# Measurements link magma melting rate to tectonic plate subduction rate

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Determining the origin and rate of magma production in subduction zone volcanoes is essential to understanding the formation of continental crust and the recycling of subducted materials back into Earth's mantle.

Now, geologists at the University of Illinois report new measurements of rock samples from Kick'em Jenny, a submarine volcano in the Caribbean, that link the rate at which magma is produced beneath subduction zone volcanoes to the rate at which tectonic plates converge in this plate tectonic setting.

"We can use the geochemical measurements to constrain a geophysical parameter, the melt production rate; we then relate the melting rate at an individual subduction zone to its plate convergence rate, which can also be measured," said Craig Lundstrom, a UI professor of geology. "We can then use this information in similar situations to understand the rate at which magma is produced in other settings."

Lundstrom and graduate research assistant Fang Huang report their findings in the November issue of the journal *Geology*, which is published by the Geological Society of America.

The geochemical technique is based on uranium decaying to lead through a long decay chain of short-lived nuclides. For example, U-235 (a "parent" with a half-life of 700 million years) will decay to Pa-231 (protactinium-231: a "daughter" with a half-life of 33,000 years). By measuring the ratio of parent and daughter species in a rock sample (a

technique called uranium-series dating), scientists can determine whether the rock is in secular equilibrium (and quite old), or in uranium series-disequilibrium (and very young).

Using multiple-collector inductively coupled plasma-mass spectrometry, Huang and Lundstrom analyzed 12 rock samples from Kick'em Jenny, a submarine volcano located about 8 kilometers north of Grenada in the southern Lesser Antilles arc.

At Kick'em Jenny, the Atlantic oceanic plate is being pushed beneath the Caribbean plate at a rate of 2-4 centimeters per year, one of the lowest convergence rates of any subduction zone.

In Kick'em Jenny lavas, the researchers found there was twice as much protactinium than should be present if the system was in secular equilibrium. This is the largest protactinium-uranium disequilibrium found in any subduction-zone volcano.

The relationship between melting rate and convergence rate centers on the role of water during melting. "An essential part of all volcanoes at subduction zones is the amount of water involved in the mantle melting process," Huang said. "During subduction, water is released from the subducting slab into the mantle wedge, which lowers the melting point of the rock. When less water is transported to the mantle, less melt is produced."

At Kick'em Jenny, water is being added very slowly, because the subducting plate is going down very slowly, Lundstrom said. This results in a slower melting rate, which produces a higher ratio of protactinium to uranium 235.

"This is the first study to show that there is a straightforward relationship between this uranium disequilibrium system and the rate of tectonic

plate convergence," Lundstrom said. "No doubt these short-lived nuclides can be used for a variety of other processes in volcanoes, from determining how fast crystals form to how fast magma moves under mid-ocean-ridge volcanoes."

Source: University of Illinois at Urbana-Champaign