaries, and their submarine distributaries as parts of a holistic sedimentary system, rather than as separate entities.

Dr. Steve Kuehl, center, and VIMS students Tara Kniskern and Dave Fugate on a research cruise collecting seabed samples for future MARGINS work.

Kuehl and colleagues recently submitted a 3-year "Source to Sink" proposal to trace the origin, transport, and deposition of sediments within New Zealand's Waipaoa Sedimentary System, or WSS for short. The WSS lies along the east coast of New Zealand's North Island and encompasses the main body of the Waipaoa River, its headwaters and nearby streams, and the continental shelf and canyons that collect the river's sediments or funnel them further offshore. It was previously deemed a model site for "Source to Sink" field projects.

If funded, Kuehl's team will begin fieldwork later this year. His team is both interdisciplinary and international, with scientists from VIMS, five other U.S. research institutions, and three research partners in New Zealand, including the National Institute of Water and Atmospheric Research (NIWA). VIMS and NIWA signed a General Cooperation Intention in 1998 to foster cooperation in education and research.

The WSS is an ideal field laboratory because its small size eases logistics and because its distinct boundaries provide a closed system whose sediment budget can be calculated readily. Research in the WSS also benefits from the large quantities of sediment that the Waipaoa carries for a river of its size.

"Because the river's discharge rates are so high, its sedimentary signals are huge," says Kuehl. "That makes them easy to measure."

The Waipaoa's extreme turbidity is largely due to human activity. Between 1870 and 1900, ranchers burned most of the Waipaoa's beech and podocarp forests to sheep pasture, which gullies and landslides quickly began to scour. The resulting sediments now choke the river's floodplain, which in some areas has risen 10 meters since the turn of the century. This vast plug of sediment is presumably making its way offshore, where the researchers expect it will leave a clear signal in seafloor sediments.

"The same sorts of things are going on in Virginia," says Kuehl, noting the increased turbidity and shoreline erosion experienced in the Chesapeake since European settlement, "but in a much less extreme way."

Thus the WSS provides a field laboratory in compact caricature. "It only takes about two hours to drive from the river's mouth to its headwaters," says Kuehl, "and the continental shelf is narrow, only about 30 to 40 km wide." Moreover, because the Waipaoa carries so much sediment, its seafloor deposits are written in large, easily readable print.

Kuehl and his team hope to use the passages that humans have recently penned in those sediments to help decipher the record of significant prehistoric events.

"We like to view human impacts in the Waipaoa as an opportunity rather than a problem," says Kuehl. He notes that deforestation in the Waipaoa basin probably increased sedimentation there by a factor of 10, comparable to what geologists might expect following a volcanic eruption or change in climate. Studying the Waipaoa's recent human signal should thus allow geologists to better understand such events elsewhere.

The Waipaoa's extreme sediment load provides another unique research opportunity for Kuehl's team. Kuehl notes that water in rivers, even very turbid rivers like the Amazon, is typically less dense than the salty seawater into which it flows. Thus, a river's freshwater discharge usually floats atop the salt water beneath. The Waipaoa's sediment-laden discharge is unique in that it can be denser than seawater, or "hyperpycnal."

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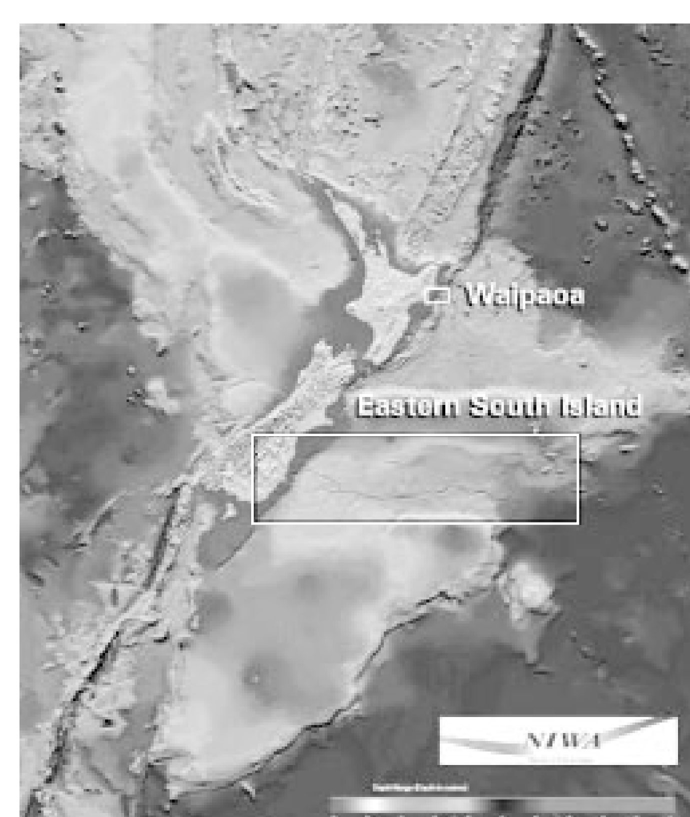

This composite shows elevation of New Zealand and bathymetry of surrounding ocean floor. MARGINS research is proposed for the Waipaoa and Eastern South Island sites.

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Unlike regular surface plumes, hyperpycnal flows move along the seafloor, and can significantly affect seafloor sediments and bottom-dwelling organisms. Kuehl notes that Tropical Cyclone Bola, which struck New Zealand in 1988 with torrential rains, "flushed a plug of sediment out of the Waipaoa system that left a 1-meter-thick layer of goop on the continental shelf, wiping out the bottom community."

Kuehl's team expects that studying these extreme cases will provide fresh insights into the more mundane problems facing oysters and other bottom dwellers in places like the Chesapeake Bay.

Kuehl's team plans to conduct their submarine research using a pair of instrumented tripods brought to New Zealand this winter for a related VIMS research project (see page 5). These, combined with river monitoring equipment provided by NIWA and box cores for taking shallow sediment samples, should allow the team to trace the passage of sediment from sheep pasture to seafloor in real time.

Kuehl hopes that future work using the resources of the Ocean Drilling Program will extend the team's reach farther beneath the seafloor and farther back in time.