CRUST - Interuniversity Center for 3D Seismotectonics with territorial applications

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A releasing-bend at the northern termination of the Alfeo-Etna shear zone (Western Ionian Sea, Italy): seismotectonic implications and relation with Mt. Etna volcanism

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Abstract

Offshore data in the western Ionian Sea indicate that the NW-SE trending dextral shear zone of the Alfeo-Etna fault system turns to N-S direction near the Ionian coastline, where the Timpe fault system occurs. This latter deform the lower eastern slope of Mt. Etna, showing NNW-SSE to NNESSW orientation and resulting from E-W trending regional extension. They are seismically active having given rise to shallow and low-moderate magnitude earthquakes in the last 150 years. Morpho-structural data show that NW-SE trending right-lateral strike-slip faults connect the Timpe fault system with the upper slope of the volcano, where the eruptive activity mainly occurs along N-S to SW-NE trending fissures. As a whole, morpho-structural, geodetic and seismological data, seismic profiles and bathymetric maps suggest that similar geometric and kinematic features characterize the shear zone both on the eastern flank of the volcano and in the Ionian offshore. The Alfeo-Etna fault system probably represents a major kinematic boundary in the western Ionian Sea associated with the relative motion of Africa and Eurasia since it accommodates, by dextral transtensional kinematics, differential motion of adjacent western Ionian compartments. Along this major tectonic alignment, crustal structures such as releasing bends, pull-apart basins and extensional horsetails occur both offshore and on-land, where they probably represent the pathway for magma uprising from depth.

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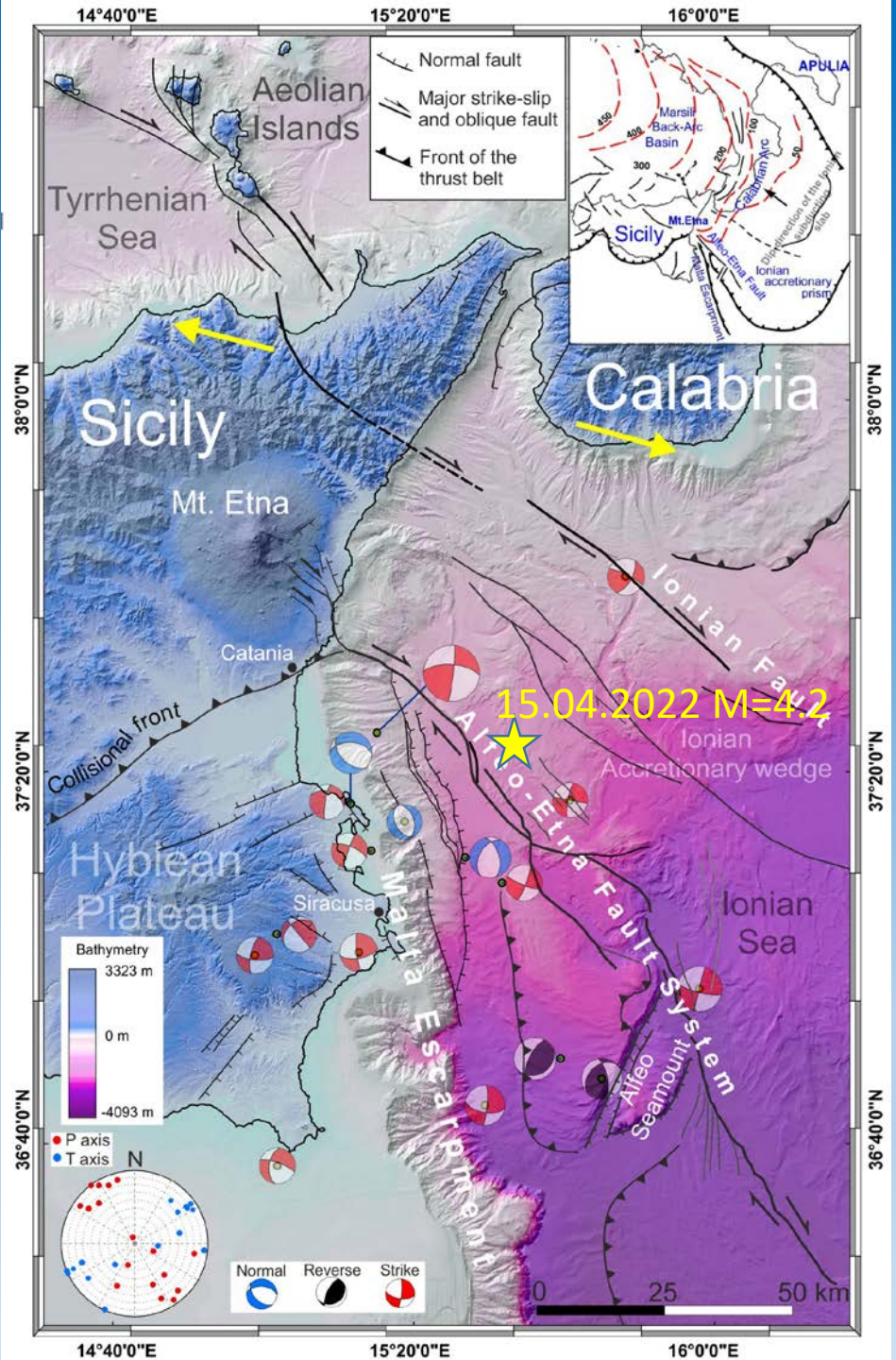
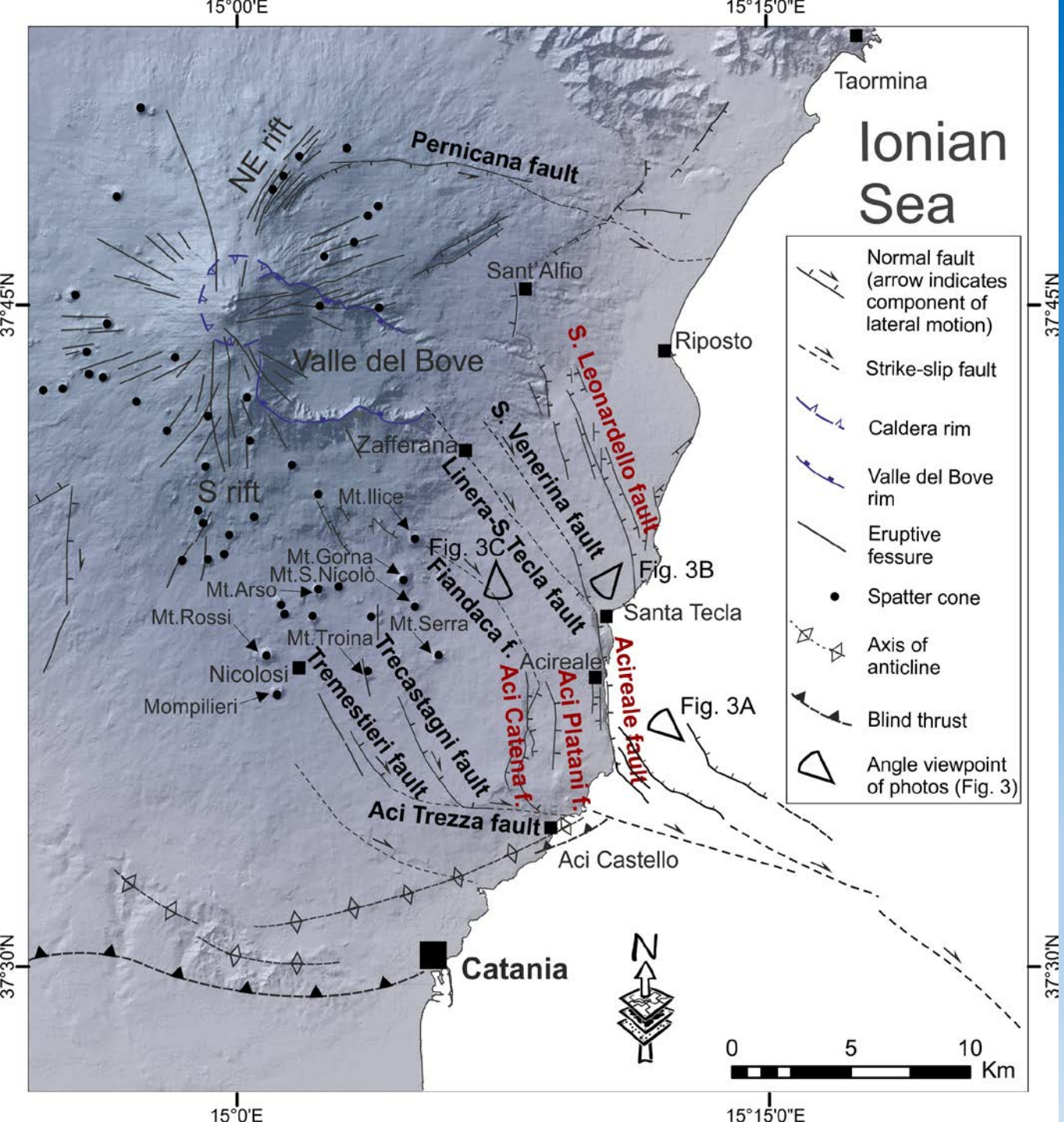
Geodynamic setting



Tectonic sketch-map of eastern Sicily and Ionian offshore. Main tectonic features are from Gutscher et al. (2016) and Polonia et al. (2016).

Yellow arrows indicate the direction of geodetic extension between Sicily and the Calabria–Ionian sector (from D'Agostino and Selvaggi, 2004; Serpelloni et al., 2010; Palano et al., 2012; De Guidi et al., 2013).

Inset shows the location of Mt. Etna in the geodynamic framework of the eastern Mediterranean, at the southern edge of the subducting Ionian slab (dashed lines with numbers indicate its depth in km).

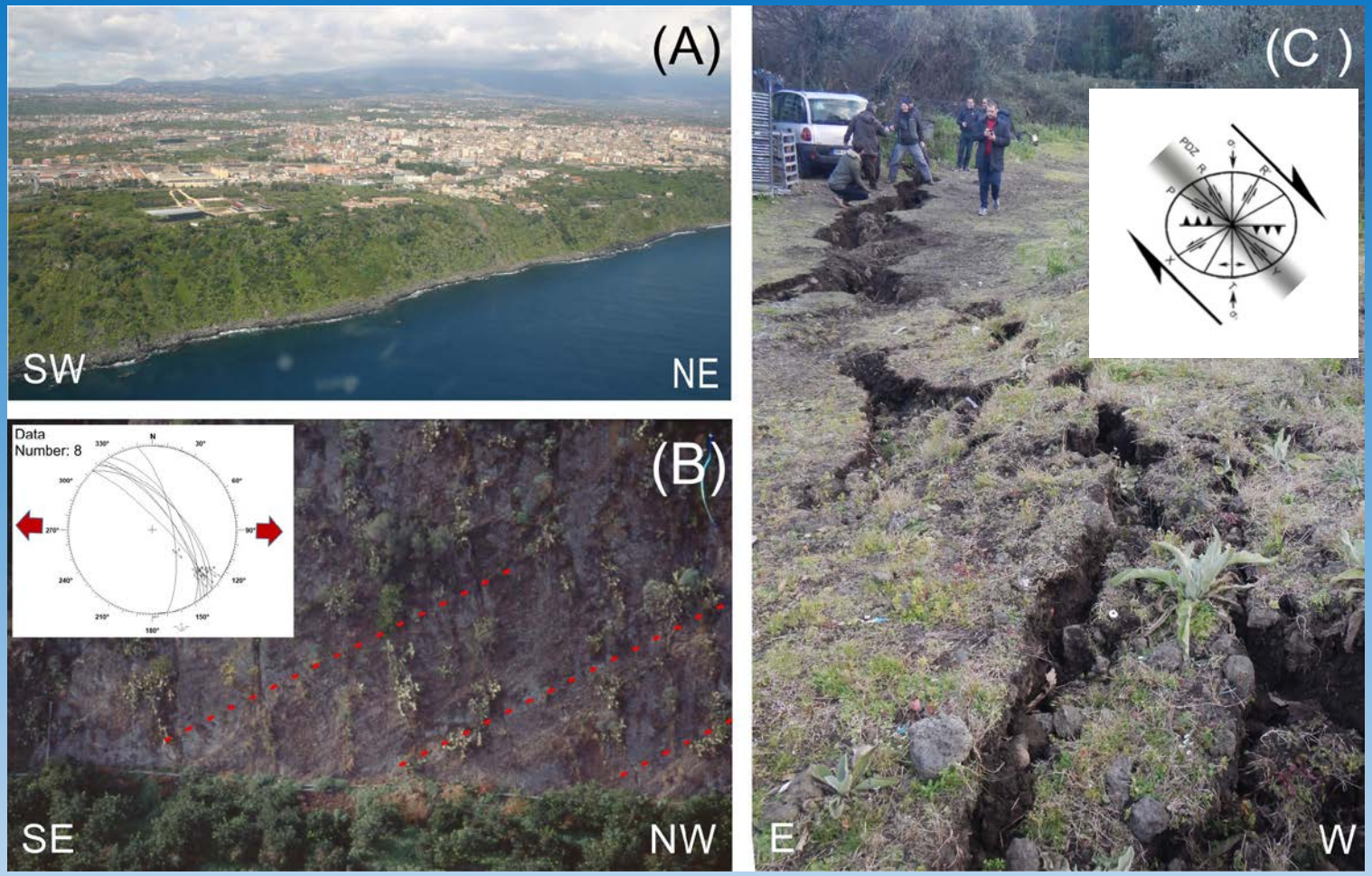


Structural data

Structural map of the eastern and southern flanks of Mt. Etn. Faults labelled in a red colour belong to the Timpe Fault System (from Monaco et al., 2010; Barreca et al., 2013; 2018).

The eastern sector of the Pernicana Fault and the Aci Trezza Fault aseismically transfer the extension towards the offshore and limit to the north and to the south, respectively, the sliding sector of the volcanic edifice (see Mattia et al., 2015).

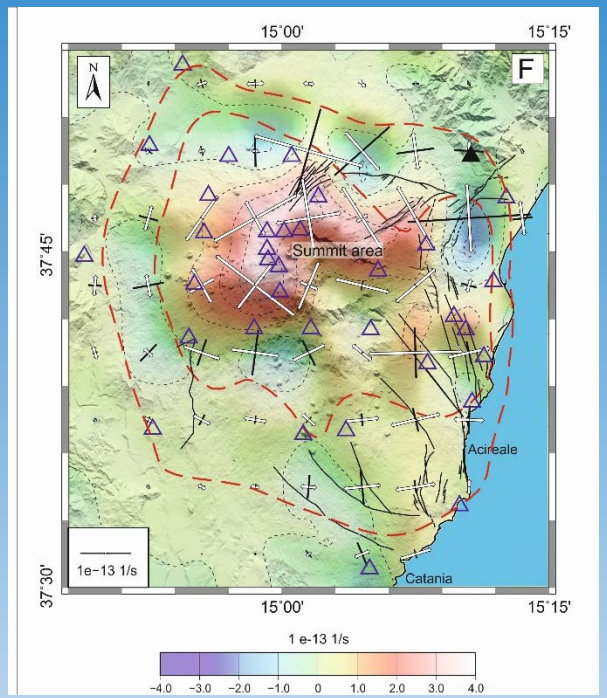
Field data



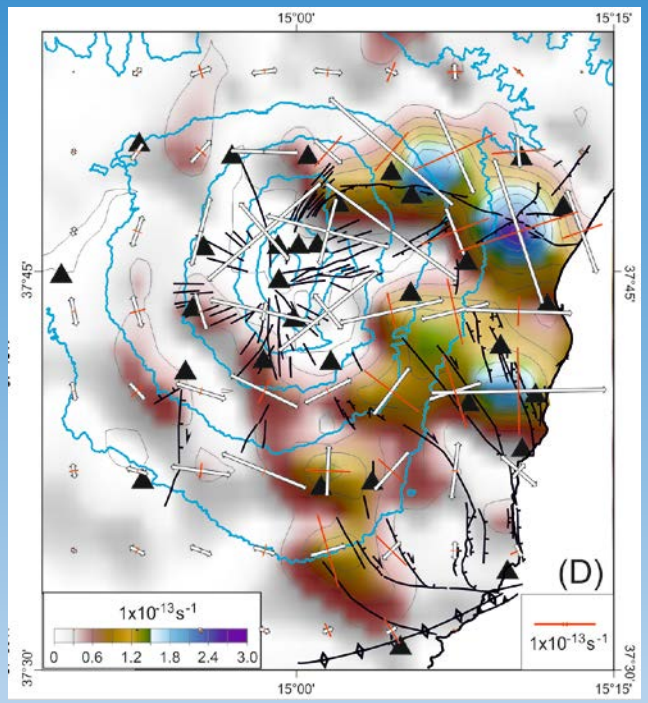
(A) View from the south-east of the Acireale Fault scarp. (B) View from the north-east of kinematic indicators of oblique motion (dextral-normal) along the south-eastern sector of the Linera–S.Tecla fault scarp; inset shows the stereographic projection (Daisy3 software) of fault planes and slickenlines measured in this site; the red arrows indicate the computed extension direction. (C) View from the north of the N–S-trending left-stepping en-echelon open ground fractures formed during the 26 December 2018 seismic event along the Fiandaca fault.

GNSS data

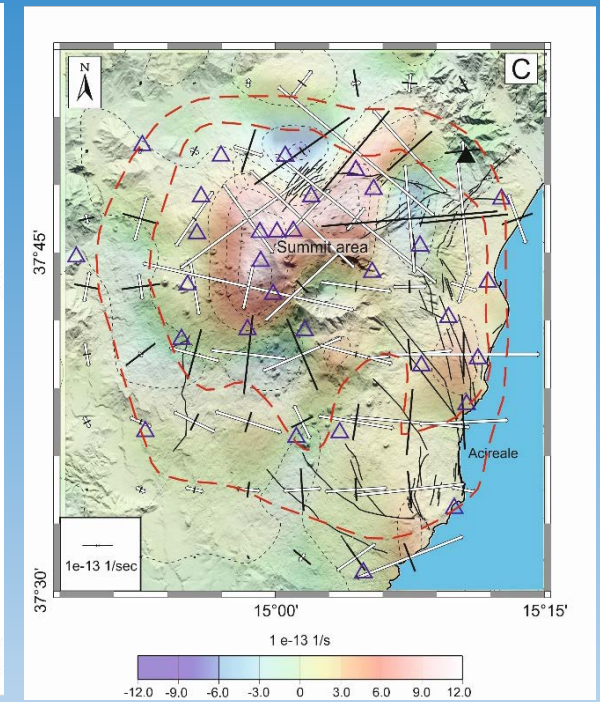
In the southeastern flank, which represents the northern termination of the Alfeo–Etna shear zone, the geodetic shear strain rate associated with the component of the strain tensor field shows a pure strike-slip style of deformation resulting from equal magnitudes of the extensional and compressional principal axes.



June 2009 - May 2010



January-March 2017

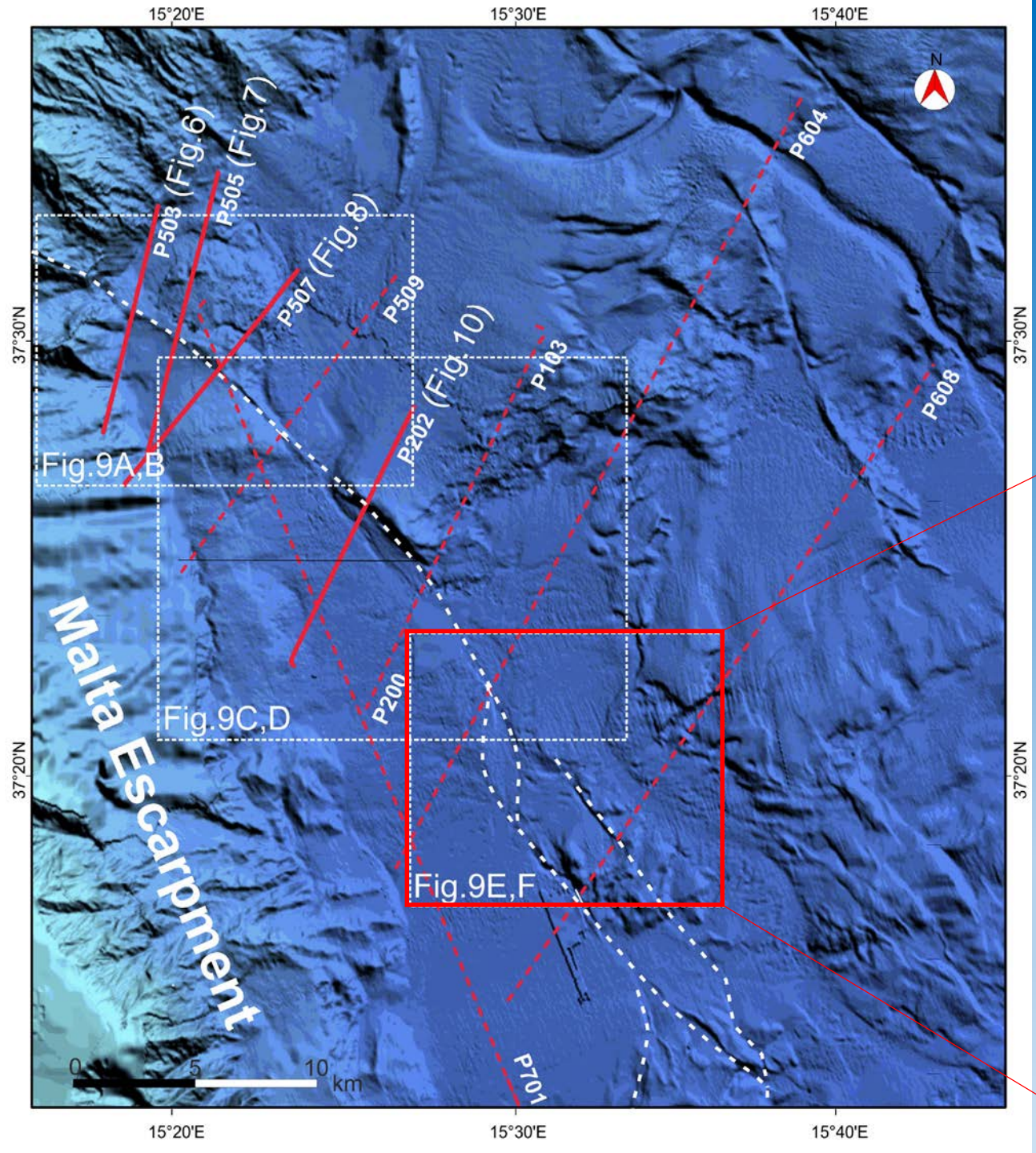


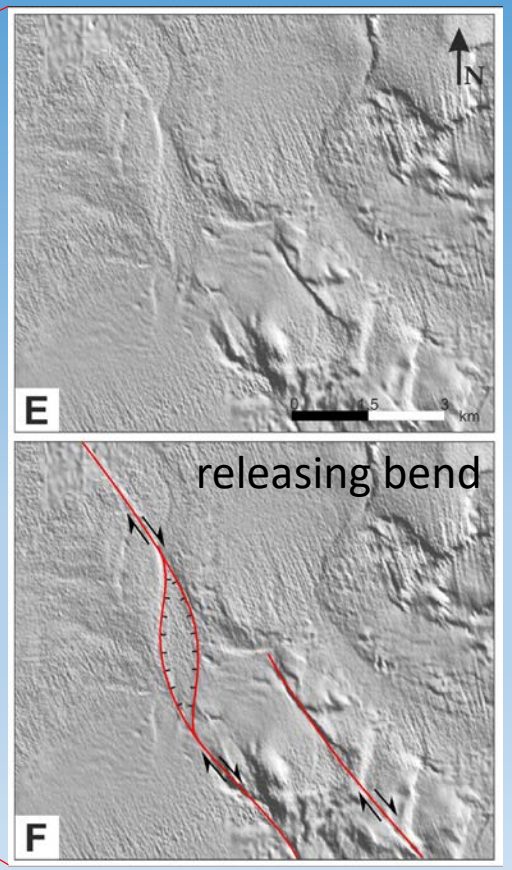
January - May 2019

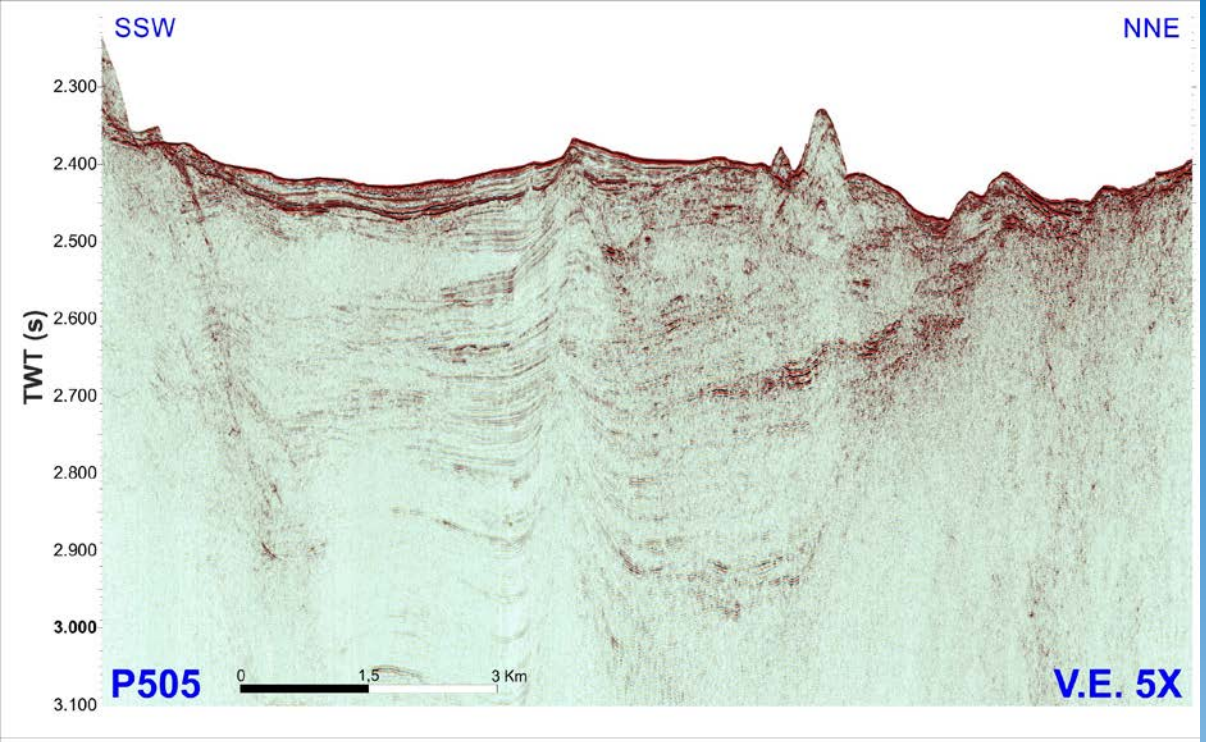
Geodetic shear strain rate at Mt. Etna, modelled through the inversion of the GNSS velocities, associated with the component of the strain tensor field. Open arrows indicate extensional strain rates and solid arrows correspond to compressional strain rates. Triangles indicate the GNSS stations.

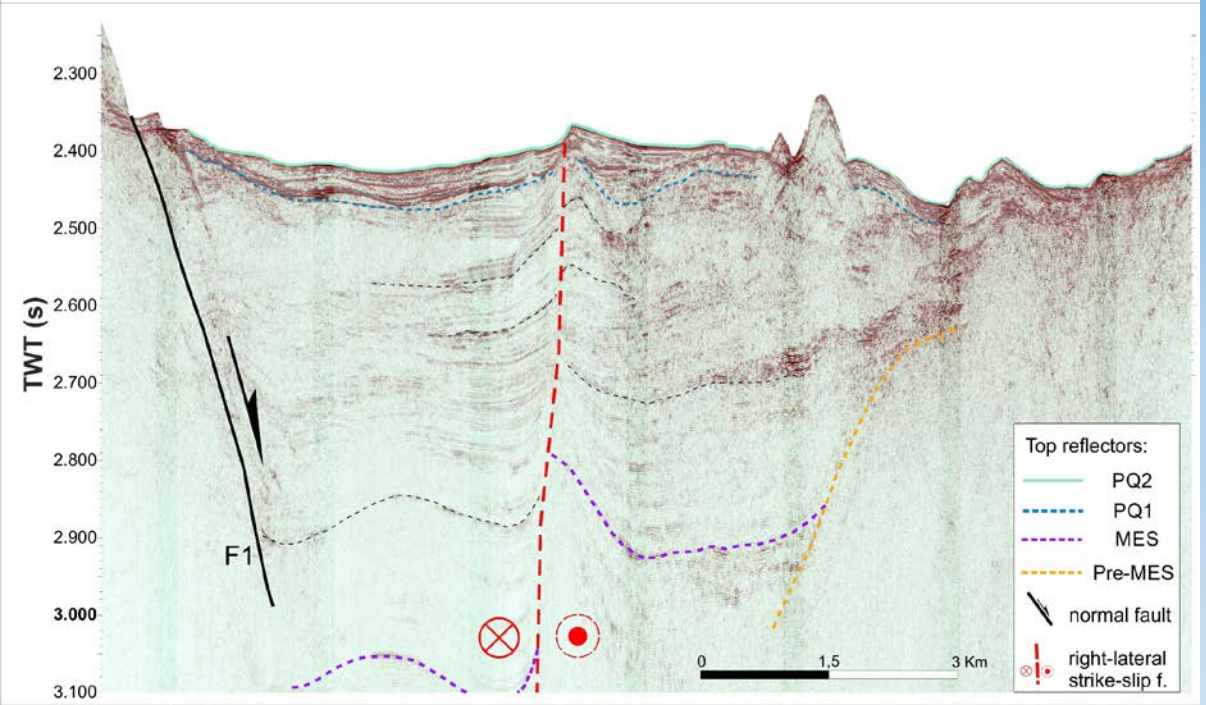
Marine seismic reflection data

Location of seismic grid of the Poseidon expedition POS496 in the Catania-Siracusa offshore (Krastel, 2016). Solid red lines are the profiles showed below. White dashed line is the trace of the North-Alfeo Fault (from Gutsher et al., 2016)

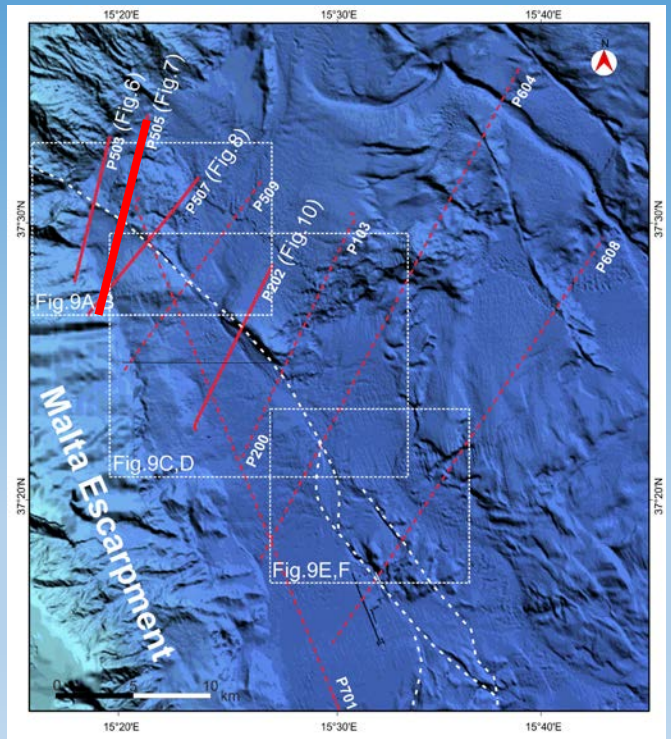








The p505 seismic profile and its interpretation



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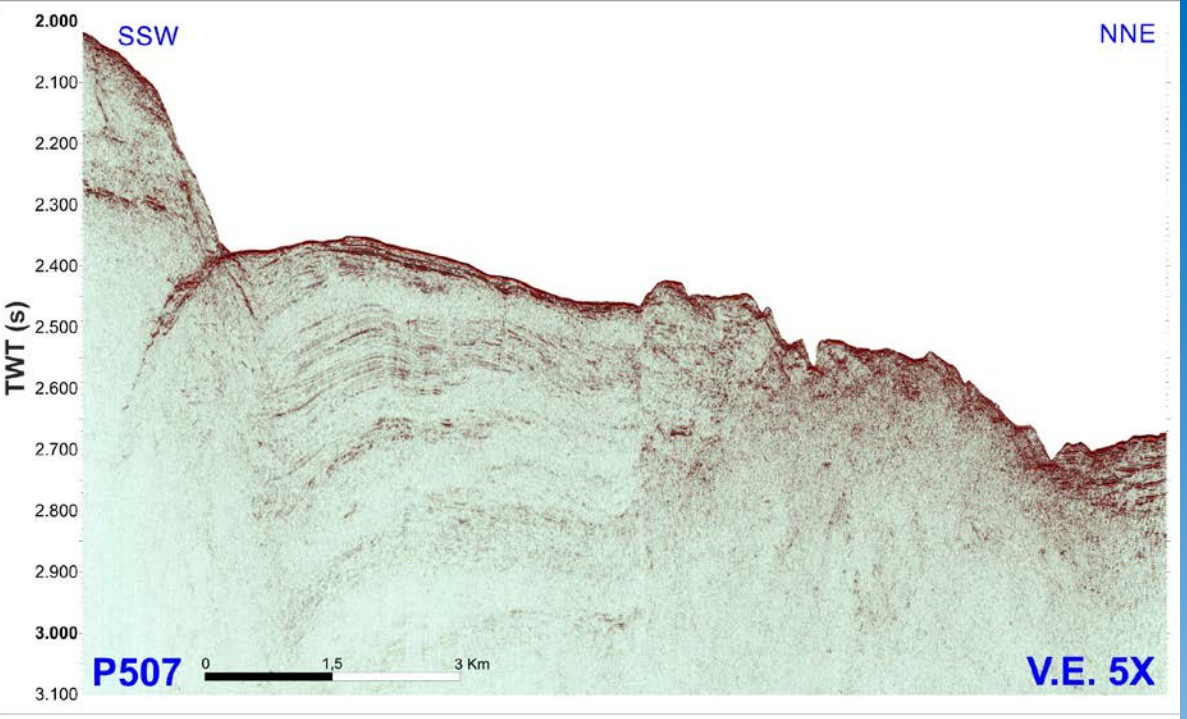
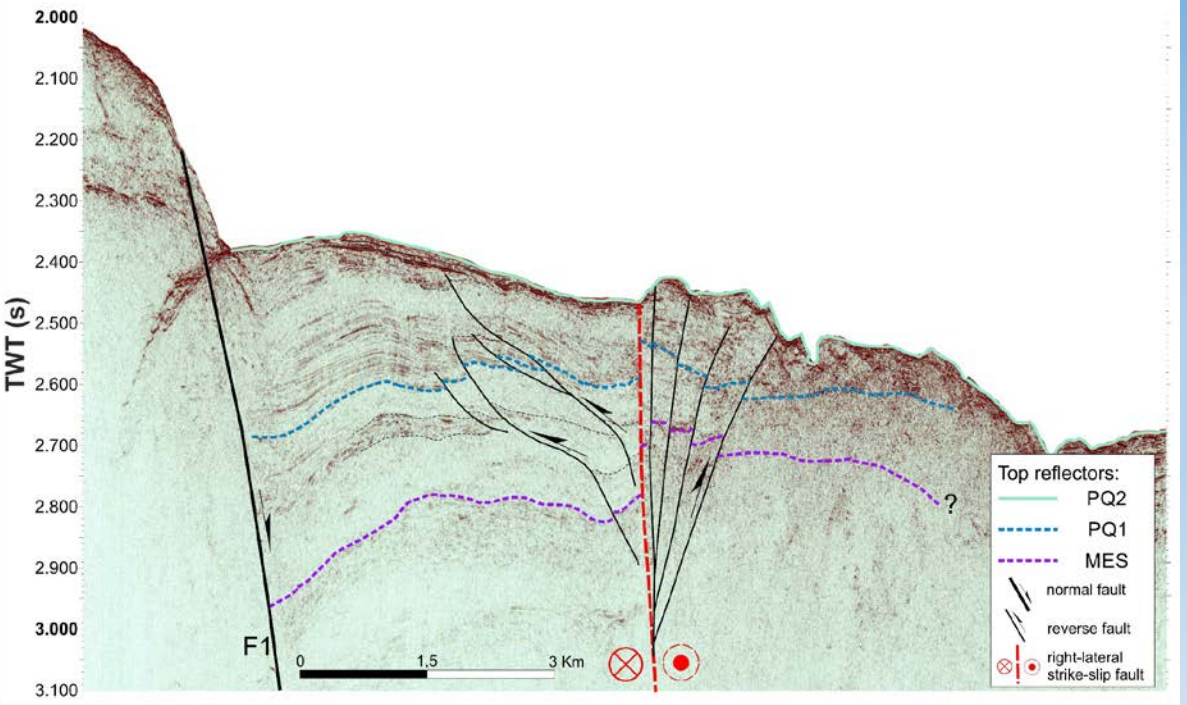
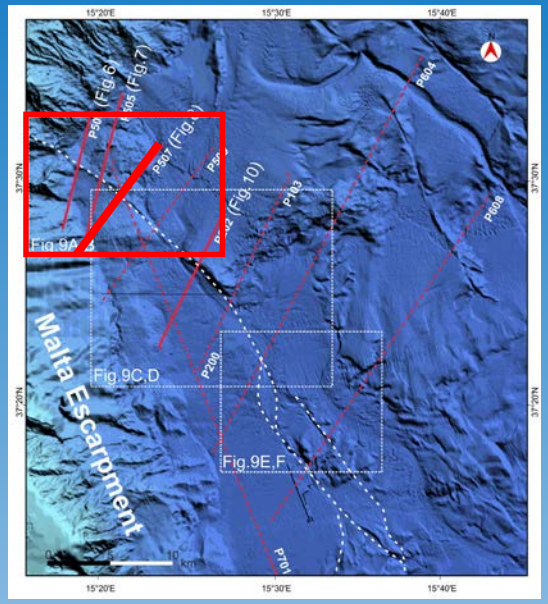
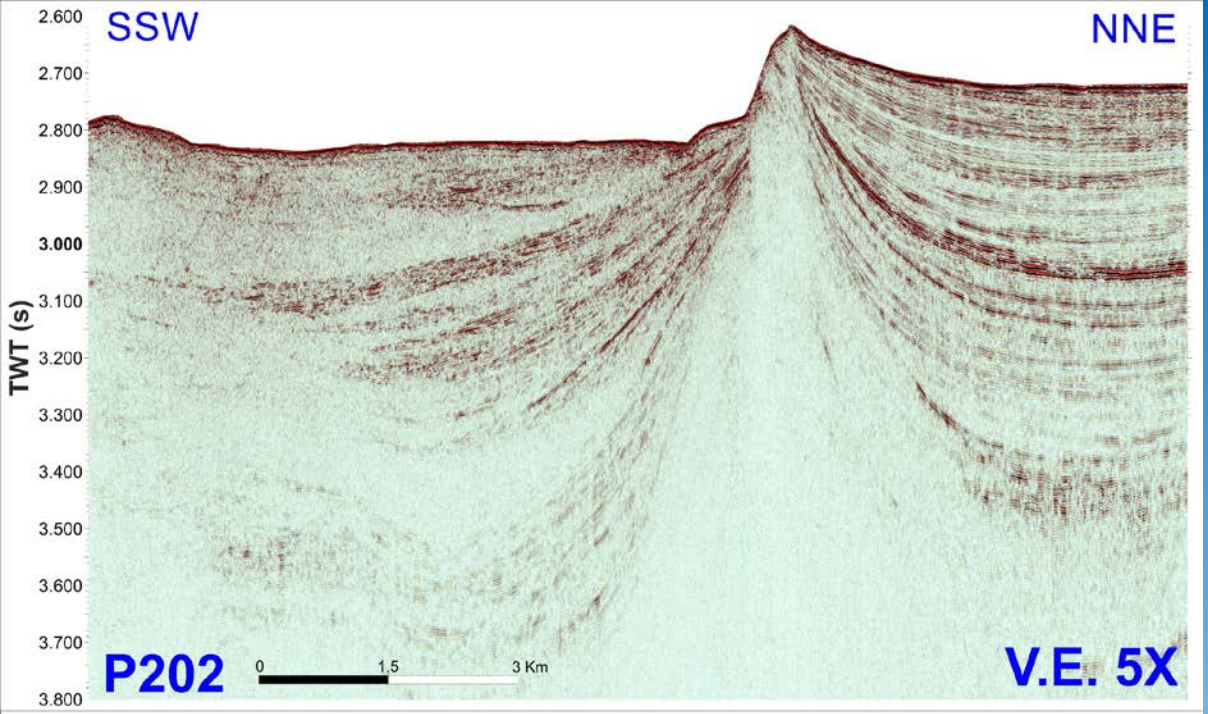


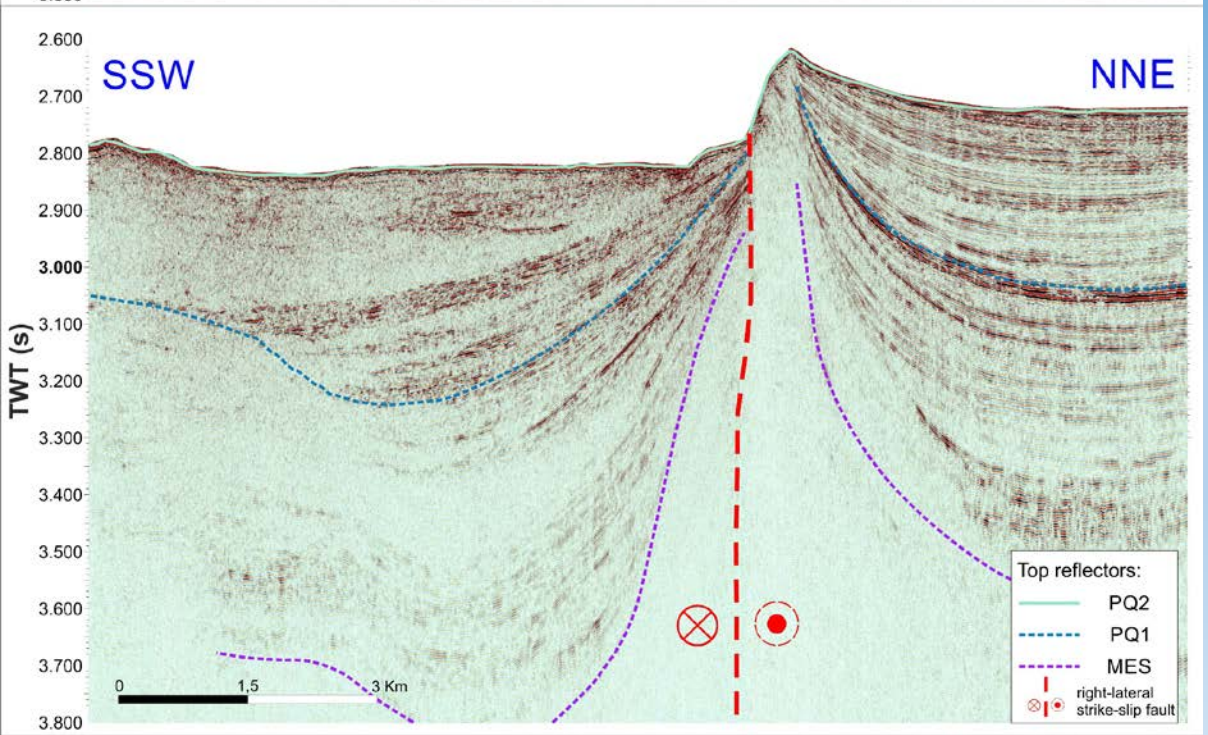


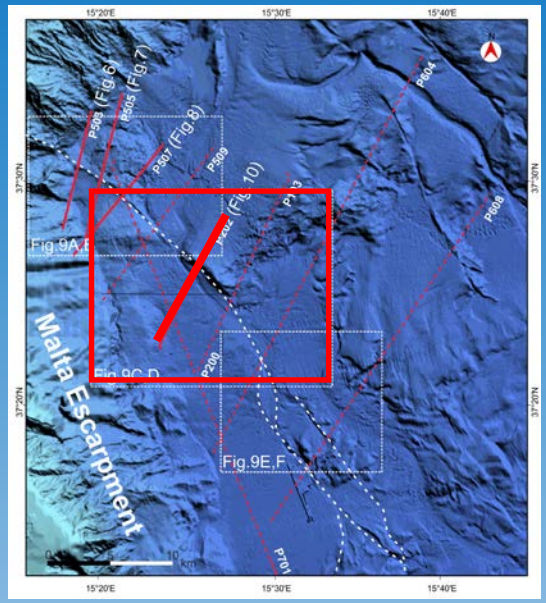


restraining bend

The p202 seismic profile and its interpretation





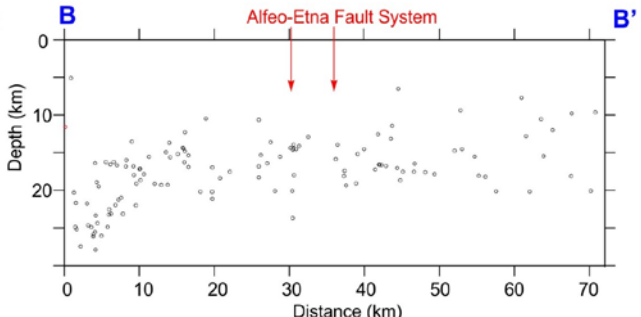


diapirism

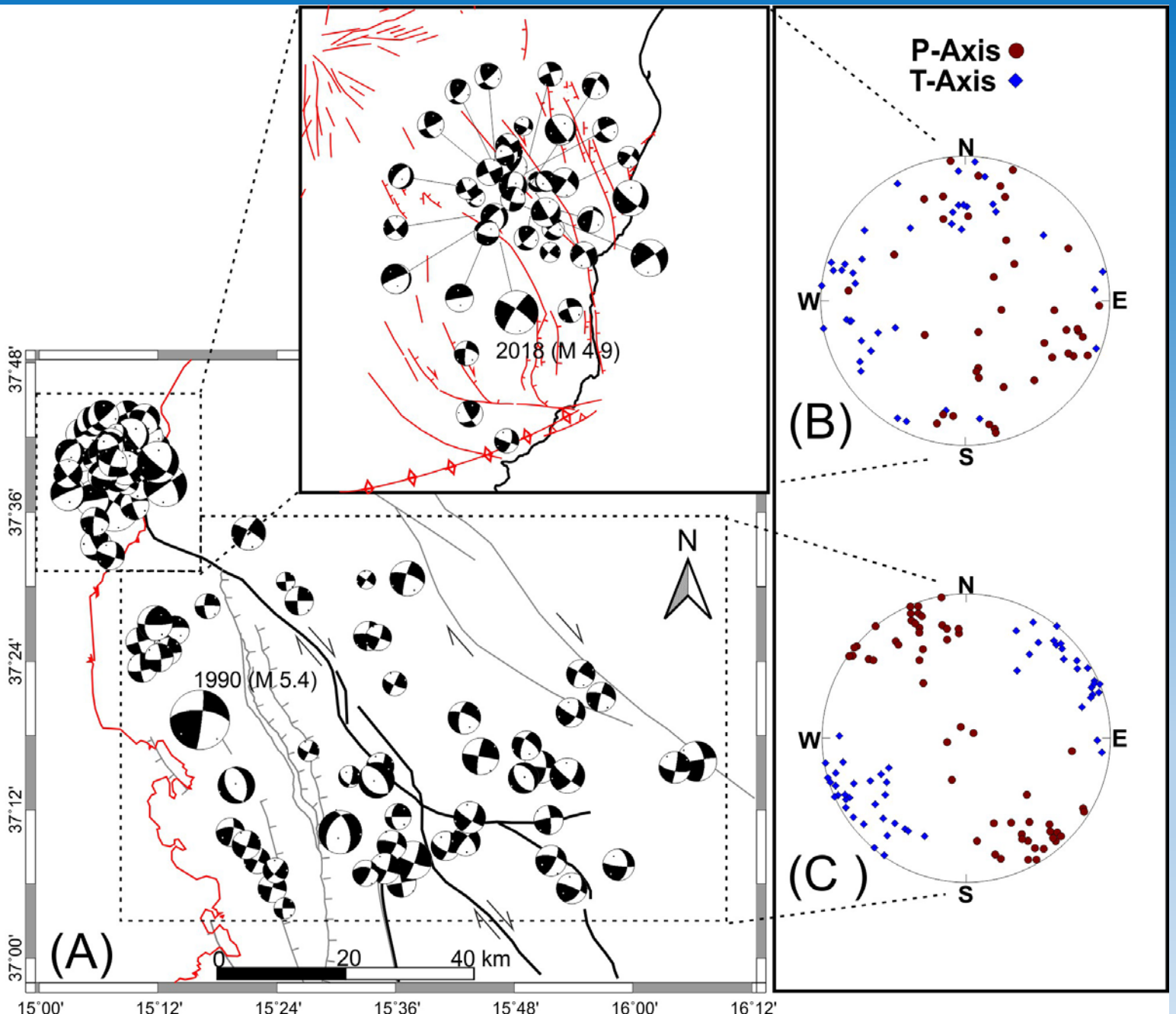
Seismological data

The seismic pattern of the last 40 years has been investigated by referring to the catalogues available by the Istituto Nazionale di Geofisica e Vulcanologia, which contain instrumental observations of the seismic activity in Italy since the 1980s (https://istituto.ingv.it/it/risorse-e-servizi/archivi-e-banche-dati.html; https://www.ct.ingv.it/index.php/monitoraggio-e-sorveglianza/banche-dati-terremoti/terremoti)

Cross sections incorporate all relocated events within ±3 km (AA') and ±6 km (BB') from the cross-section lines.



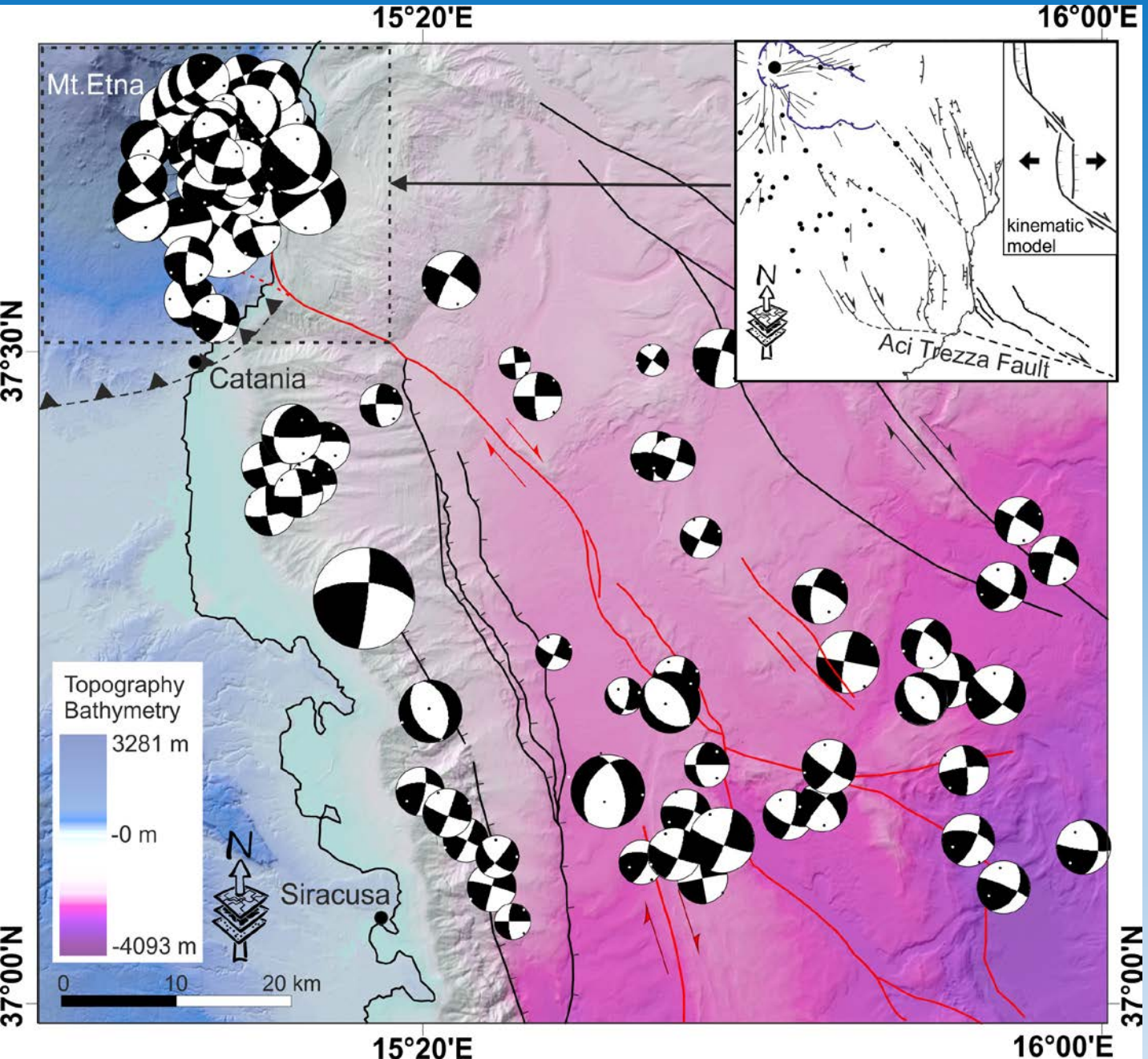
Seismological data



A) Map showing the focal solutions deduced from data collected by Scarfì et al., 2021.

Diagrams (B) and (C) show P–T axes distribution in the Etnean and Ionian areas, respectively.

Kinematic Interpretation



Seismotectonic map of the western Ionian Sea and Mt. Etna area. The Alfeo–Etna faults (after Gutsher et al., 2016; Polonia et al., 2016; Barreca et al., 2018) are red colored .

Inset shows the kinematic interpretation of the volcano-tectonic structures occurring in the eastern sector of Mt. Etna in the framework of the Alfeo–Etna shear zone (releasing sectors, see Woodcock and Fisher, 1986; Sylvester, 1988; Woodcock and Schubert, 1994).