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THE PRIMARY ROLE OF THE PAGANICA-SAN DEMETRIO FAULT IN THE SEISMIC LANDSCAPE OF THE MIDDLE ATERNO VALLEY BASIN

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ABSTRACT: Blumetti A. M., Guerrieri L. & Vittori E., *The primary role of the Paganica-San Demetrio fault in the seismic landscape of the Middle Aterno Valley basin.* (IT ISSN 0394-3356, 2011)
The Paganica-San Demetrio fault, which caused the April 9, 2009 earthquake, has played a key role in the evolution of the Middle Aterno Valley basin since the Middle Pleistocene. Its minimum offset, marked by the elevation of the remnant paleosurface of the Anzano Plateau, is in excess of 700 m. In our interpretation, the Assergi and Campo Imperatore faults with their assumed listric geometry would merge into the Paganica-San Demetrio master fault.

RIASSUNTO: Blumetti A. M., Guerrieri L. & Vittori E., *Il ruolo primario della faglia Paganica-San Demetrio nel paesaggio sismico del bacino della media Valle dell'Aterno.* (IT ISSN 0394-3356, 2011)
La faglia Paganica-San Demetrio, cui è legato il terremoto del 9 Aprile 2009, ha giocato un ruolo primario nell'evoluzione del bacino della media Valle dell'Aterno almeno a partire dal Pleistocene Medio. Il suo rigetto minimo, calcolato sulla base della differenza in quota tra la media Valle dell'Aterno e lembi dislocati di una paleosuperficie, supera i 700 m. Nella nostra interpretazione essa è da considerare la master fault del blocco tettonico del Gran Sasso alla quale le faglie di Assergi e Campo Imperatore, ad andamento listrico, si raccordano in profondità.

Key words: Block faulting, morphotectonics, Central Apennines.

Parole chiave: Tettonica a blocchi, morfotettonica, Appennino centrale.

1. INTRODUCTION

On April 6 2009 a Mw 6.3 earthquake rocked the Middle Aterno Valley basin (Abruzzo, Central Italy) causing about 300 casualties and strong damage to the L'Aquila city and its surroundings.
The Paganica-San Demetrio fault, which bounds the Middle Aterno Valley basin to the N-E, has been considered the causative fault of this event. This paper aims at better pointing out the long-term role of this fault in the Quaternary evolution of the Middle Aterno Valley basin.

2. REGIONAL GEOLOGICAL FRAMEWORK

The characteristic landscape of Central Apennines, marked by fault-bounded basins and ranges, has been interpreted as the long-term effect of block-faulting and fast uplift starting approximately 0.8 Myr ago (BLUMETTI & GUERRIERI, 2007 and references therein). NE-SW extension across the Apennines is still active, as suggested by geodetic data that indicate rates ranging from 3 to 5 mm/yr (respectively, FAURE WALKER *et al.*, 2010; D'AGOSTINO *et al.*, 2008).
Moreover, the size of these tectonic basins and of the associated fault-generated mountain fronts has been considered a peculiar feature, indicative of the local seismic potential (concept of *seismic landscape*, *e.g.* MICHETTI *et al.*, 2005).
The Middle Aterno Valley basin (L'Aquila) is a sector of Central Apennines (Fig. 1) located between the Gran Sasso and the Monti d'Ocre morphotectonic units. In this region, surface geology and geophysical data reveal a composite structural setting given by several over-thrust tectonic units belonging to the transitional domain between the Lazio-Abruzzi carbonate shelf platform and the Umbria-Marche pelagic basin, dissected by a network of Quaternary normal faults, in places located close to the uppermost traces of older thrust planes (APAT, 2006). Stratigraphic and morphological evidence suggest ongoing activity along several of these faults (Fig. 1; BAGNAIA *et al*., 1992; BLUMETTI, 1995; GALLI *et al*., 2008) as confirmed by historical seismicity (three I_{mcs} ≥ IX events hit this same area in 1461, 1703 and 1762 (Gruppo di Lavoro CPTI, 2004).

3. PAGANICA-SAN DEMETRIO FAULT AND QUATERNARY EVOLUTION OF THE MIDDLE ATERNO VALLEY BASIN

The Quaternary evolution of the L'Aquila region can be synthesized in two phases. The Lower Pleistocene landscape was characterized by several lacustrine basins controlled by normal faults. Nevertheless, the low uplift rates allowed to form a low energy relief landscape with wide pediments mainly formed by areal erosional processes (DEMANGEOT, 1965).
After the dramatic increase of uplift rates and faults

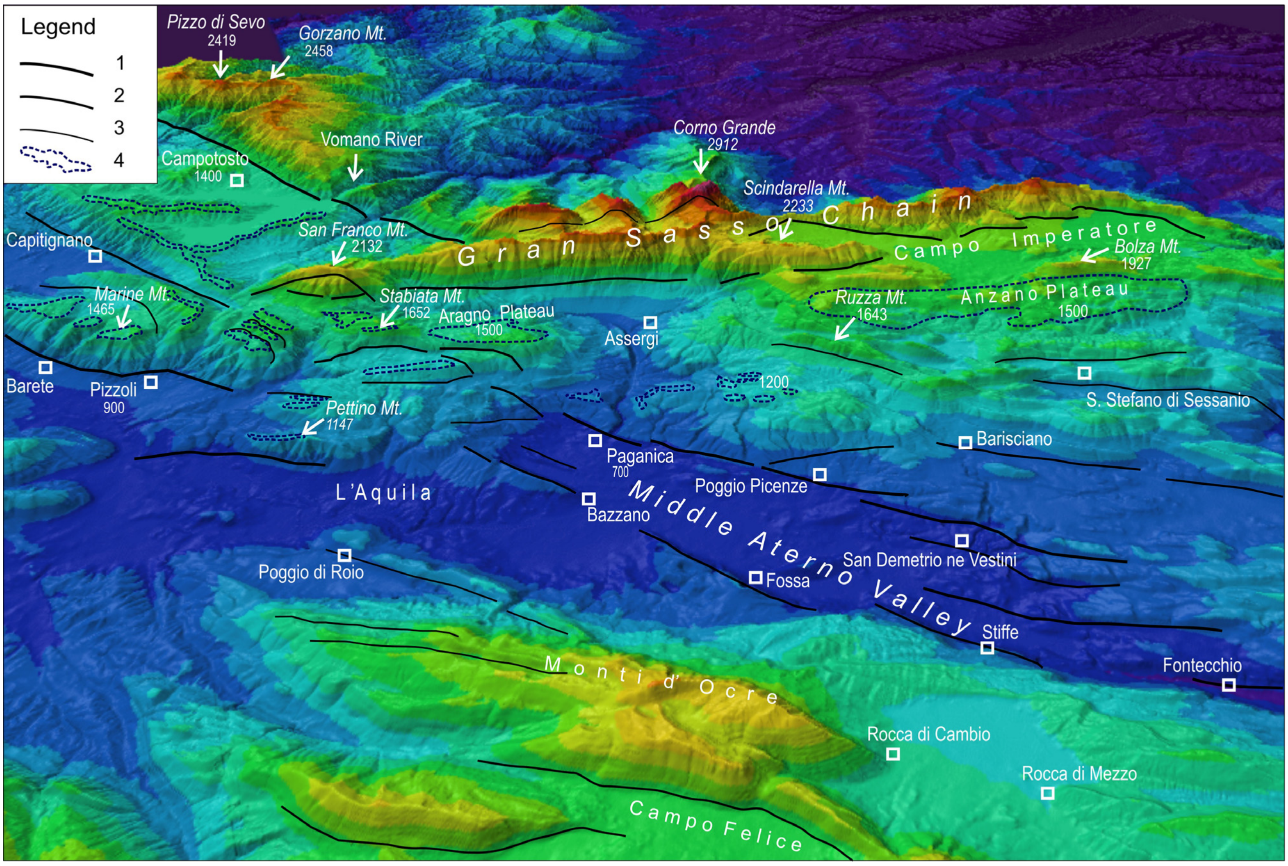

Fig. 1, 3D view (based on a 20 m DTM) of the L'Aquila region with reported the net of capable faults, defining a seismic landscape. The major faults (1) are signed by prominent fault escarpments and bound first order tectonic blocks. Minor faults within the major blocks, sometimes with an evident listric geometry, can be ranked in two categories: (2) high slip rate faults at the base of large fault escarpments generally representing reactivations of old thrusts; these bound second order blocks; (3) faults that produce lower fault scarps and bound third order blocks. Remnants of low relief landscape (4) can be used as throw markers.

Immagine 3D (basata su un DTM a 20 m) della regione aquilana, con riportate le faglie capaci che definiscono il paesaggio sismico. Le faglie principali (1) sono caratterizzate da versanti di faglia che bordano blocchi tettonici di primo ordine. Faglie minori all'interno dei blocchi principali, talvolta con evidente andamento listrico, possono essere gerarchizzate in due categorie: (2) faglie alla base di grandi versanti di faglia, con elevato slip rate e che generalmente invertono piani di sovrascorrimento; queste definiscono blocchi di secondo ordine; (3) faglie che producono scarpate di faglia minori e bordano blocchi di terzo ordine. Lembi di un paesaggio a bassa energia di rilievo (4) possono essere utilizzati come riferimento nel calcolo dei rigetti post Pleistocene Medio

activity since the end of the Lower Pleistocene (DEMANGEOT, 1965; AMBROSETTI *et al.*, 1982) these pediments have been displaced and are now preserved as remnants at different elevations in the present landscape, that is deeply dissected by linear erosion.

We interpret that during this period (about 800 kyr) the Middle Aterno Valley unit (with an average surface at about 700 m a.s.l.) has been downthrown by the Paganica - San Demetrio normal fault with respect to the 1500 m a.s.l. high Anzano and Aragno Plateau summit paleosurface area. At the same time, this zone was downthrown with respect to the Gran Sasso chain (highest elevation in the Apennines, close to 3000 m a.s.l.) by the WNW-ESE trending south-dipping Assergi and Campo Imperatore normal faults, which have a listric geometry, possibly representing reactivations of old thrusts at depth (D'AGOSTINO *et al.*, 1997). The region at the footwall of the Paganica-San Demetrio fault (*i.e.* the Gran Sasso Chain together with Anzano and Aragno Plateau zone) in our view is a single first order morphotectonic unit. This block has been displaced in several tectonic units of lower rank by very long and important faults, like the Assergi and Campo Imperatore faults (slip rates 0.67-1 mm/yr; GIRAUDI & FREZZOTTI, 1995; GALLI *et al.*, 2002) as well as by a set of secondary very shallow listric faults (*e.g.*, the Ruzza Mt. and S. Stefano di Sessanio faults) that have an arc shape in plant view and are mostly gravity driven (BAGNAIA *et al.*, 1992). Based on their likely listric geometry, the Assergi and Campo Imperatore faults should join at depth the Paganica - San Demetrio high angle normal fault. Gravity-driven movements may have contributed to the total slip

observed on the higher listric faults (NIJMAN, 1971; BLUMETTI, 1995; DRAMIS & BLUMETTI, 2005) and this would account for their very high slip rate.
In this model, the Paganica - San Demetrio would be the master fault of the whole Gran Sasso - Middle Aterno Valley fault system, despite the lack of a clear fault-generated mountain front related to it. Actually, the Middle Aterno Valley border lacks the prominent fault-generated mountain front typical of other basins. Instead, at the footwall of the bounding fault, the extension is accommodated along several NW-SE trending normal faults which cause an horsts and *graben* landscape. The elevation of about 1500 m of the Anzano Plateau is gradually reached through a set of narrow ridges and small elongated basins. Moreover, in the area where surface faulting occurred in 2009, *i.e.* along the Paganica fault segment, the presence in the footwall of a paleo-drainage since at least the end of Lower Pleistocene (Paleo-Raiale, *sensu* MESSINA *et al.,* 2009) contributed to smooth the fault escarpment. Relict forms of this paleo-landscape and different orders of fluvial deposits terraced by the progressive activity of the Paganica fault are still preserved in its footwall. Volcanic deposits dated between 560 and 360 kyr B.P., being displaced of about 150 m, constrain the Paganica fault long term slip rate to ca. 0.4 mm/yr (MESSINA *et al.,* 2009).
The primary role played by the Paganica-San Demetrio fault has important consequences in terms of seismic hazard, being now acknowledged as the main seismic source of the basin. If, as suggested here, the Campo Imperatore and Assergi faults move as its splays, their seismic potential would be directly controlled by that of the main fault.

REFERENCES

AMBROSETTI P., CARRARO F., DEIANA G. & DRAMIS, F. (1982) - *Il sollevamento dell'Italia centrale tra il Pleistocene inferiore e il Pleistocene medio.* Contributi conclusivi per la realizzazione della Carta Neotettonica d'Italia. CNR-PFG, **513**, 219–223.

APAT (2006). *Foglio 359 L'Aquila. Carta Geologica d'Italia alla scala 1:50000.* S.EL.CA., Firenze.

BAGNAIA R., D'EPIFANIO A. & SYLOS LABINI S. (1992) - *Aquilan and Subaequan basins: an example of Quaternary evolution in central Apennines, Italy.* Quaternaria Nova, **2,** 187-209.

BLUMETTI A.M. & GUERRIERI L. (2007) - *Fault-generated mountain fronts and the identification of fault segments: implications for seismic hazard assessment,* Boll. Soc. Geol., It. **126** (2), 307-322.

BLUMETTI A.M. (1995) - *Neotectonic investigations and evidence of paleoseismicity in the epicentral area of the January-February 1703 Central Italy earthquakes.* in Perspectives in Paleoseismology L. SERVA (Editor), Bull. of the American Association of Engineering Geologists, Special Volume **6**, 83-100.

D'AGOSTINO N., SPERANZA F. & R. FUNICIELLO (1997) - *Stili e geometrie della tettonica estensionale quaternaria nell'Appennino Centrale: l'area del Gran Sasso d'Italia*, Il Quaternario, **10** (2), 389-394.

D'AGOSTINO N., AVALLONE A., CHELONI D., D'ANASTASIO E., MANTENUTO S., & SELVAGGI G. (2008) - *Active tectonics of the Adriatic region from GPS and earthquake slip vectors.* Journal of Geophysical Research, **113,** B12413.

DEMANGEOT J. (1965) - *Géomorphologie des Abruzzes Adriatiques*. Memoirs et documents, CNRS, Paris.

DRAMIS F. & BLUMETTI A.M. (2005) - *Some considerations concerning seismic geomorphology and paleoseismology.* Tectonophysics, **408,** 177-191.

FAURE WALKER J. P., ROBERTS G. P., SAMMONDS P., & COWIE, P. A. (2010) - *Comparison of earthquakes strains over 102 and 104 year timescales: insights into variability in the seismic cycle in the central Apennines, Italy,* Journal of Geophysical Research (Solid Earth), doi:10.1029/2009JB006462.

GALLI P., GALADINI F., MORO M., & GIRAUDI C. (2002) - *New paleoseismological data from the Gran Sasso d'Italia area (central Apennines).* Geophys. Res. Lett., **29** (7), 1134, doi:10.1029/2001GL013292.

GALLI P., GALADINI F., & PANTOSTI D. (2008) -*Twenty years of paleoseismology in Italy.* Earth Science Review, **88**, 89-117.

GIRAUDI C. & FREZZOTTI M. (1995). *Paleoseismicity in the Gran Sasso massif (Abruzzo, central Italy),* Quat. Int., **25**, 81-93.

Gruppo di lavoro CPTI, 2004. *Catalogo Parametrico dei Terremoti Italiani, versione 2004 (CPTI04).* INGV, Bologna. / http://emidius.mi.ingv.it

MESSINA P., GALLI P., GIACCIO B. & PERONACE E. (2009) - *Quaternary tectonic evolution of the area affected by the Paganica Fault (2009 L'Aquila earthquake).* In: Atti 28° Convegno Nazionale GNGTS, Trieste, 47-50.

MICHETTI A.M., AUDEMARD F. & MARCO S. (2005) - *Future trends in paleoseismology: Integrated study of the seismic landscape as a vital tool in seismic hazard analyses*. In: Paleoseismology, integrated study of the Quaternary geological record for earthquake deformation and faulting, A.M. MICHETTI, F. AUDEMARD & MARCO S. (Eds), Special Issue, Tectonophysics, **408** (1 -4) **,** 3-21.

NIJMAN W. (1971) - *Neotectonics of the Velino-Sirente area, Abruzzi, Central Italy.* Koninkl. Nederl. Akademie van Wetenshappen, Amsterdam, Proceedings, **74** (2), 156-184.

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