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Earthquake source scaling, stress drops and seismic efficiency of intermediate-depth earthquakes

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The mechanism for intermediate depth and deep earthquakes is still under debate. In contrast to conditions in the crust and shallow lithosphere, at temperatures and pressures corresponding to depths >50 km one would expect rocks to yield by creep or flow and not by brittle failure, so there has to be a physical mechanism that allows for brittle or brittle-like failure for intermediate-depth earthquakes. Two such mechanisms have been proposed: dehydration embrittlement and thermal shear runaway.

In order to better understand the rupture mechanism it is important to study the earthquake sources and their behavior or scaling as a function of earthquake size. In this study different source parameters are analyzed including rupture area, stress drop and radiated seismic energy for a range of magnitudes and compared to typical values observed for shallow earthquakes. We study these source parameters for a large number of earthquakes in the Bucaramanga Nest, a concentrated pocket of seismic activity with median depth of 160 km and more than 15 earthquakes per day.

Relatively high stress drops but typical radiated seismic energies compared to their shallow counterparts are observed for Bucaramanga Nest earthquakes suggesting a very low seismic efficiency. A significant portion of the energy budget is being used for rupturing the rocks or increasing temperature and possibly partial melting during rupture. These observations are thus more indicative of a thermal shear runaway process than dehydration embrittlement.