Pinpointing hot spots: Small droplets of friction-generated melts weaken faults and can lead to 'megaquakes'

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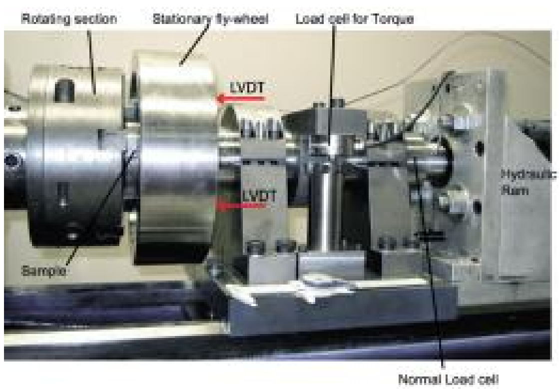

Researchers used a rotary shear apparatus to identify 'melt welts.'

(Phys.org)—Scientists at Scripps Institution of Oceanography at UC San Diego have come a step closer to deciphering some of the basic mysteries and mechanisms behind earthquakes and how average-sized earthquakes may evolve into massive earthquakes.

In a paper published in the Aug. 30 issue of the journal *Nature*, Scripps scientists Kevin Brown and Yuri Fialko describe new information gleaned from laboratory experiments mimicking earthquake processes. The researchers discovered how fault zones weaken in select locations shortly after a fault reaches an earthquake tipping point.

They coined such locations as "melt welts" and describe the mechanism akin to an ice skater's blade reducing friction by melting the ice surface. The mechanism may be similar to "hot spots" known in automobile brake-clutch components.

"Melt welts appear to be working as part of a complicated feedback mechanism where complex dynamic weakening processes become further concentrated into initially highly stressed regions of a fault," said Brown, first author of the study and a professor in the Geosciences Research Division at Scripps. "The process allows highly stressed areas to rapidly break down, acting like the weakest links in the chain. Even initially stable regions of a fault can experience runaway slip by this process if they are pushed at velocities above a key tipping point."

Arrows point to 'melt welts' (left), areas where faults weaken, and scanning electron microscope closeups (top and bottom on right)." alt="Arrows point to 'melt welts' (left), areas where faults weaken, and scanning electron microscope closeups (top and bottom on right).

"This adds to the fundamental understanding of the earthquake process because it really addresses the question of how these ruptures become energetic and dynamic and run away for long distances," said Fialko, a paper coauthor and a professor in the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics at Scripps.

The study's results, supported by funding from the National Science Foundation, appear to help answer a longstanding paradox in seismology. Key fault zones such as the San Andreas Fault produce far too little heat from friction compared with the size and magnitude of the earthquakes they produce. Laboratory experiments show that thermal energy normally released by friction during slip can become rapidly reduced, potentially helping to account for a "low heat flow paradox." The melt welts also may help explain certain questions in earthquake rupture dynamics such as why some slowly slipping tremor-generating events can snowball into massive earthquakes if they pass a velocity tipping point.

"This may be relevant for how you get from large earthquakes to giant earthquakes," said Brown, who used the example of last year's magnitude 9.0 earthquake off Japan. "We thought that large patches of the fault were just creeping along at a constant rate, then all of a sudden they were activated and slipped to produce a mega earthquake that produced a giant tsunami."

Fialko says the melt welt finding could eventually lead to improved "shake" maps of ground-shaking intensities, as well as improvements in structural engineering plans. Future studies include investigations about why the melt welt weakening occurs and if it applies to most or all common fault zone materials, as well as field research to locate melt welts along fault zones.

The Scripps Marine Science Development Center provided the machinery used in the study's experiments.

Provided by University of California - San Diego