When glacier motion goes seismic: Asperities and creeping zones revealed by regional-scale GPS and passive-source seismic monitoring of a 'glacier fault' in West Antarctica

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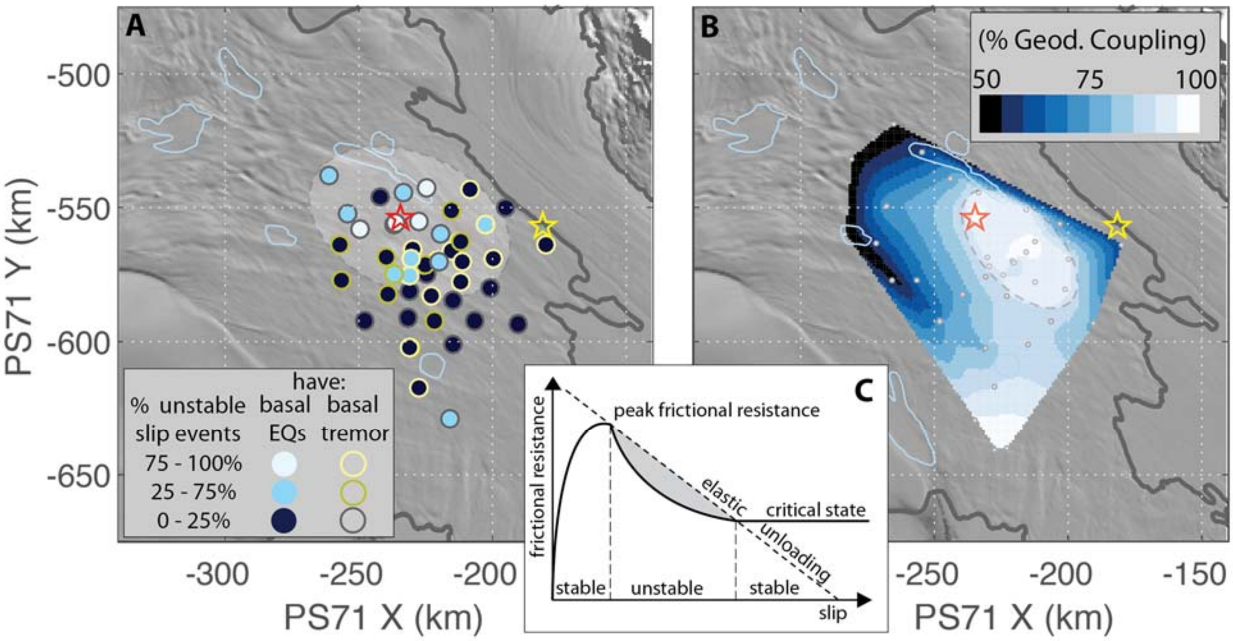

Abstract: Unstable (accelerating) frictional sliding is responsible for some of the most catastrophic natural phenomena such as earthquakes and landslides. Glacier sliding, however, is supposed to be of the stable kind due to the viscous nature of ice. This established paradigm of glacier motion is, however, challenged by observations from Whillans Ice Plain, West Antarctica. This immense slab of ice, that is ca. 100 by 100 by 1 km in size, experiences tidally-paced stick-slip cycles during which it moves very slowly (about 0.01 m per hour) for most of the time but then jerks forward by up to 0.6 m in 20-30 minutes. Each slip event release as much energy as an earthquake of moment magnitude 7. As part of a multi-year project funded by the US National Science Foundation we have instrumented the Whillans Ice Plain with a network of GPS receivers and seismometers, including deep borehole seismometers. These new data reveal that the glacier bed is highly heterogeneous on regional and local scales, with much of it being seismically quiet, which is what glaciological sliding laws would predict. Nonetheless, abundant micro seismicity is detected near the previously identified 'hypocenter' of Whillans stick-slip events. We interpret the subglacial sources of micro seismicity as areas where the ice base is eroding relatively rigid geologic materials while the seismically quiet parts of the bed are blanketed by a deformable subglacial till (analogous to gouge on fault planes). Nothing about the subglacial setting of Whillans Ice Plain appears unusual suggesting that unstable sliding is an ubiquitous contributor to ice motion in Antarctica and elsewhere and should be represented in modeling of glaciers and ice sheets.

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L1 Lecture Theatre

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