

7th EUREGEO

Bologna | Italy | June 12th - 15th 2012

EUropean
Congress
on REgional
GEOscientific
Cartography
and
Information
Systems

Sustainable
Geo-Management



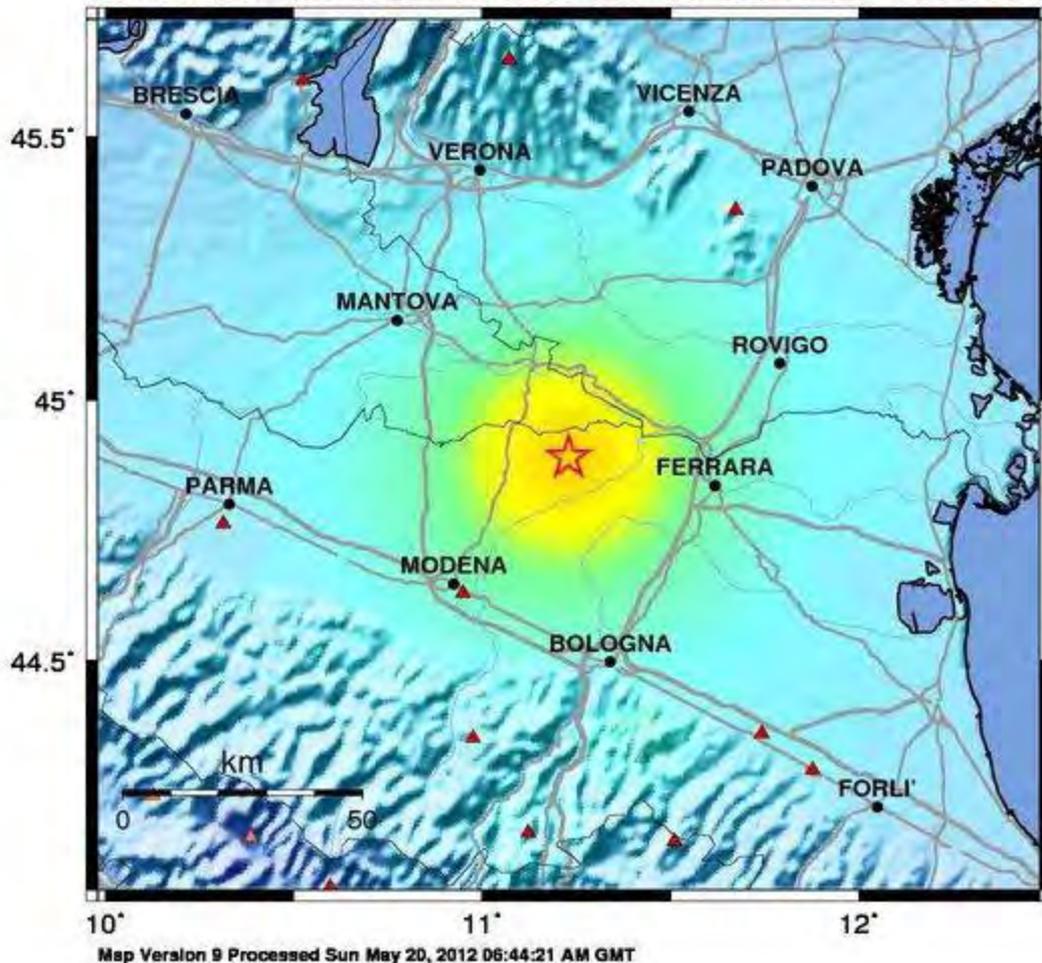
The 2012 May 20 earthquake in the Emilia plain.

The geologic point of view

Luca Martelli



in coordination with DPC
Ufficio Rischio Sismico e Vulcanico



On May 20, 2012 at 04:03 (local time) an earthquake $M_L=5.9$ struck the Po Plain.

The epicenter was located east of Mirandola and north of the Final Emilia (Modena Province). The same day another 2 shocks $M_L > 5$ were felt.

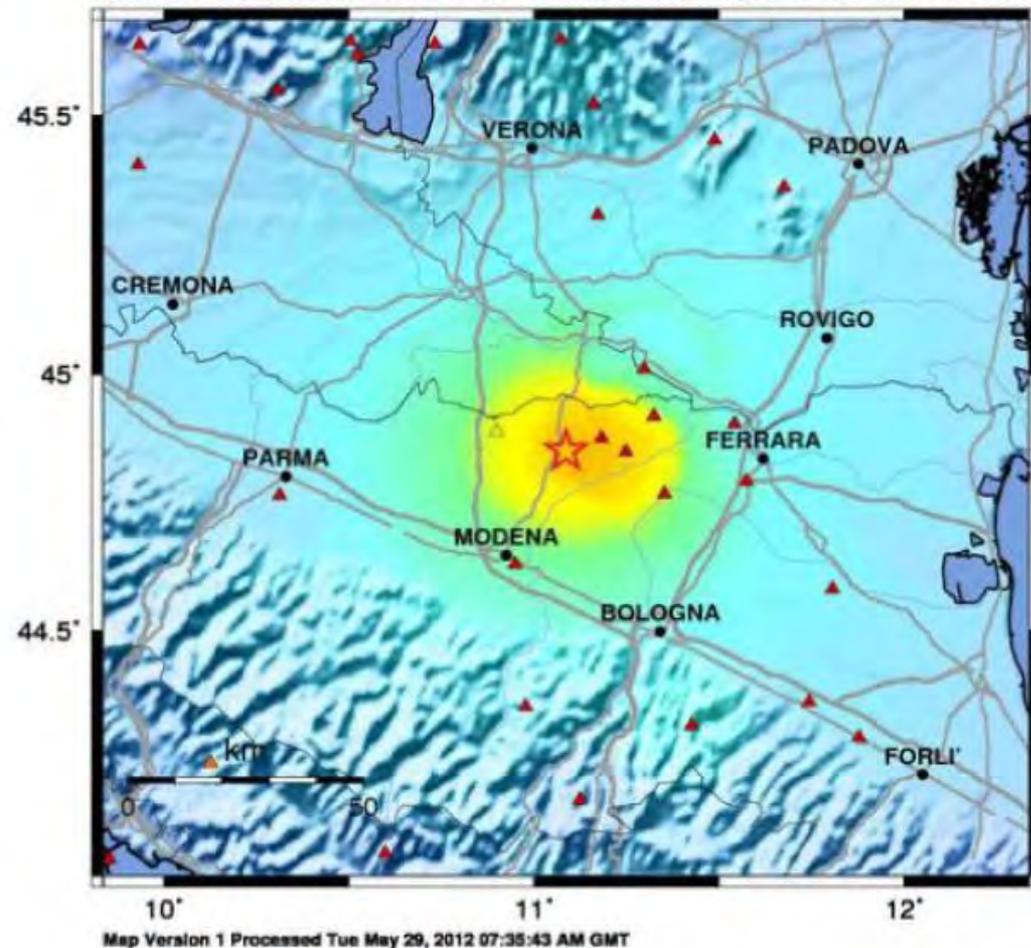
In the municipalities of Mirandola, S. Felice sul Panaro and Finale Emilia effects up to $I_{EMS} = VII$ were observed (data from QUEST report, INGV).

People evacuated after the shocks of 20/5 were about 7000

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.1	0.5	2.4	6.7	13	24	44	83	>156
PEAK VEL.(cm/s)	<0.07	0.4	1.9	5.8	11	22	43	83	>160
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X

Scale based upon Wald, et al., 1999

epicenter coordinates: 44.89°N , 11.23°E
depth: 6.3 km



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INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Waldt, et al.; 1999

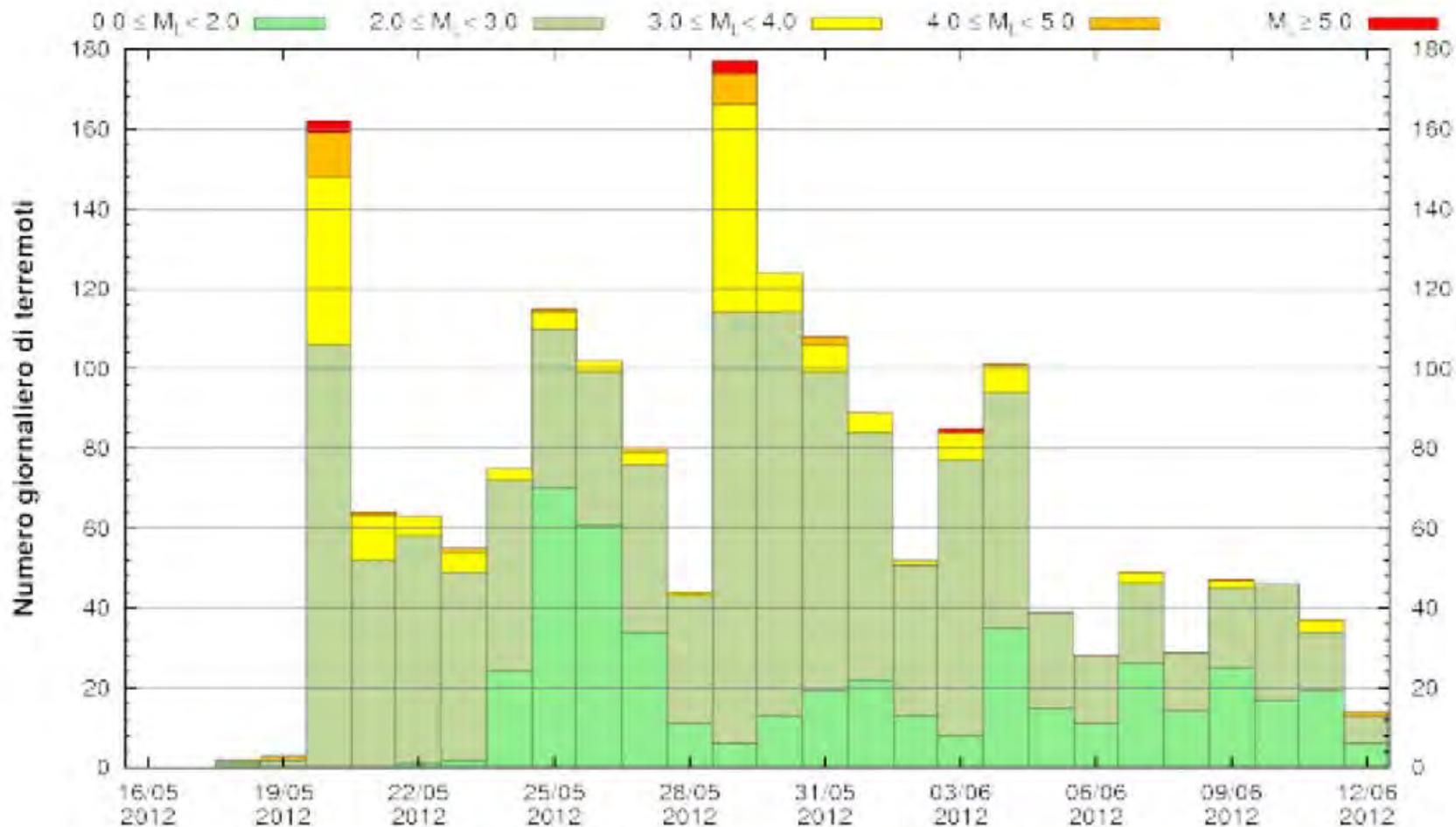
epicenter coordinates: 44.85°N, 11.09°E
depth: 10.2 km

At 09:00 (local time) on May 29, 2012 another strong earthquake, $M_L=5.8$, shaken the Modena Plain.

The epicenter was located near Medolla (MO), 10 km WSW from the 20/5 main shock.

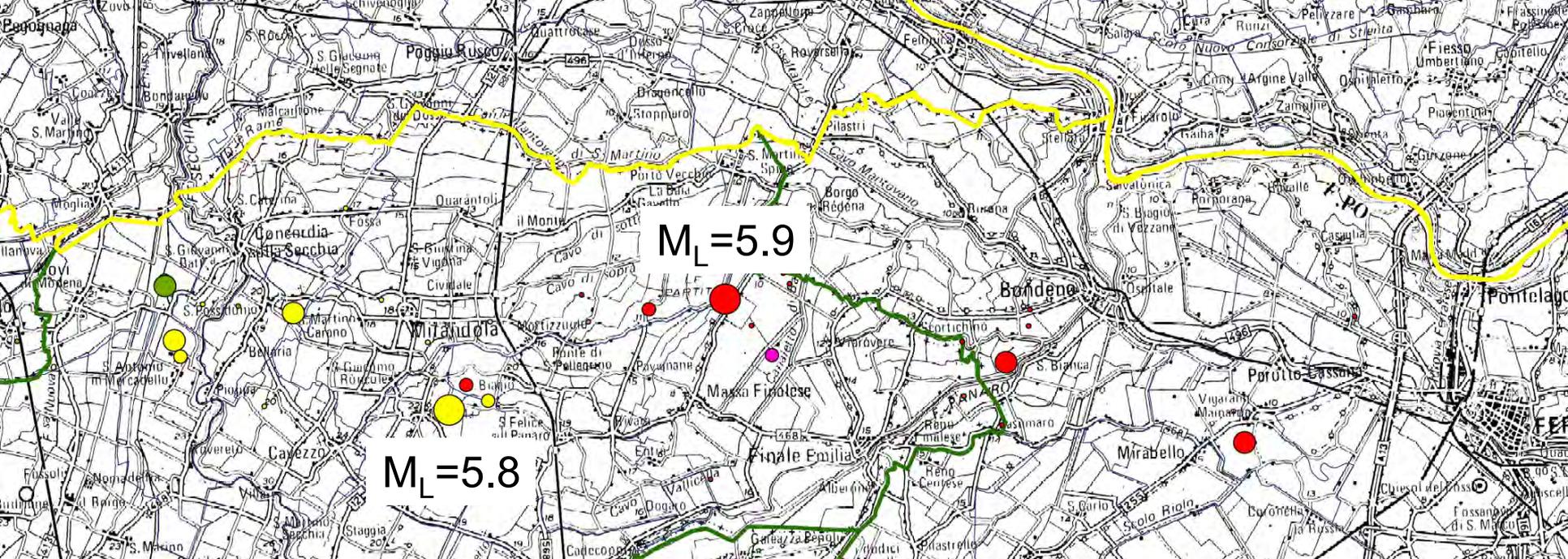
Also this new shock caused effects up to $I_{EMS}=VII$ (from QUEST report, INGV), aggravating the situation in the municipalities of Medolla, Concordia sulla Secchia, Cavezzo and S. Possidonio (MO), and in some towns of the Mantua province.

daily number of shocks, updated June 12, 08:00 local time



Aggiornamento: 06/12/12 07:46:57 (ora locale)

da <http://iside.rm.ingv.it/>



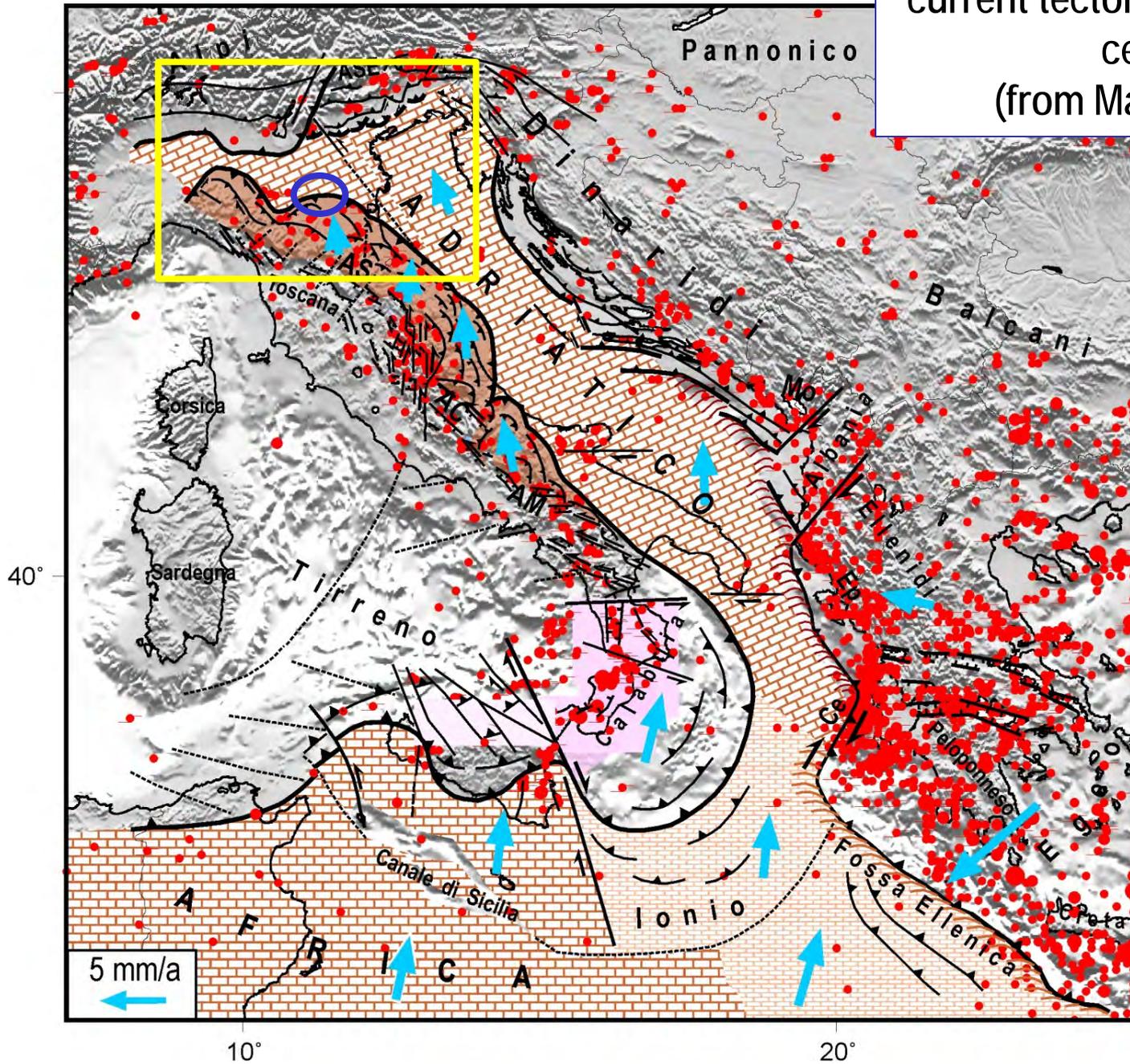
After these new shocks, the number of evacuated people increased to more than 16.000.

People of the most affected municipalities ($I_{EMS} \geq 6$) are about 200.000.



Maps of the epicenters $M_L > 4$ from May 20 to June 3. The symbol size is proportional to the magnitude. Red dots: earthquakes from 19 to 22 May; pink dots: earthquakes of 23 and 24 May; yellow dots: earthquakes of 29 and 30 May; green dots: earthquakes from 2 to 6 June.

current tectonic framework of the
central Mediterranean
(from Mantovani et al., 2009)



Geological - structural framework

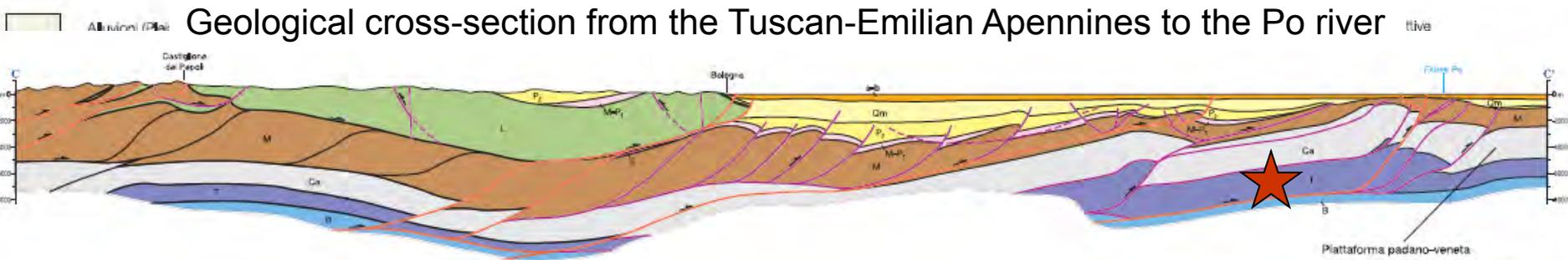
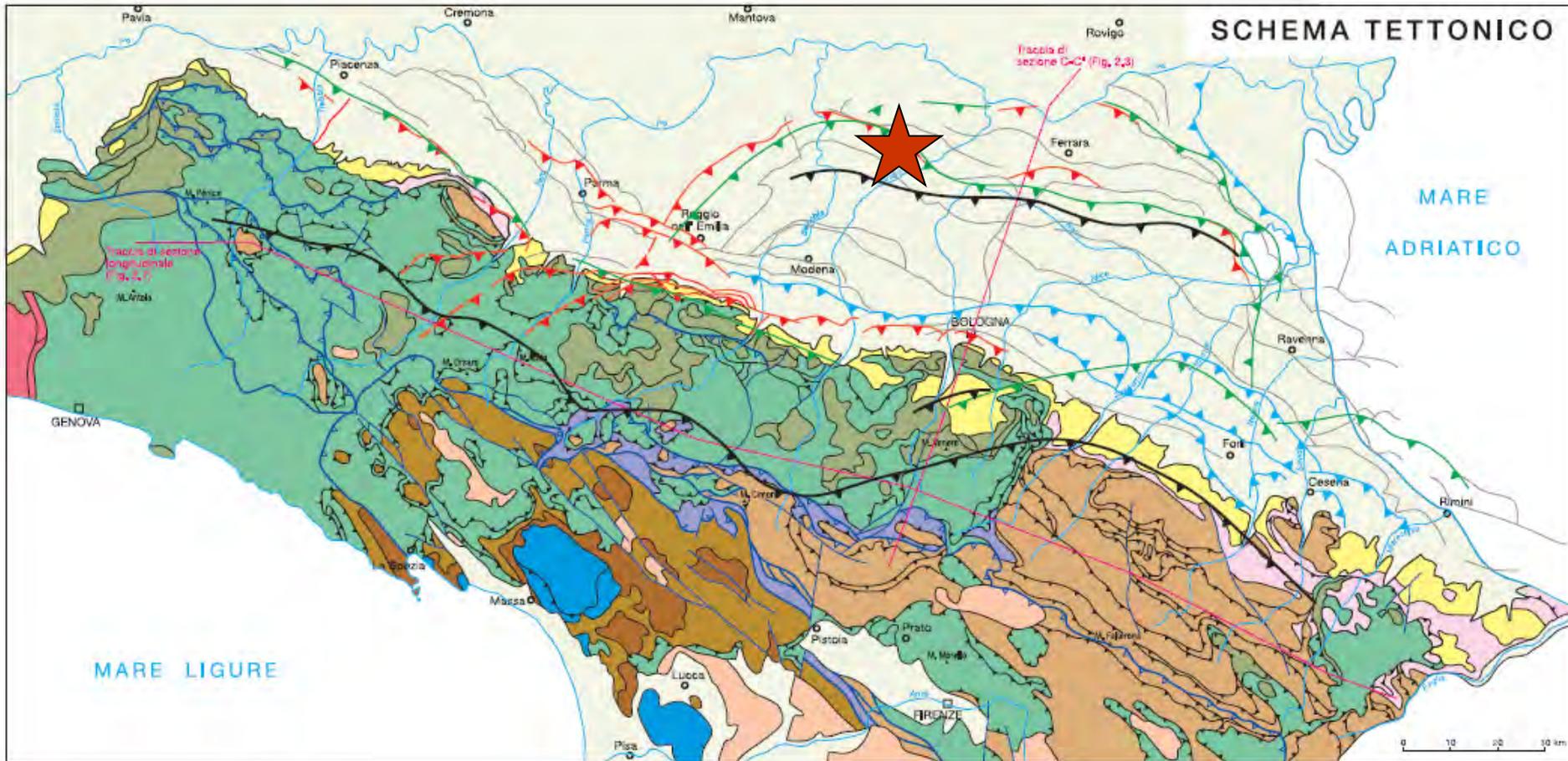
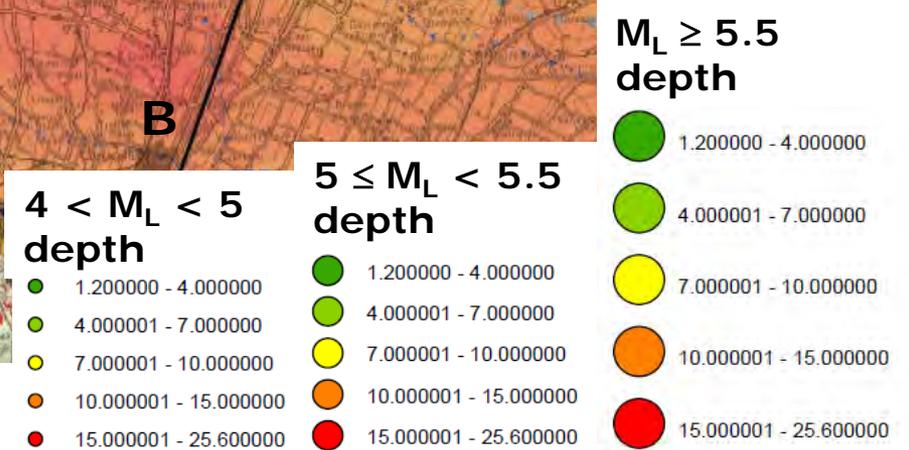
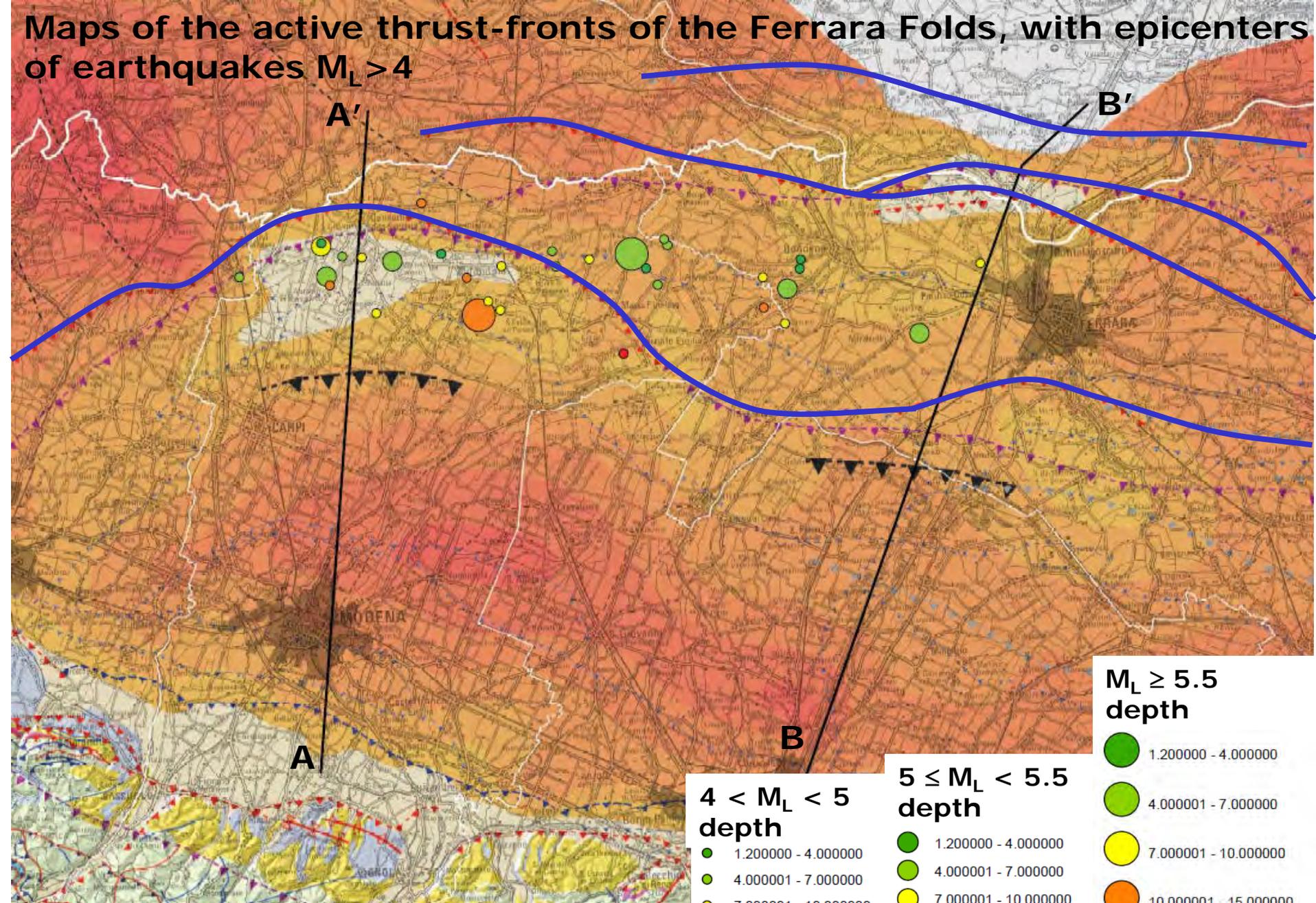
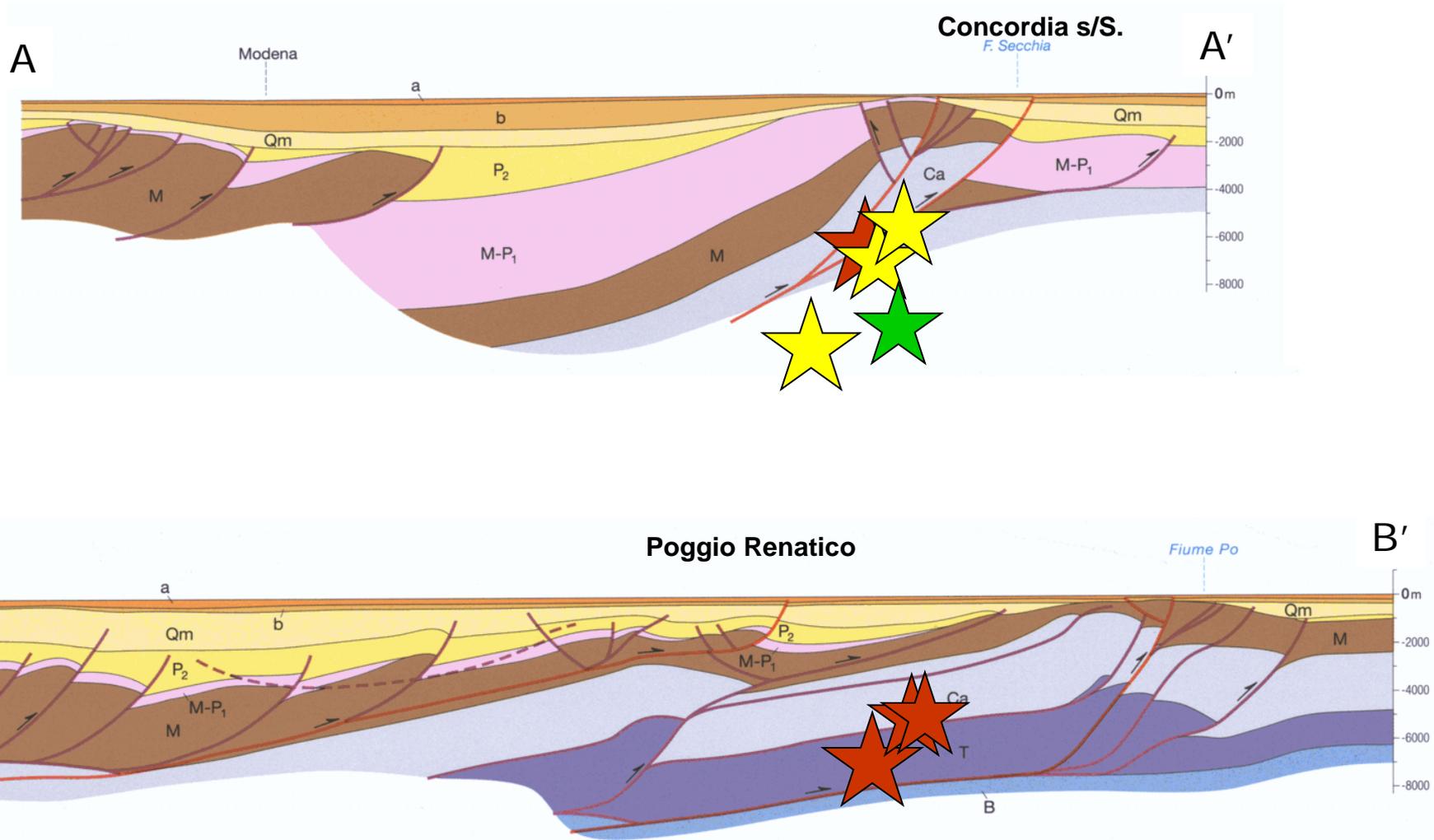


Fig. 2.3

Maps of the active thrust-fronts of the Ferrara Folds, with epicenters of earthquakes $M_L > 4$

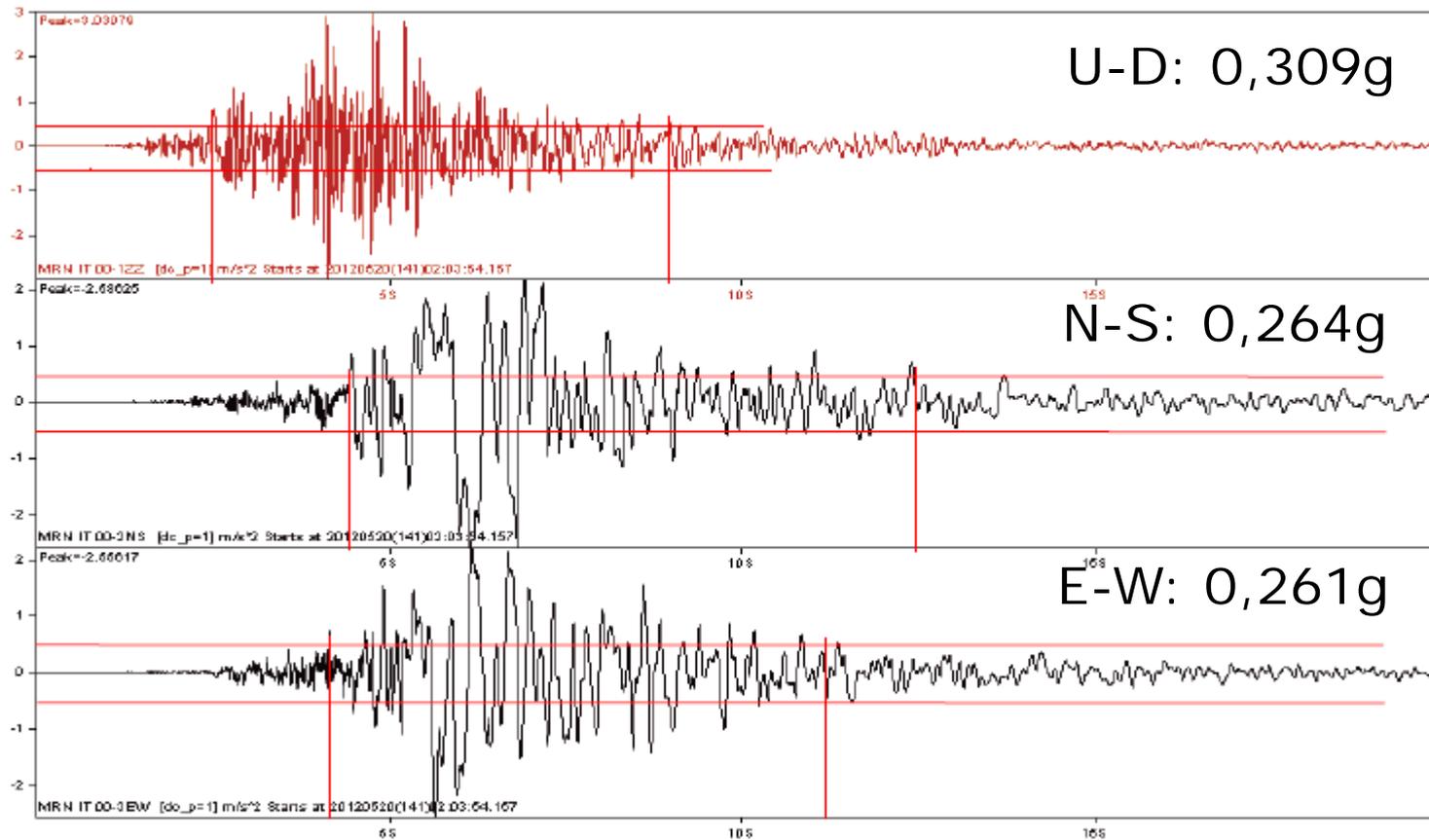


from Seismotectonics Map of the Emilia-Romagna Region, 2004



Geological cross-section through the Modena plain (A-A') and the Bologna-Ferrara plain (B-B'), with projection of hypocenters $M_L > 5$. The symbol size is proportional to the magnitude. Red dots: earthquakes of 20 May; yellow dots: earthquakes of 29 May; green dot: earthquake of 3 June

accelerometric records of the main shock (from RAN Mirandola station)



reference PGA (average) for Mirandola municipality: 0,141g

Sezione geologica A-A'
sud

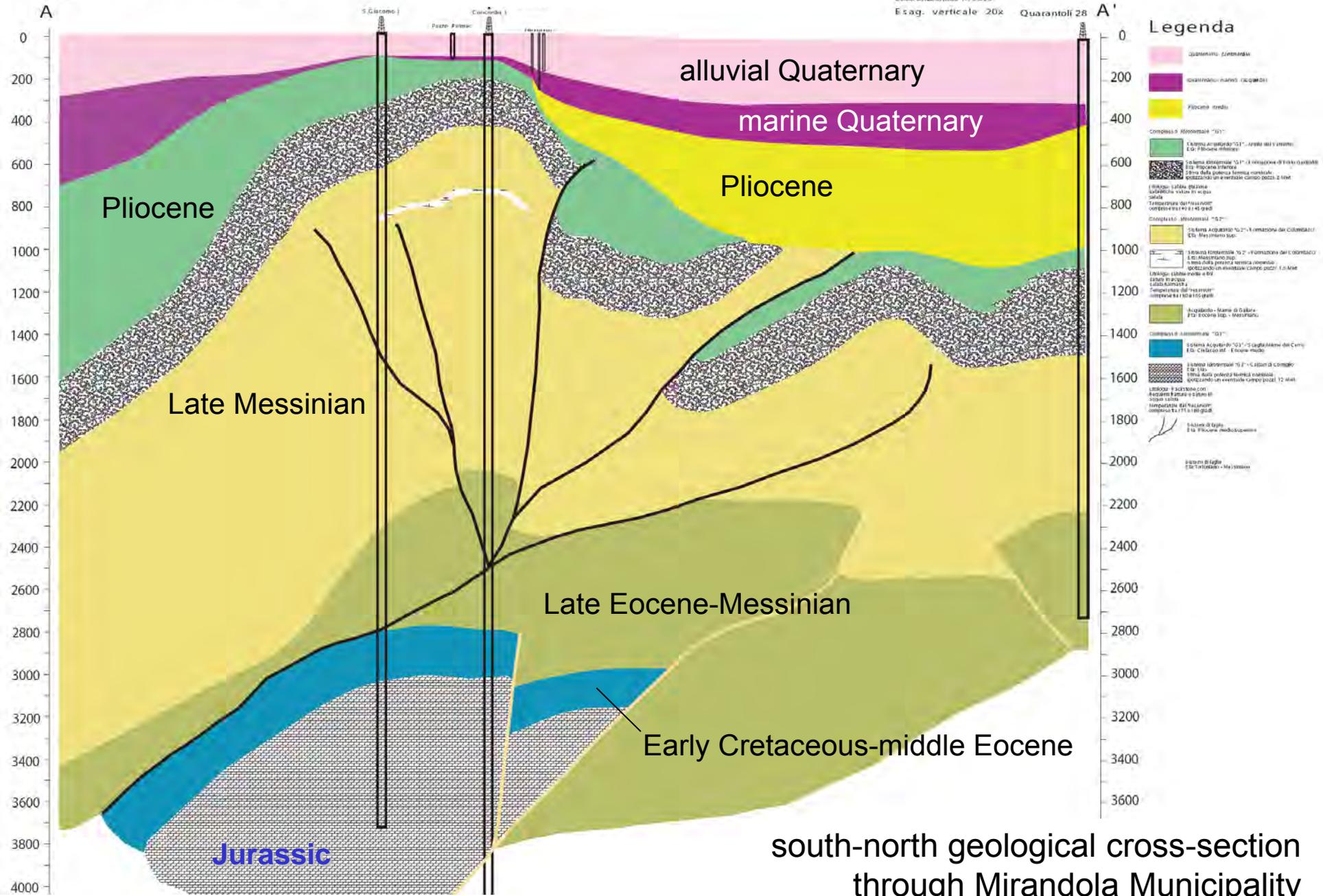
Mirandola

Tavola 1

Scala orizzontale 1:10.000
E.sag. verticale 20x

nord

Quarantoli 28 A'



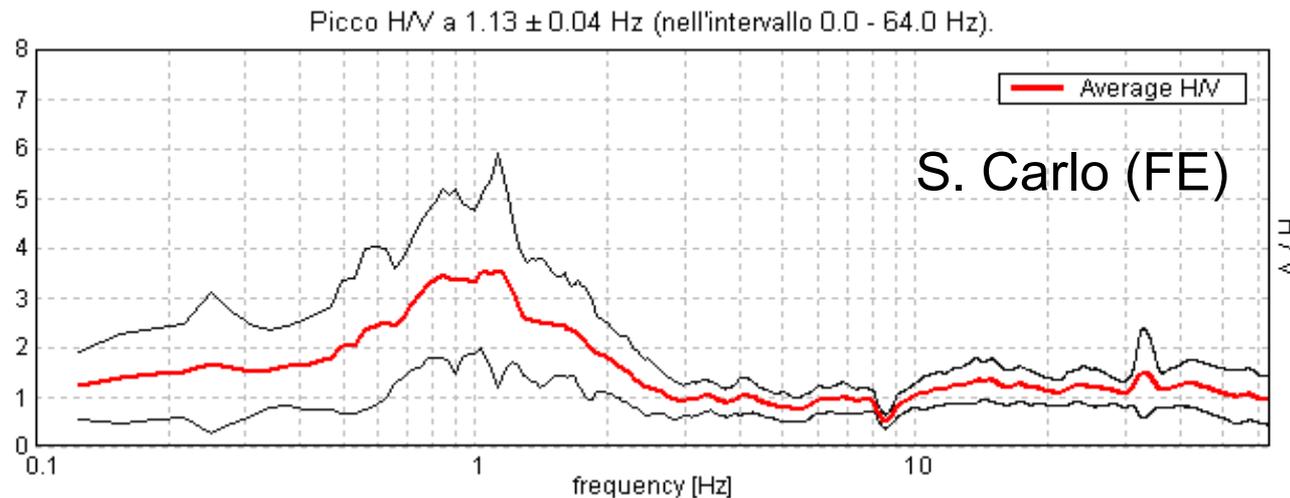
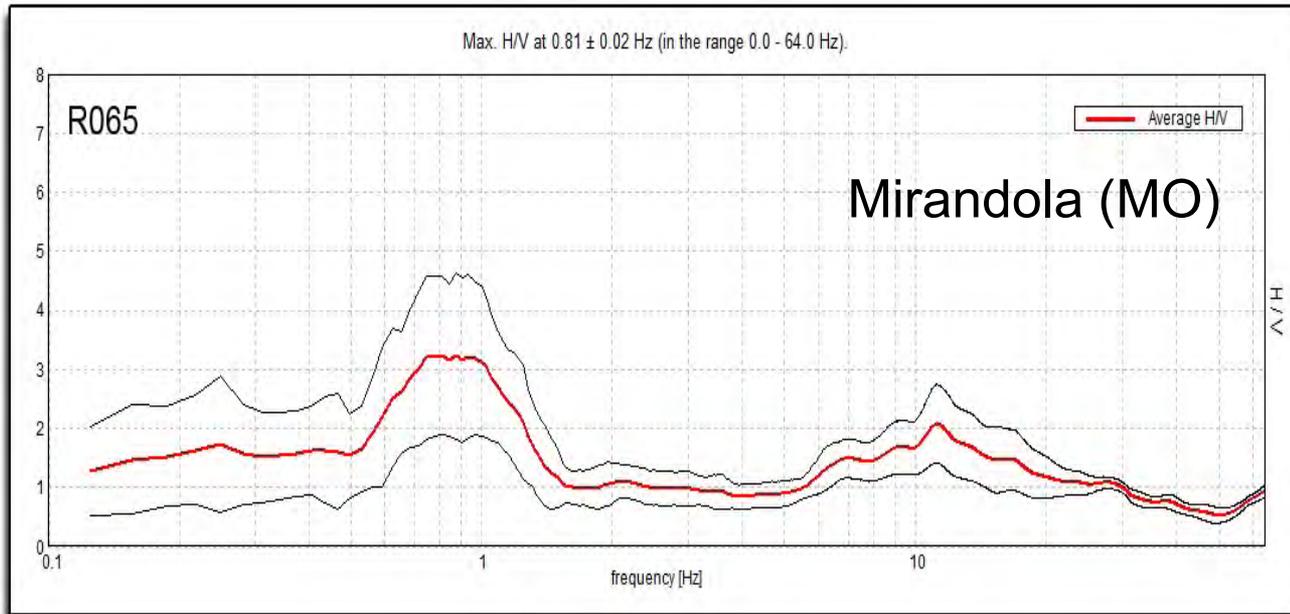
south-north geological cross-section
through Mirandola Municipality

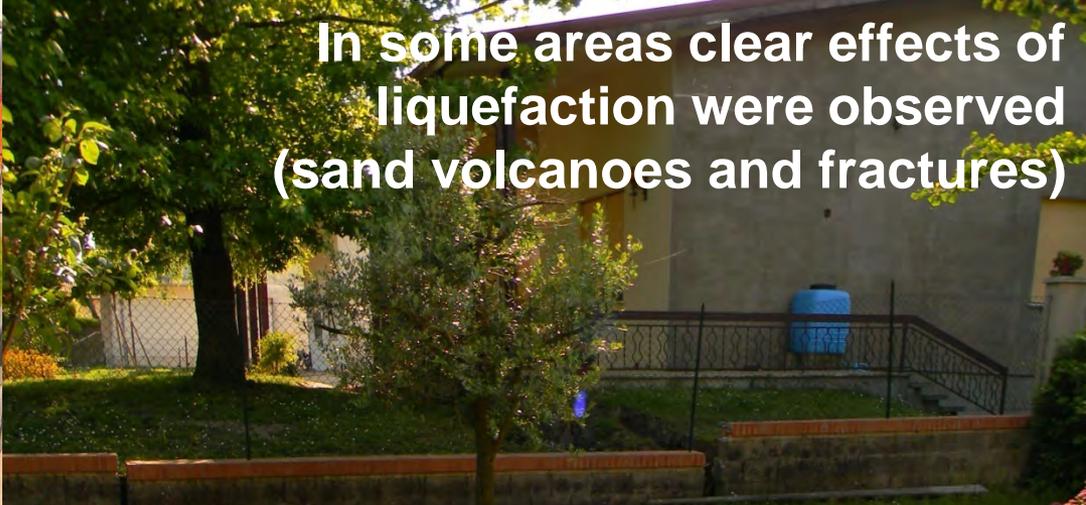
in particular, large buildings have been damaged, like castles and towers, churches and bell towers, warehouses



A possible cause, in addition to the vulnerability:
the F_0 of deposits of this area is between 0.75 and 1 Hz, close to that of large buildings.

A suggestion for future research.





In some areas clear effects of liquefaction were observed (sand volcanoes and fractures)

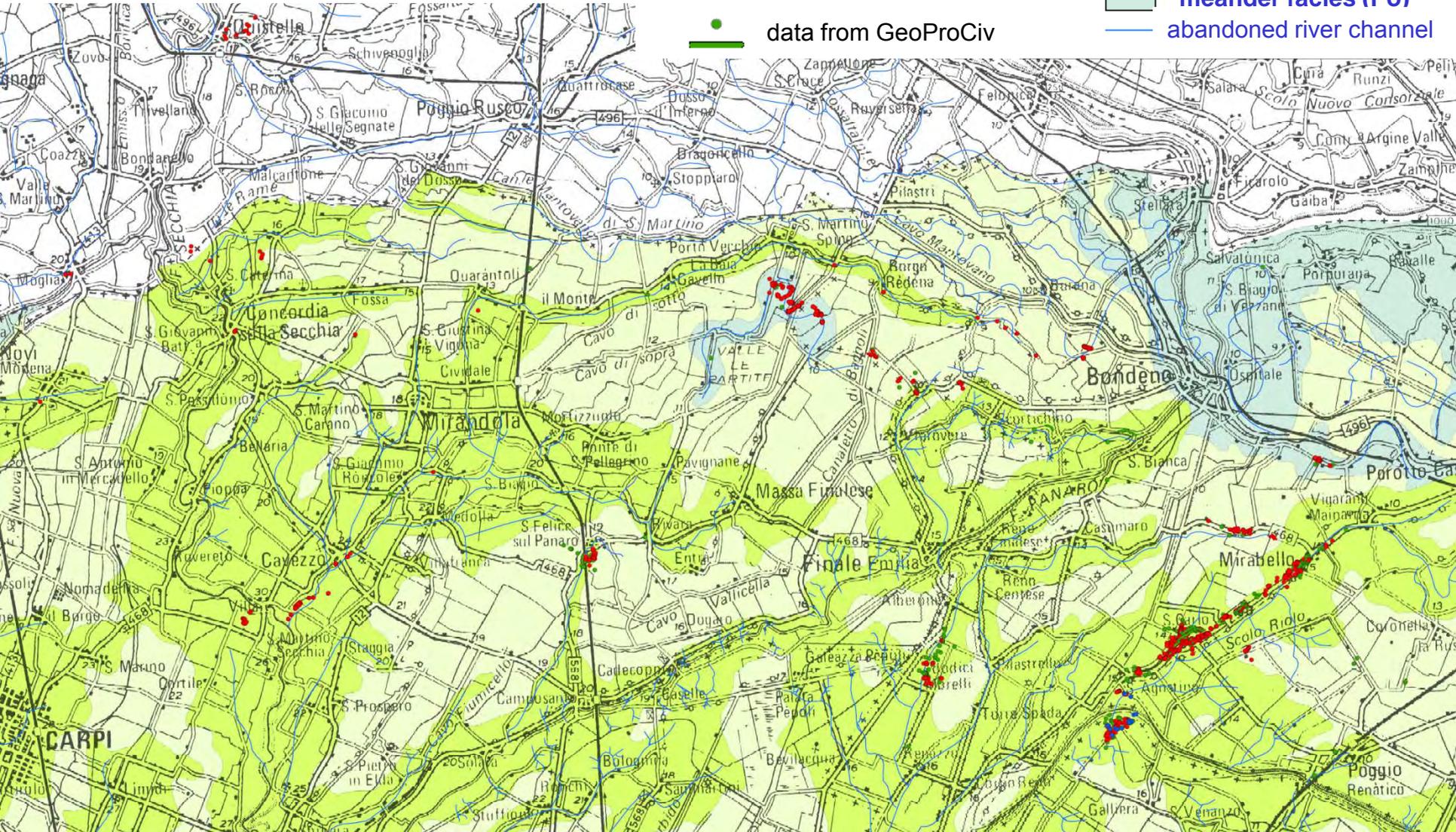
Combination of 1) predisposing and 2) triggering factors:

- 1) saturated sands, slightly densified, in the first 15 m of depth,
- 2) shock $M > 5.5$.



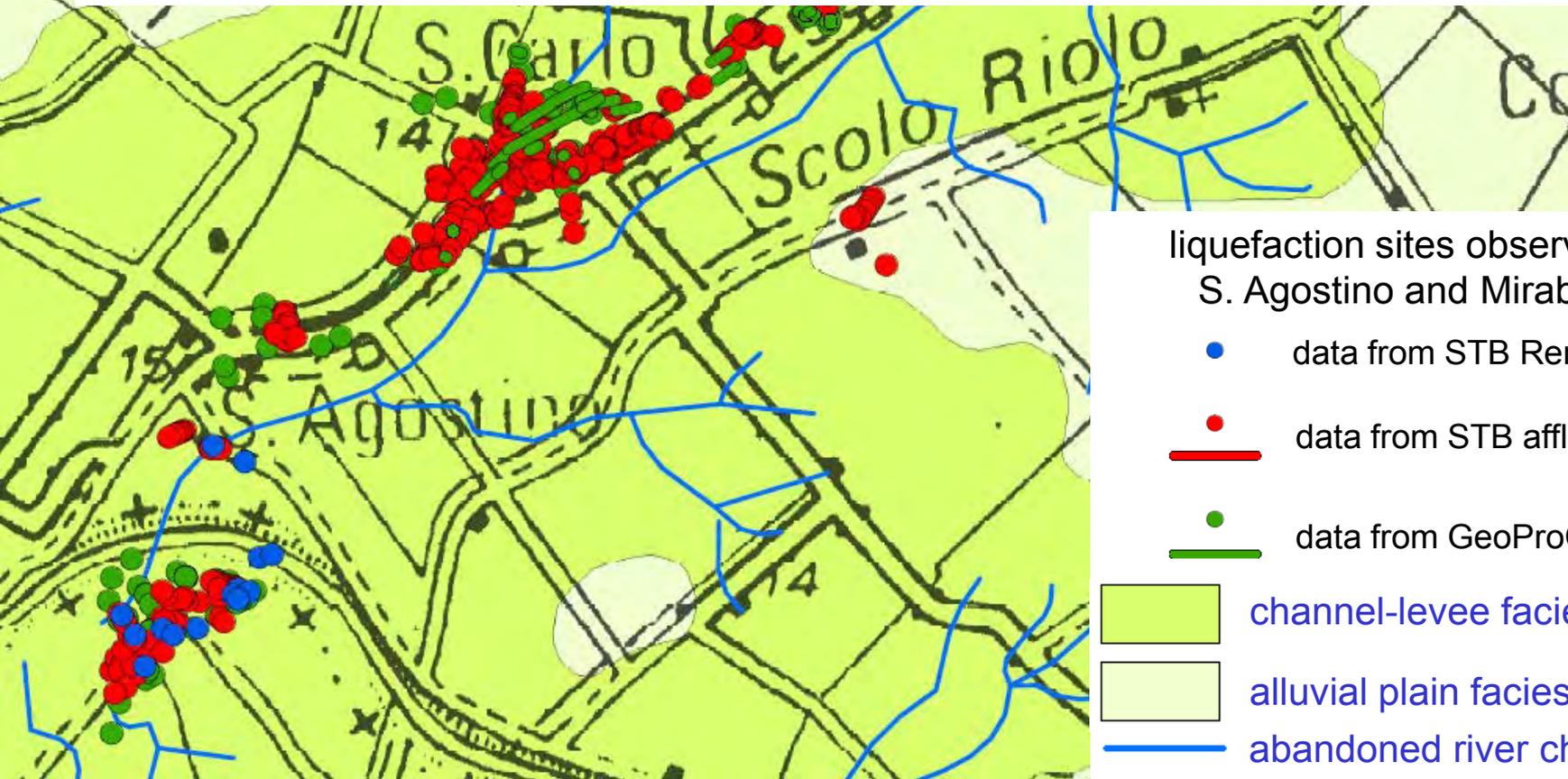
Map of observed liquefaction effects; updated June 7, 2012

- data from STB Reno
- data from STB Affluenti Po
- data from GeoProCiv
- channel-levee facies
- alluvial plain facies
- meander facies (Po)
- abandoned river channel





The main effects of liquefaction were observed in correspondence of abandoned river channels

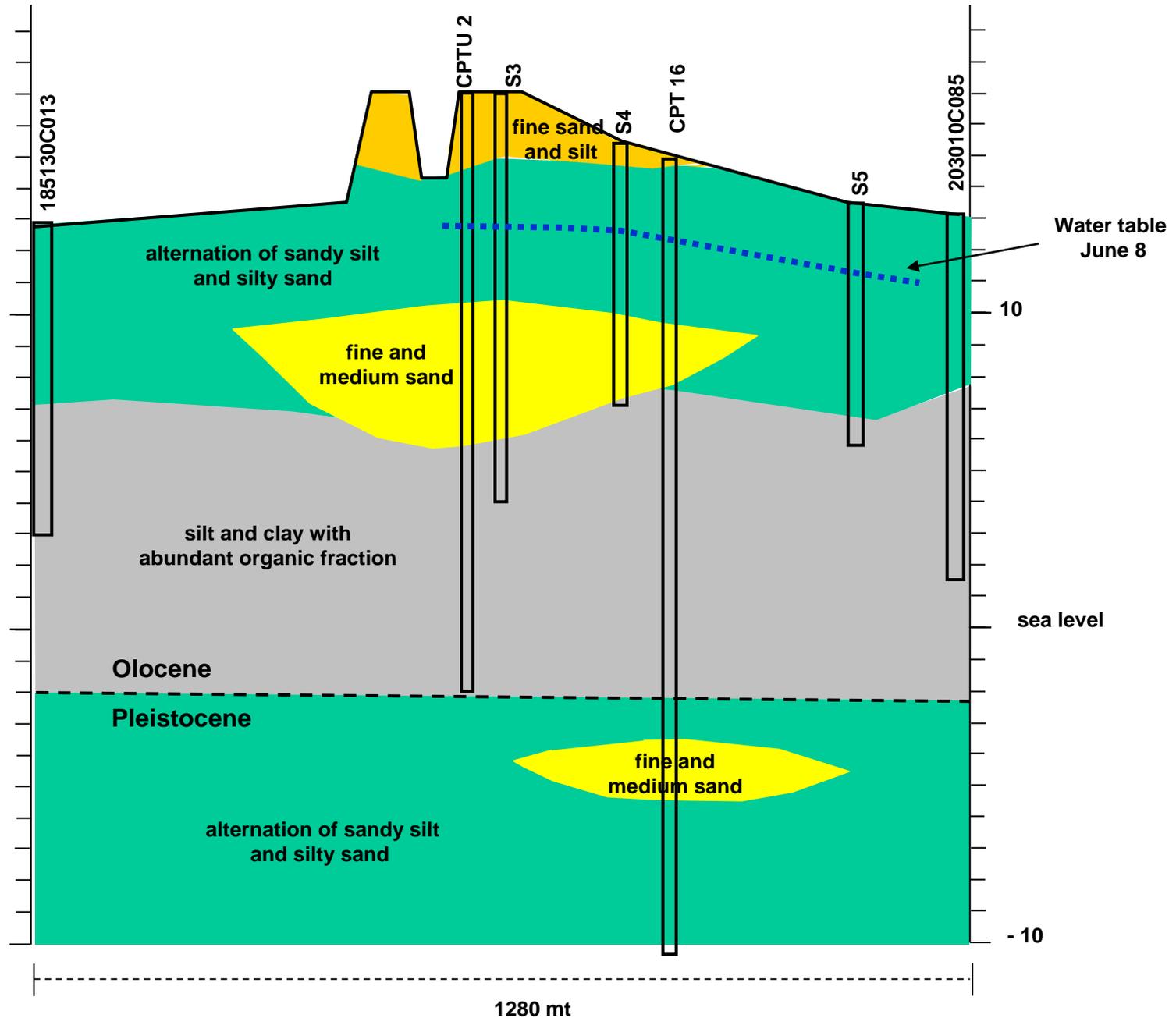


liquefaction sites observed in S. Agostino and Mirabello

- data from STB Reno
- data from STB affluenti Po
- data from GeoProCiv

- channel-levee facies
- alluvial plain facies
- abandoned river channel

geological cross-section WNW-ESE through S. Carlo (south area)



during the major shocks a rising of the water table of over 3 m was observed

Water table June 8

10

sea level

- 10

1280 mt

To evaluate the effects of liquefaction and to verify the safeness of buildings and networks most affected by this phenomenon (towns of S. Carlo and Mirabello, in the province of Ferrara), RER and DPC have established a multidisciplinary team consisting of geologists, engineers and geotechnical engineers of the Regional Authority, DPC, Province of Ferrara, engineering departments of Ferrara and Florence Universities, GeoProCiv, and professional geologists and engineers.

This working group is coordinated by the regional Geological, Seismic and Soil Survey and DPC – Ufficio Rischio Sismico e Vulcanico.

Also geologists and engineers from CNR (IGAG, IMAA, IAMC), Urbino and Basilicata Universities and Milan Polytechnic are involved in this study.

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Thanks for your attention!

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