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Earthquakes, elevations and the construction of continental plateaux

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It has long been noted that larger thrust earthquakes (M>∼5) are rare at higher elevations in continental fold-and-thrust belts. For example, the cut-off is the 1250 m elevation contour in the Zagros fold-and-thrust belt, while thrust events are rare above 3500 m in the Himalayas and other fold-and-thrust belts marginal to the Tibetan Plateau. There are various possible explanations for this phenomenon, including aspects of the critical wedge model, but one interpretation which has addressed the relationship is the recognition that higher elevation regions resist major seismogenic thrusting due to the additional gravitational potential energy (GPE) added from the increase in height.

Here we have investigated the elevation distribution of earthquake data sets for the Qilian Shan (at the northeast margin of the Tibetan Plateau) and the Zagros, to identify a relationship between elevation and earthquake magnitude. Preliminary findings show a gradual reduction of larger thrust events rather than an abrupt termination. Regression analysis has additionally been carried out on the plots created to test the strength of the relationship found between elevation and magnitude. We aim to repeat this analysis over a variety of different areas via the use of public–domain datasets for seismicity and topography in an attempt to quantify this relationship.

We are also investigating an alternative model, where increase in height, and therefore in lithostatic load, creates a thicker zone of distributed deformation above the temperature dependent brittle-plastic transition. This could potentially suppress the ability of large earthquakes to propagate through the entire brittle crust, while still allowing smaller earthquakes to continue to develop above and also below the brittle-ductile transition. Future work will involve laboratory analysis to mimic the increasing conditions of confining pressure experienced by rocks as the regional elevations increase. This will aim to understand how large earthquakes may evolve to distributed deformation. An additional area of interest is what effects and modifies topographic slope of such regimes.