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The Structural Geology Contribution to the Africa-Eurasia Geology

Basement and Reservoir Structure, Ore Mineralisation and Tectonic Modelling

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Hinterland-Verging Thrusting in the Northern Sicily Continental Margin: Evidences for a Late Collisional Stage of the Sicilian Fold and Thrust Belt?

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Abstract

The Sicilian Fold and Thrust Belt developed during Neogene-Quaternary times characterized by main African-wards tectonic transport direction. Recent investigations highlighted extensive hinterland-verging tectonic structures active during late Pliocene-Pleistocene time suggesting a late collisional stage of the Sicilian Fold and Thrust Belt that could be a precursor of a change in the subduction polarity in the central belt of Mediterranean.

Keywords

Backthrusting • Subduction polarity • Sicilian Fold and Thrust Belt • Central Mediterranean geodynamics

1 Introduction

Backthrusting, nappe refolding, and normal faulting frequently characterize late collisional stage of an orogen. Shortening driven by backthrusting is widely reported in the Alpine orogen, where it has been proposed to be responsible for the increase of subsidence [1]; moreover, delamination and backthrusting have been considered as related to subcritical condition of a Coulomb-type accretional wedge [2]. The southern Tyrrhenian is a key area where tectonic structures are accommodating the deformation in the transition belt between oceanic subduction and continental collision, both formed in the context of the convergence between Africa and Europe.

2 Geological Settings, Materials and Methods

We investigated the northern Sicily continental margin (the onshore as well as the offshore sectors), by using differently-penetrative seismic reflection data, including a deep crustal profile across central Sicily, calibrated with detailed stratigraphic and structural surveys and borehole data. Interpretation of the medium-to-high resolution seismic reflection profiles, combined with the deep seismic reflection data, led us to define both the deep and the shallower structural setting of the study area, revealing structural variations in the tectonic edifice architecture. Seismic reflection profiles available for the Northern Sicily and its offshore were used to unravel the deep structural setting of the submerged part of the Sicilian Maghrebian FTB. Sicily is a segment of the Apennine-Tyrrhenian System (Fig. 1) resulting from both the post-collisional convergence between Africa and Europe and the coeval roll-back of the subduction hinge of the Ionian lithosphere. During the last 15 My the building-up of the Sicilian Fold and Thrust Belt (SFTB) was characterized by a three-stage evolution: two main shortening events generated and developed at different structural levels (shallow- and deep-seated thrusts following a thin-skinned thrust-model) and at different time intervals, involving mainly the Meso-Cenozoic carbonate cover of the ancient African passive continental margin; these two events were followed by a more recent, thick-skinned thrust-model stage involving the crystalline basement in the internal sector of the chain and affecting the Plio-Pleistocene deposits in the frontal area as well. In northern Sicily (Cefalù seismic zone) the tectonic edifice is affected by extensional processes that were related to lateral extension on pre-existing faults and to an inferred mantle-upwelling beneath the Etna volcano [3].

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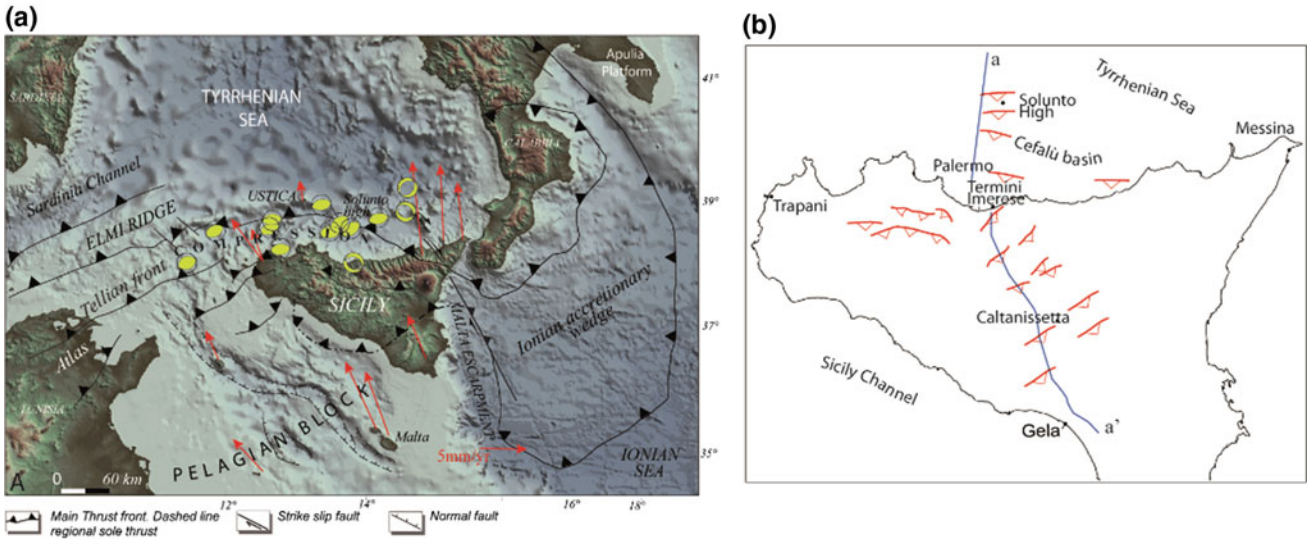

Fig. 1 **a** Simplified regional sketch of Sicily and its offshore in central Mediterranean Sea, showing the main tectonic features, focal mechanisms of earthquakes along the southern Tyrrhenian margin (from [9]) and GPS site measurements (red arrows; from [10]). **b** Distribution of the main recognized backthrust features (red line)

3 Results

The uppermost Neogene to Quaternary sedimentary successions, filling a complex wedge-top depozone developed on top of the Sicilian FTB, point out the prolonged syn-sedimentary tectonics, following the "step by step" growing and wedging of the Sicilian FTB during the progressive deepening of the deformational processes.

During the thin-skinned, shallow-seated Event 1 (Serravallian-early Tortonian) the emplacement of thin thrust sheets along low-angle 'décollement' planes is followed by the development of wide, wedge-top basins characterized by marine sedimentation, open towards the foredeep depozone. During the thin-skinned, deep-seated Event 2 (late Tortonian-Early Pliocene) thrusting of thick carbonate-platform units over the Iblean-Pelagian foreland was accompanied by internal deformation of the carbonate units, which were offset by high-angle, reverse, locally transpressional faults. This stage is associated with the development of small and confined wedge-top basins. During the thick-skinned Event 3 (Late Pliocene-Pleistocene) the deformation evolved at the depth of the crystalline basement by the activation of a forward sole thrust. This event evolved, in the inner sector, by activation of northward back-verging compressional faults that affected the already deformed tectonic wedge (Fig. 2).

4 Discussion

During the tectonic Event 3, the outward accretion of the FTB seems to have decreased in favor of back-verging thrusts and vertical growth, mostly in the inner sector of the orogen. Here a large number of N-verging thrusts controlled the tectonic evolution of the uppermost Miocene-Pleistocene deposits. In the offshore sector (southern Tyrrhenian border), some of these tectonic features seem to be responsible for the geometry of the main submerged structural highs, shaping the uneven physiography of the modern northern Sicily margin. The most recent of these features were locally reactivated by a compressional stress field with a dominant NW-SE orientation and responsible for the shallow (depth < 15 km) and low-to-medium magnitude seismicity recorded in the southern Tyrrhenian Sea. GPS site velocity up to 10 mm/y is consistent with right-transpressional deformation and convergence between Sardinia and Sicily. As a matter of fact widespread right-lateral strike-slip faults affect the main front of the Kabylian-Calabrian units in western-central northern Sicily margin [4], as well as the eastern sector along the Tindari fault system [3]. After having depicted the active deformational pattern, we analyzed the relationships with the regional (central Mediterranean) geodynamic setting. Along the northern Africa boundary (e.g. NW Algeria Neogene margin; [5, 6]) a late

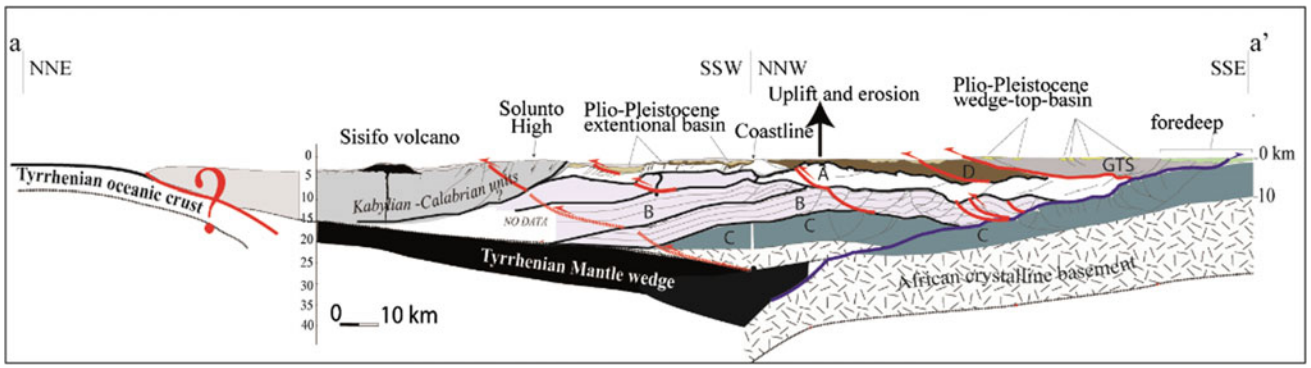

Fig. 2 Regional geological cross section showing the main tectonic units forming the Sicilian FTB. The main thrust related to the subsequent tectonic events have been distinguished: black line for thin skinned Event 1 and 2; blue line for thick skinned Event 3; red line for backthrust. **a** deep water succession; **b** and **c** carbonate platform succession; **d** Numidian Flysch deposits; GTS: Gela Thrust System. Section trace in Fig. 1b

Miocene-Quaternary northern migration of the plate margin producing opposite-verging structures is reported; moreover, a plate boundary reorganization during the latest 0.8–0.5 My with the development of backthrusts have been documented in the Mediterranean region [7], where shallow compressional structures and geodetic data [8] let to predict the development of a south-directed subduction of the Tyrrhenian lithosphere.

5 Conclusions

The results of this study suggest that the most recent tectonic processes in the study region are representative of a late collisional stage in the northern Sicily mountain building and, at a larger scale, they could be a precursor of a change in the subduction polarity in the central belt of Mediterranean Sea, as a consequence of the ongoing collision of the African promontory with the thinned continental to oceanic sectors (Algerian and Tyrrhenian basins) of the European plate.

References

1. Roure, F., Howell, D.G., Muller, C., Moretti, I.: Late Cenozoic subduction complex of Sicily. J. Struct. Geol. **12**, 259–266 (1990)
2. Torres Carbonell, P.J., Dimitri, L.V., Olivero, E.B.: Progressive deformation of a Coulomb thrust wedge: the eastern Fuegian Andes Thrust-Fold Belt. Geol. Soc. Lond. Spec. Publ. **349**, 123–147 (2011)
3. Billi, A., Presti, D., Orecchio, B., Faccenna, C., Neri, G.: Incipient extension along the active convergent margin of Nubia in Sicily, Italy: Cefalù-Etna seismic zone. Tectonics **29**, TC4026 (2010)
4. Sulli, A.: Structural framework and crustal characteristics of the Sardinia Channel Alpine transect in the central Mediterranean. Tectonophysics **324**(4), 321–336 (2000)
5. Yelles, K., Domzig, A., Deverchere, J., Bracene, R., De Lepinay, B.M., Strzerzynski, P., Bertrand, G., Boudiaf, A., Winter, T., Kherroubi, A., Le Roy, P., Djellit, H.: Plio-Quaternary reactivation of the Neogene margin off NW Algiers, Algeria: the Khayr-Al-Din bank. Tectonophysics **475**, 98–116 (2009)
6. Mauffret, A.: The Northwestern boundary of the Nubia (Africa) plate. Tectonophysics **429**, 21–44 (2007)
7. Goes, S., Giardini, D., Jenny, S., Hollenstein, C., Kahle, H.-G., Geiger, A.: A recent tectonic reorganization in the south-central Mediterranean. Earth Planet. Sci. Lett. **226**, 335–345 (2004)
8. Billi, A., Presti, D., Faccenna, C., Neri, G., Orecchio, B.: Seismo tectonics of the Nubia plate compressive margin in the south Tyrrhenian region, Italy: clues for subduction inception. J. Geophys. Res. 112 (2007)
9. Pondrelli, S., et al.: The Italian CMT dataset from 1977 to the present. Phys. Earth Planet. Inter. **159**, 286–303 (2006)
10. Devoti, R., Esposito, A., Pietrantoni, G., Pisani, A.R., Riguzzi, F.: Evidence of large scale deformation pattern from GPS data in the Italian subduction boundary. Earth Planet. Sci. Lett. **311**, 230–241 (2011)