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Data Show Antarctic Ice Streams Stick, Slip Like an Earthquake

University Park, Pa. -- A seismologist at Washington University in St. Louis and colleagues at Penn State and Newcastle University, U.K., have found seismic signals from a giant river of ice in Antarctica that make California's earthquake problem seem trivial.

Douglas A. Wiens, Washington University professor of earth and planetary sciences; Sridhar Anandakrishnan, associate professor of geosciences and J. Paul Winberry, Penn State; and Matt A. King, NERC fellow, Newcastle, combined seismological and global positioning system (GPS) analyses to reveal two bursts of seismic waves from an ice stream in Antarctica every day, each one equivalent to a magnitude seven earthquake. The GPS analyses were performed by Penn State and Newcastle University researchers.

The ice stream is essentially a giant glacier 60 miles wide and one-half mile thick. The data show that the river of ice moves about 18 inches within 10 minutes, remains still for 12 hours, then moves another eighteen inches. Each time it moves, it gives off seismic waves that are recorded at seismographs all around Antarctica, and even as far away as Australia.

Seismic waves from what are loosely called "glacial earthquakes," mainly near Greenland, were originally reported in 2003, and the numbers have been increasing in recent years. Some scientists think the waves come from the phenomenon of calving, where a big chunk of ice breaks off of a glacier and floats away in the ocean, a very violent activity that could generate strong seismic signals. The new results show that at least some of the glacial earthquakes are produced by sudden sliding of large ice sheets.

The Antarctic signals were first detected by seismographs deployed by Wiens and his colleagues in 2001-2003 at a location about 500 miles away from the ice stream.

"At first we didn't know where the waves were coming from, but eventually we were able to narrow down the source to the ice stream." Wiens said.

Prior to this discovery, researchers were not aware that ice streams radiated seismic waves.

"By some measures, the seismic impact is equivalent to a very large earthquake, but it doesn't feel like it because the movement is much slower than a real earthquake," Wiens said.

"The data look an awful lot like an earthquake, but the slip lasts for 10 minutes, while on the other hand, an earthquake of this size would last for just ten seconds. I guess you could call it an earthquake at glacial speed. This is very strange behavior, and we need to understand more about it," he added.

GPS instruments placed directly on the ice stream can detect where slipping motion begins and where it stops. Scientists describe the motion as a stick-slip, which is the classic motion of earthquakes, occurring when the area around a fault moves slowly but the fault is stuck, remaining stationary until the stress builds up and the fault finally slips.

"The GPS shows us directly how the ice stream moves," Wiens said. "The slip starts in a certain part of the ice stream and then it moves out, rather like a landslide might start at a certain point and then move out to envelope an entire mountainside. The GPS tells us which part moved first and what other parts moved next and so forth."

The data show that the slip always starts from the same spot on the bed of the ice stream, what glaciologists call a "sticky" spot, which has more friction than the surrounding part of the bed.

"Glaciologists had thought that they understood how glaciers move, and they thought they move slowly and continuously by creep, but now this indicates that they move with a fast slip, almost like an earthquake," Wiens said.

The study is published in the June 5 issue of Nature on-line and was funded by the National Science Foundation.

Wiens said that it is important to understand the physics behind what is controlling this kind of slip.

"This stick-slip phenomenon may provide a clue about what makes these ice streams move faster or slower," he said. "This particular ice stream has been slowing down over the last few decades, and no one knows why."

Wiens plans to study seismic records of stick-slip events going back several decades to see if there are changes, and also to search for similar signals from other ice streams.

"We need to understand what controls the speed of the ice streams, because that will affect how fast the ice in Antarctica will go away and sea level will rise as global warming melts the West Antarctic Ice Sheet."

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