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Paleoseismic evidence of legendary earthquakes: The apparition of Archangel Michael at Monte Sant'Angelo (Italy)

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Abstract

The Gargano promontory, a carbonate massif belonging to the Adria microplate, the foreland of both the Apenninic and Dinaric mountain chains, is a well-known seismogenic area, with historic earthquake up to I_{max}=X MCS (July 30,1627, M=6.7). Nevertheless, paleoseismic data on the region are still scarce, and no trench fault stratigraphy has been analysed along the major, E–W trending, right-lateral strike-slip fault system that cuts through the whole massif, the South Gargano Line (SGL). The over 60 km long on-shore trace of the SGL, the Mattinata Fault, is clearly segmented. This study focused on the eastern active fault segment, the Monte Sant'Angelo Fault (MSA), to verify the associated seismic potential.

Analysis of contemporary descriptions of the August 10,1893 earthquake (M=5.2) coupled with field-work allowed identification of surface faulting along the MSA. Along the fault there is paleoseismic evidence of the occurrence of larger earthquakes. After collecting geomorphic evidence of paleo-earthquakes, we selected two trench sites at the base of two prominent fault escarpments, where the MSA is characterized by significant vertical components of fault displacement. The preliminary results demonstrate that: i) the recent vertical slip-rate of the MSA range between 0.2–0.3 and 0.7 mm/yr; ii) the MSA moves with incremental slip episodes, with vertical surface offset up to several decimeters; iii) based on the stratigraphic and geomorphic evidence of surface faulting observed and assuming a rupture length of around 20+ km, the seismic potential of the MSA segment would be similar to that displayed by the western SGL segment during the 1627 event.

A large earthquake on the MSA is reported only in ancient legends, the most relevant of which being the one describing the apparition of Archangel Michael at Monte Sant'Angelo traditionally dated AD 493. Using a multidisciplinary approach, combining paleoseismic and historical data it has been possible to interpret the legend, and hereby identify an event of surface faulting before 8th century AD. A recent scarplet, up to 1 m high, on the MSA can be seen to be related to this legendary earthquake, which in turn seems to correspond to the maximum possible magnitude. Geologic phenomena observed during the earthquake at the site of the sanctuary appear to lie at the very origin of the veneration of the place.

Keywords: Active tectonics; Surface faulting; Historical seismology; Seismic hazard; Gargano; Archangel Michael

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"And behold, there was a great earthquake; for an angel... descended from heaven.... His appearance was as lightning" (Mathew, 28, 2–3).

1. Introduction

The assessment of seismic hazard requires the understanding of seismic behaviour and seismic history of every seismic fault of an area. Paleoseismology (from both stratigraphic and geomorphic evidence) and seismology (including historic as well as instrumental records) provide the main data for such evaluation. Studying historical data, certain questions arise when dealing with oral traditions: the reliability of these sources and how to use the information derived. There is, however, an increasing awareness of the possibility to recognise memories of past geologic events, in particular legends and myths, using a multidisciplinary approach (Bentor, 1989; Guidoboni, 1989; Vogt, 1991; Nur, 1991; Piccardi, 2000).

This paper illustrates the case of the Gargano region (Southern Italy), an area of special interest in terms of active tectonics and earthquake hazard characterization for the Italian peninsula and in general for the Adriatic region. This is because it is an area of faulted foreland that has experienced important historic earthquakes. Nevertheless, the active tectonics and the relationship between local structures and earthquake sources is still poorly studied. Notwithstanding several papers describing the tectonic setting of the area, several problems are still open concerning the activity, geometry, kinematics, and capability of the Mattinata fault, the most important tectonic structure of the Gargano. These issues will be addressed by integrating new geomorphic data on the fault scarp, stratigraphic evidence of recent faulted deposits, structural observations, available historic seismicity and earthquake ground effects descriptions.

The Mattinata fault is a spectacular East–West trending fault, over 60 km long on-land, that cuts through the whole Gargano massif. It shows clear evidence in seismic reflection profiles for both westward (beneath the Candelaro River alluvial plain) and eastward (offshore) prolongation (Fig. 1). According to Piccardi (1998) this right-lateral segmented structure is capable of repeated Holocene surface faulting, and responsible for the most relevant historic seismic events in the area. Nevertheless, paleoseismic data from the region are still scarce, and no trench fault stratigraphy has been analysed along the major, E–W trending, right-lateral strike-slip fault.

The strongest and most-documented historic earthquake in this area, the July 30, 1627, San Severo earthquake (I_{max}=X MCS, M=6.7; Gruppo di Lavoro CPTI, 1999), arguably ruptured the western, ca. 30 km long, fault segment of the Mattinata fault (Piccardi et al., 2002; Borre et al., 2003). This study focused on the 20 km long on-shore eastern fault segment, the Monte Sant'Angelo fault (MSA), in order to verify the associated seismic potential. The MSA shows clear evidence of recent surface faulting, such as young bedrock scarps, banded limestone fault planes, faulted Holocene deposits and deflected streams. The strongest event quoted in the modern seismic catalogue on the MSA is the August 10, 1893 Mattinata earthquake (I_{max}=VIII–IX MCS, M_a=5.2; Gruppo di Lavoro CPTI, 1999), but another strong local earthquake was reported in the historic seismic catalogues dated to AD 493 (e.g., Bonito, 1691; Mercalli, 1883; Baratta, 1901). This event, described as an "*immenso tremore*" in the famous legend of the descent of Archangel Michael at Monte Sant'Angelo, was excluded from the modern catalogue because of the extremely hagiographic nature of the account, and the unreliable dating of the event. Therefore, the aim of the present study has been to understand if the eastern segment of the Mattinata fault is able to produce earthquakes of the same magnitude as the western one, and in this case the sacred legend would represent the only report of such a shock.

The paper is structured as follows. First it summarizes the results of a study of the active tectonics of the Gargano region, characterizing the kinematics of the major seismogenic structure, the Mattinata fault, and defining the large-scale geodynamics of the area by presenting a comprehensive model of the regional pattern of active tectonic deformation. In particular, the Monte Sant'Angelo fault (MSA), the most prominent active fault in the area, is analysed in detail.

Secondly, it analyses historical data, also taking into account data from oral tradition, in order to