



Is the April 6th 2009 L'Aquila earthquake a confirmation of the "seismic landscape" concept?

Anna Maria Blumetti (1), Valerio Comerci (1), Luca Guerrieri (1), Alessandro Maria Michetti (2), Leonello Serva (1), and Eutizio Vittori (1)

(1) Geological Survey of Italy, ISPRA - High Institute for the Environmental Protection and Research, Via Curtatone, 3 - 00185 Roma, Italy (annamaria.blumetti@isprambiente.it) , (2) Università degli Studi dell'Insubria - Sede di Como, Facoltà di Scienze MM. FF. NN., Dipartimento di Scienze Chimiche ed Ambientali, Via Valleggio, 11 - 22100 Como, Italy

In the Central Apennines, active extensional tectonics is accommodated by a dense array of normal faults. Major tectonic elements are typically located at the foot of fault escarpments, tens of kilometres long and some hundreds of meters high. Subordinate faults within major blocks produce additional topographic irregularities (i.e. minor graben and fault scarps; Blumetti et al. 1993; Serva et al. 2002; Blumetti and Guerrieri, 2007).

During moderate to strong earthquakes ($M > 6$) one or several or all these faults can be rejuvenated up to the surface, and should be therefore regarded as capable faults. Thus, their total throw is the result of several surface faulting events over the last few hundreds of thousands of years. This is true for landscapes that have a "typical" earthquake magnitude (i.e. the earthquake magnitude that better "characterizes" the local landscape; Serva et al. 2002; Michetti et al. 2005) of either 6 or 7. According to this model in the L'Aquila region the seismic landscape is the result of repeated magnitude 7 events. In other words, the maximum magnitude to be expected is around 7, but clearly smaller events can also occur, like in the April 6, 2009 case.

The L'Aquila region is well known for being characterized by a high seismic hazard. In particular, two events with Intensity X MCS occurred on November 26, 1461 and February 2, 1703. The latter was the third major seismic event of a seismic sequence that in two weeks shifted from Norcia (January 14) to L'Aquila (February 2). Two other destructive earthquakes hit the same area in 1349, IX-X MCS, and in 1762, IX MCS.

Concerning the February 2, 1703, event, a good dataset of geological effects was provided by contemporary reports (e.g. Uria de Llanos, 1703): about 20 km of surface faulting along the Pizzoli fault, with offsets up to about half a meter and impressive secondary effects such as a river diversion, huge deep-seated gravitational movements and liquefaction phenomena involving the "ejection of stones and whitish sulphureous water" along the Aterno River (Blumetti, 1995). Such evidence is in line with a characteristic magnitude 7 landscape and therefore the 1703 event may be considered the typical earthquake producing the seismic landscape in that area.

Surface faulting related to the 2009 event was nearly continuous for a length of 2.6 kilometres with offset not exceeding 10 cm (Blumetti et al., 2009) along the Paganica Fault (Bagnaia et al., 1992). Only spot evidence of very small and thin fractures was reported elsewhere, NW and SE of the village of Paganica, both aligned or not to the Paganica fault ruptures. Minor, but unequivocal, coseismic ruptures occurred also along the Bazzano and Roio Faults. Secondary effects were mapped in an area of 1000 km² including gravitational phenomena, most of them rock falls/avalanches and small slides mostly affecting artificial material (Blumetti et al., 2009).

Thus, in terms of characteristics and distribution of geological effects, the 1703 earthquake intensity has been unquestionably higher than the 2009 one (at least one degree, according to the ESI intensity scale).

As suggested by the local "seismic landscape" and the historical and paleoseismological evidence, the April 6, 2009, earthquake should not be seen as the "characteristic" earthquake neither for the Paganica Fault nor for the L'Aquila region. Also, as already observed during the September 26, 1997, M5.6 and M6 Colfiorito earthquakes (e.g. Vittori et al., 2000), coseismic surface displacement along several faults during moderate events should not be seen as a surprise but as a typical feature of the seismic landscape of the Central Apennines, and of similar regions characterized by crustal extension.

Reference

- Bagnaia R., D'Epifanio A., Sylos Labini S. (1992) – Aquilan and Subequan basins: an example of Quaternary evolution in central Apennines, Italy. *Quaternaria Nova*, 2, 187-209.
- Blumetti A.M., Dramis F. & Michetti A.M. (1993) - Fault-generated mountain fronts in Central Apennines (Central Italy); geomorphological features and seismotectonic implications. *Earth Surface Processes and Landforms*, 18, 203-223.
- Blumetti A.M. (1995) - Neotectonic investigations and evidence of paleoseismicity in the epicentral area of the January-February 1703 Central Italy earthquakes. *Bulletin of the American Association of Engineering Geologists*, Special Volume n. 6: "Perspectives in Paleoseismology", Texas A&M University, Chapter 7, 83-100.
- 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. (Ital.J.Geosci.)*, 126 (2), 307-322.
- Blumetti, A.M., Comerci, V., Di Manna, P., Guerrieri L., Vittori E. (2009) - Geological effects induced by the L'Aquila earthquake (6 April 2009; ML=5.8) on the natural environment. Preliminary Report. 38 pp.
http://www.apat.gov.it/site/_files/Inqua/2009_abruzzo_earthquake_report.pdf.
- Chiarabba, C. et al. (2009) - The 2009 L'Aquila (central Italy) Mw 6.3 earthquake: Main shock and aftershocks. *Geophys. Res. Lett.*, 36, L18308,
- 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: Michetti A.M., Audemard F., Marco S. (Editors), "Paleoseismology, integrated study of the Quaternary geological record for earthquake deformation and faulting", Special Issue, *Tectonophysics*, 408 (1-4), 3-21.
- Serva L. Blumetti A.M., Guerrieri L. & Michetti A. M. (2002) - The Apennine intermountain basins: the result of repeated strong earthquakes over a geological time interval. *Boll. Soc. Geol. It. Special Volume 1*, 939-946.
- Uria de Llanos A. (1703) - *Relazione ovvero itinerario fatto dall'auditore Alfonso Uria del Llanos per riconoscere li danni causati dalli passati terremoi seguiti li 14 Gennaro e 2 Febraro M.DCCIII*: Stamperi Gaetano Zenobj, Roma.
- Vittori E., G. Deiana, E. Esposito, L. Ferreli, L. Marchegiani, G. Mastrolorenzo, A.M. Michetti, S. Porfido, L. Serva, A.L. Simonelli, E. Tondi (2000) - Ground effects and surface faulting in the September-October 1997 Umbria-Marche (Central Italy) seismic sequence. *Journal of Geodynamics*, 29, 535-564.