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Volcanism triggered by giant megathrust earthquakes

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We studied the effect of megathrust earthquakes at several convergent plate boundaries on Earth and have found evidence that large earthquakes at these boundaries lead to increased volcanic activity in adjacent arcs. Following the earthquakes M8.3 in Guatemala (1902), M9.0 in Kamchatka (1952), and M9.5 in Chile (1960), the cumulative number of new eruptions at all three of these volcanic arcs sharply increased. In some cases (e.g. Chile) activity increased almost instantaneously after the quake, and lasted for several years. This suggests that changes of the static stress field and processes deeper and additional to just "shaking the shallow system" are involved.

Using numerical models, we simulated the coseismic fault dislocations of the megathrust earthquakes and calculated the resultant stress change at all of the historically active volcanoes. For Guatemala, Kamchatka and Chile, our models suggest that volcanoes erupting after a major earthquake underwent a significant pressure change ($>$ 0.1MPa) at depths of up to $>$30km. A consistent result of all models is that the pressure change is negative, i.e. that the pressure under the volcanoes decreased. Likely short-term consequences (weeks to months) of stress changes are opening of magma pathways, bubble liberation and bubble growth in mid- to shallow crustal magma reservoirs, which may lead to eruption of magma already stored in volcanic edifices. Probable long-term consequences (years to decades) are generation of new melt in the shallow mantle beneath the arcs by decompression and associated ascent of new basaltic magma, rejuvenating dormant or sleeping volcanoes.

We also simulated the co-seismic dislocation of the M9.0 Indonesia (2004) earthquake and calculated the related stress changes beneath the nearby Sumatran arc volcanoes. Similar to the examples given above, our models suggest that the 2004 megathrust earthquake caused a pressure decrease of up to 0.1MPa under the volcanoes of NW Sumatra. At the time of writing (Jan 21, 2005), no volcano in northern Sumatra showed

unusual activity (the last significant eruption in northern Sumatra occurred in 1937 at Geureudong Volcano). This could imply that none of the nearby volcanoes was critically close to eruption at the time of the December 26th earthquake. However, conditions at deeper magmatic levels have most certainly changed, similar to the historic examples above, and so we expect renewed activity in northwestern Sumatra over the next month to years.