Links between earthquake depths, lithosphere thickness and rheology on the continents

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Abstract

Over the last decade advances in earthquake seismology have allowed us to make increasingly detailed maps of the variations in lithosphere (plate) thickness on the continents. The variations are dramatic, with some places up to 300 km thick, and clearly relate to the geological history of the continents as well as their present-day deformation. Though the horizontal resolution of the maps is currently about 200 km, that is still sufficient to show that many features which are apparently isolated in the middle of continents, such as intracratonic basins, intraplate earthquakes and volcanism, are in fact either within or on the edge of thick lithosphere, and correlate also with variations in plate strength that control the scale of geological structures and stratigraphy. Where the lithosphere thickness is about 120 km or less earthquakes are generally confined to upper crustal material that is colder than about 350oC. On the edge of thick lithosphere, the entire crust may be seismogenic, with earthquakes sometimes extending into the uppermost mantle if the Moho is colder than 600oC; but generally the continental mantle is aseismic. In such regions, earthquakes in the lower crust at 400-600oC require the crust to be anhydrous (granulite facies) and are a useful guide or proxy to both composition and strength. These correlations have important implications for earthquakes in slowly deforming regions on the edge of continental shields or platforms, where the large seismogenic thickness can host very large earthquakes, as shown by historical and modern events and also by dramatic Holocene and late-Quaternary fault scarps.

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