First detailed recordings of earthquakes on ultraslow mid-ocean ridges

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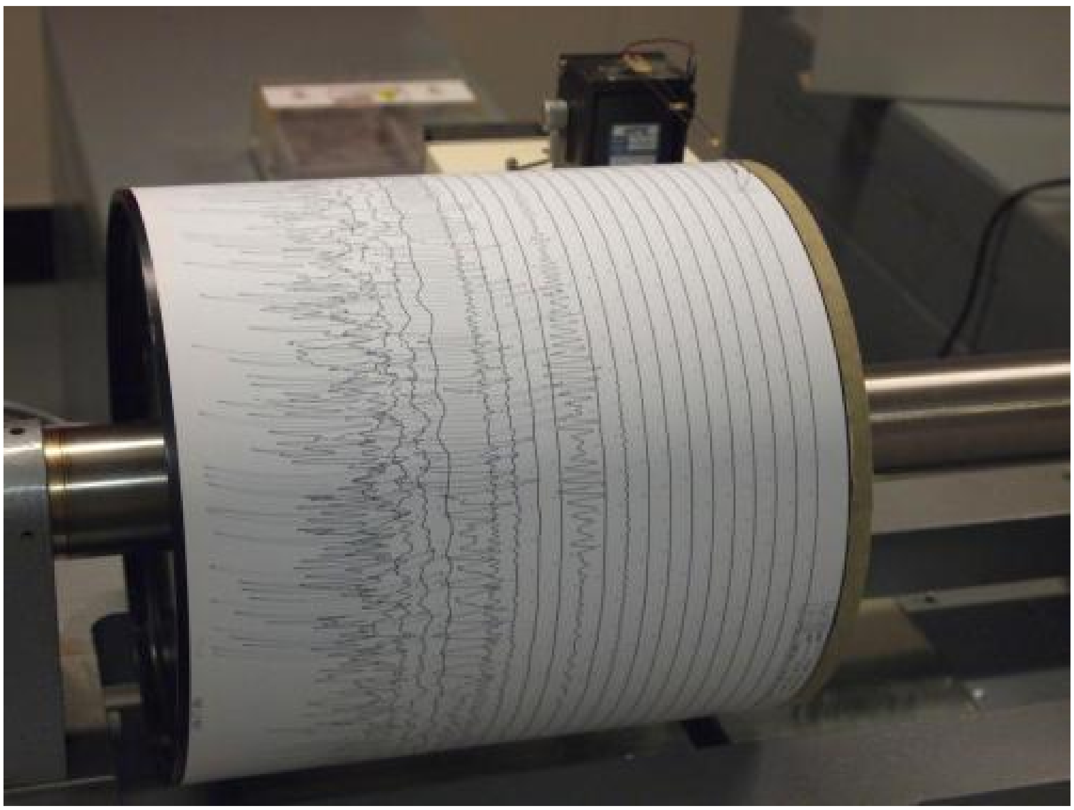

Seismogram being recorded by a seismograph at the Weston Observatory in Massachusetts, USA. Credit: Wikipedia

The earthquake distribution on ultraslow mid-ocean ridges differs fundamentally from other spreading zones. Water circulating at a depth of up to 15 kilometres leads to the formation of rock that resembles soft soap. This is how the continental plates on ultraslow mid-ocean ridges may move without jerking, while the same process in other regions leads to many minor earthquakes, according to geophysicists of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI). Their study is going to be published advanced online in the journal *Nature* on Wednesday, June 29, 2016.

Mountain ranges like the Himalayas rise up where continental plates collide. Mid-ocean ridges, where the continents drift apart, are just as spectacular mountain ranges, but they are hidden in the depths of the oceans. On the seabed, like on a conveyor belt, new ocean floor (oceanic lithosphere) is formed as magma rises from greater depths to the top, thus filling the resulting gap between the lithospheric plates. This spreading process creates jerks, and small earthquakes continuously occur along the conveyor belt. The earthquakes reveal a great deal about the origin and structure of the new oceanic lithosphere. On the so-called ultraslow ridges, the lithospheric plates drift apart so slowly that the conveyor belt jerks and stutters and, because of the low temperature, there is insufficient melt to fill the gap between the plates. This way, the earth's mantle is conveyed to the seabed in many places without earth crust developing. In other locations along this ridge, on the other hand, you find giant volcanoes.

Ultraslow ridges can be found under the sea ice in the Arctic and south of Africa along the Southwest Indian Ridge in the notorious sea areas of the Roaring Forties and Furious Fifties. Because these areas are so difficult to access, earthquakes have not been measured there. And so until now, little was known about the structure and development of around 20 percent of the global seabed.

With the research vessel Polarstern, a reliable workhorse even in heavy seas, the researchers around Dr Vera Schlindwein of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI), have now for the first time risked deploying a network of ocean bottom seismometers (OBS) at the Southwest Indian Ridge in the Furious Fifties and recovered them a year later. At the same time, a second network was placed on a volcano in the more temperate latitudes of the Southwest Indian Ridge. "Our effort and our risk were rewarded with a unique set of earthquake data, which for the first time provides deep insights into the formation of the ocean floor when spreading rates are very slow," explains AWI geophysicist Vera Schlindwein.

Her results turn current scientific findings on the functioning of ultra-slow mid-ocean ridges upside down: Schlindwein and her PhD student Florian Schmid found that water may circulate up to 15 kilometres deep in the young oceanic lithosphere, i.e. the earth crust and the outer part of the earth mantle. If this water comes into contact with rock from the earth mantle, a greenish rock called serpentinite forms. Even small quantities of ten percent serpentinite are enough for the rock to move without any earthquakes as if on a soapy track. The researchers discovered such aseismic areas, clearly confined by many small earthquakes, in their data.

Until now, scientists thought that serpentinite only forms near fault zones and near the surface. "Our data now suggest that water circulates through extensive areas of the young oceanic lithosphere and is bound in the rock. This releases heat and methane, for example, to a degree not previously foreseen," says Vera Schlindwein.

The AWI geophysicists were now able to directly observe the active spreading processes using the ocean floor seismometers, comparing volcanic and non-volcanic ridge sections. "Based on the distribution of earthquakes, we are for the first time able to watch, so to speak, as new lithosphere forms with very slow spreading rates. We have not had such a data set from ultra-slow ridges before," says Vera Schlindwein.

"Initially, we were very surprised that areas without earth crust show no earthquakes at all down to 15 kilometres depth, even though OBS were positioned directly above. At greater depths and in the adjacent volcanic areas, on the other hand, where you can find basalt on the sea floor and a thin earth crust is present, there were flurries of quakes in all depth ranges," says Vera Schlindwein about her first glance at the data after retrieving the OBS with RV Polarstern in 2014.

The results also have an influence on other marine research disciplines: geologists think about other deformation mechanisms of the young oceanic lithosphere. Because rock that behaves like soft soap permits a completely different deformation, which could be the basis of the so-called "smooth seafloor" that is only known from ultra-slow ridges. Oceanographers are interested in heat influx and trace gases in the water column in such areas, which were previously thought to be non-volcanic and "cold". Biologists are interested in the increased outflow of methane and sulphide on the sea floor that is to be expected in many areas and that represents an important basis of life for deep-sea organisms.

More information: Mid-ocean-ridge seismicity reveals extreme types of ocean lithosphere, *Nature*, DOI: 10.1038/nature18277

Provided by Alfred Wegener Institute