Ferrara Earthquake Sequence 20.5.2012 – 29.5.2012

Information as of 31.5.2012, updated version 1.6.2012

James Daniell[1,4], MSc; Dr. Andreas Hoechner[2,4]; Prof. Dr. Friedemann Wenzel[3,4]; Prof. Dr. Jochen Zschau[2,4]

[1] General Sir Monash Foundation, Australia and Karlsruhe Institute of Technology, Geophysical Institute
[2] GFZ German Research Centre for Geosciences
[3] Karlsruhe Institute of Technology, Geophysical Institute
[4] Center for Disaster Management and Risk Reduction Technology CEDIM

1. Time, Location and Magnitude

Two series of strong earthquakes hit the Emilia-Romagna region in northern Italy starting on Sunday, 20.5.2012 and on Tuesday 29.5.2012 respectively, affecting mostly the provinces of Ferrara, Bologna, Modena and Reggio nell'Emilia. The largest event had a moment magnitude of 6.1 and occurred on 20.5.2012 at 4:04 a.m. local time (GEOFON, see GFZ). It was followed by several aftershocks, two having a magnitude of more than 5. The main shock of the second series, having a magnitude of 5.8, happened on 29.5.2012 at 9:00 a.m. and was also followed by two events of more than magnitude 5 on the same day.

A foreshock of the whole series with magnitude 4.1 occurred approximately three hours before the first event.

The following table lists the events of magnitude more than 5 according to GEOFON.

Origin Time UTC	Magnitude	Latitude	Longitude
2012-05-20 02:03:53	6.1	44.91°	11.24°
2012-05-20 03:02:49	5.2	44.90°	11.17°
2012-05-20 13:18:02	5.1	44.82°	11.38°
2012-05-29 07:00:04	5.8	44.94°	11.07°
2012-05-29 10:55:57	5.5	44.93°	10.99°
2012-05-29 11:00:25	5.1	44.92°	11.00°

2. Tectonic Background

The events listed above are located along an E-W trending line 40 km north of Bologna and have similar reverse thrust type source mechanisms. This indicates that

they may lie on the same active fault, the so-called Mirandola fault. This is a 'blind fault', as it is covered by sediments of the Po plain and thus not visible at the surface. It was formed as a result of the NS-convergence between the African and Eurasian tectonic plates which occurs at a rate of roughly 1 cm / year. The rather complex interplay between these plates and the Adriatic microplate lead to flexuring of the crust and N-verging seismically active faults in the Southern Po plain.

The Mirandola blind thrust has been previously identified as a potential source for a M>5.5 earthquake (Valensise and Pantosti, 2001, Burrato 2003).

3. Ground Shaking

In both cases, felt intensities exceeded the value of 7 on the Modified Mercalli Scale, whose highest value is 12. Some of the smaller towns close to the epicenters saw massive damage. Intensity 5 was experienced in the entire Eastern Po plain. Shaking was also felt in Switzerland, Slovenia and France.

4. Losses (as of 31.5.2012)

From the first earthquake on 20 May: 7 fatalities (4 direct, 3 indirect (heart attacks)), around 50 injured, 6000 homeless and 400-500 million € losses (0.3% of Emilia-Romagna's GDP).

From the second quake on 29 May: 17 fatalities, 350 injured, 9000 additional homeless, and estimates of loss exceeding that of the first event (>500 million Euros).

Significant heritage losses (e.g. towers of Castle of Finale Emilio have collapsed, several churches and other historic buildings damaged or destroyed) as well as large industry and residential losses.

From the two earthquakes, around 500 million € damage to the cheese, ham and other agricultural industries in the region are estimated (Coldiretti, press conference, 2012). About 550000 wheels of Parmesan were destroyed worth about 220 million €.

Additional taxation will occur in Italy until the 31 December 2012 to the value of 2 cents per liter for petrol, to fund recovery from these earthquakes (Italian Government Press Conference, 30 May 2012).

5. General Information

The earthquakes happened in the Po plain, which is seismically not very active by Italian standards, the hazard is assumed to be low to moderate, but exposure is very high. In 1346, a magnitude 5.8 earthquake took place approximately at the location of the 29 May 2012 event. From 1561-1574, a series of 4 events were felt with intensity greater than 7 in the region of these 2 recent events, with the largest being the November 1570 event of a very shallow depth and magnitude 5.5 (EMS=7.5) occurring about 40 km east of the 20 May 2012 event, close to Ferrara (INGV,

Website, 2012). A repetition of this event, could lead to even larger damage than that of the recent earthquakes depending on the proximity of its epicenter to the city of Ferrara.

The magnitude 5.8 event on 29 May can be considered an aftershock of the magnitude 6.1 event on 20 May. Events with aftershocks almost as large as the main shock are unusual but can happen. In 1997, the region around Assisi, some 200 km SE of the present earthquake sequence, was hit by an earthquake of magnitude 5.8 which was followed by an even larger event of magnitude 6.1 9 hours later.

The present events were smaller than the one that hit L'Aquila in April 2009, which was of magnitude 6.3 and caused 308 deaths and direct economic losses of 10.2 billion € due to its proximity to the city. The foreshock is also reminiscent of the L'Aquila earthquake: there, a magnitude 4.1 event preceded the main shock by seven days, and two smaller events (magnitude 3.5 and 3.9) by a few hours. Unfortunately, foreshocks can be identified as such only after the main shock has occurred and thus cannot be used to predict the main shock. Deterministic earthquake prediction is not possible so far, but the seismic hazard can be assessed in a probabilistic sense.

6. Additional Sources and References

http://earthquake-report.com/ and CATDAT
http://geofon.gfz-potsdam.de/
http://earthquake.usgs.gov/earthquakes/
http://www.ingv.it/eng/earthquakes/monitoring/

Burrato et al. (2003): An inventory of river anomalies in the Po Plain, Northern Italy: evidence for active blind thrust faulting. Annals of Geophysics, Vol. 46, p. 865–882.

"Danni sismici in località elencate nella Banca Ipermediale delle Vetrate Italiane (BIVI)". Istituto per la conservazione e la valorizzazione dei beni culturali, http://web.archive.org/web/20110722030704/http://www.icvbc.cnr.it/bivi/conservazione/danni_sismici_emilia.htm

Guidoboni, Emanuela; Ferrari G., Mariotti D., Comastri A., Tarabusi G. & Valensise G. (2007). "CFTI4Med, Catalogue of Strong Earthquakes in Italy (461 B.C.-1997) and Mediterranean Area (760 B.C.-1500)". INGV-SGA.

Terremoti in Italia until 2002, http://www.portaleabruzzo.com/nav/terremoti_home.asp

Valensise, G. and D. Pantosti (Editors) (2001): Database of potential sources for earthquakes larger than M 5.5 in Italy, Ann. Geofis., 44 (suppl. to n. 4), pp. 180, with CD-ROM.

Wikipedia: 1570 Ferrari Earthquake Report, http://en.wikipedia.org/wiki/1570_Ferrara_earthquake