Earthquake impact on submarine slopes: Subtle erosion versus significant strengthening

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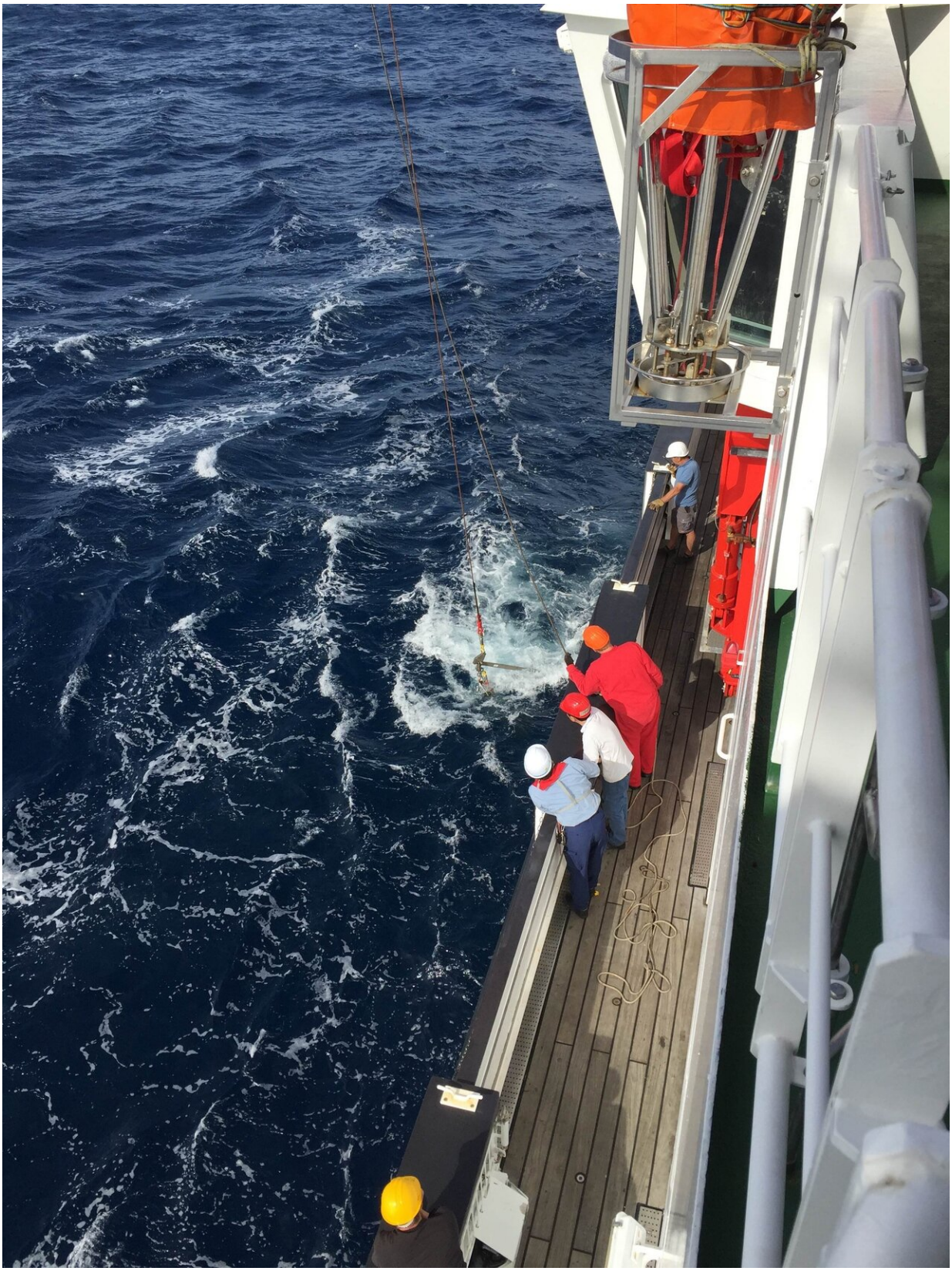

Scientists and shipboard crew await the arrival of a new sediment core onboard research vessel RV Sonne in 2016. Credit: T. Schwestermann

Active margins, where an oceanic plate slides under a continental plate, may cause earthquakes and tsunamis. Further, they are known for shifting sediments from margin slopes into deep ocean trenches. Geologists now found evidence of earthquake-triggered surface sediment erosion on a submarine slope close to the area of the 2011 Tohoku-Oki earthquake.

Whereas most previous research assumed that sediment transport by earthquakes only happened by sliding of sediment packages (i.e. submarine landslides), that are several meters thick, the recently-discovered process of surficial remobilization involves the stripping of only a thin veneer of sediment over an extensive area. At first view a few missing centimeters of sediment do not look very spectacular. However, the fact that it affects a vast area has tremendous implications for all studies based on the remobilization of marine sediment by earthquakes, such as research on pre-historical earthquakes, deposition of organic carbon into the deep ocean and even the potential tsunami hazard by submarine landslides. "Surficial remobilization was hypothesized based on studies of basin deposits. However, to really understand this important process it is crucial to investigate the place where it takes place: the submarine slopes," explains Jasper Moernaut, Assistant Professor at the Department of Geology.

Mind the gap

The researchers combined chemical and physical analyses to detect small centimeter scale gaps in the sediment taken from a slope offshore Japan. Subsequent dating then revealed the potential of the gaps being caused

by seismic shaking. "We were quite amazed when we found that not only one, but three gaps were present in this small 15 cm section of sediment core," says Ariana Molenaar, Ph.D. student at the Department of Geology. "When we dated these three gaps we found that they link to the three strongest regional earthquakes with a magnitude larger than eight, indicating that this is a systematically repeating process."

No one before has examined deep sea slopes with this method. A slope site where erosion takes place is surely the last place one would take a sediment core. "Our pilot study is the first to target a submarine slope to investigate this process, showing the potential of this method," says Michael Strasser, Professor at the Department of Geology. The research team is now applying their strategy in different settings—even in lakes—to further advance their understanding of this newly-discovered process.

Contrasting effect on submarine slopes

Besides the shedding of the uppermost few centimeters, earthquake shaking has another very contrasting effect on the submarine slope: the sediments that remain actually get stronger. This process, called "seismic strengthening," occurs due to the compaction of sediments by violent shaking. "In the ocean, this leads to very stable slope sequences and thus a remarkable absence of submarine landslides," says Jasper Moernaut. So the good news is that—despite the frequent occurrence of strong earthquakes at active ocean margins—tsunamis triggered by submarine landslides are relatively uncommon in these regions.

More information: Ariana Molenaar et al. Earthquake Impact on Active Margins: Tracing Surficial Remobilization and Seismic Strengthening in a Slope Sedimentary Sequence, *Geophysical Research Letters* (2019). DOI: 10.1029/2019GL082350

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