limite superiore. Considerando che l'ultimo terremoto su questa faglia potrebbe essere avvenuto intorno all'anno 500 e che il tempo di ricorrenza per questa struttura utilizzato per i calcoli di pericolosità sismica è di 1627 anni, l'anticipo effettivo potrebbe essere di poco superiore al secolo.

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A FORESHOCK-MAINSHOCK PAIR, THE 9 JANUARY (MW6.1) - 11 JANUARY (MW7.3) 1693 EARTHQUAKES CASE (SOUTHEASTERN SICILY). PART II: ACTIVE TECTONIC INVESTIGATION AND SEISMOLOGICAL DATA: IMPLICATION FOR SEISMOTECTONIC CONSTRAINTS

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The 9 January (Mw6.1) and 11 January (Mw7.3) 1693 earthquakes occurred in eastern Sicily as a foreshock-mainshock pair. These events triggered numerous environmental effects, described by historical accounts, besides severe damage to houses and infrastructure and numerous fatalities. Environmental effects, such as liquefactions, landslides, fractures and ruptures are mainly clustered in the eastern sector of the Hyblean Plateau. However, historical accounts do not report a clear description of surface faulting in the area of maximum damage. For this reason and given the absence of relevant active faults in the eastern sector of the Hyblean Plateau, various Authors proposed several faults, located nearby, as sources of the 1693 foreshock-mainshock pair. These structures, differing in location, attitude and kinematics are: the NNW-SSE normal to oblique Malta Escarpment Fault System, located in the Ionian offshore; the N-S strike-slip Scicli Ragusa Fault System, the NE-SW normal Avola Fault, the ENE-WSW reverse Monte Lauro Fault, the NNW-dipping Sicilian Basal Thrust and lastly the STEP Faults located in the Ionian offshore (Fig. 1a, see DISS Working Group, 2018 and references therein).

The boxer method (Gasperini et al., 1999) application on a revaluation of the 1693 macroseismic fields of the foreshock-mainshock pair (Barbano and Pirrotta, this volume), returns two, partially overlapped, NNE-SSW directed, seismogenic sources. This evidence suggests that the source responsible can be a unique, NNE-SSW oriented, seismogenic fault, located in the eastern sector of the Hyblean Plateau that broke two times during January 9 and January 11, 1693.

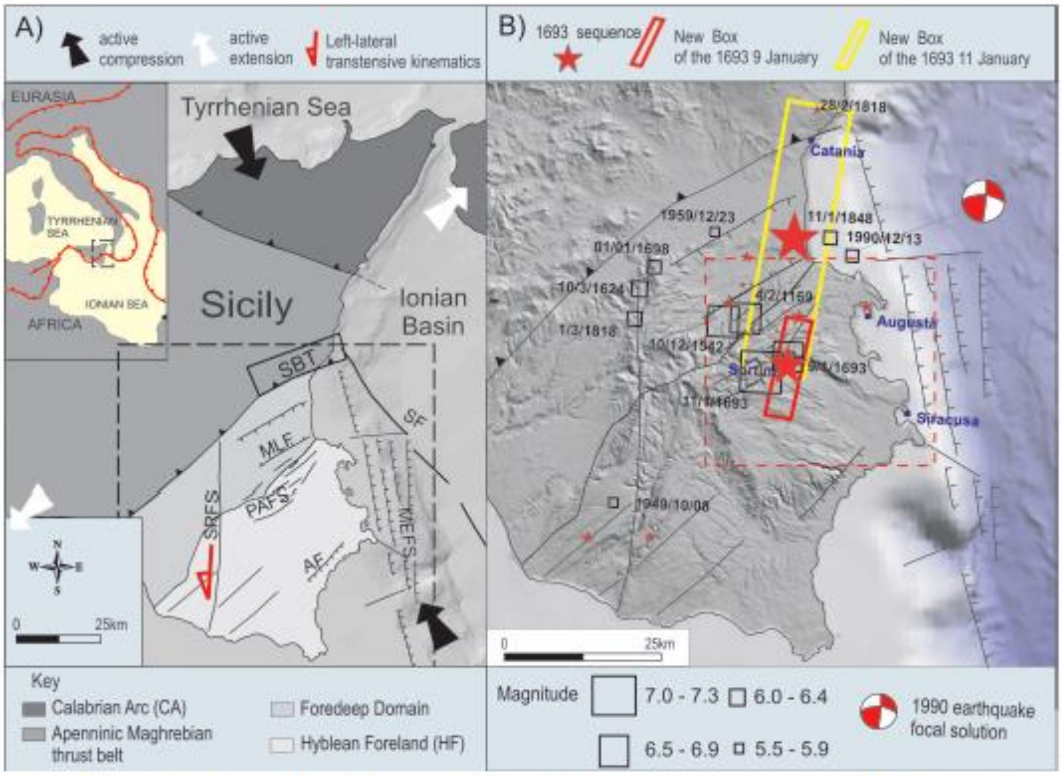

Fig. 1 - a) Eastern Sicily: main geodynamic sectors, principal stress axes and principal regional faults proposed as seismogenic master faults of the 1693 earthquakes (DISS Working Group 2018). MEFS = Malta Escarpment Fault System, SRFS = Scicli Ragusa Fault System, AF = Avola Fault, PAFS= Pedagaggi Agnone Fault System; MLF = Monte Lauro Fault, SBT = Sicilian Basal Thrust, STEP = Slab Transfer Edge Propagator fault system. Dashed square shows location of Fig. 1b; b) Southeastern Sicily DEM. Squares are the epicenters of the strongest historical earthquakes (from Rovida *et al*., 2016). Stars are the epicenters of revised 1693 seismic sequence shocks. Yellow and red rectangle are the source models of the 1693 earthquake proposed by Barbano and Pirrotta (this volume). Focal mechanism (balloon) refers to the 1990 earthquake (from Amato *et al*., 1995); red dashed square is the location of Fig. 2.

We carried out geological, geomorphological and morphometric analyses in the area where maximum damage and environmental phenomena occurred during the 1693 seismic sequence, with the aim to recognize recent activity of faults and to associate them a seismotectonic potential.

First, we performed DEM and aerial photos analyses and geological-structural surveys to map faults in detail and to constrain their geometry and kinematics. In addition, we carried out geomorphologic and morphometric studies of four rivers flowing in the area (Cantera, Mulinello, Marcellino and Anapo rivers) with the aim to define the activity of the intercepting faults. Finally, we analysed instrumental seismicity, recorded during 1994-2013 by local network to relate observed faults with the seismicity of south-eastern Sicily.

Geological-structural analysis reveals that the study area is dissected by numerous faults, NE-SW and NW-SE oriented, many of them known in literature. Morphostructural and tectonic-geomorphology investigations indicate a general high degree of tectonic activity of the study area and recent activity of some previously mapped faults. We grouped active faults in two systems: the Palazzolo Villasmundo Fault System (PVFS) and the Augusta Floridia Fault System (AFFS) (Fig. 2).

AFFS consists of normal faults directed from NW-SE up to NNW-SSE that create several horsts and grabens and correspond to faults already mapped in literature. PVFS dips to west, it

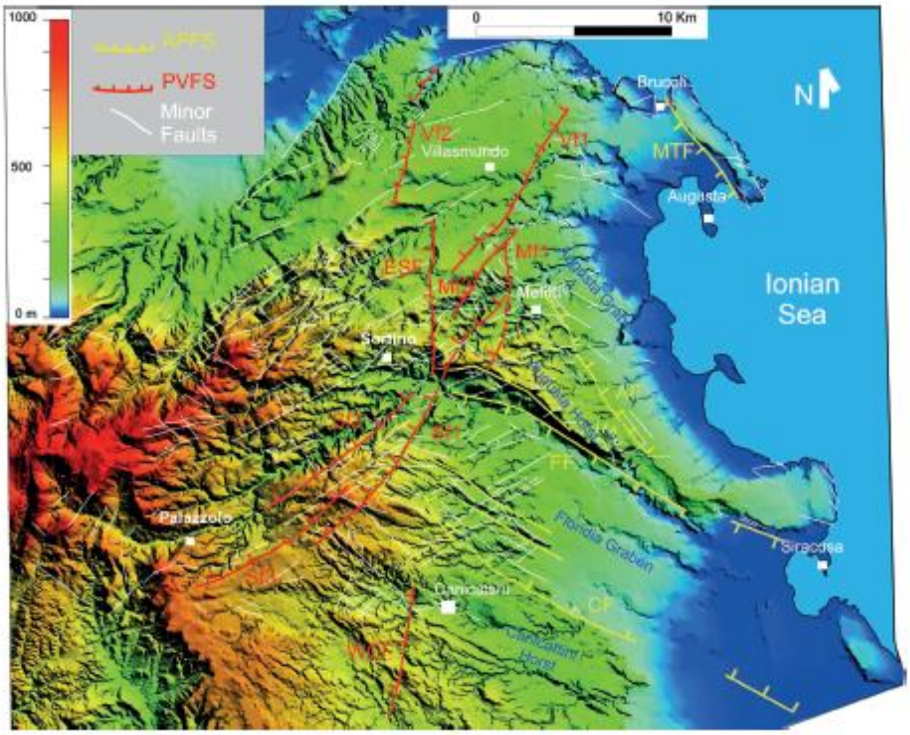

Fig. 2 - DEM and mapped faults. PVFS is the Palazzolo Villasmundo Fault System (in red): Sf1, Sf2 and Sf3 are the Sortino Faults, ESF is the East Sortino Fault; Mf1 anf Mf2 are the Melilli Faults and Vf1, Vf2 and Vf3 are the Villasmundo Faults, WCF is the West Canicattini Fault. AFFS is the Augusta Fault System (in yellow); CF is the Canicattini Fault, FF is the Floridia Fault, AF is the Augusta Fault and MTF is the Monte Tauro Fault.

is highly segmented and composed by numerous faults with a direction ranging from NE-SW to NNE-SSW in the northern sector. Some of these faults coincide with the Pedagaggi Agnone Fault System, known in literature, which accommodated the flexure of the foreland below the orogenic thrust belt up to lower Pleistocene.

PVFS shapes a segmented pattern with faults of second hierarchical order (about 10 km long) separated by minor geological complexity, like gaps and step-overs, that act as barriers capable to arrest the propagation of the brittle deformation at the surface. According to the segmentation model proposed by Boncio *et al.* (2014) these faults can joint at depth in a unique master fault whose dimension is about 34 km (considering the fault belt length). In the northern and southern sectors, we observed some morphological scarps associated to N-S directed, west dipping faults (Fig. 2).

Geomorphic indexes highlight recent activity of the PVFS and AFFS. In particular, a likely inversion of kinematics is observed for the PVFS. Indeed, the hypsometric curve of the Mulinello, Marcellino and Anapo rivers show sectors in rejuvenation in the hangingwall of the faults belonging to PVFS; similarly, SL anomalies of all the four rivers lies at the hangingwall of these faults instead of the footwall. Finally, knickpoints on the long profile of the four rivers, in proximity of the faults of PVFS, show a different anomalous shape with respect to those of normal faults. These results indicate a likely reactivation of the normal faults of PVFS as reverse ones, as already suggested by other Authors (e.g. Catalano *et al.*, 2010) that observed

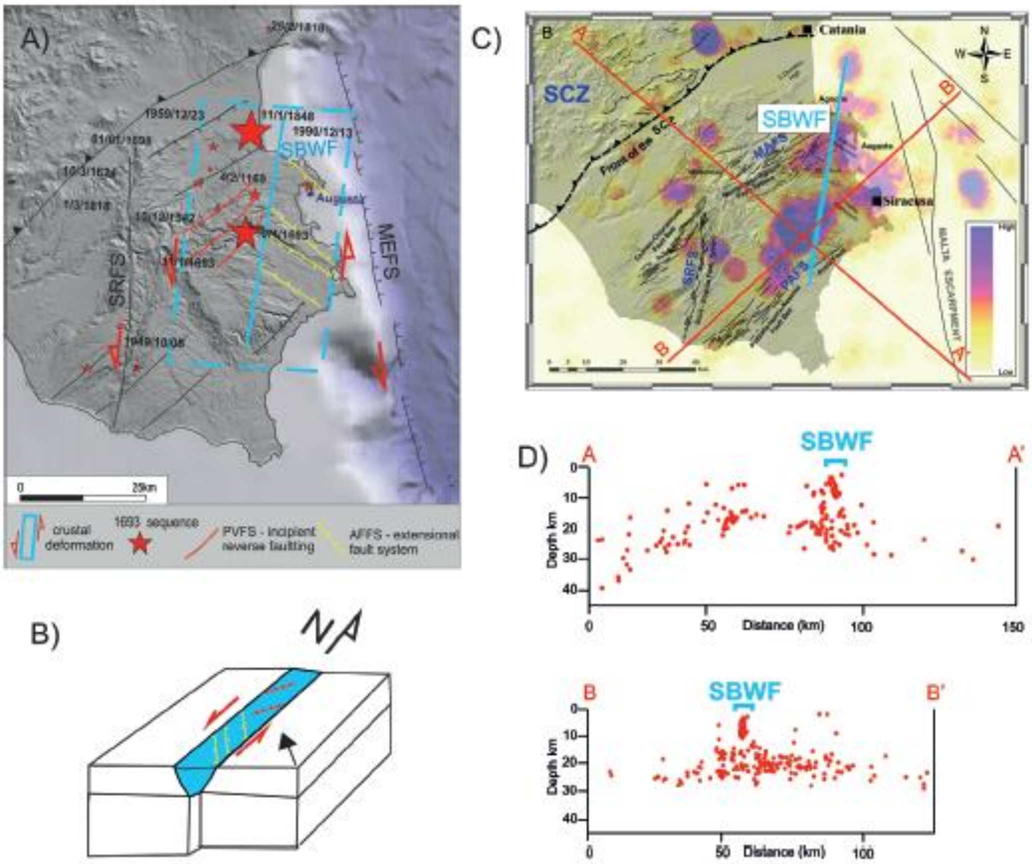

Fig. 3 - A) Main fault systems and Sicilian Blind wrench fault (SBWF); b) model of SBWF according to Riedel's experiment; c) seismicity during 1994-2013, the blue line is SBWF and d) distribution in depth of shocks across SBWF (modified from Musumeci *et al*., 2014)

an inversion of tectonic motion, from normal to reverse, on the N70-80 oriented fault planes of the Pedagaggi Agnone Fault System, starting from Upper Pleistocene.

Even if further geological-structural investigation are required, preliminary geological and morphometric data support the hypothesis that AFFS is an active extensional system; whereas PVFS is an active reverse system that exploits ancient normal faults. From a geodynamic and structural point of view, the coeval coexistence of these two systems can be explained considering that both AFFS and PVFS are the expression on the surface of a deep left lateral wrench fault, that we named Sicilian Blind Wrench Fault (SBWF) (Fig. 3a). According to Riedel's experiment, the crustal sector above a blind wrench fault can be affected by a multitude of structures reflecting the strain field, among which normal and reverse faults (Fig. 3b): AFFS could be the extensional system associated to the wrench fault, whereas PVFS could be the compressional one. Sicilian Blind Wrench Fault is compatible with the southern Sicily geodynamic, indeed it could play the same role of the Ragusa Scicli Fault System and the Malta Escarpment Fault System that separate crustal blocks of the foreland that move with different velocity in the context of the convergence between Eurasia and Africa Plates (Fig. 3a).

We compared structural results (fault location, geometry and kinematics) with data coming from seismicity, both historical and instrumental, with the aim: (i) to define the activity and to constrain the geometry and kinematics of the faults investigated at surface; (ii) to observe evidence of the existence of SBWF; (iii) to relate active faults with the seismotectonic setting of southeastern Sicily.

SBWF well matches with the macroseismic area of the 1693 main shocks and the source models proposed by Barbano and Pirrotta (this volume), and with the area were most of the seismogeological effects during this seismic sequence occurred.

We analysed instrumental seismicity occurred during 1994-2013 and relocated by Musumeci *et al.* (2014). Shocks are mainly characterized by strike slip or transtensive mechanisms and a low-to-moderate energy release at depth 10-25 km. Most of the earthquakes are located offshore in the Ionian Sea between Catania and Siracusa on land in the Augusta area and in the eastern sector of the Hyblean Plateau. In addition, seismicity distribution depicts an alignment of earthquakes and two main clusters of seismicity, in the eastern side of the Hyblean Plateau, along a nearly N-S direction (Fig. 3c and d) (Cultrera *et al.*, 2015; Musumeci *et al.*, 2015). This band of seismicity overlaps the hypothesized NNE-SSW SBWF. In addition, considering its possible prosecution in the Ionian offshore SBWF holds compatibility with the 11 January shock also as it regards the occurrence of the tsunami.

Given the previous discussed evidence we hypothesize that SBWF is a possible candidate for Hyblean Plateau seismicity and in particular for the 1693 seismic sequence. The 9 January foreshock enucleates in the south, near Sortino and strongly damaged the localities along the eastern side of the Hyblean plateau; the 11 January mainshock enucleates northern in the Catania plain or offshore and completely destroyed the previous damaged localities and the villages located north of Catania that were not damaged by the 9 January shock.

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ANALYSIS OF SOURCE PARAMETERS FOR BOTH NATURAL AND INDUCED SMALL SEISMICITY IN ITALY

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In this study we analyse and discuss some source parameters obtained by Full Moment Tensor (FMT) inversions of small earthquakes with ML comprised between 0.3 and 3.0 occurred in Italy. To perform the FMT inversion we use HybridMT technique (Andersen, 2001; Kwiatek *et al.*, 2016) supported by a detailed 1D velocity model. This methodology is based on the concept that the first P-pulse area is proportional to the seismic moment. The data-input is obtained from