NEW SEISMOLOGICAL, STRUCTURAL AND MARINE GEOLOGY CONSTRAINTS FOR A SEISMOTECTONIC MODEL OF THE HINGE ZONE BETWEEN NORTHERN SICILY AND SOUTHERN TYRRHENIAN
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Northern Sicily and its Tyrrenian off-shore are located in a very complex geodynamic context, where both the Sicilian-Maghrebian belt, associated to the collision between African and European Plates, and the more recent opening Tyrrenian Basin coexist (Scandone et al., 1979; Finetti and Del Ben, 1986; Malinverno and Ryan, 1986; Patacca et al., 1990; Faccenna et al., 1996; Monaco et al., 1998; Giunta et al., 2000b; Pepe et al., 2000; Lo Iacono et al. 2011). This area represents therefore an important hinge zone between the two previous geodynamic elements evolving together since late Pliocene, which is part of a wider W–E trending right-lateral regional shear zone, extending for about 300 km from the Ustica-Eolie alignment to the Pantelleria rift.

The Northern Sicilian-Maghrebian chain courses WE from Trapani Mts to the Peloritani Mts and is composed by a set of tectonic units deriving from the deformation of the Northern African Continental Margin.

The architecture of the tectonic edifice, from the Late Oligocene, is the result of three main tectonic phases, characterized by compressional, extensional, and transcurrent tectonics (Giunta et al., 2000b).

The first compressional phase, responsible for the building of the thrust belt, is represented by fold associations, cleavage and foliation, thrust and contraction, which shortened the original paleo-tectonic domains forming flat-ramp, duplex, enveloping, and breaching geometries.

This deformational style persisted, in the most internal sector of the thrust belt, until the Late Miocene. At that time the activation of low-angle top-to-the-north extensional faults produced a general stretching of the belt by re-orientation and inversion of pre-existing structures.

The recent pattern of the Sicilian Maghrebides has been interpreted as an effect of a complicated grid of neotectonic high-angle strike-slip faults, which have been affecting the tectonic edifice since the Pliocene (Boccaletti et al., 1990a; Nigro, 1998; Giunta et al., 2000a; Renda et al., 2000), identifying a hinge zone between emerged Sicilian orogen, with a moderate thickened crust, and the southern Tyrrenian, characterized by crustal thinning. Starting from the Pleistocene is also active a Tyrrenian verging extensional net and dip slip system, over imposed to previous transcurrent one, which accommodates the recent uplift of the emerged sectors of the chain.

The brittle neotectonic pattern has been reconstructed on detail in the northern emerged areas of the Sicilian chain, where two main high-angle strike-slip systems occur, respectively NNW-SSE to W-E mainly right-lateral, and N-S to NW-SE left-lateral one (Fig. 1).

The structures occur from the kilometer to the meter scales and seem to control the recent evolution of the northern Sicilian coastline, determining the formation of either uplifting restraining zones, coinciding with the main morphostructural highs, and the interposed coastal plains located in the tectonic depressions along the subsiding releasing areas.

The interpretation of recent morphobatymetric maps allows to infer the neotectonic pattern also in the submerged areas, which highlights the continuity of the main morphostructural element between the emerged and submerged sectors, and the general coherence of the structural lineament trends controlling the genesis and the evolution of the main plio-pleistocenic clastic sedimentation areas (Giunta et al., 2004).

In the hinge zone between the Northern Sicily chain and the Tyrrenian basin the earthquake hypocenters distribution highlights the presence of two main types of seismicity (Giunta et al., 2002b, 2004, 2008; Gueguen et al., 2002): the first one, characterized by deep hypocenters (down to about 600 km) affecting the easternmost sector of the area, is associated
with the subduction of the Ionian lithospheric slab beneath the Calabrian arc the second one characterized by shallower hypocenters (down to about 30 km) is expression of the brittle strain crossing the whole orogen (Neri et al., 1995). This latter seismogenic zone is strictly connected to the deformation field active within the hinge zone (Fig. 2).

Statistical analysis allows to extract from the overall distribution of seismicity some clusters of events that belong to individual sequences of aftershocks. This analysis highlights that the hypocenters tend to concentrate around high-angle dipping surfaces; moreover, the elongation axes of the clusters are mainly oriented between WNW and NE, well fitting the orientation of the main fault bands (Giunta et al., 2008).

The analysis of the collected fault-plane solutions of the major events of the latter 30 years (DBMI11, Locati et al., 2011; Pondrelli, 2004) shows transpressional and transtensional mechanisms likely related to NW-SE and NE-SW fault lineaments, and compressional and
transpressional mechanisms, mainly oriented from ENE to NW, either generally high-angle dipping and only in few cases low-angle. This evidence well fit the geological-structural data collected in the on-shore areas.

The structural setting sketched by the integration of above mentioned geological and seismological data underlines an intense mechanical heterogeneity of the rock volumes where the strain is accommodated by fault arrays also superimposed on inherited geometries such as flat-ramp, thrusts and/or low-angle normal faults.

The geometric characters of the rocks volumes seems to confirm the occurrence of a simple-shear deformational style according with a neotectonic model related to NW-SE trending maximum compressional stress axis producing a non-coaxial strain, even if in particular areas different seismogenic conditions are possible, due to the accommodation of the deformation leading a marked mechanical heterogeneity (Neri et al., 2003, 2005).

Recently some seismological data of the main seismic sequences affecting the Northern Sicilian sector and its offshore has been checked with the aim to improve the above mentioned seismotectonic model. Particularly, the 1992-1993 Pollina, 1998 S. Vito high, 2002 Palermo, 2009-2012 Caprileone seismic sequences have been analyzed.

More events of the above mentioned seismic sequences were relocated using a process based on the HYPODD program (Waldhauser, 2001) and an eight layers velocity model optimized relocating some thousands events of the Southern Tyrrhenian (Chironi et al., 2000). Moreover, new focal mechanisms were calculated using the FPFIT code (Reasenberg and Oppenheimer, 1985).

The hypocentral relocation allowed well defining the seismogenic volume geometries involved in the analyzed seismic sequences. The new focal mechanisms confirm a large structural heterogeneity of seismogenic volumes as observed in the structural analysis in the onshore sector of the chain (Fig. 3).

These new analysis of seismological data seems to confirm the congruence of the seismotectonic model of the hinge zone, where a main NW-SE stress field is still active, which induce a non-coaxial deformation expressed by a complex strike slip system: NE-SW/N-S trending antithetic, and WNW-ESE/W-E trending synthetic, both transpressional or transtensional.

![Fig. 3 – Focal mechanisms of the main events of the seismic sequences calculated by the FPFIT code.](image-url)
The analyzed seismic activity also highlights the activation of rock volumes with a high degree of mechanical anisotropy, where variously oriented seismogenic structures can be active.

References


