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Assessing the recurrence period of large earthquakes and tsunami in the Gulf of Cadiz and SW Iberia margin using thin-sheet neotectonic modeling

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The eastern end of the Azores-Gibraltar plate boundary is characterized by distributed compressional/transpressional deformation that accommodates the collision between the Africa and Eurasia plates. Despite this, the active faults in the area can generate very large earthquakes and destructive tsunamis, such as the Great Lisbon Earthquake, that occurred in the 1st November 1755 (estimated Mw = 8.7). The largest instrumental earthquake recorded was the 28th of February 1969 Mw=8.0, localized in the Horseshoe abyssal plain with a thrust fault mechanism.

In this study, we used a thin-shell approximation (SHELLS- Bird, P., Computers and Geosciences, 25, 383– 394, 1999) to model the neotectonics of this segment of the Africa-Eurasia plate boundary and put constraints on the recurrence periods of large earthquakes and tsunamis. In relation to previous neotectonic models in the region we use a better constrained structural map, based on recently acquired multi-beam bathymetry, backscatter data and numerous high quality multi-channel seismic profiles. Importantly, the map shows the existence of several NNE-SSW to ENE-WSW trending thrust faults, associated with prominent bathymetric features, and a set of very long (up to 600 km) WNW-ESE strike-slip lineaments, which extend between the western Horseshoe Abyssal Plain and the eastern Gulf of Cadiz.

Different models have been tested, for various plate boundary conditions (i.e. geometry and relative plate velocities) and fault networks, and the results compared with the seismic strain release, recent GPS observations and the stress orientation. The modeling results suggest that, when “mature”, the long strike-slip lineaments will probably accommodate most of the relative motion between Africa and Eurasia (aprox. 4 mm/a) along a “transform-type” plate boundary. This scenario, however, is associated with only minor thrust faulting in the region and predicts a strong attenuation of the velocity field between the northern Morocco and Gibraltar, in contradiction with present day GPS measurements. In our preferred tectonic model, the strike-slip lineaments appear as segmented features and a significant amount of the Africa-Eurasia plate convergence (1-2 mm/a) is accommodate along the NE-SW thrust fault systems located in the northern Gulf of Cadiz and the SW Iberia margin, probably linked through NE-SW transfer faults. Accordingly, several large active faults can generate earthquakes with a magnitude greater than 8.0 and an overall recurrence period lower than 1000 years. For the very large, “1755-like” earthquake and tsunami, the thin-sheet modeling results imply a recurrence interval of 10 000 years.