



Integrated geostructural, seismic and infrared thermography surveys for the study of an unstable rock slope in the Peloritani Chain (NE Sicily)

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ABSTRACT

This paper presents a multidisciplinary study about the instability of a rock slope on Peloritani Chain, northeastern Sicily. Several rockfalls affected the studied slope in the last decades, also causing the disruption of the main road, connecting the shore villages to the city of Messina. The complex geology and tectonics are the main causes of the poor mechanical properties of the rocks, exacerbated by high fracturing and weathering. Geostructural surveys allowed identifying the main discontinuity sets, most of which matches with the regional fault systems. Kinematic and stability analyses were carried out to define the main failure typologies and to realize two models describing the past rockfalls, as well as possible future events. For the deep investigation of the slope, horizontal borehole drilling and seismic active prospecting were performed so to estimate the thickness of the rock with poor mechanical properties. The contours of the most unstable areas along the slope have been better outlined through infrared thermography images, giving information about the thermal radiance behavior of the rock constituting the surface slope.

The integrated approach of different methodologies, besides defining the instability features of the study area, demonstrates the reliability of such techniques, particularly in a geologically complex region where rockfalls represent one of the main causes of landslide fatalities.

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1. Introduction

Jointed rock slopes are often subject to instability phenomena, especially in those areas having a complex tectonic history. Failure mechanisms are strongly influenced by geology and topography (Evans et al., 2007; Lo, 2014; Budetta, 2011) and the discontinuities in a rock mass affect not only its geomechanical quality, but also its strength and deformability (e.g. Norrish and Wyllie, 1996; Hantz et al., 2003; Jaboyedoff et al., 2004; Pappalardo, 2015).

In orogenic contests, the mechanical properties of the rock are weakened, particularly along the discontinuities where the movements act, because of the tectonic stress. These conditions occur especially close to important tectonic structures, such as fault segments controlling the slope deformation (Tokiwa et al., 2011) and stability. Willenberg et al. (2008) describe a crystalline rock mass in Switzerland, where the main instability area laid in a high density of faults and fracture

zone. This is a public safety issue, particularly when the effects of the slope instability may involve potential elements at risk (Saroglou et al., 2012; Pappalardo et al., 2014).

In Italy, rockfalls represent one of the main causes of landslide fatalities (Guzzetti et al., 2005) and the natural predisposition to recession of rock slopes is a typical environmental threat (Apuzzo et al., 2013), especially in mountainous settings, such as the one taken into account for this study.

The study area lies on the Peloritani Mountains, in a highly tectonized sector of northeastern Sicily where different fault systems dissect the geological formations. Here several rockfalls occurred, during the last decades, at a 100 m long rock slope, threatening the public safety. Indeed, the surveyed rock slope (SRS) faces NE, strikes NW–SE (with a direction ranging between 040/70 and 050/80) and boards the Road 113 (a route connecting the coastal villages to the main city of Messina). The top of the slope drops, respect to its base, of about 30 m, with a mean terrain slope of 70°. This crystalline slope, standing on the southwestern flank of a deep valley, is characterized by highly persistent, intricate sets of fault and joint. Due to their weathering and unfavorable orientation with respect to the slope facing, these may serve as detachment surfaces. The landslides occurred in the last twenty years, caused the disruption of the Road 113 for extended periods,

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because of the accumulation of the debris, leading to repeated remedial works for the protection of the road.

In such a geologically complex areas, where the condition of the slopes is often critical, a single approach for the study of rock masses seems not to be exhaustive. For this reason, this paper provides a multidisciplinary study of SRS instability, supported by (1) careful geological survey, allowing the recognition of the main fault planes and the measurement of their direction, (2) geostuctural and geomechanical

analyses, for the estimation of the rock quality of SRS, as well as of the most probable kinematics of failures, (3) horizontal borehole drillings and seismic tomography, to evaluate in depth the condition of the slope, and (4) infrared thermography to analyze the shape of the thermal emission along the slope and to match it with the different elements occurring (such as vegetation, weathered rock, bare rock), so to point out the presence of potential unstable portions of the rock mass.

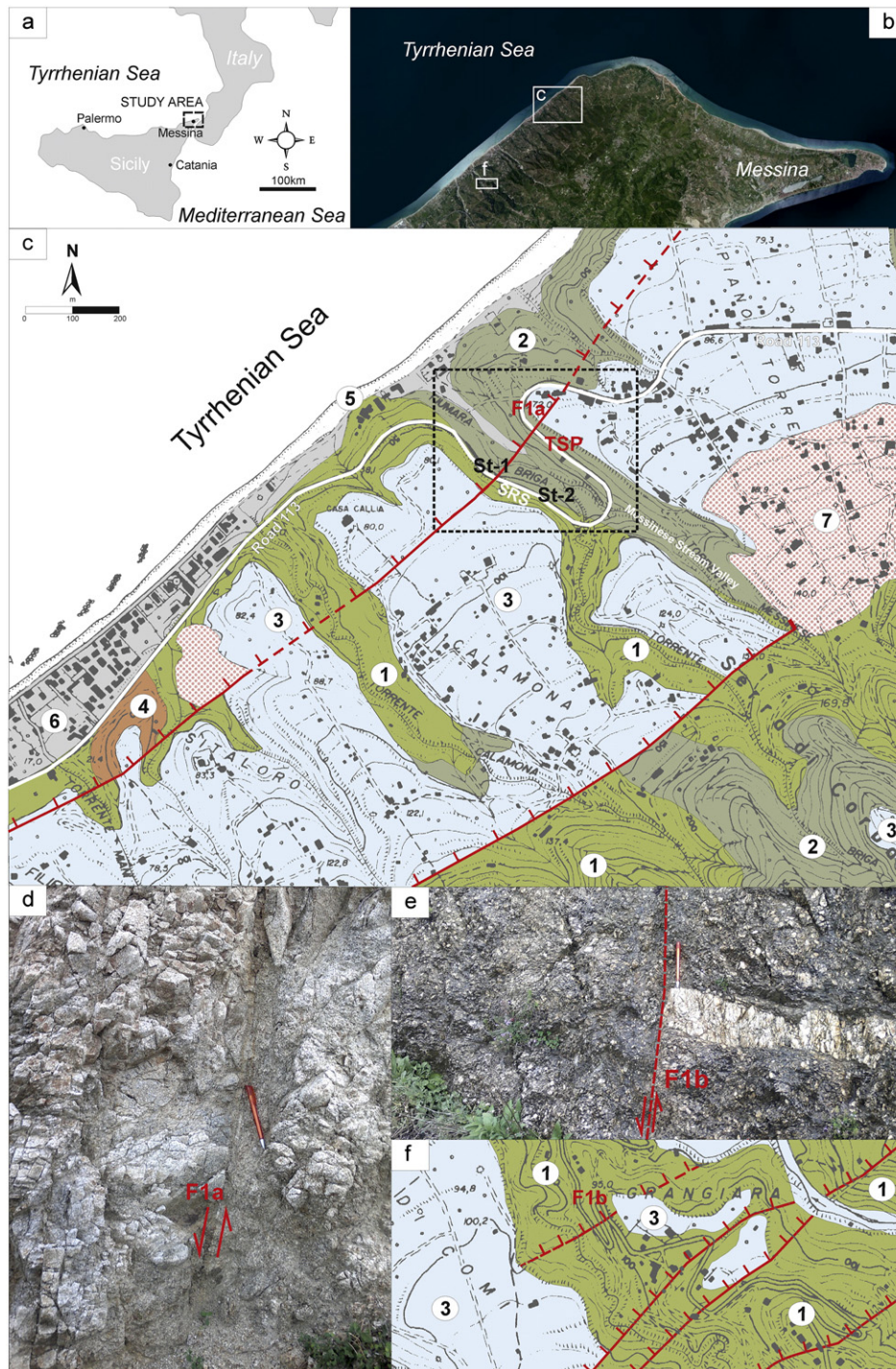


Fig. 1. a – Geographical location of the study area; b – location of the geological maps; c – geological map of the study area: (1) biotite paragneiss, (2) mica schist, (3) marine terrace, (4) marly clay, (5) shore sand, (6) alluvial deposit and (7) debris. The dashed rectangle encloses the study area. Red lines indicate fault segments (dashed if presumed). F1a is the location of the fault segment in d. TSP is the shot point for the IRT survey (see the section on [Infrared thermography](#)). St1 and St2 are locations of the geostuctural stations; d – F1a segment surveyed on a mica schist rock mass in the study area; e – F1b surveyed on a gneiss outcrop (f). Interformational throws are visible if aplitic lenses are present; f – geological map of the sector where F1b segment was surveyed.

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