Field GPS data inversion to model Fiandaca tectonic lineament that caused seismic event on 26th December 2018 (Mt. Etna Volcano, Sicily)

De Guidi G.[1,2], Cannavò F.[3], Figlioli A.[1], Giuffrida S.[1], Russo D.[1], Carnemolla F.[1,2], Brighenti F.[1,2]

1 Università di Catania, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Italy
2 CRUST, Centro inteRUniversitario per l'analisi SismoTettonica tridimensionale con applicazioni territoriali, Università di Catania, Italy
3 Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Catania Osservatorio Etneo, Italy

GEODynamic & GEOMatic Lab

1 Introduction

GEOLOGICAL SETTING

Mt. Etna Volcano (Sicily, Italy) is located on the southern boundary of the Apennine-Maghrebid chain(Fig.1). In the Mt. Etna area tectonic and volcanic process, linked to the regional extension interact to define a complex framework (De Guidi et al, 2018); from the seismic historical and instrumental data, appears that more than 80% of the earthquakes affecting the volcano are shallow (h<5 Km) and located mainly in the eastern sector (Gresta et al, 1990; 1998).

In this context the Nizzeti Fault shows a NNW-SSE trend in its southern portion and NNE-SSW in the northern portion and a normal kinematics with a slight right transtensive component, this system forms a cumulative slope up to 100 m high (Monaco et al, 2010).
On the last centuries, The Nizzeti fault was seismically active on 1866-1899, on 1988 (Azzaro et al, 1989) and, on 2018-2019 asismic creep phenomena occured along the fault with fractures in the ground and damage to buildings.
The Fiandaca fault extends for 5km in length between the towns of Fleri and Acicatena , is oriented NNW-SSE and runs east from the Linera fault (Monaco et al, 2010). It is characterized by scarce morphological evidence and by a predominantly normal kinematics, with a subordinate right lateral component. In the last two centuries, during different seismic events, numerous fractures in the soil and damage to human works have been found in correspondence with the aforementioned fault.

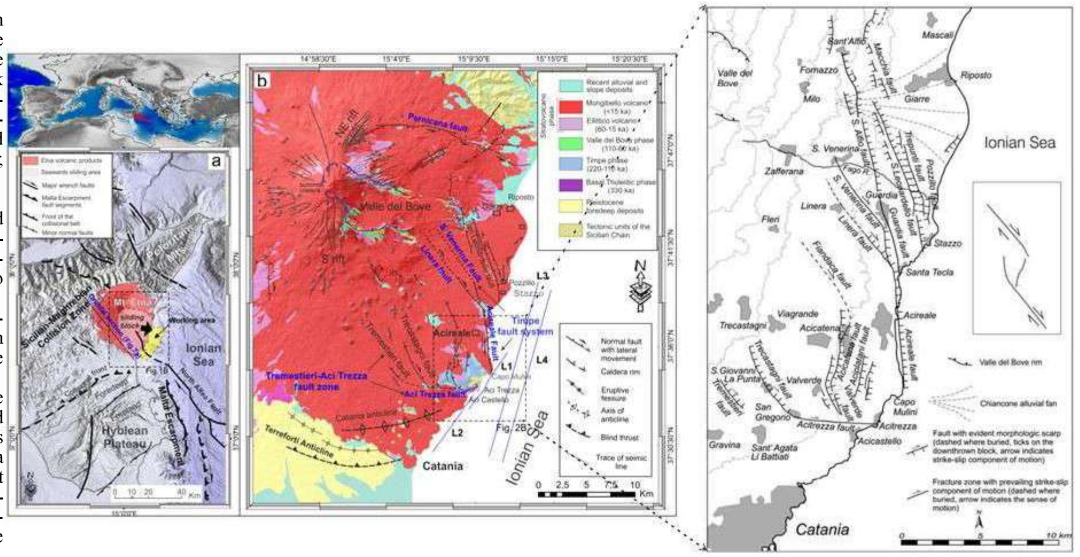

Fig.1: Geological and tectonic setting of Mt. Etna volcano eastern flank, Barreca et al, 2018; Monaco et al, 2010.

THE SEISMIC EVENT OF 26TH DECEMBER 2018

On 24 December 2018, a volcanin crisis on the summit area occured on Mount Etna due to the ascent of a dyke which caused the opening of an eruptive fracture about 2km long at the eastern flank of the volcano and an intense seismic swarm. On 26 December 2018, a seismic event occured on the Fiandaca Fault.

In particular the Fiandiaca fault responded cosismically to the rupture in correspondence with the areas closest to the northern tip of the structure, while those closest to the southern tip had a slower and more distributed post-seismic response characterized by aseismic creep.
This seismic event is usefull in order to investigate the interactions between regional stress, local extension phenomena induced by magma rising, gravitational forces, and the geomechanical characteristics of the substrate of Mt. Etna.

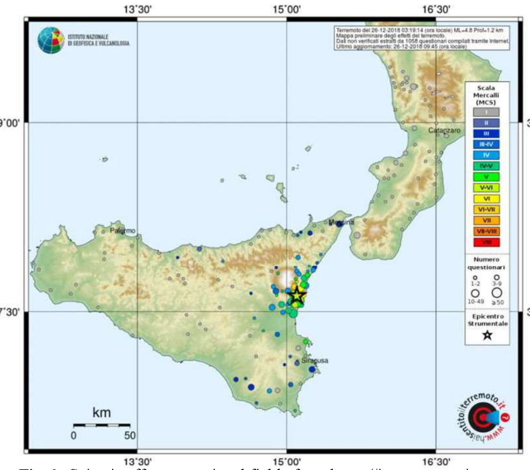

Fig. 2: Seismic effect on regional field, from https://ingvterremoti.com.

2 Geodetic data

GNSS DATA NETWORK

The GNSS network along Nizzeti and Fiandaca Faults is composed by 7 benchmarks (3 on Fiandaca fault and 4 on Nizzeti fault) realized after an accurate geological and geo-structural survey. The aim of this network is the monitoringof the deformations occurring along the two structures (Fig.3).
Monitoring campaign started on December 2018. Actually 13 campaing were carried out: 6 for Fiandaca fault (from December 2018 to September 2020) and 7 for Nizzeti fault (from December 2018 to September 2020).

GNSS DATA PROCESSING

GNSS data processing was carried out by AUSPOS (Australian Surveying and Land Information Group) web-based service; the elaboration is performed using 15 IGS reference stations close to the benchmark investigated. After data processing the time series and velocity field were realised(Fig. 4).

VELOCITY FIELDS

The next step was to realize velocity fields for each benchmark, Along the Nizzeti fault, the benchmarksshow an orietation of about WSW-ESE and velocities ranged fromfrom 30.5 mm/y on NFW2 until 57,3 mm/y on point NFE3, oriented toward ESE.
Along the Fiandaca fault, FNC1 and FNC2 show a velocity field oriented toward ESE and a value of about 59,3 mm/y and 35,7 mm/y. FNC3 shows a velocity field oriented toward NW anda value of 48 mm/y (Fig. 3)

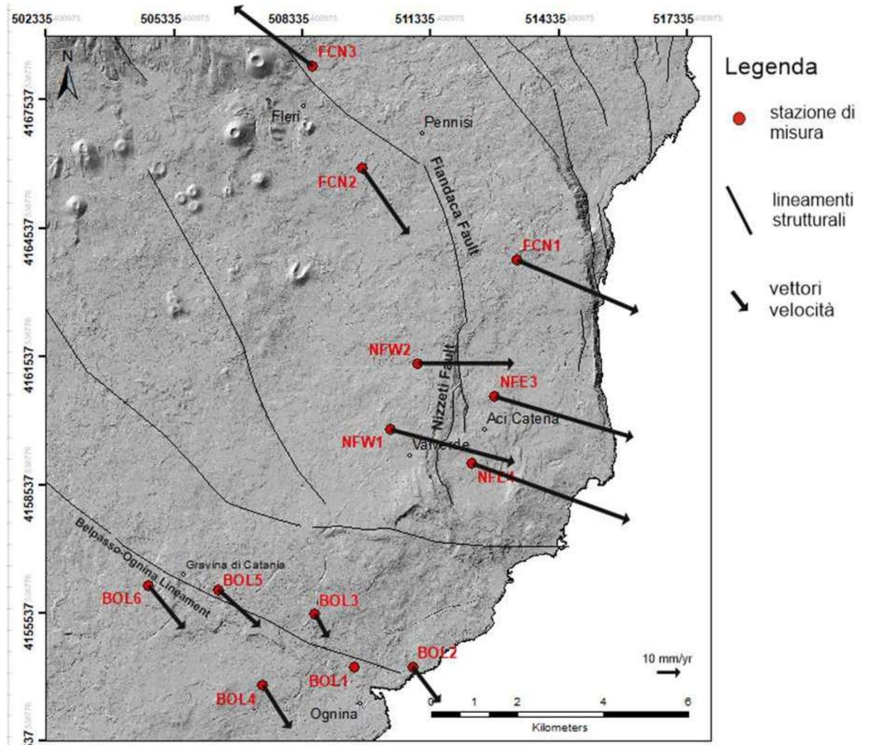

Fig. 3: GNSS Unict-Net with Velocty Field

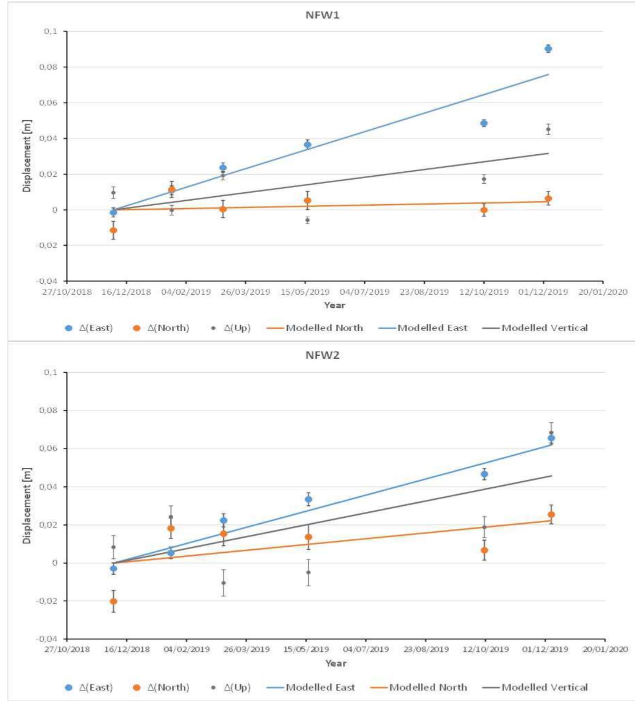

Fig. 4: Rappresentative GNSS time series.

3 Result

Discussion and Conclusion

The final model, obtained by GAME's inversion process, is suitable with the dynamic, geometric, seismic and geological aspect of the tectonic structures analyzed. To inverted the data on GAME, we choose the source paramenters for the Fiandaca and Nizzeti Faults: i) coordinates; ii) geometric parameters (figure 5 and Tab. 1).

In order to better constrain Fiandaca's tectonic source parameters we added the GNSS data of the permanent stations: EBDA and ELIN which belong to the ETN@NET managed by INGV-OE. Earthquake sensor was introduced in order to verify the maximum magnitude produced by the modeled structures (5.1 Mw, in this case).
Theorical Okada source models, associated with 26th December 2018 seismic event, was verified by De Guidi et al. (2012) in which fault planes about 7 Km long are allowed to produce seismic event with magnitude of 5; in fact the length parameter modelled for these tectonic structures is about 7600 m that justifies the magnitude of 5.1 (fig. 6).

According to Monaco et al. (2020) we observe that the main seismic events,occured during the period between November 2018 and February 2019, are located above 2 Km in depth, which is suitable with our results (fig. 5).
Moreover the modelled structures show an comparable orientation with literature data (fig. 1).
The results obtained from the inversion of the GPS data allowed the creation of a source model that found a good congruence in terms of geometric, kinematic and seismic parameters of the faults in question as described by recent studies (eg De Guidi et al., 2012; Monaco et al., 2020)..

Sorgente Fiandaca										
E (m)	N (m)	U (m)	Azim	DIP	Len (m)	Wid (m)	Stk-s (m)	Dip-s (m)	Tens (m)	
513557	4168678	200	310°	89.9°	3300	1400	0	0.5	0.5	Max
511148,313	**4168438,869**	**100**	**309,282°**	**88°**	**3091,561**	**1000,81**	**-0,829**	**0,166**	**0,034**	**Parameters**
512118	4163918	-100	300°	80°	3000	1000	-1	0	0	Min
		83,1	5,14°		71,29	238,38	0,066	0,11	0,3	**Sigma**
Sorgente Nizzeti										
512900	4165200	0	360°	70°	4600	2300	0	0,5	0,5	Max
512899,998	**4164803,504**	**-299,646**	**358,686°**	**70°**	**4591,621**	**2092,607**	**-0,5**	**0,299**	**0,001**	**Parameters**
512400	4164700	-300	350°	60°	4300	1700	-1	0	0	Min
155,629	249,52	88,23	1,388°	5,97°	175,3	367,316	0,282	0,089	0,144	**Sigma**

Tab. 1: Estimated source parametres for Fiandaca and Nizzeti faults, obtained trough GAME software modelling.

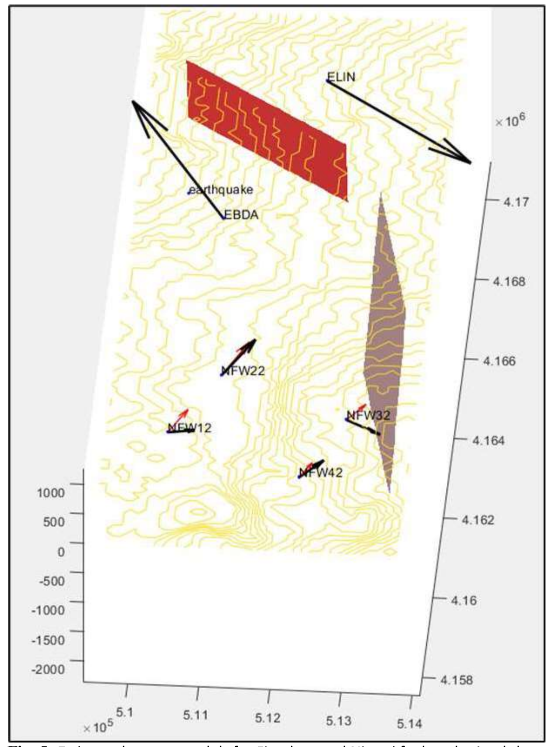

Fig. 5: Estimated source models for Fiandaca and Nizzeti faults, obtained through GAME software modelling.

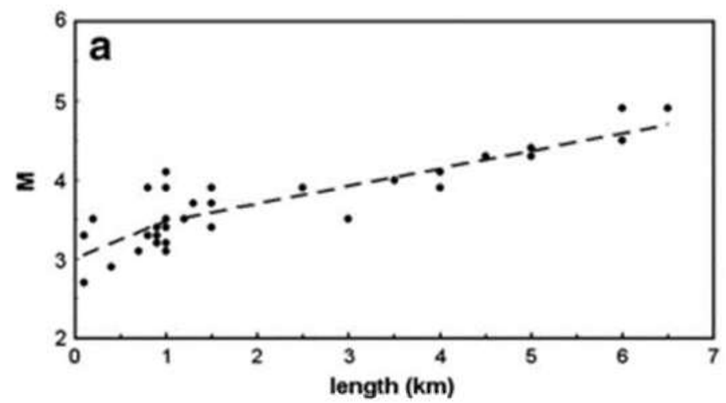

Fig. 6: Correlation between faults lenght and magnitude (De Guidi et al, 2012).

REFERENCE

Barreca, G., Branca, S., & Monaco, C. (2018). Three-dimensional modeling of Mount Etna volcano: Volume assessment, trend of eruption rates, and geodynamic significance. Tectonics, 37, 842–857.; Monaco C., De Guidi G ., Ferlito C., (2010)- The Morphotectonic map of Mt. Etna- Boll. Soc. Geol. It. Vol. 129, No. 3 (2010), pp 408-428. ; DE GUIDI G., GRIGHENTI F., CARNEMOLLA F., IMPOSA S., MARCHESE S.A., PALANO M., SCUDERO S., VECCIO A., (2018)- The unstable erastern Flank of Mt. Etna volcano (Italy): First result of a GNSS-based network at its southeastern edge. Journal of Volcanology and Geothermal Research, Elsevier: p. 1-8. -(Gresta et al, 1990; 1998).