The cause of current Australian intraplate tectonism

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Abstract

The AGSO earthquake database of Australia compiled over the last 25 years and supplemented with early and pre-seismograph historical data is the source for most earthquake hazard analyses in the continent. At present the map changes every few years because earthquakes keep happening in unexpected places.

The largest known onshore earthquake in historical time was the 1941 Meeberrie WA earthquake of magnitude Ms 6.9, one of 20 independent magnitude 6 or larger earthquakes over the last 100 years. Seven earthquakes since 1967 have ruptured the ground surface including the three $M6^{+}$ earthquakes near Tennant Creek NT in 1988. Most of these large earthquakes caused little damage because they were so distant from population centres. The most recent large earthquake Mw 6.2 was in 1997 at Collier Bay WA, almost 2000 km from the nearest city, Perth. Most Australian earthquakes are very shallow and occur within 15 km of the surface.

The two most damaging earthquakes in Australia to date were both of magnitude 5.6; at Adelaide SA in 1954, and near Newcastle NSW in 1989, the latter the most destructive natural disaster in Australia in the last 200 years. In a country that suffers potentially very damaging earthquakes relatively infrequently, one magnitude 5.5 event every two or three year on average, the combination of earthquake and urban proximity is lethal, even for such moderate sized events. This is especially true in Australia where few buildings have been designed to resist earthquakes and where the norm is to build low rise buildings of unreinforced masonry on soft foundations - a vulnerable combination.

Maps of the epicentres superimposed on AGSO's continent-wide geophysical datasets depicting crustal structure have been plotted to assist delineation of source zone so that more stationary hazard estimates can be made. Areas of major gravity anomalies in the centre of the continent do not seem to be associated with more frequent or larger earthquakes than compensated crustal sections in other parts of the continent and the same lack of correlation is observed between magnetic anomalies and earthquakes. A significant electrical conductor inferred from the magnetics which may relate to a major crustal discontinuity is not reflected by the seismicity. Broadscale geological structure as summarised in the crustal elements map does not seem to influence the location of epicentres either and some of Australia's largest mapped faults such as the Darling Fault near Perth are quite inactive today. The same is true of the topography; mountains and basins are each as likely as the other to attract earthquakes.

What is apparent is a surprising pattern of epicentres independent of the geological age or type of crustal rocks. The mechanisms of these earthquakes are usually shallow dipping thrusts with a horizontal principal stress and typically have similar principal stress azimuths within large domains but these directions rotate from one domain to another.

The pattern of earthquakes reflects a failure mode which is frequently observed in soil and rock mechanics laboratories. This pattern is also seen in rose diagrams of large scale lineaments and coastlines. The inferred intraplate stresses can be simply related to plate boundary stresses. This model also explains how the principal stress could vary from one region to another.

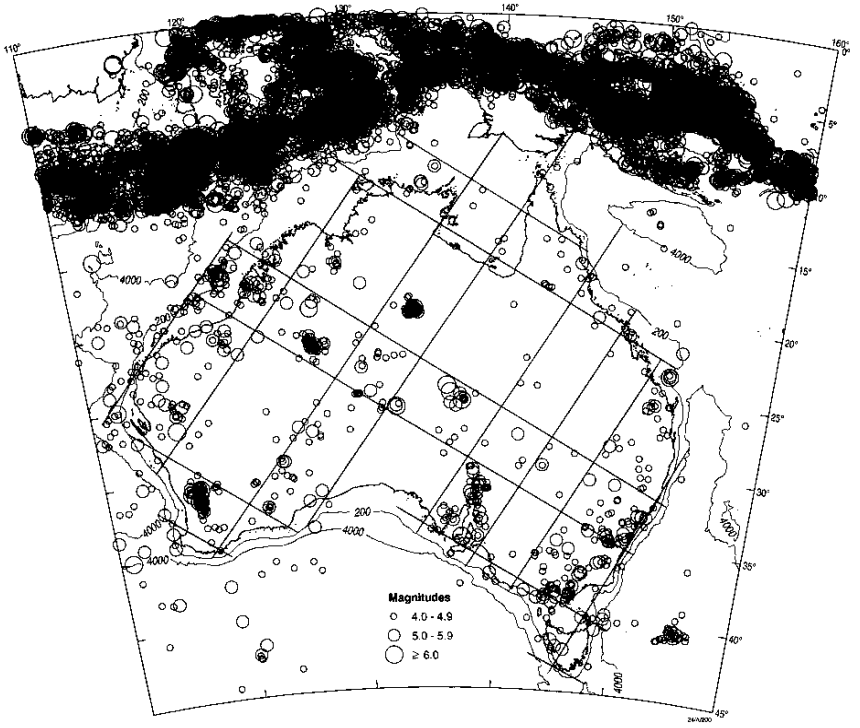

Figure Earthquake epicentres 1900 - 1997, magnitude $M \geq 4$ and shear zones

Such a pattern can be explained by simple Coulomb failure under north-south or east-west compression of the continent. GPS measurements show that Australia is drifting north relative to both Antarctica and Eurasia, the Australian Plate colliding in the north with the Pacific and Eurasian Plate and in the east with the Pacific Plate. Tensional stresses dominate its southern and western boundaries with the Antarctic and African Plates. The epicentres align into characteristic x-shapes oriented northwest and northeast across the continent. Three parallel sets of 'shear zones' can be identified, the most conspicuous running northwest across the centre of the continent from about the central coast of New South Wales to northwest Western Australia .

These 'shear zones' encompass more than 90% of all past earthquakes, 100% of the large earthquakes and known paleo-events and all the Recent volcanoes. We have commenced a statistical study of the pattern of epicentres to see whether such a pattern could reasonable be expected to occur by chance.