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Earthquake environmental effects accompanying the May 20, 2012, Finale Emilia earthquake; preliminary report

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On Sunday, May 20, 2012, at 4.02 AM, local time, in the night, an earthquake of Mw 5.9 (INGV) has been generated along the Dorsale Ferrarese near Finale Emilia; preliminary hypocentral depth has been evaluated at ca. 6 km (source INGV). A Mw 5.1 aftershock followed few hours later; a strong Mw 5.8 event occurred today, May 29. The whole sequence until now shows that several segments of the E-trending Dorsale Ferrarese has been activated, for a total length of about 40 km. The death toll is at least 22 (7 on May 20, at least 15 today); damage is locally quite severe, in particular in the historical downtown areas.

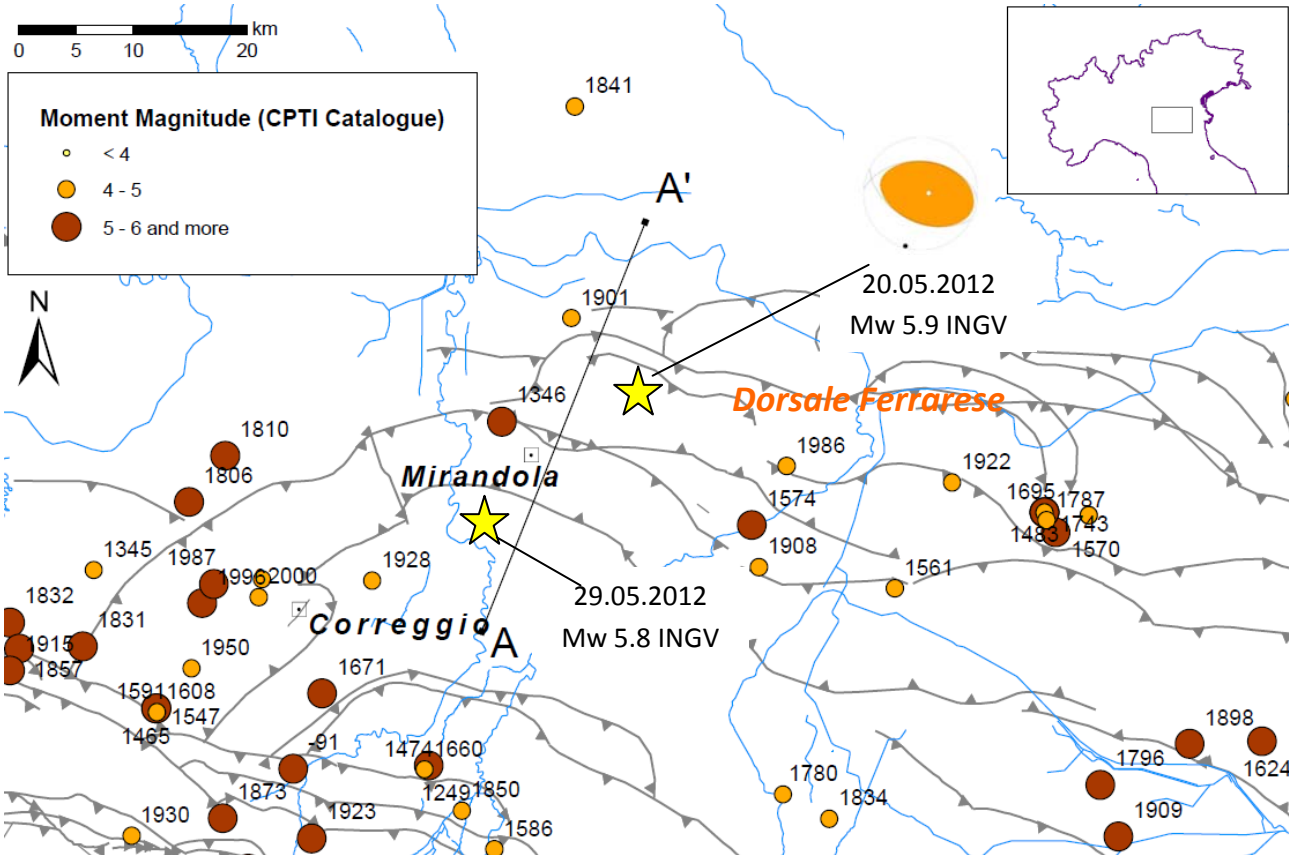

Fig 1: Capable faults, historical seismicity and drainage network in the epicentral area of the 20.05.2012 eq. (Michetti et al., 2012; modified); focal mechanism from NEIC; the trace of the geological section in Fig. 2 is also shown.

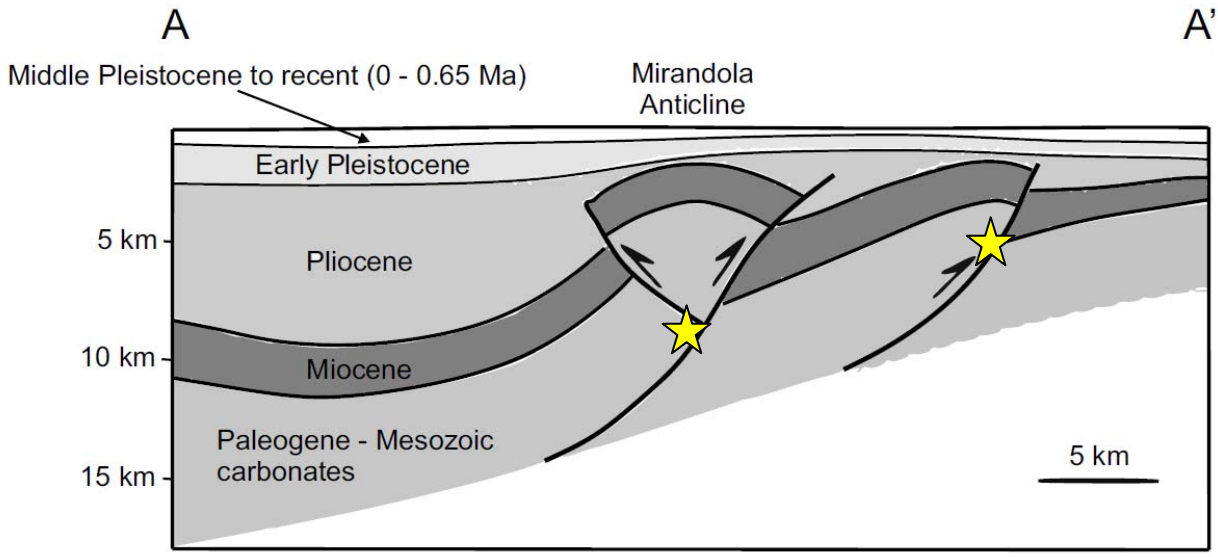

Fig. 2: Simplified cross section of the Mirandola structure, with very preliminary interpretation of the causative faults for the 20 and 29 May 2012 eqs. (Michetti et al., 2012; modified); the stars show tentative hypocentral locations.

Both the mainshock and the May 29 aftershock ruptured the Mirandola structure. The recent tectonic activity of the Mirandola structure (e.g., Scrocca et al., 2007; http://www.isprambiente.gov.it/site/it-it/Progetti/ITHACA_-_Catalogo_delle_faglie_capaci/) has been described by several Authors. The Dorsale Ferrarese is in fact part of the N Apennines buried front, characterized by a well known seismicity. The strongest historical events show Epicentral Intensity of VII-VIII on the MCS scale; in particular, the most recent of these events occurred on 1806, 1810, 1832 and 1929 (Fig. 1).

Active tectonics data show, however, that in terms of maximum credible magnitude the Po Plain - and therefore also the area affected by the present seismic sequence – it is not different from other seismic areas of the Italian territory (Fig. 1 e 2). Therefore, based on the available data, it is possible to rule out the occurrence of earthquake magnitude greater than Mw 7.0. But at the same time, in the epicentral area of the ongoing seismic sequence it is not possible to exclude events with Mw 6.0-6.5 and therefore epicentral intensity of IX in the MCS (or MM) scale.

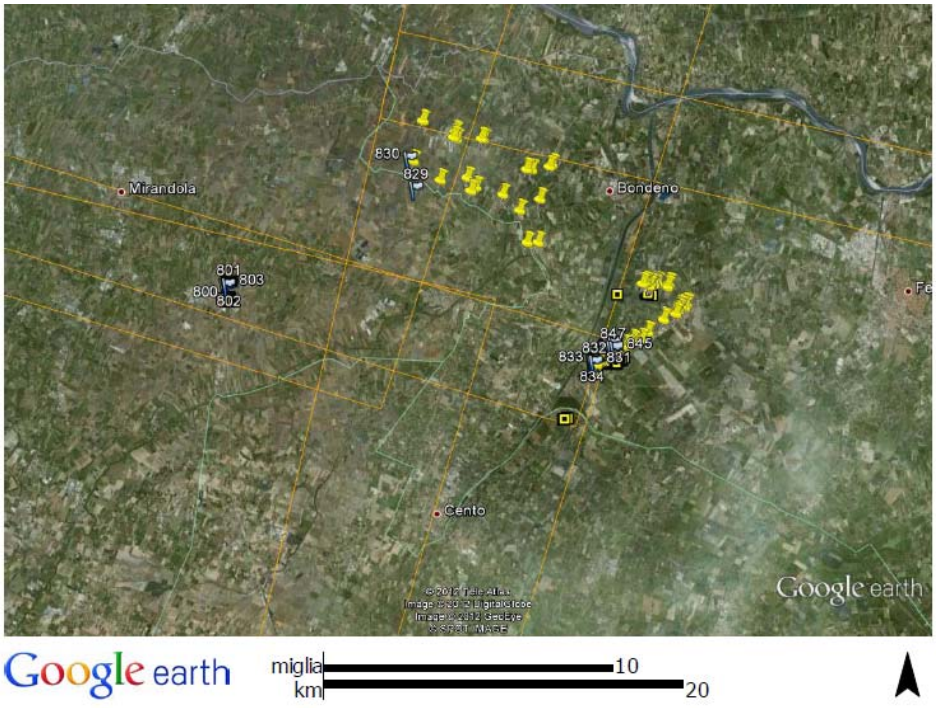

Fig. 3: Location map of the sites with earthquake environmental effects identified by the joint team INGV, ISPRA, UniInsubria, UniModena, CNR-Firenze on 20-26.05.2012; work in progress.

Scientists from Dipartimento di Scienza e Alta Tecnologia - DipSAT of UniInsubria are visiting the epicentral area since May 21st, 2012, as part of a joint emergency team including ISPRA, INGV-Emergeo, UniModena (Doriano Castaldini) and CNR-Firenze (Luigi Piccardi). The environmental effects identified until May 26 are mapped in Figure 3. Research is in progress in order to systematically survey the whole epicentral area, and to follow the evolution through time of the observed effects. At each survey point we are making detailed descriptions, sampling for grain size analyses of liquefied sands, and measurements of fracture opening and ground displacement.

The field work is based on the available excellent database of topographic maps, geological maps, airphotos, and specific cartography (e.g., the Seismotectonic Map of the Emilia Romagna Region; http://ambiente.regione.emilia-romagna.it/geologia/temi/geologia/carta-sismotettonica-della-regione-emilia-romagna-in-scala-1-250.000). A valuable amount of geomorphic, stratigraphic and structural data is also available in the literature.

The environmental effects observed until now reveal a complex pattern of ground fractures (Fig. 4), mostly associated with ejected sand (Fig. 5). Blue to gray fine sands from the fluvial network crossing the epicentral area (Fig. 1) have been extensively liquefied to form fields of sand volcanoes; reports of water fountains up to 1.5 m high are common in the area. The finest particles of the vented material might have been already washed away by the rain and irrigation activities subsequent to the mainshock. At several sites the ground water table has been reportedly uplifted by several meters.

The distribution of ground failure and liquefaction effects is essentially controlled by the local stratigraphic and geomorphic features. As shown in Figure 3, most of the identified sites are clustered or aligned in selected areas. The most severe effects occurred between Sant'Agostino and Mirabello, along a ca. 8 km narrow belt which follows the NE-trending paleo-river bed of the Reno River. This paleocourse was abandoned in the second half of the XVIII century, due to the construction of the "Cavo Benedettino", a new artificial course that today lead the Reno River straight to the East, to reach directly the Adriatic Sea instead of joining the Po River. Ground failure and ground fractures locally damaged the subsurface water pipeline network. Also the effects observed in other sectors (Mirandola, San Martino Spino, Gavello; Fig. 6) are virtually all located on the paleo courses of the Po River and its tributaries.

In particular, near San Carlo the liquefaction and lateral spreading phenomena are truly significant. The macroseismic intensity at San Carlo reaches the value of IX in the ESI 2007 scale. These phenomena show a clear evolution through time; this led to the progressive evacuation of most of the village before the strong aftershocks occurred today.

In general, it is possible to argue that the distribution and amount of damage in the epicentral area have been largely controlled by the presence of earthquake environmental effects, especially liquefaction and lateral spreading.

More pictures and updated information will be posted at http://terremotoemilia.dsat.uninsubria.it/

Fig. 4: Cemetery of Sant’Agostino, phot taken on May 21, 2012

Fig. 5: Cemetery of Sant'Agostino, ejected sand; photo taken on May 26, 2012.


Fig. 6: Gavello, among the greenhouses ca. 25 fractures with gray-blue ejected sand have been mapped; photo taken on May 26, 2012.

Fig. 7: San Carlo hamlet, near Sant'Agostino; ground failure accompanied by sand liquefaction; Doriano Castaldini for scale; photo taken on May 21, 2012.

References

Scrocca, D., E. Carminati, C. Doglioni and D. Marcantoni (2007). Slab retreat and active shortening along the central-Northern Apennines. In "Thrust belts and foreland basins: From fold kinematics to hydrocarbon systems", Lacombe, O., Lavè, J., Roure, F. & Verges, L. (eds.), Frontiers in Earth Sciences, 471-487.

Michetti A.M., Giardina F., Livio F., Mueller K., Serva L., Sileo G., Vittori E., Devoti R., Riguzzi F., Carcano C., Rogledi S., Bonadeo L., Brunamonte F., Fioraso G. (2012). Active compressional tectonics, Quaternary capable faults, and the seismic landscape of the Po Plain (N Italy). Annals of geophysics, accepted.