The North African margin
(Western Mediterranean Sea): Structure, evolution, and active deformation

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The aim of this talk is to summarize recent advances in our understanding of the tectonic evolution of the western part of the North African margin, where most of the plate convergence between Africa and Europe is taken up today. Although this plate limit appears to be poorly defined (Figure 1), its central part (Algeria) evidences several large, overlapping active thrust faults and folds that are found from the Atlas domain on land to the foot of the margin offshore. Among others, the 1980 Mw 7.3 El Asnam and 2003 Mw 6.9 Boumerdes-Zemmouri earthquakes provide support for this active deformation and call for improving earthquake mitigation. I review the recent geophysical and geological observations that argue for a clear segmentation of the fault-and-fold network, both offshore and onshore, and for strain focussing that is apparently migrating from the collisional belt on land (Miocene suture zone of the Tethyan, Maghrebian ocean) towards the foot of the Algerian margin.
Fault activity offshore was until recently ignored or not explored, whereas available geodetic and seismological data indicate that a significant part (about one third) of the relative plate convergence may be taken up there (Figure 1; Serpelloni et al., 2007). Plio-Quaternary growth strata within uplifted areas are the first evidence for this ongoing activity. They are found as stepwise, en-échelon systems on the slope and in the deep basin, from eastern Algiers to the Annaba coastline (Figure 2). Some thrusts identified turn to fault-propagation folds at the sub-surface and depict ramp-flat trajectories. They interact at depth with the Messinian salt and seafloor currents (contourites and turbidites), forming complex structures near deep-sea fans (Babonneau et al., in press) and scarps and scars on the main slope breaks and on flanks of canyons (Cattaneo et al., 2009). East of the bay of Algiers, we find that the two main slip patches of the 2003 Mw 6.9 Boumerdes earthquake are spatially correlated to two segmented cumulative scarps recognized on the slope and at the foot of the margin (Segment 12, Figure 2; Déverchère et al., 2005).
The structural inheritance from the Algerian basin opening and from the Alpine belt building history plays obviously a key role in this pattern: for instance, perched basins of the slope represent reactivated tilted blocks of the Miocene passive margin (Yelles et al., 2009). Although previous normal faults may have been set upright, the overall geometry indicates the predominance of back thrusts implying underthrusting of the Neogene oceanic crust. The Algerian margin may therefore represent a first order case study of subduction inception, a process poorly documented worldwide that is likely taking place also off northern Sicily and in the northern Ligurian basin (Figure 1; Billi et al., 2007; Larroque et al., 2009). The relative youth of the Algerian basin (less than 20 My, Schettino and Turco, 2006) is probably a favorable criterion for subduction initiation if one believes the non-conventional scenario of Cloetingh et al. (1989) of closing of young oceanic basins. Furthermore, this recent reactivation (probably less than 3 My) of the Algerian margin is obviously strongly influenced by the main preceding event, namely the subduction of the Tethyan Maghrebian ocean, implying not only an important retreat (roll-back) of this slab, but also a Cenozoic inversion of the foreland and thermal, magmatic and isostatic effects of slab evolution at depth.
From various seismic reflection and coring analyses performed recently, I show that the record of the sedimentary deposition since Miocene times and of various Quaternary and present-day instabilities on the continental slope and in the deep basin is especially helpful to identify this process. The consequences in term of earthquake size and recovery of their recurrences (identification of paleo-events) are explored using core analyses and correlations between them from high-resolution seismic data. Finally I show how and why land- and marine studies are necessary and complementary approaches in order to decipher the tectonic evolution of a reactivated margin.

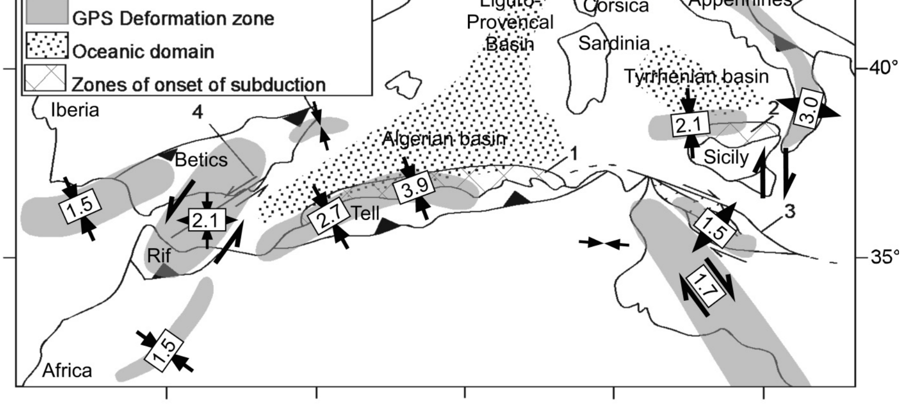

Figure 1 : Simplified presentation of zones of deformation of the south-western Mediterranean where most of the Africa-Europe convergence is accommodated today. Convergence seems to rework some contacts between Neogene oceanic lithosphere and continental lithosphere thickened during alpine orogenesis, as along most of the Algerian margin, off northen Sicily (Billi et al., 2007), and at the northern edge of the Ligurian basin (Larroque et al., 2009). Double arrows indicate the type of stress field and main directions, and numbers the GPS-derived velocities in mm/yr after Serpelloni et al. (2007). Reproduced from Strzerzynski et al. (in press)

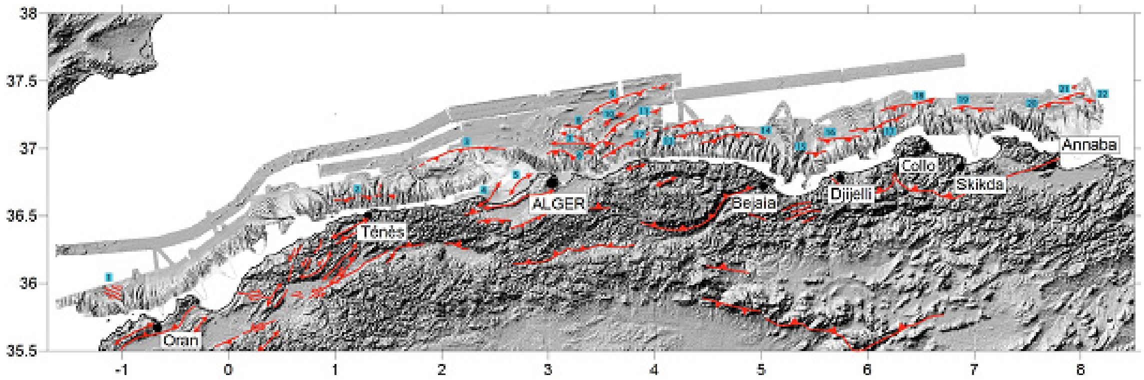

Figure 2. Main indicators of active deformation (folds and faults) charted like active faults onshore and offshore. Numbers refer to fault segments hypothesized offshore from various seismic, sedimentological and morphological markers (Domzig, 2006).

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