SUBSURFACE DATA, ANALOGUE AND NUMERICAL MODELS: AN INTEGRATED APPROACH TO RECONSTRUCT AND CONSTRAIN ACTIVE FAULT SYSTEMS (SCIACCA FAULT, ITALY)

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The analysis of an extensive number of multichannel seismic reflection profiles acquired in the northern part of the Sicilian Channel allowed a 3-D reconstruction of a regional NS-trending transfer zone. This transfer zone is composed of two major faults (Capo Granitola and Sciacca Fault) which display mainly a transcurrent tectonic regime (Fig.1). This regional

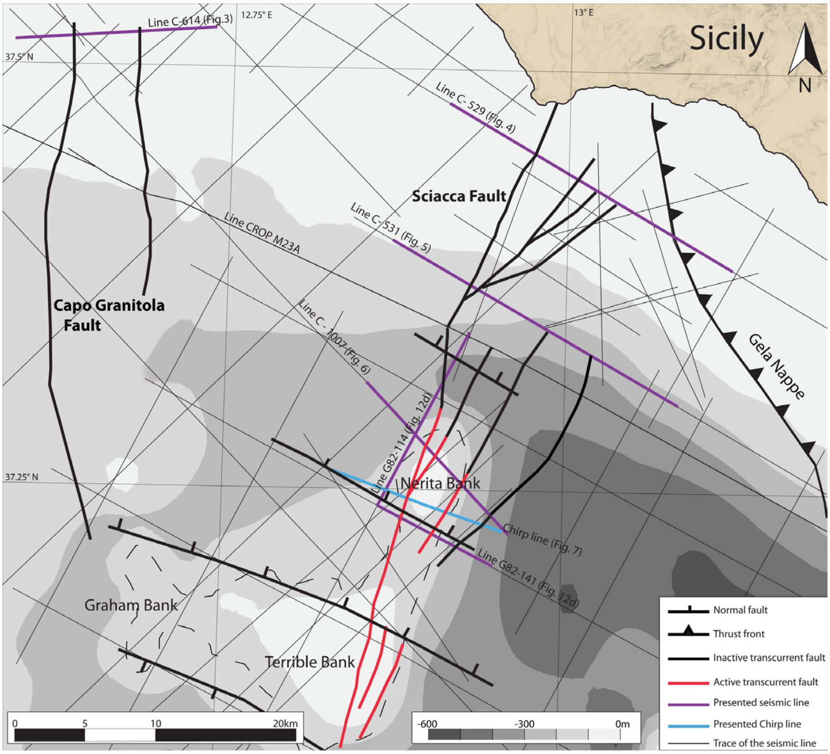

Fig. 1 - Structural sketch of the study area (from Fedorik *et al.*, under review).

tectonic lineament is of broad interest for both geodynamic and seismotectonic implications having a complex tectonic evolution in an area that is a key point for Central Mediterranean geodynamics and locally showing evidences of ongoing tectonic activity. Along this transfer zone the maximum stress directions reoriented through times (Mantovani *et al.*, 2014) and it separated different sectors of the Sicilian-Maghrebian Chain characterized by various tectonic evolution, deformation age and thrusts vergence. Moreover, it separates in two portions the Sicilian Channel Rifting Zone (a western area where the Pantelleria Graben took place and an eastern sector characterized by the presence of the Linosa and Malta troughs) where several recent submarine volcanic centers are present (Civile *et al.*, 2008; Lodolo *et al.*, 2012; Coltelli *et al.*, 2016). A well constrained 3D reconstruction of the Sciacca Fault (Fig. 2) allowed us to define (i) the present day tectonic setting of this fault, (ii) its tectonic evolution and (iii) a possible interpretation of the seismic activity along it. Regarding the present day, tectonic setting data show that this tectonic lineament consists of a system of faults composed by a sub-vertical NNE-SSW trending master fault with several splays. The evidence of transcurrent tectonics along this fault is observable at least for 70 km, from the Sicily coastline to the southern margin of the Terrible Bank (Fig.1). From reflection seismic profiles it is possible to reconstruct a complex tectonic evolution of the Sciacca Fault. This structure probably developed along the offshore continuation of an inherited weakness zone identified in western Sicily and interpreted as a carbonate platform margin developed in Permo-Triassic times. It was probably active up to Miocene as a high angle normal fault testified by the considerable thickness variations of the Miocene succession. Under a NE-SW oriented maximum stress direction, the previous normal fault was re-activated in the Lower Pliocene as a right-lateral transcurrent fault with a compressive component producing positive flower structures. The maximum stress direction changed its orientation starting from the Late Pliocene (Mantovani *et al.*, 2014), so that the present-day main compressive horizontal stress in the area of the Sicilian Channel has a NW-SE direction. This change in the orientation of the maximum stress field produced a kinematic change from

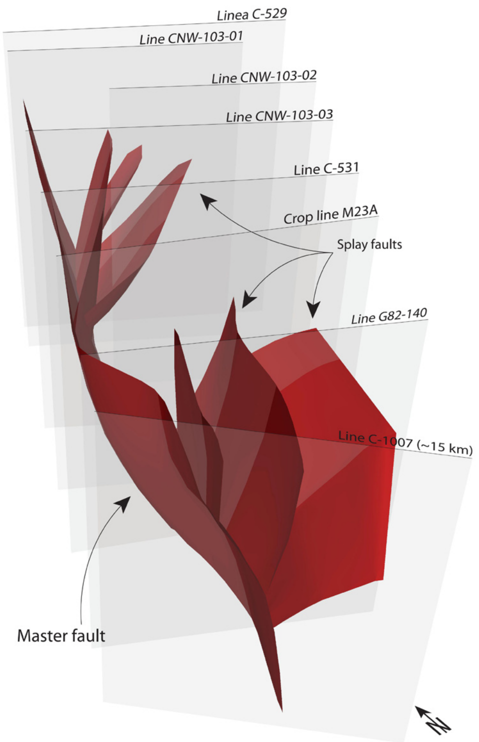

Fig. 2 - 3D model of the Sciacca Fault (Fedorik *et al.*, under review).

right-lateral to present day left-lateral strike-slip motion. Instrumental seismicity shows that the Sicilian Channel is dominated by strike-slip focal mechanisms with left-lateral component (Calò and Parisi, 2014; Soumaya *et al.*, 2015). A set of scaled analogue clay models was carried out in order to better constrain the tectonic processes that led to the structural setting displayed by seismic data. Tectonic structures and uplift/subsidence patterns generated by the models are compatible with the 3-D model obtained from seismic reflection profiles. A good fit between the Sciacca Fault and the analogue models was obtained imposing a right-lateral movement, coherently with the tectonic regime present in the area up to Lower Pliocene.

Analyzing the seismic reflection profiles, it is possible to highlight those faults or fault segments showing active tectonic evidence. Some of the faults belonging to the Sciacca Fault deform Quaternary deposits and cut the seafloor. A structural map where recent and ongoing fault activity was detected was reconstructed. However, these kinds of reconstruction are necessarily dependent on the data (seismic reflection profiles) availability, quality and distribution/spacing.

To carry out a complete map where active faults (or active fault segments) are not limited to a restricted sector near the seismic reflection profiles, numerical models are needed in order to check and verify where strain is distributed. The digital 3D model of the Sciacca Fault has been used as input data in a Stress Analysis tool (Poly3D) to check the fault system response. According to available GPS and literature data, regional strain values were applied to the modeled fault system, and the slip potentional on each fault was calculated (Fig. 3). The numerical model outputs are in good agreement with the observations coming from the seismic reflection profiles analysis and allow to constrain better and highlight which faults are most prone to be activated under the present day regional stress. The Sciacca Fault case study is a good example to test and verify how numerical models output fit with observed data and, at the same time, to constrain the seismic reflection profiles interpretation. In a more general view, the case study once again highlights (i) the importance of 3D reconstructions that lead to well constrained geological reconstructions, (ii) the importance of a multidisciplinary approach using the best and most useful information coming from subsoil data, analogue and numerical models and (iii) how seismotectonic studies, in particular, can significantly be improved merging a different kind of data (seismicity, subsoil data, stress analysis, etc.).

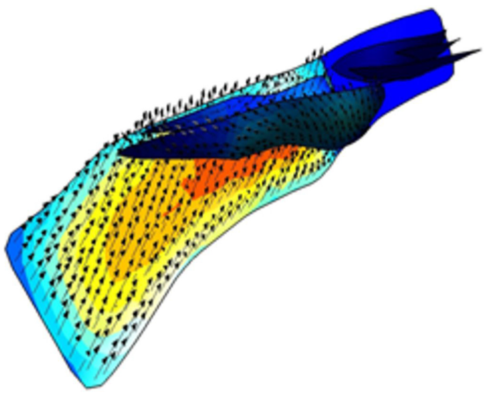

Fig. 3 - Numerical model. On the main fault a slip tendency analysis was carried out in order to check where maximum slip is expected.

References

Calò M. and Parisi L.; 2014: *Evidences of a lithospheric fault zone in the Sicily Channel continental rift (southern Italy) from instrumental seismicity data*. Geophysical Journal International, **199 (1)**, art. no. ggu249, pp. 219-225. DOI: 10.1093/gji/ggu249

Civile D., Lodolo E., Tortorici L., Lanzafame and Brancolini, G.; 2008: *Relationships between magmatism and tectonics in a continental rift: The Pantelleria Island region (Sicily Channel, Italy)*. Marine Geology, **251**, 32-46.

Coltelli M., Cavallaro D., D'Anna G., D'Alessandro A., Grassa F., Mangano G., Patanè D. and Gresta S.; 2016: *Exploring the submarine graham bank in the sicily channel*. Annals of Geophysics, **59 (2)**, art. no. S0208,DOI: 10.4401/ag-6929

Lodolo E., Civile D., Zanolla C. and Geletti R.; 2012: *Magnetic signature of the Sicily Channel volcanism*. Marine Geophysical Research, **33 (1)**, 33-44. DOI: 10.1007/s11001-011-9144-y

Mantovani E., Viti M., Babbucci D., Tamburelli C., Cenni N., Baglione M. and D'Intinosante V.; 2014: *Generation of Back-Arc Basins as Side Effect of Shortening Processes: Examples from the Central Mediterranean*. International Journal of Geosciences, **5**, 1062-1079. doi: 10.4236/ijg.2014.510091.

Soumaya A., Ben Ayed N., Delvaux D. and Ghanmi M.; 2015: *Spatial variation of present-day stress field and tectonic regime in Tunisia and surroundings from formal inversion of focal mechanisms: Geodynamic implications for central Mediterranean. Tectonics*, **34**, 1154–1180, doi:10.1002/2015TC003895.