SUBDUCTION SYTEMS IN THE WESTERN MEDITERRANEAN : ASSESSING THE ACTIVITY AND SEISMIC RISK

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Abstract

Geophysical and geochemical data indicate the presence of slabs of oceanic lithosphere, with recent subduction beneath the Gibraltar and Calabrian arc systems. Great historical earthquakes and tsunamis have been recorded in these regions, whose source remain unkown. We propose that subduction beneath Gibraltar and Calabria is active and that a large, locked seismogenic zone exists. Acqusition of additional data is required to test this hypothesis.

Key words : subduction, earthquake, tsunami, Gibraltar, Calabria

The Western Mediterranean (from S Iberia to S Italy) is the site of slow convergence between Africa and the southwest flank of Europe. Here, several Neogene basins situated on the interior of Alpine fold-and-thrust belts appear to have undergone extension and subsidence during active orogenic convergence [1,2]. The Western Mediterranean region is bounded at its extremities by two small subduction systems, with accompanying back-arc basins: the Gibraltar arc – Alboran Sea to the west and the Calabrian arc – SE Tyrrhenian Sea, to the east (Fig. 1). Arc volcanism occurs presently behind the Calabrian slab (the Aeolian Islands), but ceased in the W Alboran Sea around 5 Ma [3].

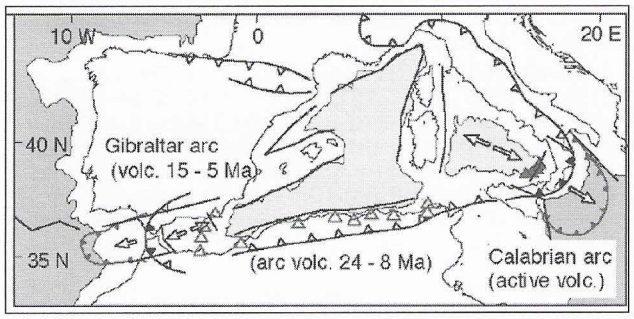

Fig.1. Geodynamic setting of the Western Mediterranean with the Gibraltar and Calabria subduction – arc systems indicated. Note the current volcanic arc in the SE Tyrrhenian Sea and the paleo-arc in the W. Alboran Sea.

Tomographic image reveal high p-wave velocity anomalies (cold, dense slabs of oceanic lithosphere) extending continuously from oceanic domains at the surface down to the 660 km discontinuity, and passing through regions of intermediate and deep focus seismicity [4,5] (Fig. 2). The regional kinematics and back-arc basin formation are best explained by models of slab-roll back during subduction [1,5,6] The question which remains is; are these subduction systems still active today ?

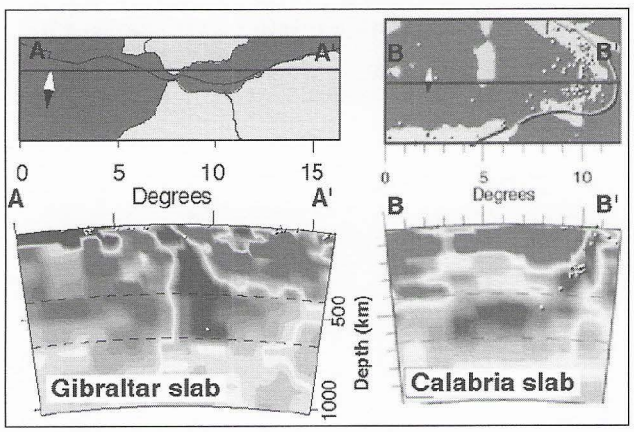

Fig. 2. Seismic tomographic images A: cross-section at 36°N across the Gibraltar Arc, B: cross-section through Calabria and Sardinia.

The Gibraltar and Calabria regions are marked by a moderately high degree of seismicity, but have been the site of devastating historical earthquakes. In particular, the sources of the great "Lisbon" earthquake of 1755 and the Catania earthquake of 1693 (which each caused upwards of 60,000 casualties), remain unknown to this day [7,8]. However, the generation of strong tsunamis (>5 m wave heights) implies a source region at least partly at sea. No instrumentally recorded subduction interface earthquakes (with a shallow-dipping, thrust-type focal mechanism) are known for either of these two sytems. Therefore, either subduction has ceased (no seismogenic zone), subduction is active and aseismic, or subduction is active and the seismogenic zone is currently locked. We favor the latter interpretation, in which case the two arcs would exhibit a similar behavior as the Nankai or Cascadia subduction zones, characterized by a large locked zone, and a recurrence time of 100 – 1000 years for great earthquakes.

The active subduction hypothesis requires testing and we propose the following criteria to determine the activity of the Gibraltar and Calabria subduction systems:

- active thrusting at the deformation front of the accretionary wedge
- active extension in the back-arc domain (subsidence or sea-floor spreading)
- great earthquakes with long recurrence interval
- independant kinematics of the upper plate block (Gibraltar / Calabria)
- active lateral bounding faults (likely with transcurrent motion)

A series of marine geophysical cruises are planned for 2003 – 2005 to constrain deformation in the Gulf of Cadiz accretionary wedge and the turbidite record in the adjacent abyssal plains.

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