SEISMOLOGY

Tectonic strain in plate interiors?

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It is not fully understood how or why the inner areas of tectonic plates deform, leading to large, although infrequent, earthquakes. Smalley *et al.*[1] offer a potential breakthrough by suggesting that surface deformation in the central United States accumulates at rates comparable to those across plate boundaries. However, we find no statistically significant deformation in three independent analyses of the data set used by Smalley *et al.*, and conclude therefore that only the upper bounds of magnitude and repeat time for large earthquakes can be inferred at present.

The occurrence of earthquakes at the interior of tectonic plates — assumed to be rigid in conventional plate tectonic theory — indicates that stresses within plates accumulate on faults and are released during large, but rare, events. How this cycle relates to the slow deformation of plate interiors is unknown, posing significant difficulties for understanding the associated hazards. Stakes are high because several, now densely populated, intraplate areas have been struck in the past by large earthquakes, including in the central United States in 1811–12, in Basel, Switzerland, in 1356, and in Newcastle, Australia, in 1989. Geophysicists are now using the global positioning system (GPS) to quantify strain in plate interiors in the hope of relating it to stress build-up on seismogenic faults.

Smalley *et al.* report significant strain from GPS measurements in the New Madrid seismic zone (NMSZ) of the central United States. They interpret their findings as indicating deformation rates comparable to those observed at much more seismically active plate boundaries[1]. If confirmed, this result could give insight into the processes that drive the occurrence of large earthquakes in plate interiors, and provide new quantitative information for seismic-hazard estimation in the New Madrid area[1].

However, independent analyses of the same data, performed by three independent groups using different analysis software and processing strategies, reveal no statistically significant site motions or strains (Fig. 1), with an average weighted misfit to a rigid-plate behaviour of 1.4 mm yr^{-1} (95% confidence). In particular, the shortening between sites RLAP and NWCC, used by Smalley *et al.*[1] as their primary argument for strain accumulation on the Reelfoot fault, is of marginal significance (1.7 ± 2.0 mm yr^{-1}; 95% confidence) and largely reflects an unexplained offset that occurred between mid-2001 and early 2002 (Fig. 1, inset). The same analyses, using 156 GPS sites distributed throughout the central and eastern United States, find no spatially coherent deviation from rigid behaviour in the far field of the NMSZ either, apart from effects due to the removal of glacial loads, with an average weighted misfit to a rigid-plate model of 1.4 mm yr^{-1} (95% confidence) as well (further details are available from the authors).

Detecting motion depends critically on the assumed uncertainties of site velocities, which decrease as data span longer times. Hence the present data do not preclude the possibility that a statistically significant tectonic signal may emerge in the future. We shall then face the challenge of deciding whether the deformation represents strain accumulating for release in a future earthquake[1] or long-term relaxation after the 1811–12 earthquakes[2,3].

Is an upper bound of 1.4 mm yr^{-1} of motion across the NMSZ consistent with longer-term data from palaeo-earthquakes in the central United States?[1] Assuming that characteristic earthquakes repeat regularly in the NMSZ (probably an oversimplification, although it is one used in National Earthquake Hazard maps), this leads to a minimum repeat time of about 600–1,500 years, consistent with earlier estimates[4] based on the palaeoseismic history[5] if one assumes occurrence of earthquakes of magnitude 7, with 1–2 m of co-seismic slip[4].

Although intraplate earthquakes indicate that tectonic stresses within plate interiors accumulate on faults and are released during large, infrequent events, deviations from rigid behaviour in the central United States and several other major plates[6,7] are below the current resolution of GPS measurements and do not reflect this cycle — at least not on a timescale of a decade or less. Longer observation spans and further improvement of geodetic techniques are needed to understand where, why and how much strain concentrates in plate interiors.

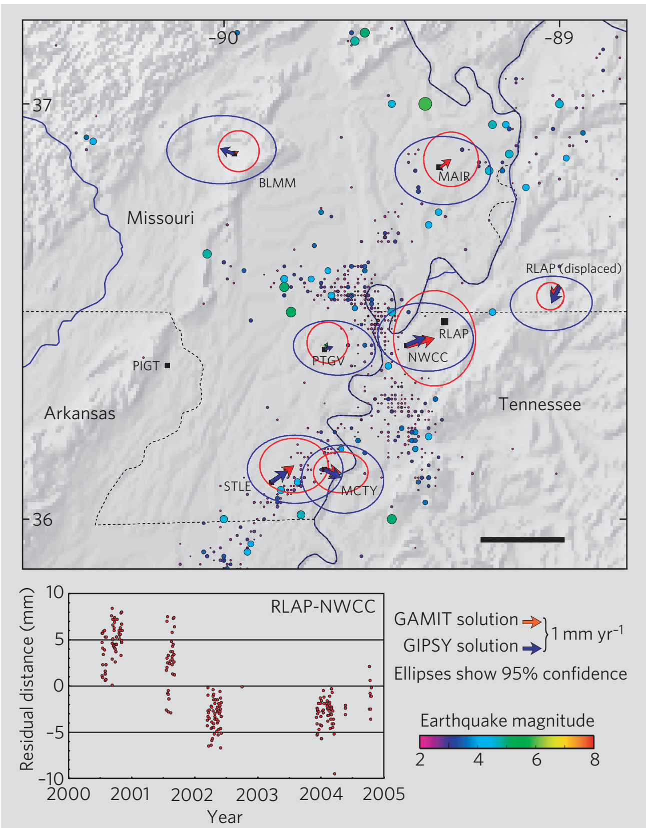

Figure 1 | Velocities and associated uncertainties (95% confidence) at continuous GPS sites in the New Madrid seismic zone. To perform these analyses, two different software packages (GAMIT and GIPSY) were used. Site velocities are within their error ellipses and hence show no statistically significant motion. Filled coloured circles show regional seismicity (United States Geological Survey catalogues; details of site names are listed in Table 1 of ref. 1, except BLMM). The different arrow types represent two independent solutions. Scale bar, 20 km. Inset, time series of daily baseline length estimates between sites RLAP and NWCC after removal of a mean. Error bars on daily estimates, omitted for the sake of clarity, are of the order of 2–3 mm.

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