Active Deformation and Paleoseismology of Northern Morocco: Onshore and Offshore Faults and the Source of the Great 1755 Earthquake and Tsunami

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The northern Morocco/ Gulf of Cadiz region has been the site of strong historical seismicity. In particular the earthquake of 1 Nov. 1755 (the Great “Lisbon“ earthquake), with an estimated magnitude of 8.7, caused widespread damage in NW Morocco. Tsunami waves heights of 5-15 m were observed along the Moroccan Atlantic coast. Recent geophysical results reveal an east dipping subduction zone, beneath the Gulf of Cadiz and Gibraltar arc, with signs of recent activity. As 11 out of the 12 M8.5 earthquakes in the past 100 years occurred in subduction zones, the Cadiz- Gibraltar subduction is a very strong candidate for the 1755 event. The results of swath mapping bathymetry, and marine seismic profiles (HR, MCSand OBS) in the Gulf of Cadiz are presented. They image a 1-10 km thick, eastward thickening pile of deformed sediments, with W, NW and SW vergent ramp thrusts, above a gently east dipping layer of undeformed sediments. This structure is an accretionary wedge, which shows signs of continued tectonic activity including: numerous active mud volcanoes (indicating active dewatering processes), folding and thrusting seen in high-resolution seismic profiles and the seafloor morphology, which shows a basement high (Coral Patch Ridge) actively indenting the deformation front. The underlying crust is thin (7-10 km thick), gently east dipping and likely oceanic in nature. Thermal modeling of the subduction fault plane, indicates a potential seismogenic zone with a downdip width of 200 km. The absence of instrumentally recorded subduction interface earthquakes suggests the presence of locked zone (like Nankai or Cascadia), with a long recurrence interval (about 1500- 2000yrs) for great earthquakes, as supported by available sedimentological data. A model with a co-seismic slip of 10 m and a long term subduction velocity of 5-6 mm/yr is consistent with this recurrence interval. Numerical modeling of the 1755 tsunami also suggests a strong contribution from the subduction faultplane. High resolution seismic profiles from the Moroccan platform at the SE limit of the accretionary wedge show signs of faulting and folding which post-date the last glacial lowstand. Onshore evidence of recent deformation is offered by folding of Pleistocene (Villefranchian) sediments in the Lalla Zara hills (northern limit of the Rharb basin) as well as 10-15° tilting of more recent Pliocene sediments. Future work will focus on the relation between active faults imaged offshore and potentially active structures onshore, which may be related to a network of E-W to ENE-WSW trending faults, like the Jebba and Nekor faults, which cross the Rif and connect to the Mediterranean coast of Morocco.

Keywords : Paleoseismology; 1755 earthquake; Tsunami; Morocco