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Earthquake focal mechanisms, seismogenic stress, and seismotectonics of the Calabrian Arc, Italy

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A B S T R A C T

Crustal earthquake focal mechanisms are investigated in the Calabrian Arc region, where the western Mediterranean subduction process is close to ending and the residual Ionian subducting slab affected by gravitational roll-back produces a strong variation of faulting regimes at shallow depth along the local section of the convergent margin. An updated database of earthquake focal mechanisms has been compiled by selecting the best-quality solutions available in the literature and in catalogs, and by adding 17 new solutions estimated in the present work. A total of 164 mechanisms are included in this database, 142 computed by waveform inversion and 22 by analysis of P-wave first motions from earthquakes with good network coverage and no less than 14 records. 60% of the solutions included in the database have never been used for regional-scale geodynamic investigations before the present study, and this makes the compiled database substantially new for our application. Focal mechanisms have been inverted for stress tensor orientations to obtain the principal stress axes over the study region. Results are compatible with three major tectonic domains subject to markedly different regional stresses along the arc. These three domains are separated by two transitional domains, which are located on top of the Ionian subducting slab edges and are likely forced in their horizontal transfer kinematics by the different tectonic regimes occurring in the adjacent major domains rather than by the regional tectonics. This along-arc differential tectonics is at least in part interpreted as the surface expression of the different deep mechanisms occurring in correspondence of the narrow Ionian slab and their lateral edges. Open tectonic questions are emphasized and proposed for future studies.

1. Introduction

Since their first processing, earthquake focal mechanisms have been revealed as fundamental in the study of the relationship between earthquakes, seismic faults, and active tectonics (Anderson et al., 1993; Dziewonski et al., 1981; Ekström and England, 1989; Ekström et al., 2005; Grimison and Chen, 1986; Jackson and McKenzie, 1988; McCaffrey et al., 1985). Focal mechanisms have been revealed as essential also in other tectonic studies such as the determination of the true sense of motion along transform faults across oceanic spreading ridges (Sykes, 1967; Wilson, 1965) or the discovery that subducting slabs may be under compression, under tension, or both in different sectors (Isacks and Molnar, 1971). Moreover, the determination of earthquake focal mechanisms is the prerequisite for computing the seismogenic stress of a region and compiling related maps of active stress (Barba et al., 2010; Gephart and Forsyth, 1984; McKenzie, 1969; Montone et al., 2004; Zoback, 1983; Zoback and Zoback, 1980), which, in addition to the study of deformation zones and related geodynamic engines, have been also used for probability maps of future earthquakes (e.g., Cinti et al., 2004) as well as for hydrocarbon field development and well planning (e.g., Lindholm et al., 1995). The rapid determination of earthquake source parameters may be also crucial for prompt rescues in the case of destructive earthquakes (Scognamiglio et al., 2010).

Although earthquake focal mechanisms have been revealed as a very powerful tool in seismotectonic studies, the reliability of these data may decrease for low magnitude earthquakes ($M<4$). Moreover, the determination of focal mechanisms is obviously limited to the temporal range of earthquake instrumental recording, with a dramatic drop of reliability for the first decades of the instrumental epoch, when the world seismic network was still poorly developed and recording equipments were rudimentary.

Focal mechanisms elaborated by using P-wave first motions may be biased by an inadequate coverage of seismic stations, whereas those elaborated by waveform analyses have so far demonstrated as being much more stable and reliable (e.g., Lay and Wallace, 1995; Pondrelli et al., 2006; Scognamiglio et al., 2009). This is the case, for instance, of at least a portion of southern Italy, where the substantial lack of offshore

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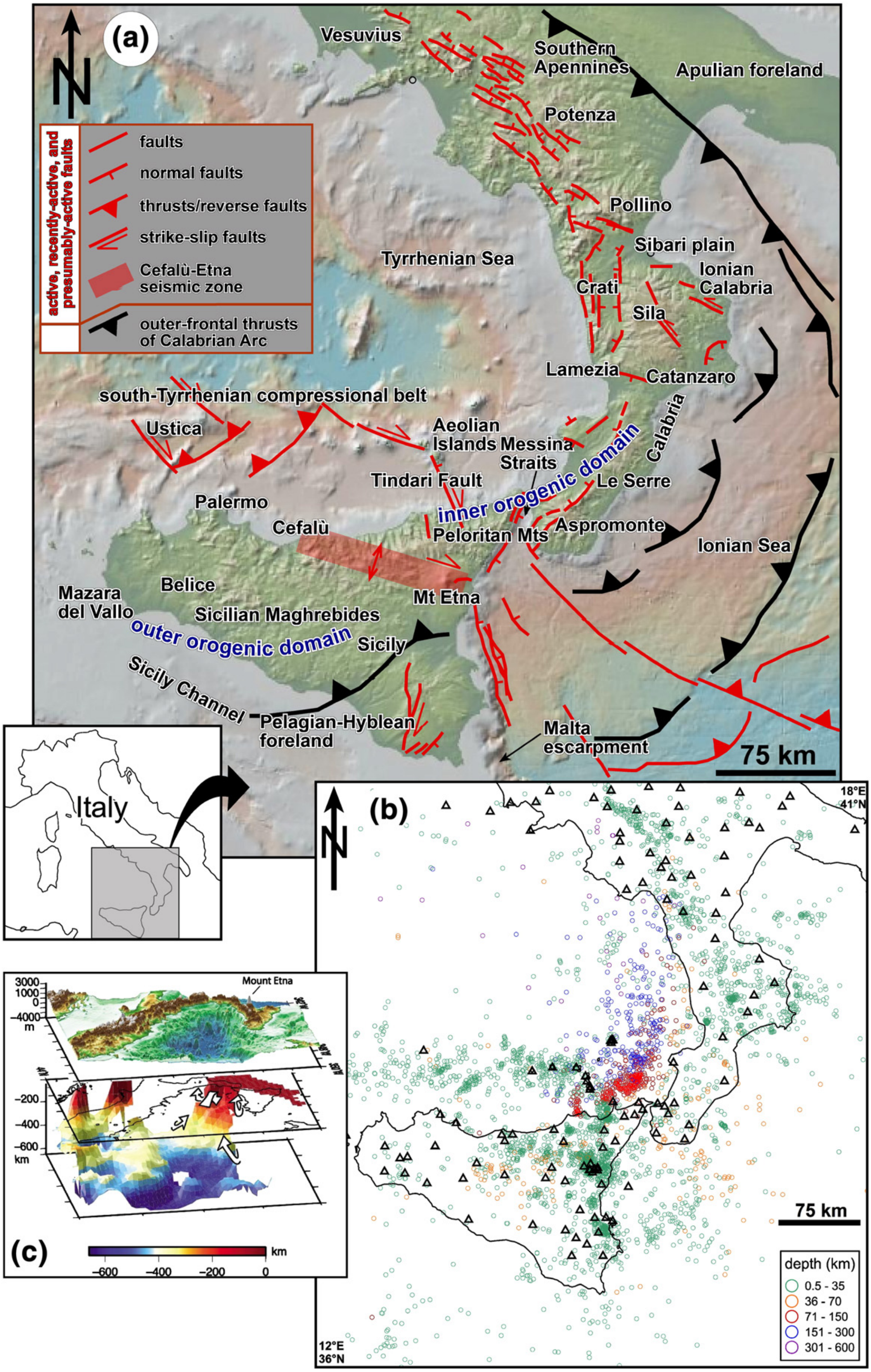
(a)
N
active, recently-active, and presumably-active faults
faults
normal faults
thrusts/reverse faults
strike-slip faults
Cefalù-Etna seismic zone
outer-frontal thrusts of Calabrian Arc
Vesuvius
Southern Apennines
Apulian foreland
Potenza
Pollino
Sibari plain
Ionian Calabria
Tyrrhenian Sea
Crati
Sila
Lamezia
Catanzaro
south-Tyrrhenian compressional belt
Ustica
Aeolian Islands
Messina Straits
Calabria
inner orogenic domain
Tindari Fault
Le Serre
Palermo
Cefalù
Peloritan Mts
Aspromonte
Ionian Sea
Belice
Mt Etna
Mazara del Vallo
Sicilian Maghrebides
outer orogenic domain
Sicily
Sicily Channel
Pelagian-Hyblean foreland
Malta escarpment
75 km
Italy
(b)
N
18°E 41°N
75 km
depth (km)
0.5 - 35
36 - 70
71 - 150
151 - 300
301 - 600
12°E 36°N
3000
1000
0
-4000
m
Mount Etna
-200
-400
-600
km
(c)
-600
-400
-200
0
km