Dipartimento Difesa del Suolo

Servizio Geologico d'Italia

GEOLOGICAL EFFECTS INDUCED BY THE SEISMIC SEQUENCE STARTED ON MAY 20, 2012, IN EMILIA (Mw = 5.9)

PRELIMINARY REPORT

Roma, 31 May 2012

1. INTRODUCTION

Since May 20, 2012, a seismic sequence (first main shock at 2:03 am GMT, M_w 5.9) is affecting a portion of Emilia region (Northern Italy), chiefly the Modena and Ferrara provinces. The seismic sequence has been characterized by several other main shocks of magnitude above 5, the largest one (M_w 5.8) on May 29 at 7 am GMT, and is still ongoing to date.

In the days immediately after the first shock, the Geological Survey of Italy – ISPRA has started to survey the epicentral area in order to document the coseismic geological effects, supporting the Civil Protection Department of Italy.

This preliminary report provides a synthetic description of the geological effects collected in the period 22 – 24 May. Further field surveys are still ongoing and their results will be illustrated in next reports.

The geological surveys were conducted by two ISPRA teams[1] together with CNR-Institute of Geosciences and Earth Resources[2], and in strict contact with other geological teams surveying the epicentral areas (EMERGEO, Universities of Modena, Insubria, Salamanca and Spanish Geological Survey).

The first aim of this report is to provide the Italian Department of Civil Protection a firsthand account of the geological effects occurred in the hit region and of the hazard they may pose during the emergency phase.

The longer term objective of this activity is to define the most complete scenario of earthquake environmental effects induced by this seismic sequence, also in order to make an independent assessment of the intensity of the earthquake through the ESI 2007 intensity scale, that is based only on coseismic effects on natural environment. In this context, this activity is a contribute to the INQUA-TERPRO Project #1229 “EEE METRICS” [3]

[1] Valerio Comerci, Pio Di Manna, Luca Guerrieri and Eutizio Vittori

[2] Luigi Piccardi

[3] PARAMETRIZATION OF EARTHQUAKE ENVIRONMENTAL EFFECTS: Exploring relationships between source parameters and intensity natural effects for Modern, Historic, Ancient and Paleo earthquake events to refine the ESI-2007 Scale

2. THE SEISMIC SEQUENCE

The seismic sequence has affected an about 40 km long, WNW-ESE trending zone mainly located in the Emilia region (Fig. 1, data from CNT-INGV website). The available focal mechanisms (e.g., http://www.bo.ingv.it/italiano/news/meccanismi-focali-della-sequenza-sismica-emiliana.html) clearly define a NNE-SSW nearly pure compression. The focal depths generally range from very shallow to 10-12 km, with only a few deeper events, rarely exceeding 20 km.

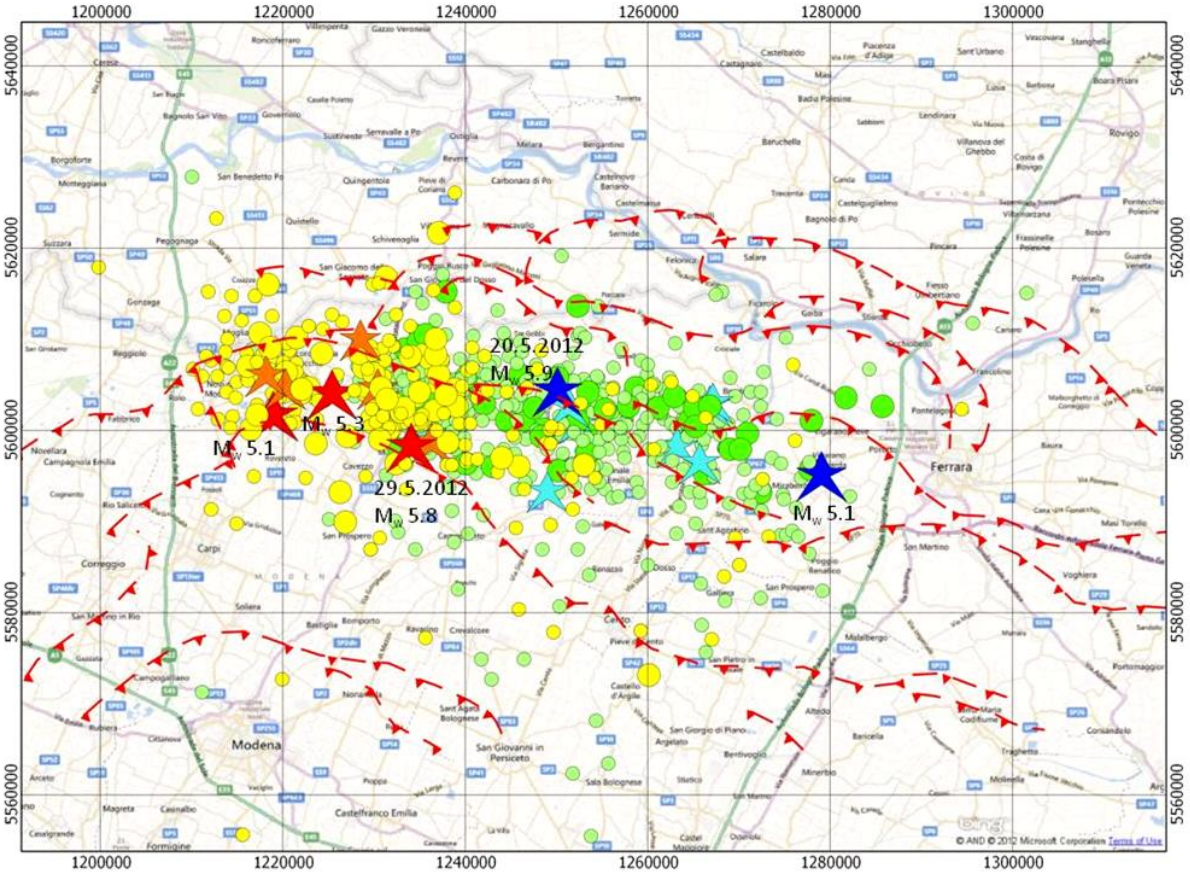

Fig. 1. Seismic sequence from May 19 to 30 (data from INGV-CNT website, elaboration by ISPRA). Green dots and blue stars are events of the first shock, yellow to red of the second main shock on May 29. The traces of the main thrusts of the buried Apenninic fold and thrust belt are also reproduced, as in ITHACA database (http://www.isprambiente.gov.it/site/it-it/Progetti/ITHACA_-_Catalogo_delle_faglie_capaci/).

The first main shock occurred on May 20, 2012, at 02:03 (GMT) and was characterized by the following seismological parameters: Mw = 5.9; focal depth: about 6 km, epicentre a few km north of Massa Finalese. An Mw = 5.1 shock followed the main shock about 11 hours later, located about 20 km east of it (6 km NE of San Carlo). The extension of the rupture zone inferred from the distribution of aftershocks appears to be about 35 km.

Nine days later, on May 29, 2012, at 07:00 (GMT) a second main shock took place about 12 km west-southwest of the first main event (Mw = 5.8; focal depth: about 10 km, epicentre near Medolla). In the same day, two major aftershocks followed 4 hours later with magnitude 5.3 and 5.1. The second, deeper, earthquake has probably ruptured a western portion of the same plane that hosted the first main shock. This second rupture appears to be ca. 25 km wide and partly overlaps with that of the first rupture.

The seismic sequence is still ongoing at the moment of the issue of this report.

3. GEOLOGICAL EFFECTS INDUCED BY THE SEISMIC SEQUENCE

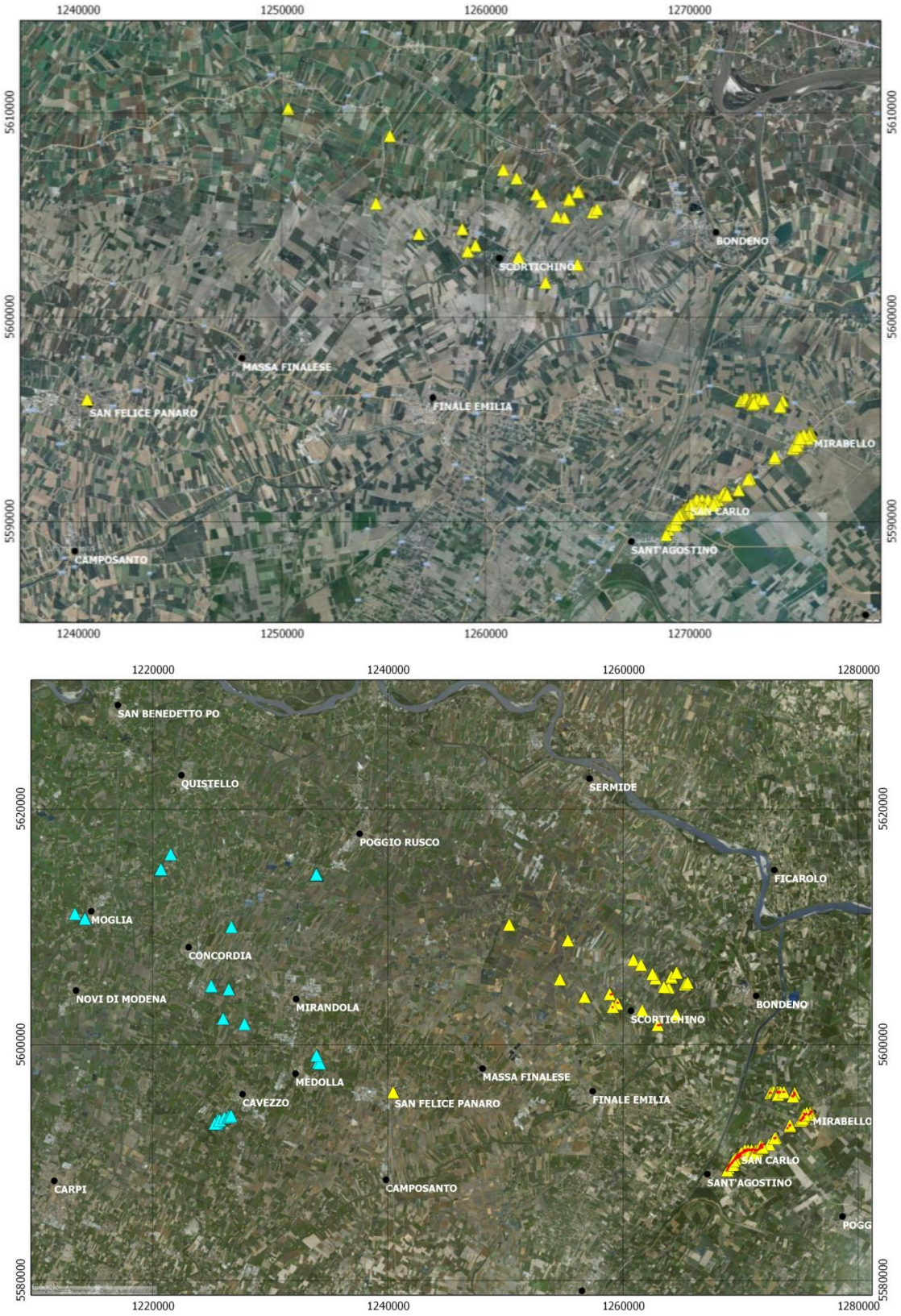

Fig. 2. Above: distribution of the 104 survey points on May 22-24. Below: Distribution of all survey points until May 30. Yellow triangles: observed effects of first shock; Cyan triangles: observed effects of second shock on May 29.

In the period 22 - 24 May 2012, data related to about two hundreds effects (mainly ground cracks and liquefactions) in 104 locations (Fig. 2, above) have been collected by the ISPRA Italian Geological Survey team (ISPRA and CNR personnel), that surveyed mainly the eastern and northern sectors of the epicentral area. A number of effects were kindly shown or referred to us by prof. Doriano Castaldini of Modena university.

Furthermore, other 39 survey points concerning the effects induced by the second shock (May 29) in the western area (cyan triangles in Fig. 2, below) have been surveyed in the period 29-31 May. These data will be described in the next report that is being delivered shortly.

Ground cracks and liquefactions

Liquefaction-type effects and ground cracks (whose origin is sometimes related to lateral spread, and in other cases still to be interpreted) have been unquestionably the most relevant types of effect induced by the earthquake on the natural environment.

The zone with the most evident and widespread effects is around San Carlo, a settlement part of the municipality of Sant'Agostino (map in Fig. 3). Large ground cracks and widespread liquefaction affected either paved roads (e.g. Via Rossini, Via Morandi, Via Gramsci, Via De Gasperi), the buildings crossed by them and farmed land (Fig.4).

Fig. 3. San Carlo (Sant'Agostino): liquefactions and ground ruptures were distributed on a NE-SW trending elongated area located on an ancient embankment of the Reno River.

Fig. 4 – San Carlo (Sant'Agostino): ground ruptures and liquefactions affected farmed lands, paved roads and buildings.

The distribution of these effects, as well as the orientation of ground cracks, clearly identifies a relatively narrow NE-SW trending elongated area, about 6.5 km long, from SW of the Sant'Agostino cemetery to San Carlo (the most damaged center), up to Mirabello. The ground ruptures were almost continuous, damaging all the constructions above them, especially the houses in San Carlo and the industrial settlements between San Carlo and Mirabello (map in Fig. 5, photos in Fig. 6).

Fig. 5. Mirabello: liquefactions and ground ruptures were distributed on 1) a NE-SW trending elongated area affecting mostly industrial settlements an located on an ancient embankment of the Reno River; 2) a WNW-ESE trending elongated area some km NW of the Mirabello village.

Ground ruptures were very often characterized by a significant offset (generally lowering to NW) that reached more than 50 cm between San Carlo and the Sant'Agostino cemetery. Opening of cracks was generally in the order of several centimetres, but occasionally it reached also 40-50 cm. These data are related to the survey date (22-24 May); however, the process of lateral spreading is still ongoing, because widening of throw and opening of ground cracks has been observed in following surveys, the last one on May 31.

Liquefaction was very often associated to ground cracks. In some cases aligned emission cones were clearly identifiable (elevation generally lower than 30-40 cm). The areal extension of ejected material (poorly sorted grey fine sand) was very different ranging from a few square meters up to many hundreds of square meters, depending on amount of emitted water and local slope angle. Commonly, grain size of sand gets finer, up to clayey silt, moving upwards in emission cones. Sampling has been carried out in many sites for grain size analysis in ISPRA laboratory.

It is noteworthy that all the northeast-southwest effects between Sant'Agostino and Mirabello were concentrated on the ancient embankment associated to a previous talweg of the Reno river. This has certainly contributed to the occurrence of ground open cracks and liquefaction and significantly enhanced their size.

Nevertheless, liquefaction and ground cracks were also found in other areas of the Po River flood plain that were not related to ancient embankments. Among them, aligned WNW-ESE trending ground cracks with associated widespread liquefaction were found

NW of Mirabello, Other similar features were found near Scortichino (loc. Obici), Burana and towards San Martino Spino (Figs. 7 and 8). Seemingly, the distribution of liquefaction is related to the local recent geomorphological evolution, dominated by a complex network of braided paleo-drainages and abandoned meanders.

Fig. 6 – Mirabello: ground ruptures and liquefactions affected farmed lands, public and private gardens and industrial settlements.

Fig. 7 – Distribution of survey points (liquefactions and ground ruptures) between Scortichino , Burana and San Martino Spino

Fig.8 – Left: Scortichino, loc. Obici. Ground rupture with liquefaction . Right: Burana. Ground rupture with liquefaction in a channel

Hydrological anomalies

The water wells located in the epicentral area have generally recorded a relevant increase (up to 8-9 meters) of the groundwater level immediately after the main event, and reportedly already hours before at some places. Very often, fluidified sand has been ejected out of wells, sometimes from the well itself, often following paths on the outer side of the casing, most likely associated to liquefaction (Fig. 9). Also the smell of H_2S has been sometimes noted, reportedly occurring already days before the event.

Fig. 9 – San Carlo (Sant'Agostino): sand ejected out of wells, most likely due to liquefaction

4. CONCLUSIONS

The scenario of geological effects collected in the period 22-24 May 2012 is still partial and is being completed by field surveys in progress in the western area, that has been affected by the second main shock on May 29. A second report taking into account also these data will be delivered in next days.

All the collected data are being provided to the Italian Department of Civil Protection and published on the EEE Catalogue portal at the address:

http://www.eeecatalog.sinanet.apat.it/emilia/earthquake/index.php