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Constraining the mechanism of deep earthquakes in diverse tectonic settings

German Prieto (1), Manuel Florez (2), and Linda Warren (3)

(1) Universidad Nacional de Colombia, Departamento de Geociencias, Bogota, Colombia (gaprietogo@unal.edu.co), (2) Department of Earth, Atmospheric and Planetary Sciences, MIT, Cambridge, MA. , (3) Department of Earth and Atmospheric Sciences, Saint Louis University, Saint Louis, MO

Earthquakes deeper than about 50 km depth represent one of the open questions in seismology. High pressure and temperature conditions should prevent brittle rupture to occur, but about 25% of global catalogs are deep earthquakes. Many deep earthquakes occur along (or related) to subducting lithosphere and mechanisms such as dehydration embrittlement or phase transformation have been used to explain their presence.

We show seismological observations of three kinds. A deep continental lithospheric mantle earthquake in Wyoming occurs at much higher temperatures than needed to sustain brittle rupture. Rupture characteristics suggest that rupture occurs within a ductile or transitional regime. We have found a large number of small earthquakes located within the mantle wedge above a subducting plate, again in a region where ductile behavior is expected. We present a simple model to explain their presence and suggest that these types of mantle wedge earthquakes should be observed in other subducting regions. Finally, using a precise relocation technique, we are able to separate the seismicity of the upper and lower planes of double seismic zones. Our initial results show that the seismicity behavior for the two regions are different, suggesting the driving mechanism is also different.