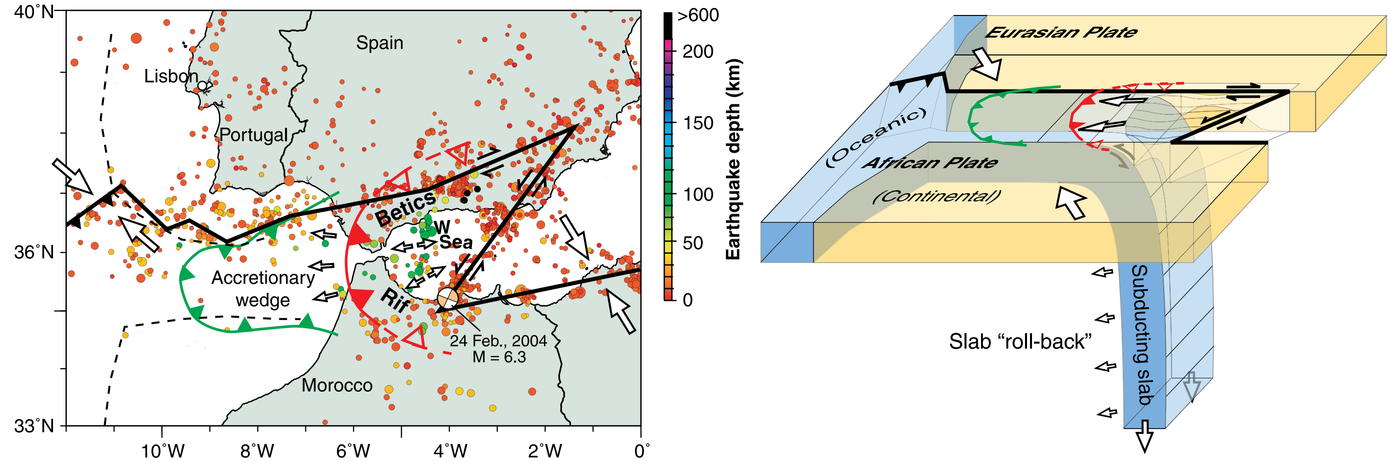

Seismicity and tectonics. (**Left**) Simplified tectonic boundaries and seismicity (from U.S. Geological Survey PDE Catalog 1980–2004, $M > 3$) in the southern Iberia region. Arrows indicate relative motions of major plates and tectonic blocks. Bathymetric contours are shown at 1000-m intervals (from General Bathymetric Chart of the Oceans 1-min digital Atlas). The dashed line shows the inferred limit between continental and oceanic lithosphere. (**Right**) Three-dimensional block diagram indicating sinking and roll-back of oceanic lithosphere belonging to the African Plate.

the form of coarse-grained, sandy "turbidite" deposits laid down by submarine gravity slides during great earthquakes (*13*). These deposits suggest that events of the magnitude of the Great Lisbon earthquake occur periodically at ~1000- to ~2000-year intervals.

As the 250th anniversary of this greatest natural disaster in recorded European history approaches, the Gulf of Cadiz has become the target of a concerted international effort, supported by the European EuroMargins Program. Five oceanographic cruises are planned between summer 2004 and 2005. Three new proposals have been submitted to the Integrated Ocean Drilling Program to search for clues beneath the sea floor. Together, the new studies may help to unlock the secrets of this region's past and its likely future.

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GEOSCIENCE

Tidal Triggering Caught in the Act

Ross S. Stein

The lunar tides beat our entire planet, rhythmically stressing and relaxing every geological fault twice daily. These tiny stress changes may trigger small shocks on faults critically stressed for failure in future large earthquakes. Tantalized by this possibility, scientists have long searched for earthquakes triggered by tides, but the results have been, at best, equivocal. Tidal triggering does occur beneath some active volcanoes and mid-ocean ridges (*1*), and several studies report triggering of extensional and thrust earthquakes (*2, 3*). Yet strike-slip earthquakes, which are by far the most common, have shown little or no tidal influence (*2, 4*). In a recent paper in *Earth, Planets and Space*, Tanaka *et al.* (*5*) provide powerful insights into how tidal triggering works on strike-slip and thrust faults.

The stress imparted by earthquakes strongly influences the occurrence of subsequent earthquakes, such as aftershocks and successive main shocks (*6–8*). Seismicity rates increase where the Coulomb stress is calculated to rise (increased shear and unclamping), and generally drop where the Coulomb stress is calculated to decrease, a phenomenon most evident among strike-slip earthquakes. If, then, stress governs seismicity, why can we not more readily see a seismic response to the ubiquitous and predictable tides?

Stress magnitude is one answer. Typical earthquake-induced stress changes are about 1 to 10 bars, whereas the tidal Coulomb stresses are about 0.01 bar. The tidal effect is thus much weaker and might lie below a threshold. Frequency is another answer. Theoretical arguments (*9*) and laboratory evidence (*10*) suggest that the tidal oscillations are too brief to nucleate abundant earthquakes. Either way, if the tides only subtly influence seismicity or do so only near magma chambers, they are all but useless as a seismic sentinel.

Tanaka *et al.* (*5*) find that earthquakes are triggered by the tides only when the tidal stress adds to—that is, acts in the same direction as—the regional tectonic stress. Nearly all previous studies sought for an increased rate of earthquakes when the tidal stress is high or rising. In a sense, Tanaka *et al.* reframe the tidal triggering hypothesis in terms of the tidal stress azimuth rather than its phase. Reckoned this way, up to 10% of earthquakes are tidally triggered, an unexpectedly high percentage. Such a relationship had been predicted (*9*) but not demonstrated. Perhaps the biggest surprise is that tidal triggering is more common in Japan's tectonic regions than in its volcanic sites (*5*).

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Published by AAAS