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Topographic controls on the rupture area of great subduction earthquakes

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Subduction megathrust earthquakes cause catastrophic damage. Can a large-scale investigation of their rupture areas give insights into earthquake mechanics and aid hazard prediction? This study presents a compilation of rupture events on the South American margin and correlates their spatial distribution with features of the subducting slab. Correlation is observed visually between “rupture ends” and the position of more prominent topographic anomalies; the statistical significance of this relationship was assessed. Topographic features with kilometre-scale relief were shown to have a significant effect on rupture end location.

Rupture areas of recent (post 1973) great earthquakes (Mw>8.0) were compiled from seismometer records. Uplift and intensity records were used for older events (Kelleher 1972). The spatial distribution of rupture ends was compared to the location of fracture zones and topographic features within the subducting plate. Ridges, seamount chains and young fracture zones were classified as topographic features based on their elevation above the surrounding seafloor. Numerical simulations used for statistical tests generated random earthquake locations and magnitudes, obeying earthquake scaling relationships and magnitude-frequency distribution observations. These simulations show that 100% more earthquake rupture ends plot within 50km of ‘large’ topographic features (>1200m above local mean depth) than would be expected. Moreover, the observed number of earthquake ends within 50km of these features is only reproduced by 5-7.5% of simulations run. However if smaller topographic features (>600m tall) are included as well, only 7% more earthquake ends plot within 50km than a random distribution, a statistically insignificant result. Using observed rupture patterns and randomly positioned features produces the same results. Qualitatively, these re-

sults are supported by the observation that all bar one of the topographic features 600-1200m above local mean depth are overlapped by at least one great earthquake. Thus it is demonstrated that subduction of kilometre-scale topographic features significantly influences the segmentation of great earthquake ruptures. Smaller topographic features and seafloor-age discontinuities do not have this effect. These findings can be used to predict the earthquake rupture areas which will fill a seismic gap, existing at 20°S since 1877.