Kinematics of the western Mediterranean : New GPS constraints on deformation along Africa-Iberia plate boundary

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1. Introduction

Present day tectonic processes in Morocco occur within the context of ongoing NW-SE convergence between Africa and Iberia. However, the location Africa- Eurasia boundary is equivocal and ideas to explain the striking topographical symmetry of the region as well as the apparently synchronous subsidence of the Alboran Sea and uplift of the Betic and Rif mountain belts during the Neogene and Quaternary are still widely debated (e.g., backarc extension due to an eastward subducting slab, break- off of a subducting lithospheric slab, crustal extrusion due to forces transmitted across the Eurasia- Africa plate boundary; and delamination of the lithospheric mantle root).

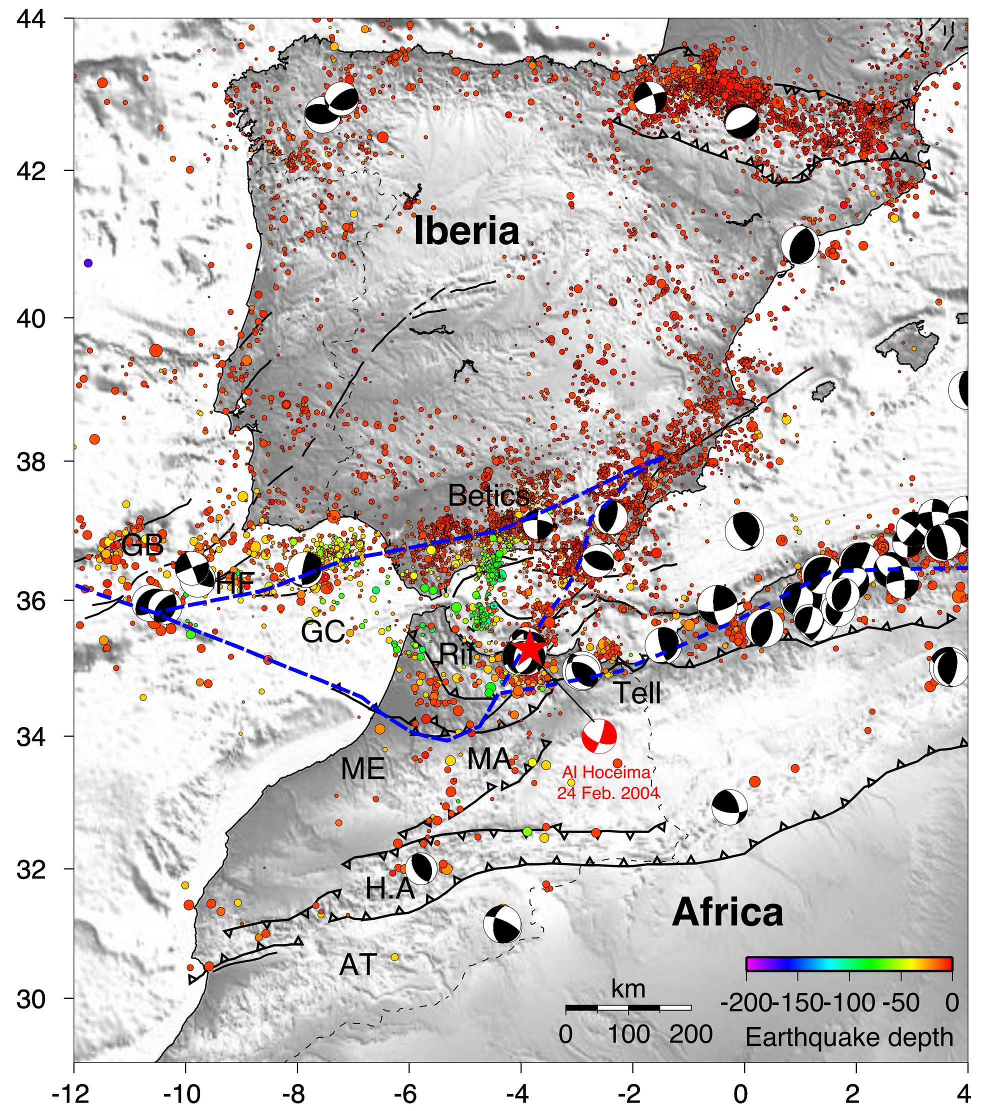

Figure 1: *General structural setting map: seismicity and major faults in the Iberian-Maghreb region. Topography and bathymetry are from SRTM (`http://topex.ucsd.edu/www_html/srtm30_plus.html`). The blue line corresponds to the proposed kinematic Model (see text for discussion). The seismicity is from NEIC catalog (`http://earthquake.usgs.gov/earthquakes/eqarchives/epic/`). Focal mechanisms are from Harvard CMT catalog (`http://www.seismology.harvard.edu/CMTsearch.html`)*

2. GPS data and velocity

We use velocities from 65 continuous stations and 31 survey-mode GPS sites as well as kinematic modeling to investigate present day deformation along the Africa-Iberia plate boundary zone in the Western Mediterranean. The derived GPS velocity field shows southwestward motion (3.5$\pm$0.3 mm/yr) of the central part of the Rif Mountains with respect to Africa, consistent with prior published results. Stations in the southwestern part of the Betic Mountains of southern Spain move west-southwest with respect to Eurasia (2-3$\pm$0.4 mm/yr). The western component of Betics motion is consistent with partial transfer of Nubia-Eurasia plate motion into the southern Betics. The southward component of Betics motion with respect to Iberia is kinematically consistent with south, southwest motion of the Rif Mountains with respect to Africa.

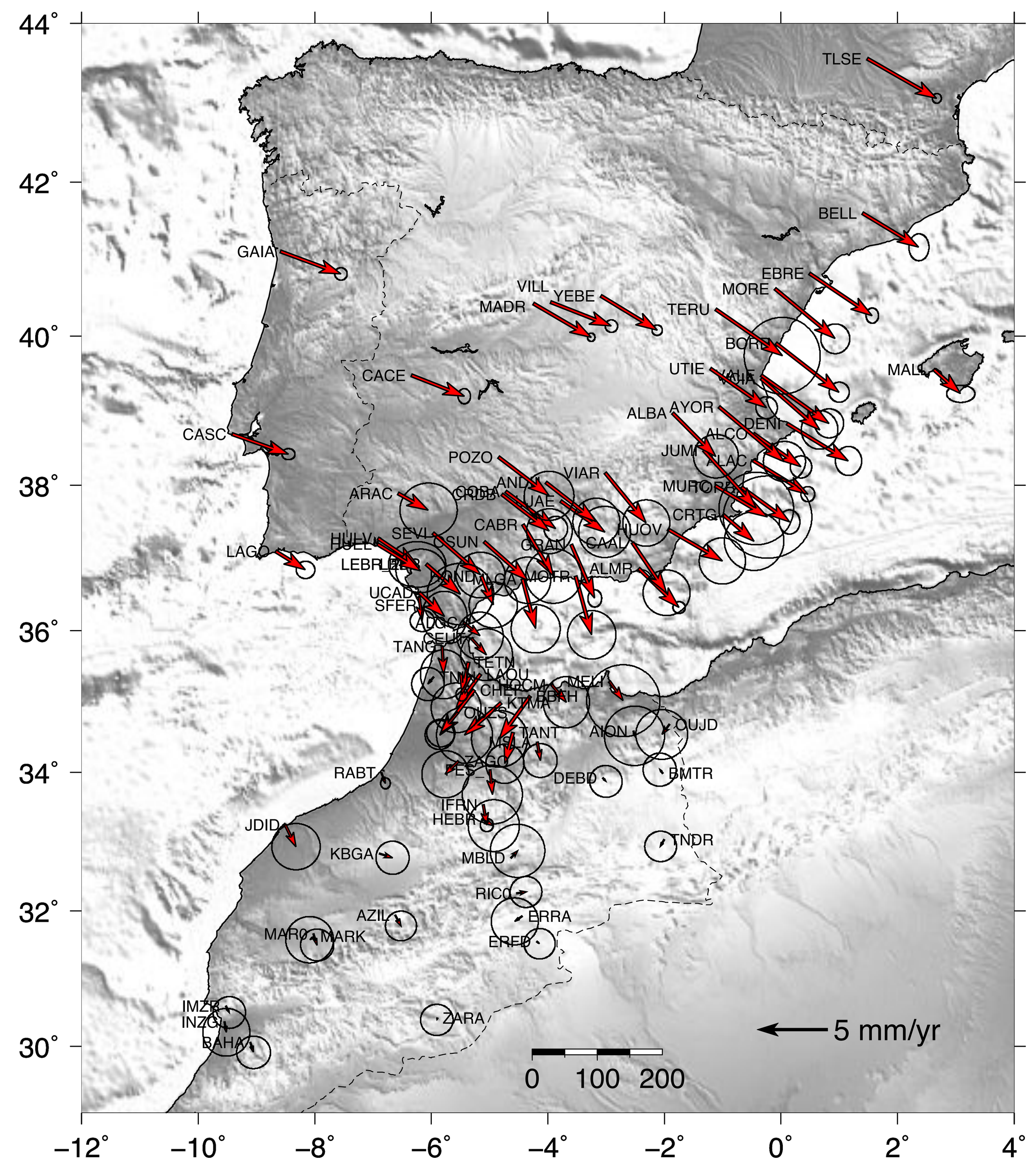

Figure 2: *GPS site velocities with respect to Africa and 95% confidence ellipses.*

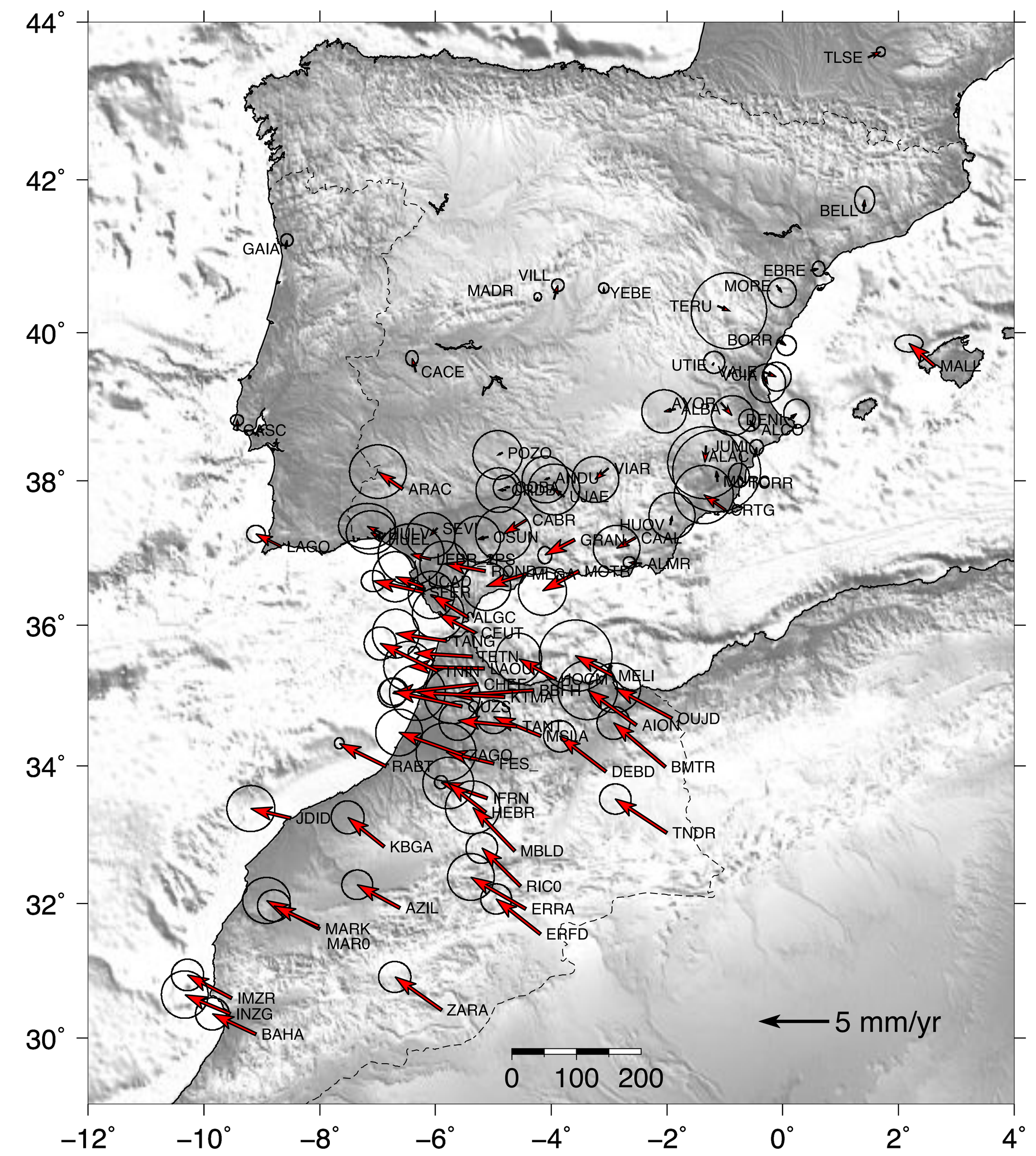

Figure 3: *GPS site velocities with respect to Eurasia and 95% confidence ellipses.*

3. Block modeling

We use block modeling, constrained by GPS, mapped surface faults, and seismicity to estimate the geometry and rates of strain accumulation on plate boundary structures. Our preferred plate boundary geometry includes one block between Iberia and Africa encompassing the southern Betics, Alboran Sea, and central Rif. This geometry suggests a wide transpressive boundary in the westernmost Mediterranean, where deformations are mainly accommodated by the Gloria-Azores fault system to the west and the Rif-Tell seismic lineament to the east. Block boundaries encompass aspects of earlier interpretations suggesting three main deformation styles: (i) Extension along the NE-SW trending Trans-Alboran shear zone, (ii) Dextral strike-slip in the Betics corresponding to a well defined E-W seismic lineament and (iii) Right lateral strike-slip motion extending west to the Azores and right-lateral with compression, extending east along the Algerian Tell. We interpret differential motion in the Rif-Alboran-Betic system to be driven by both surface processes related the Africa-Eurasia oblique convergence and sub-crustal dynamic processes associated with the long history of subduction of the Neotethys ocean lithosphere. The dextral slip identified in the Betic Mountains in S Spain may be related to the offshore fault that produced the Great 1755 Lisbon Earthquake, and as such may represent a significant seismic hazard for the W Mediterranean region.

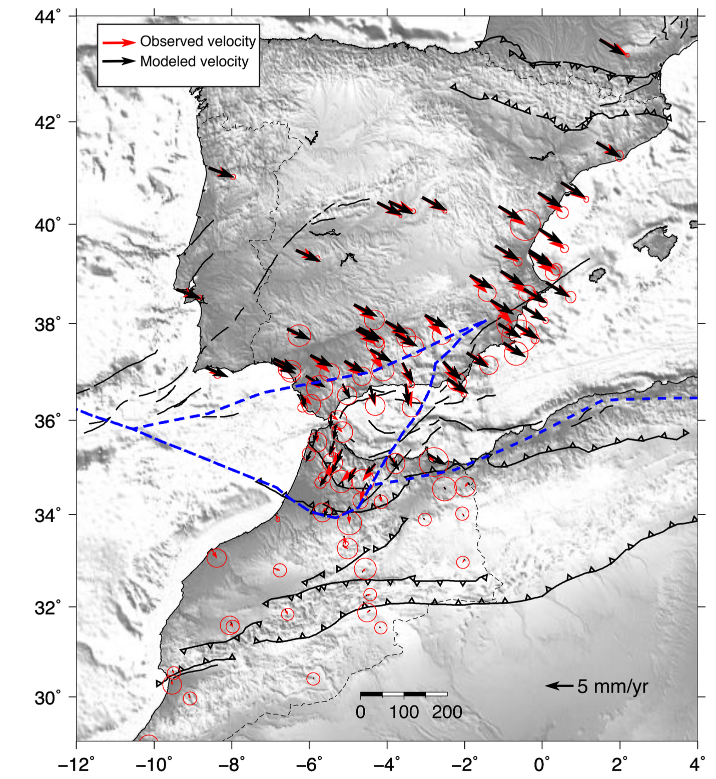

Figure 4: *Observed and modeled GPS velocities. Model boundaries are blue dashed lines. Faults are vertical and assigned locking depths of 15 km except for the faults south of the Rif that have a 30° dip down to the North.*

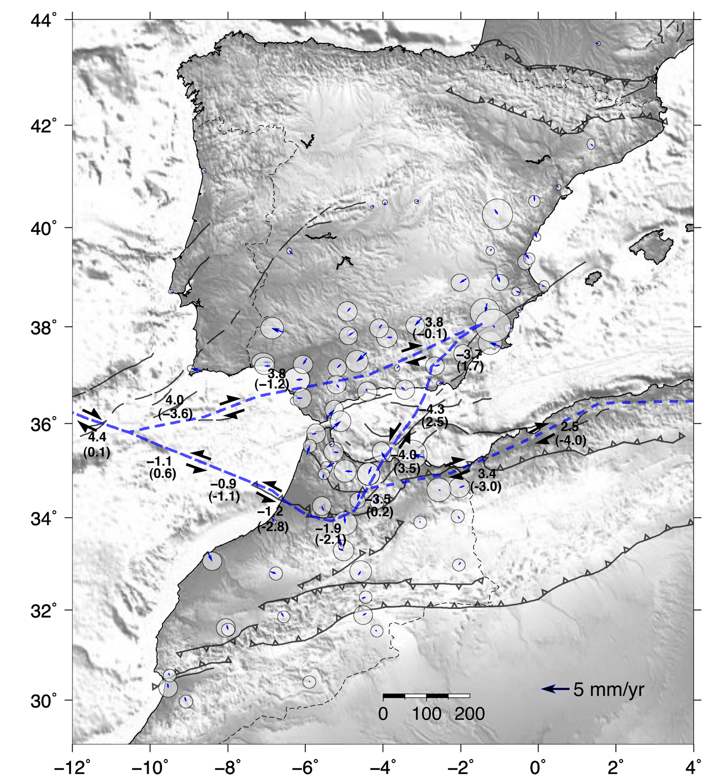

Figure 5: *Residual velocities (observed minus predicted). Strike-slip and fault-normal slip on block bounding segments; rates in mm/yr (fault normal component in brackets; negative for left lateral and compression).*

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