Three-dimensional modelling of the Calabrian Subduction Interface

Francesco E. Maesano, Mara M. Tiberti and **Roberto Basili**

Istituto Nazionale di Geofisica e Vulcanologia (INGV), Rome, Italy

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OBJECTIVES

Reconstruct in detail the shallow subduction interface (<20 km)

Constrain the deep part of the slab top surface (40 - 350 km)

Obtain a seamless 3D surface of the Calabrian subduction

Update the Italian database of seismogenic sources

1 Tectonic setting

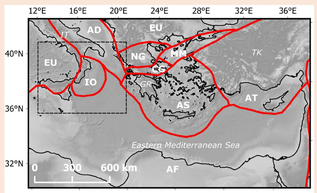
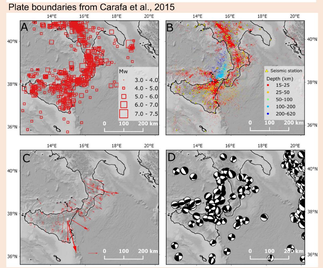
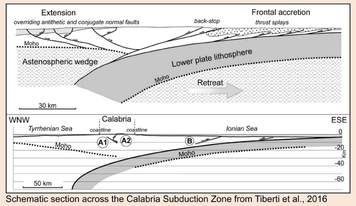


Plate boundaries from Carafa et al., 2015



A - Historical seismicity from CPTI15 (Rovida et al., 2016).
B - Instrumental seismicity 2005-2016 (ISIDe WG, 2016).
C - GPS velocities. Fixed Africa reference (Devoti et al., 2011).
D - Regional Centroid Moment Tensor solution (http://www.bo.ingv.it/RCMT/).



Schematic section across the Calabria Subduction Zone from Tiberti et al., 2016

The Calabrian Arc is a one-of-a-kind subduction zone. It features one of the shortest subduction segments (<150 km), one of the thickest accretionary wedges, and the oldest subducted (280 Myr) oceanic crust of the World.

The evolution of the Calabrian Arc is controlled by slab roll-back that started in the Late Miocene (8-10 Myr; Goes et al., 2004; Faccenna et al., 2005), due to the sinking of the Ionian oceanic crust. The effect of plate convergence on the subduction process gradually decreased since the start of continental collision in Sicily (late Miocene -Pliocene).

At present, the subduction process controls the south-eastward migration of the upper plate and active faulting within it (Tiberti et al., 2016). Despite a convergence rate of 1-5 mm/yr (e.g. Devoti et al., 2011) and significant in-slab seismicity below 40 km depth (Chiarabba et al., 2008), its shallow interface shows little signs of seismic activity.

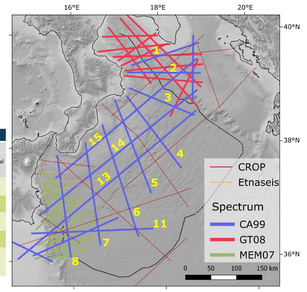
2 Dataset and method

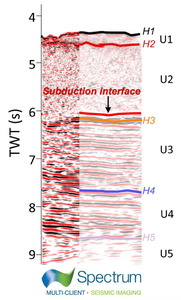
Shallow interface (<20 km): 54 seismic profiles; Total length: 8658 km; Covered area: 99043 km^2

Deep slab (20-350 km): Seismic events (2005-2016): 6352; Subset (3D distance<7.3 km): 5711; M range: 0.3 - 5.8

Characteristics of the seismic reflection dataset.

Survey	Number of lines	Total length (km)	Record length (s)	Acquisition parameters: Source	Source depth (m)	Streamer depth (m)	Streamer length (m)	Shotpoint interval (m)	Group interval (m)
CA99	16	3391.4	6 – 12	Airgun Array 3410 c.i.	6	8	6000	25	12.5
MEM07	15	1530.5	12	Airgun Array 2200 c.i.	6	8	7200	37.5	12.5
GT08	12	1712.6	8	Airgun Array 5000 c.i.	6	8	8100	25	12.5
CROP	6	1625.6	17-20	High Pressure (140 bar) Airgun	6	12	4500	62.5	25
Etnaseis	5	398.2	11-17	Airgun array 840 c.i. 3810 c.i.	23	20 21	4475 2375	42.5 45 50	25

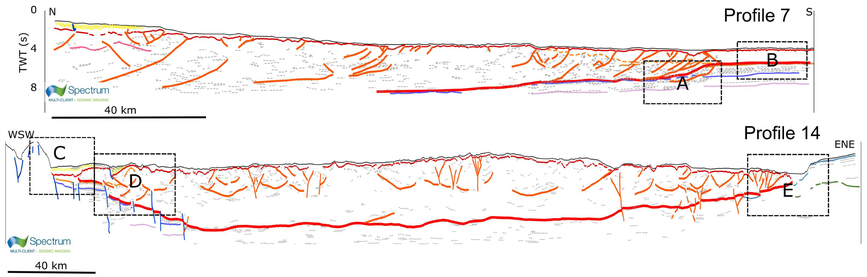


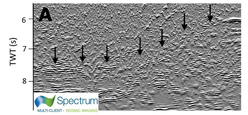


Picked reflectors and seismo-stratigraphic units.

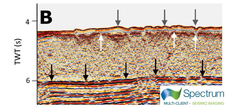
ID	Horizon/Units	Type
H1	Top **U1** (Plio-Pleistocene)	Seafloor
H2	Top **U2** (Post-Messinian evaporitic accretionary wedge); Top **U6** (Pre-Messinian accretionary wedge)	Unconformity
H3	Top **U3** (Ionian unit; Paleocene ? - Tortonian)	Unconformity and correlative conformity
H4	Top **U4** (Ionian unit; Triassic – Cretaceous)	Unit top
H5	Top **U5** (Ionian oceanic crust; Permian ? – Triassic)	Unit top
H6	Top **U7** (Calabrian metamorphic unit)	Unit top
H7	Top **U8** (Apulia Platform; Mesozoic – Messinian)	Unconformity
H8	Base **U8** (Apulia Platform; Mesozoic – Messinian)	Unit base

3 Multichannel seismic reflection profiles

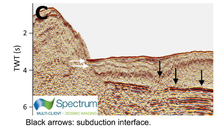




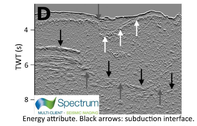
Energy attribute. Black arrows: subduction interface.



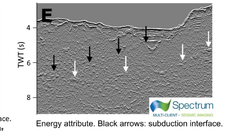
Black arrows: subduction interface.
White arrows: folded unconformity H2.
Grey arrows: deformation of the seafloor (H1).



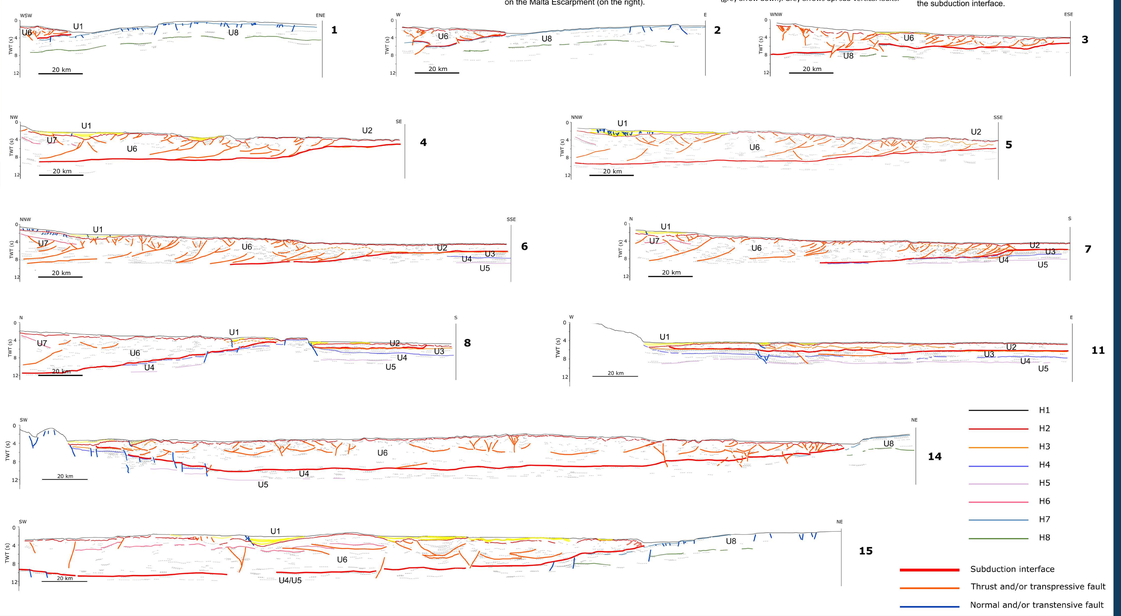
Black arrows: subduction interface.
White arrows: onlap of the undeformed U1 (on the left) on the Malta Escarpment (on the right).



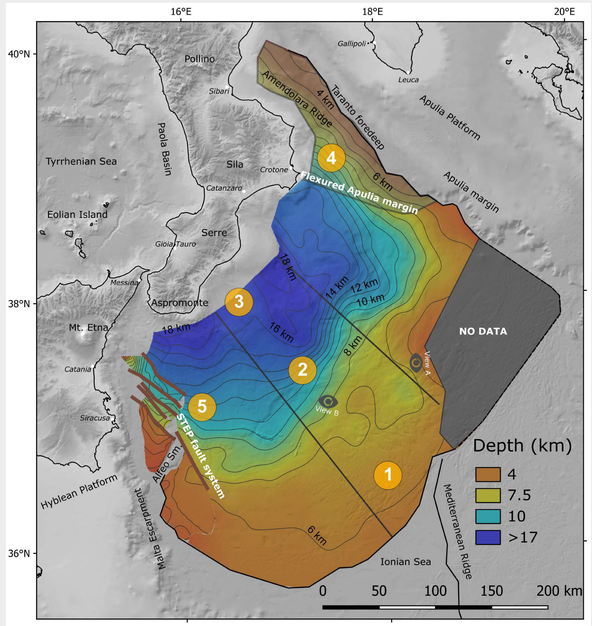
Energy attribute. Black arrows: subduction interface.
White arrows: deformed H2 unconformity by fault (grey arrow down). Grey arrows up: sub-vertical faults.

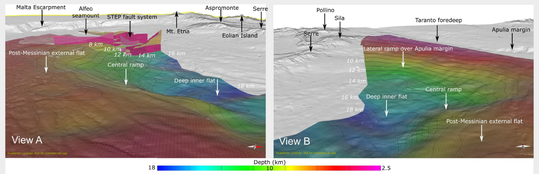


Energy attribute. Black arrows: subduction interface.
White arrows: high energy reflector within U8 under the subduction interface.

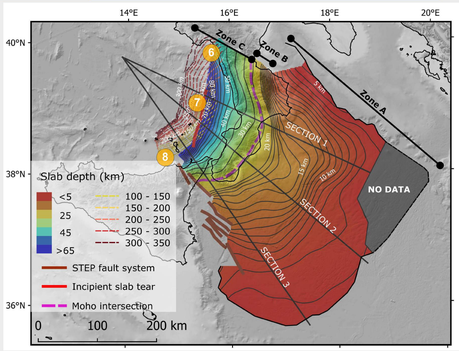


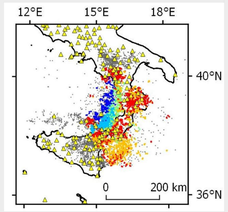
4 Results I: Shallow subduction interface (<20km)





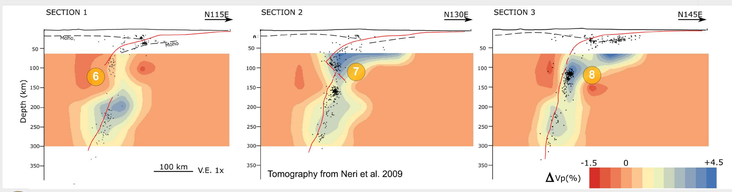
5 Results II: 3D Calabrian subduction





Seismicity distribution (2005-2016)

Seismic station
Dataset
Subset: 3D dist<7.3 km
Depth (km)
15
400

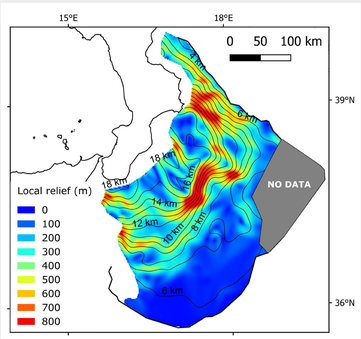


6 Slab window (Chiarabba et al., 2008). Eastward shift of the deeper slab (20 km offset)

7 Incipient slab tear. Eastward shift along a NNE-SSW, SE dipping plane (15 km offset)

8 Continuous slab

Shallow Interface Roughness



1 Outer wide flat area between 5 and 8 km: subduction interface propagating at the base of the tectonically stacked Messinian evaporites. Low roughness.

2 Central ramp 8 km to 14 km: steeper in the northern part (up to 18°) than in the southern (ca. 7°). High roughness (up to 800 m) in the central northern part.

3 Deeper flat area between 14 and 19 km: subduction interface at low angle (ca. 4°). Higher geometrical variability, high roughness values (up to 700 m) along NW-SE trend.

4 Northern margin: allochtonous units over the Apulia Platform. Subduction interface deformed by transpressive structures

5 Southern margin: the interface is interrupted by a system of NW-SE high angle faults interpreted as a Subduction Transform Edge Propagator (Maesano et al., 2016)

Acknowledgments and References

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(1) Carafa, M. M. C.et al. (2015), Neotectonics and long-term seismicity in Europe and the Mediterranean region, J. Geophys. Res. Solid Earth, 120,doi:10.1002/2014JB011751. **(2)** Chiarabba, C. et al. (2008), The southern Tyrrhenian subduction zone: Deep geometry, magmatism and Plio-Pleistocene evolution, Earth and Planetary Science Letters, doi:10.1016/j.epsl.2008.01.036. **(3)** Devoti, R. et al. (2011), Earth and Planetary Science Letters, doi: 10.1016/j.epsl.2011.09.034. **(4)** Faccenna, C. et al. (2005), Constraints on mantle circulation around the deforming Calabrian slab, Geophys. Res. Lett., doi:10.1029/2004GL021874. **(5)** Goes, S. (2004), A recent tectonic reorganization in the south-central Mediterranean, Earth and Planetary Science Letters, doi:10.1016/j.epsl.2004.07.038. **(6)** ISIDe working group (2016) version 1.0, doi: 10.13127/ISIDe. **(7)** Maesano, F.E., et al. (2016) Deep view of the Subduction-Transform Edge Propagator (STEP) fault in the Calabrian Subduction Zone, EGU General Assembly 2016. **(8)** Neri, G., et al. (2009), Subduction beneath Southern Italy close the ending: results from seismic tomography. SRL doi: 10.1785/gssrl.80.1.63 **(9)** Rovida A., et al. (2016), CPTI15, the 2015 version of the Parametric Catalogue of Italian Earthquakes. Istituto Nazionale di Geofisica e Vulcanologia. doi: 10.6092/INGV.IT-CPTI15. **(10)** Tiberti, M.M., et al. (2016), Understanding seismogenic processes in the southern Calabrian Arc: a geodynamic perspective, Italian Journal of Geosciences, doi:10.3301/IJG.2016.12