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Applying the Multiple Inverse Method to the analysis of earthquake focal mechanism data: New insights into the active stress field of Italy and surrounding regions

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ABSTRACT

In order to obtain new insights into the active tectonic setting of the Italian territory and surrounding regions, the Multiple Inverse Method (MIM) has been applied to the analysis of fault plane solutions from more than 700 earthquakes with $M_w \geq 4$. The active stress field in the top 40 km of the lithosphere has been defined for four 10 km-thick layers, each including 810 square cells of 1.5° side. The obtained stress field maps point out that most of the upper crustal seismicity of the Western and Central Alps is controlled by a strike-slip regime, which is dominant also in part of the Dinarides, Albanides and Hellenides and in a large sector encompassing eastern Sicily and the Malta area to the eastern Tunisia offshore. On the other hand, the well-known extensional belt occurring in the interior of the Apennines appears to extend well beyond the backbone of Italy, potentially reaching the outer foothills of the northern Marche region, while the adjacent Adria block (extending to the eastern Po Plain and the outer Dinarides) sticks out as a major area characterised by dominant thrust faulting in the upper crust. A similar regime characterises also a large sector of the western Tyrrhenian Sea, from NE Tunisia through western Sicily and the west coast of Sardinia, to the Provence coast. Besides lateral variations, our analysis also points out a significant vertical heterogeneity of the stress field, the deeper levels (20 to 40 km) investigated in this study being characterised by dominant horizontal maximum compression even in areas of upper crustal extension.

The application of the MIM to a large seismological dataset, providing basic information for the compilation of active stress maps, contributes to a better understanding of active tectonic processes and may be used for improving seismotectonic zoning and reservoir management.

1. Introduction

The geodynamic setting of the Mediterranean area (Fig. 1a) is particularly complex: within the general framework of slow ~NNW-SSE convergence between the Eurasian and the African plates, a rather articulated pattern of subduction/continental collision, lateral escape and extensional zones occurs (e.g. Carminati et al., 2010; Devoti et al., 2008, 2011; Dewey et al., 1989; Di Bucci et al., 2010; Faure Walker et al., 2012; Fernandes et al., 2003; Nocquet, 2012; Nocquet and Calais, 2004; Rosenbaum and Lister, 2004; Serpelloni et al., 2007; Ward, 1998, and references therein). This complexity is reflected in the stress field distribution (Amato and Montone, 2007; Montone et al., 2004, 2012; Pierdominici and Heidbach, 2012; Pondrelli, 1999, and references therein) that, in turn, provides fundamental information on the active deformation and seismotectonic behaviour of the various parts of the Mediterranean puzzle.

The active stress analysis carried out in this study is focussed on the Italian area and surrounding regions (Fig. 1b). Concerning the Italian territory *s.s.*, available seismotectonic models and seismic hazard maps (Albarello et al., 2000; Meletti et al., 2000, 2008) consistently indicate active extension in the axial zone of the Apennine chain, where the main active structures consist of dominantly NW-SE striking normal faults bounding Quaternary continental basins (e.g. Ascione et al., 2007; Caiazzo et al., 2006; Faure Walker et al., 2012; Galadini et al., 2001; Santo et al., 2011; Spina et al., 2008, and references therein). A general agreement exists on the fact that a roughly NE-SW oriented minimum stress axis (σ_3) is dominant over this axial part of the orogen (e.g. Borghini et al., 2000; Montone et al., 1999, 2004, and references therein). On the other hand, the active tectonics and seismotectonic behaviour of the outer zones of the Apennines belt is much more controversial. For instance, according to Meletti et al. (2000), earthquakes occurring in the outer

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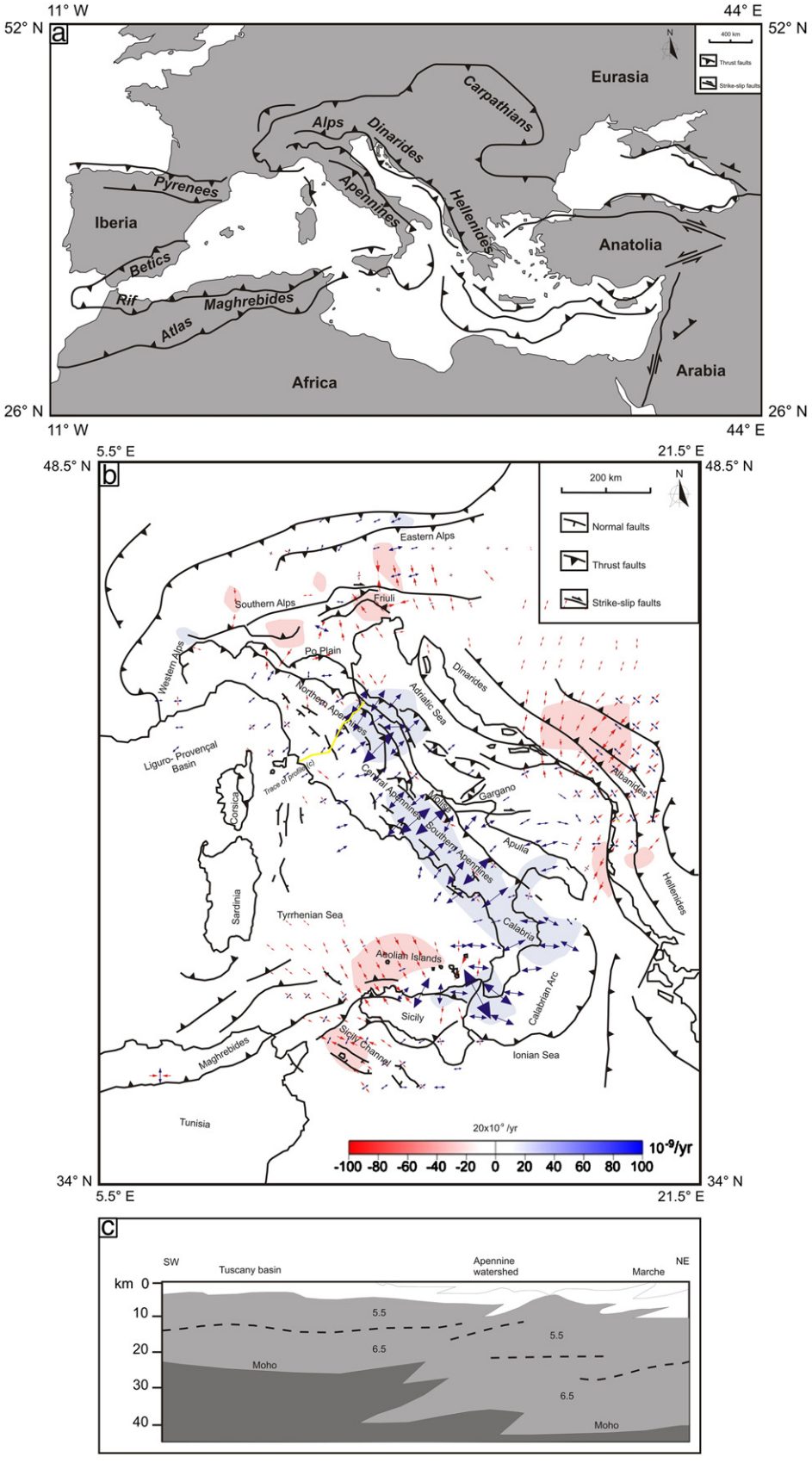

Fig. 1. (a) Tectonic sketch map of the Mediterranean region, showing the main Alpine features (after Piccardi et al., 2011). (b) Tectonic sketch map of the Italian area and the surrounding regions (after Piccardi et al., 2011), also showing (after Devoti et al., 2011) GPS velocity-derived principal axes of the strain-rate 2D tensor and 2D dilatation-rate map (red compressional and blue extensional) and trace of the CROP 03 deep seismic profile. (c) The seismic-velocity model of the CROP 3 line through the Apennines (V_P values are km/s; modified after Morgante et al., 1998).