Geophysical Research Abstracts
Vol. 19, EGU2017-18881-1, 2017
EGU General Assembly 2017

A quantitative analysis of global intermediate and deep seismicity

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The seismic activity in subduction zones around the world shows a large spatial variabilty with some regions exhibiting strong seismic activity down to depths of almost 700km while in other places seismicity terminates at depths of about 200 or 300 km. Also the decay of the number of seismic events or of the seismic moment with depth is more pronounced in some regions than in others. The same is true for the variability of the ratio of large to small events (the b-value of the Gutenberg-Richter relation) that is varying with depth. These observations are often linked to parameters of the downgoing plate like age or subduction velocity.
In this study we investigate a subset of subduction zones utilizing the revised ISC catalogue of intermediate and deep seismicity to determine statistical parameters well suited to describe properties of intermediate deep and deep events. The seismicity is separated into three depth intervals from 50-175km, 175-400km and >400km based on the depth at which the plate contact decouples, the observed nearly exponential decay of the event rate with depth and the supposed depth of phase transition at 410 km depth where also an increase of the event number with depth is observed. For estimation of the b-value and the exponential decay with depth, a restriction of the investigated time interval to the period after 1997 produced significantly better results indicating a globally homogeneous magnitude scale with the magnitude of completeness of about Mw 5. On a global scale the b-value decreases with depth from values of about 1 at 50-175km to values of slightly below 0.8 for events below 400km. Also, there is a slight increase of the b-value with the age of the subducting plate. These changes in the b-value with depth and with age may indicate a varying fragmentation of the slab. With respect to the ratio of the seismic moment between deeper and shallower parts of the subduction zones a dependence on the age is apparent with older slabs exhibiting higher ratios indicating stronger hydration of older slabs and consequently stronger seismic activity at depth in older and thicker slabs. Furthermore, older slabs show the tendency to larger b-values. This indicates stronger fragmentation of older slabs favoring smaller events.
Between 50 km and 300 km depth, seismicity in subduction zones decays nearly exponentially with depth. However, the majority of subduction zones show between about 60 km and 100 km lower seismic activity than expected by an exponential decay. This observation correlates well with findings from petrological studies that rocks are rarely scraped off from the downgoing plate at these depths indicating low seismic coupling and low stresses at the plate interface in a depth range below the seismogenic zone and above 100 km depth were dehydration reactions become virulent. Interestingly, the percentage of this deficit becomes larger with plate age for event frequency (reduced number of events), but decreases for moment release (events have larger magnitudes). It is observed that the forearc high is located above the plate interface with reduced seismic coupling. The forearc high is thus an indication of upward directed return flow along the seismically decoupled plate interface. In addition, it is found that the topography of the forearc high is larger above shallow dipping slabs.
A correlation of the depth dependent seismic behavior with the subduction or trench velocity is not observed for the investigated subduction zones. Plate age seems to be the dominating factor for properties of intermediate deep and deep seismicity.