7th EUREGEO

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EUropean Congress

FROM DRAWING ANTICLINE AXES TO 3D MODELLING OF SEISMOGENIC SOURCES: EVOLUTION OF SEISMOTECTONIC MAPPING IN THE PO PLAIN

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THE PROBLEM

The Po Plain is a challenging area for active tectonics studies.
In this almost flat region:

- ✓ Strain rates are low;
- ✓ Seismicity is moderate and infrequent;
- ✓ Regional tectonic signal is larger than local ones;
- ✓ Sedimentary rates are much higher than tectonic ones;
- ✓ Locally, large man-induced vertical ground motion.

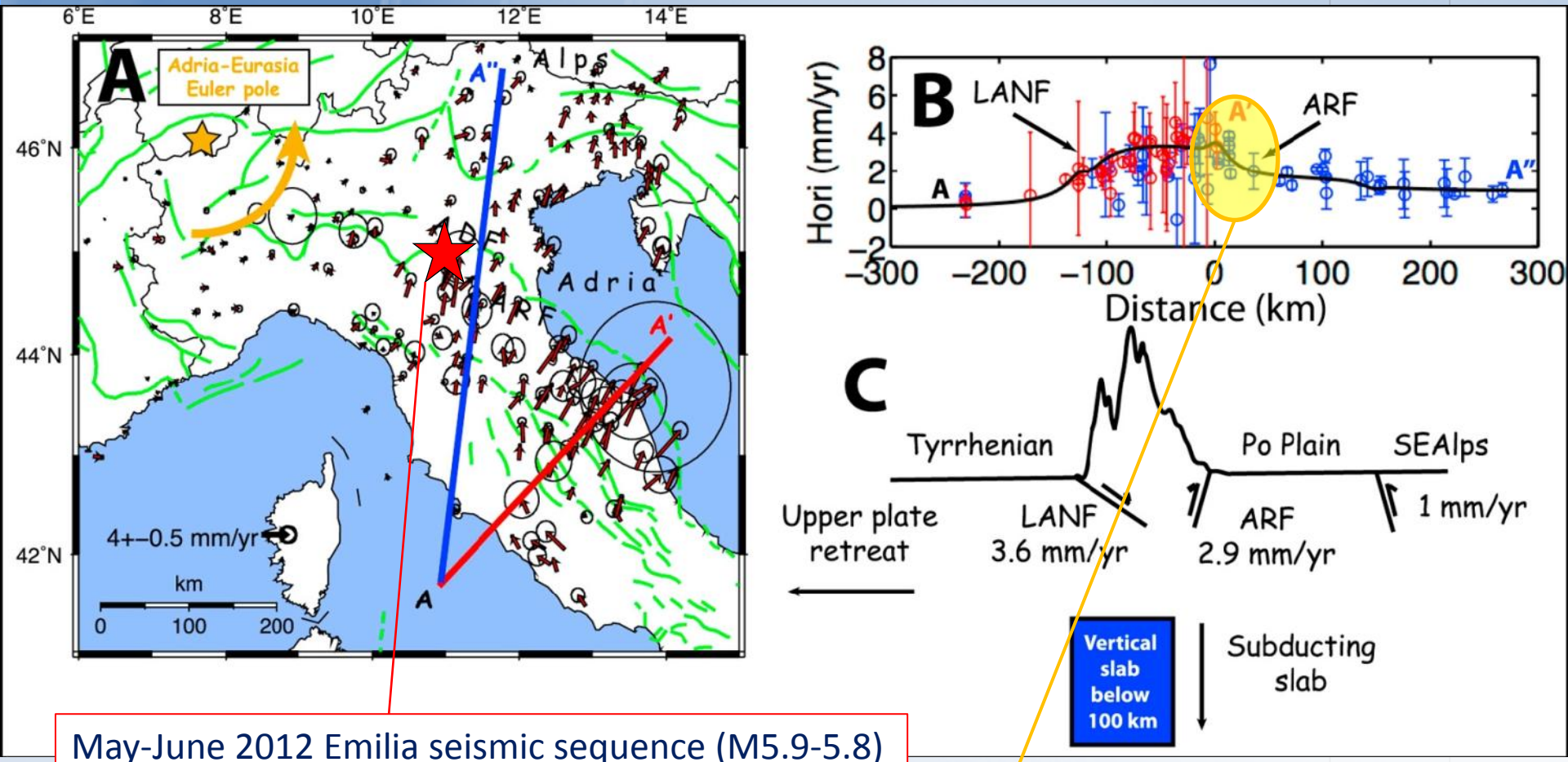
Hence:

- ✓ **Faulting** and **folding** is is almost everywhere **blind**.

To identify and characterize Seismogenic Sources we need an approach that integrates morphotectonic analysis and (possibly) high resolution subsurface geological and geophysical datasets.

ACTIVE DEFORMATION: GPS

GPS velocities not able to capture the activity of the outer blind thrust fronts!

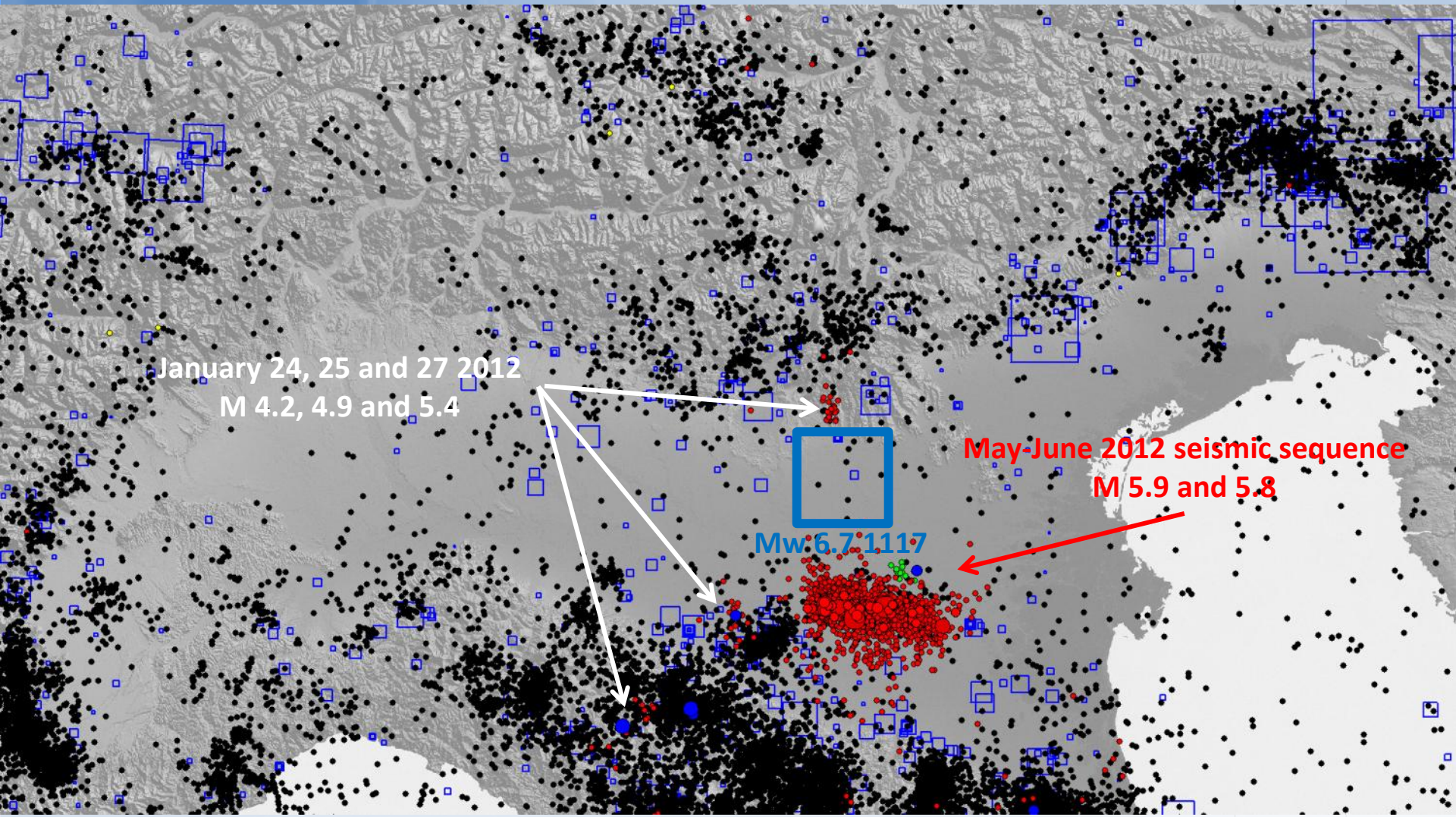


May-June 2012 Emilia seismic sequence (M5.9-5.8)

Bennett et al., 2012

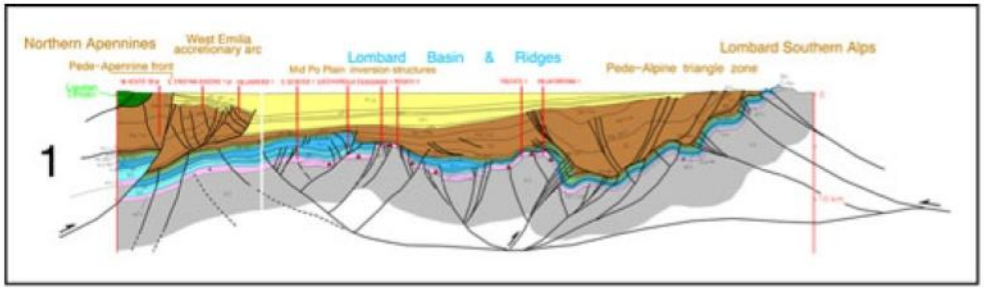
Active shortening localized along the mountain front

HISTORICAL AND INSTRUMENTAL SEISMICITY



CPTI11 - http://emidius.mi.ingv.it/CPTI11/
ISIDe - http://iside.rm.ingv.it/iside/
Catalogo della Sismicità Italiana - http://csi.rm.ingv.it/

REGIONAL vs LOCAL TECTONIC SIGNAL



uLs : late Lias
mLs : middle Lias
lLs : early Lias
Rh : Rhaetian
No : Norian
uCa : late Carnian
lCa : early Carnian
mTr : middle Triassic
Sc : Scythian
uPe : late Permian
Vr : Variscan & pre-Variscan basement

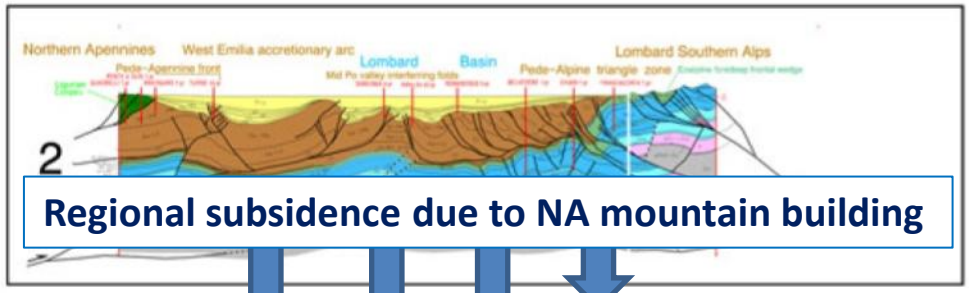
uEo : late Eocene
mEo : middle Eocene
lEo : early Eocene
Pa : Paleocene
Sn : Senonian
Tu : Turonian
uCr : late Cretaceous
Ab : Albian
Ap : Aptian
Br : Barremian
Mm : Malm
Dg : Dogger

Olc : Oligocene
Pls : Pleistocene
uPl : late Pliocene
mPl : middle Pliocene
lPl : early Pliocene
uMe : latest Messinian
lMe : late Messinian
Se : Serravallian
La : Langhian
Aq : Aquitanian
Ol : Oligocene

Evaporite cycles (Late Permian, Carnian, Norian, Malm–Neocomian, late Messinian)

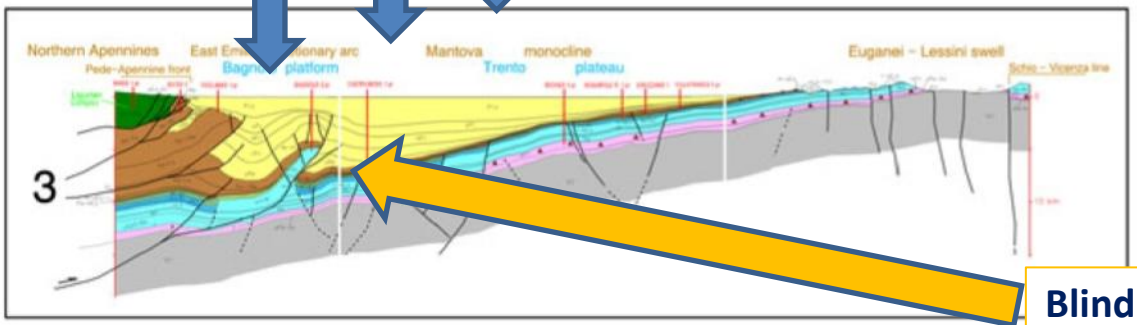
Volcanics & volcanoclastics (Anisian–Ladinian and Eocene–Oligocene)

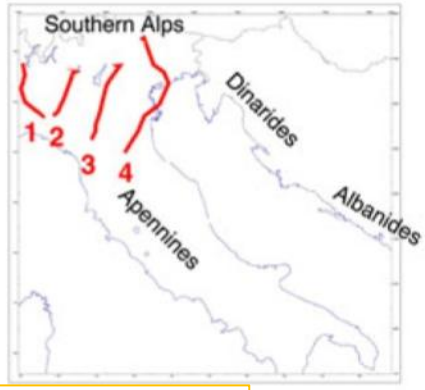
Hydrocarbon exploration well (pr = projected)



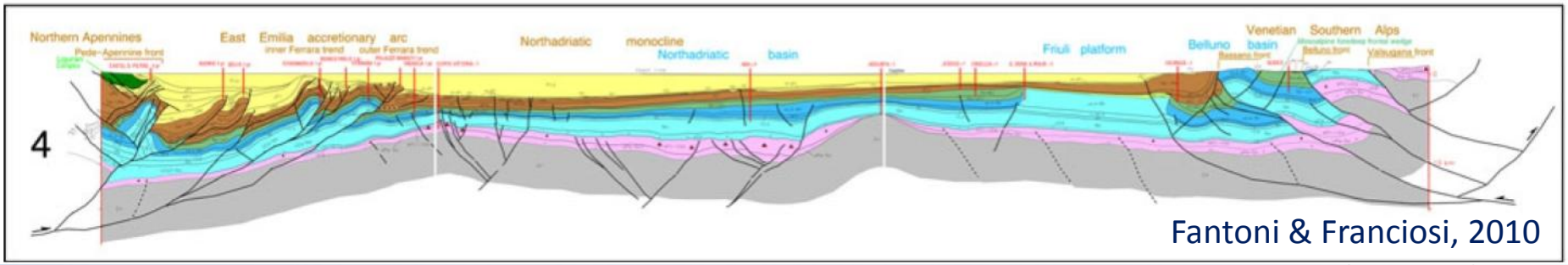
Vertical exaggeration = 2 : 1
0 20 40 km

Regional subsidence due to NA mountain building





Blind faulting and folding



Fantoni & Franciosi, 2010

DRAWING ANTICLINE AXES

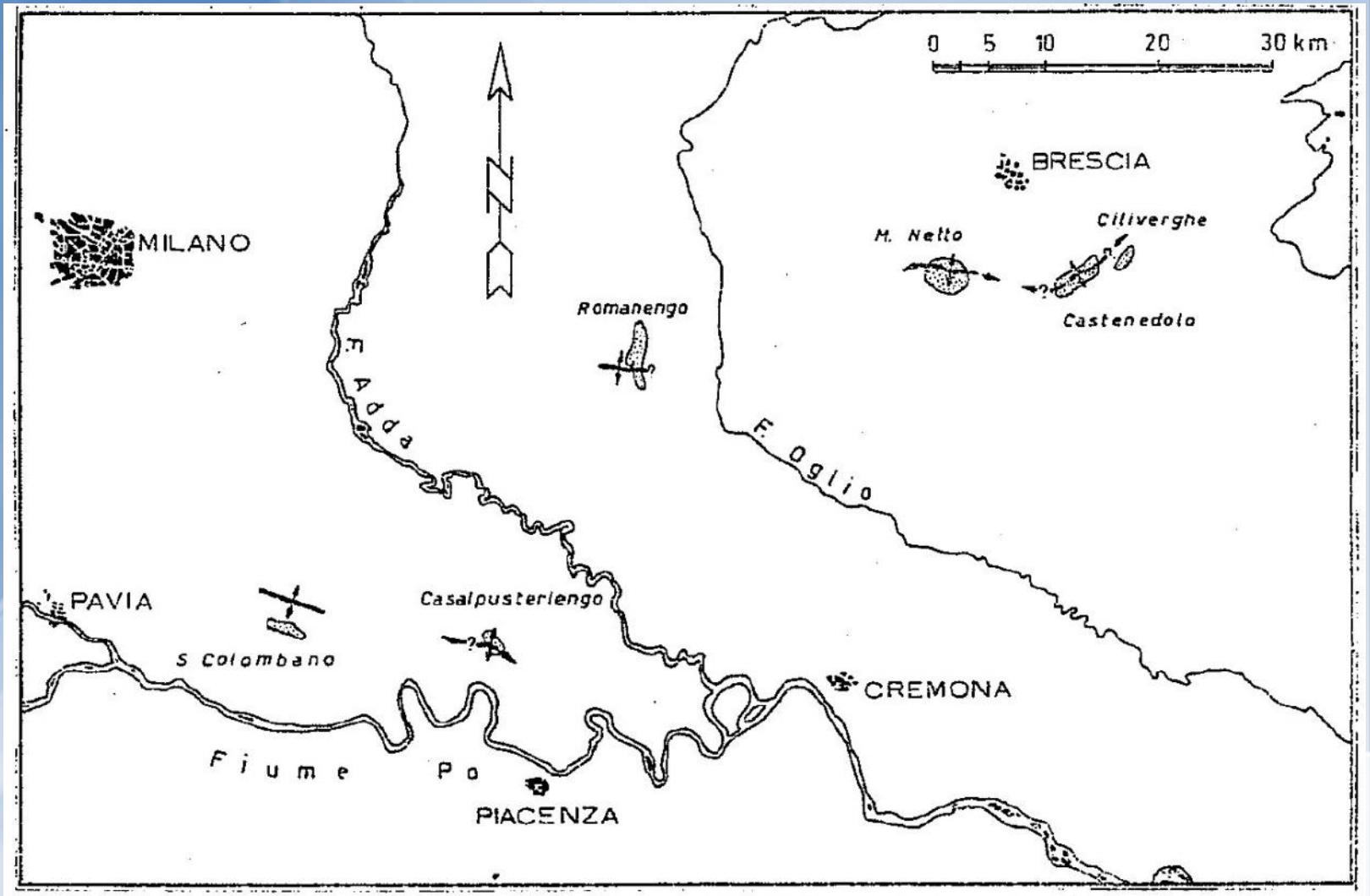
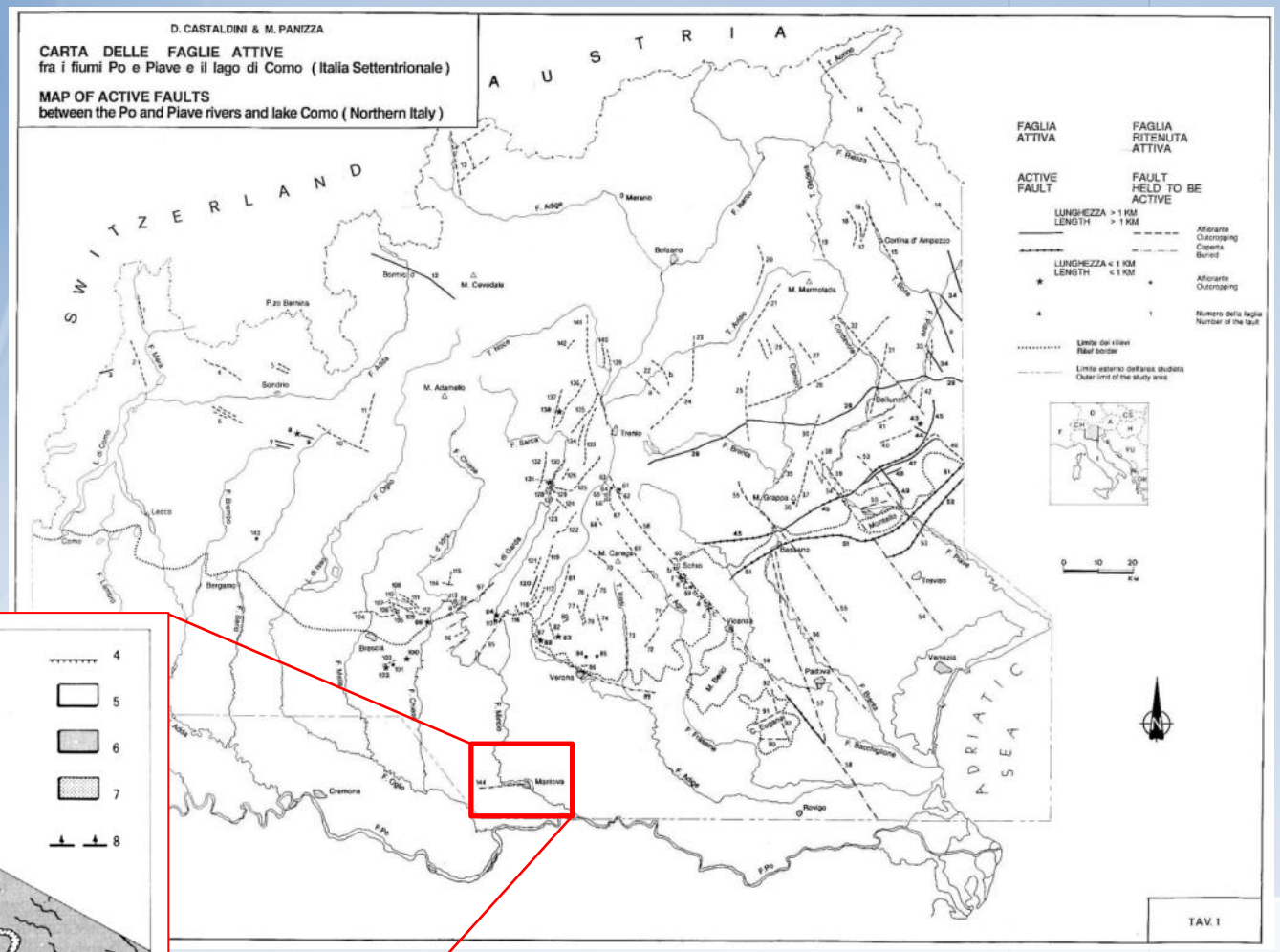


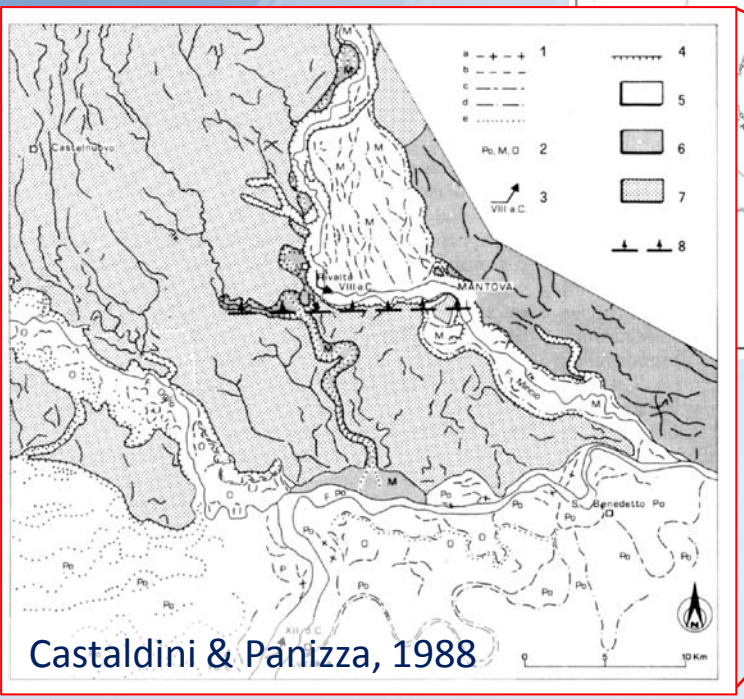
Fig. 1. -- I rilievi isolati della Pianura Lombarda (aree punteggiate) e gli assi delle rispettive anticlinali (linee nere con due frecce).

Desio, 1965

ACTIVE FAULTS AND THEIR GEOMORPHOLOGICAL EVIDENCE



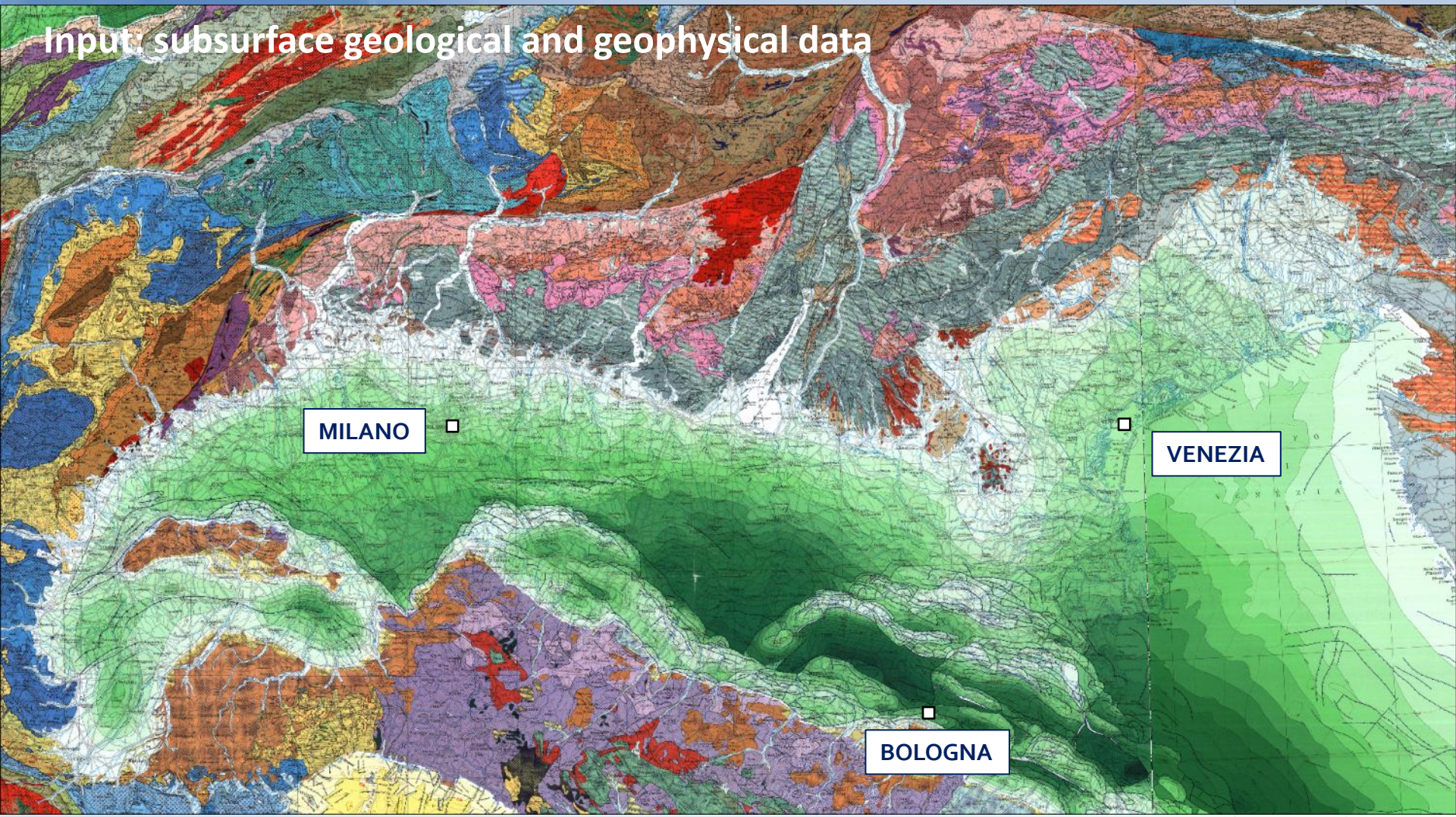
Castaldini & Panizza, 1991



Castaldini & Panizza, 1988

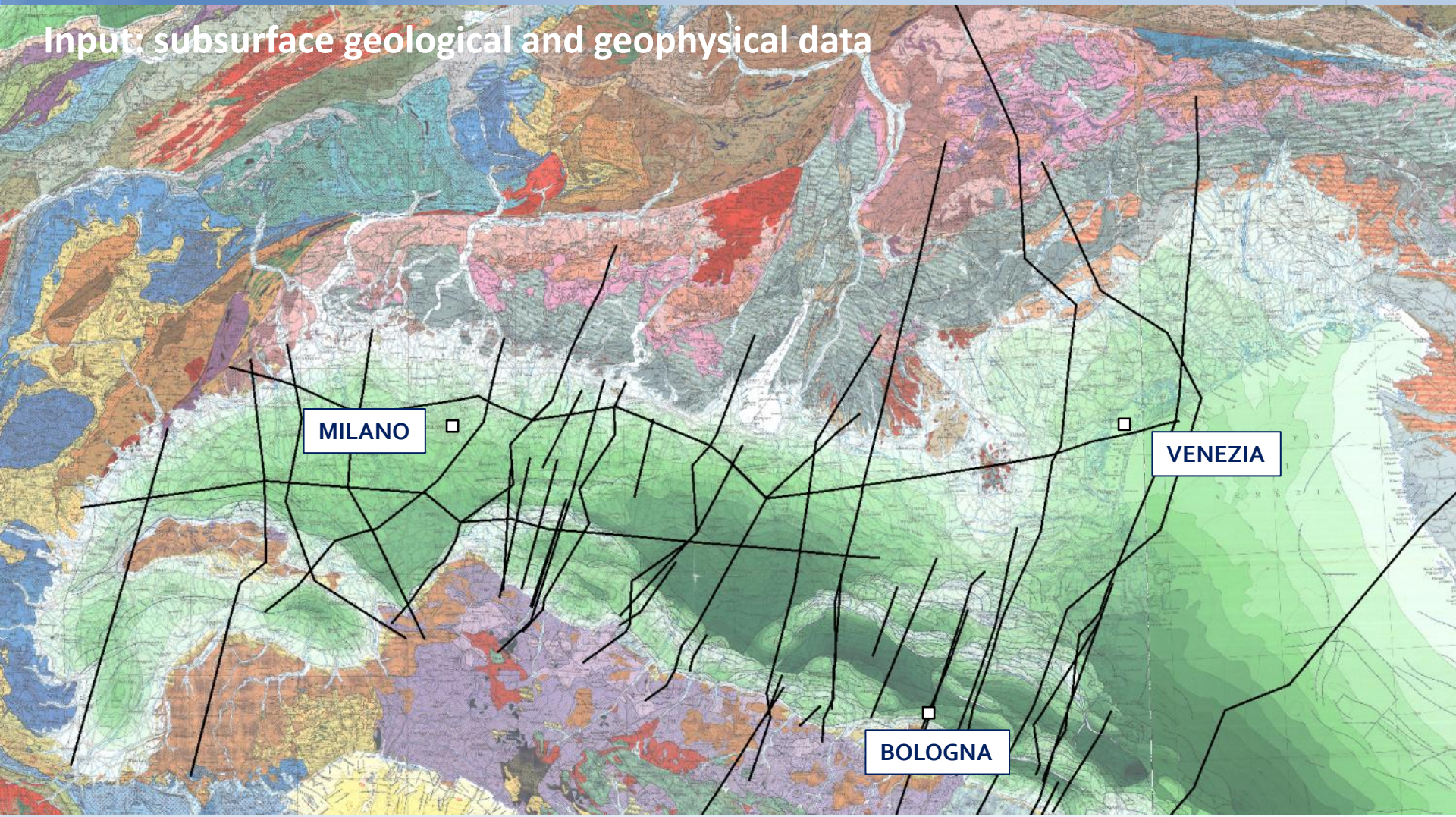
Active faults mostly concentrated in the mountain areas

BUILDING A SEISMOGENIC SOURCE MODEL



Bigi et al., 1992 – Modello Strutturale d'Italia

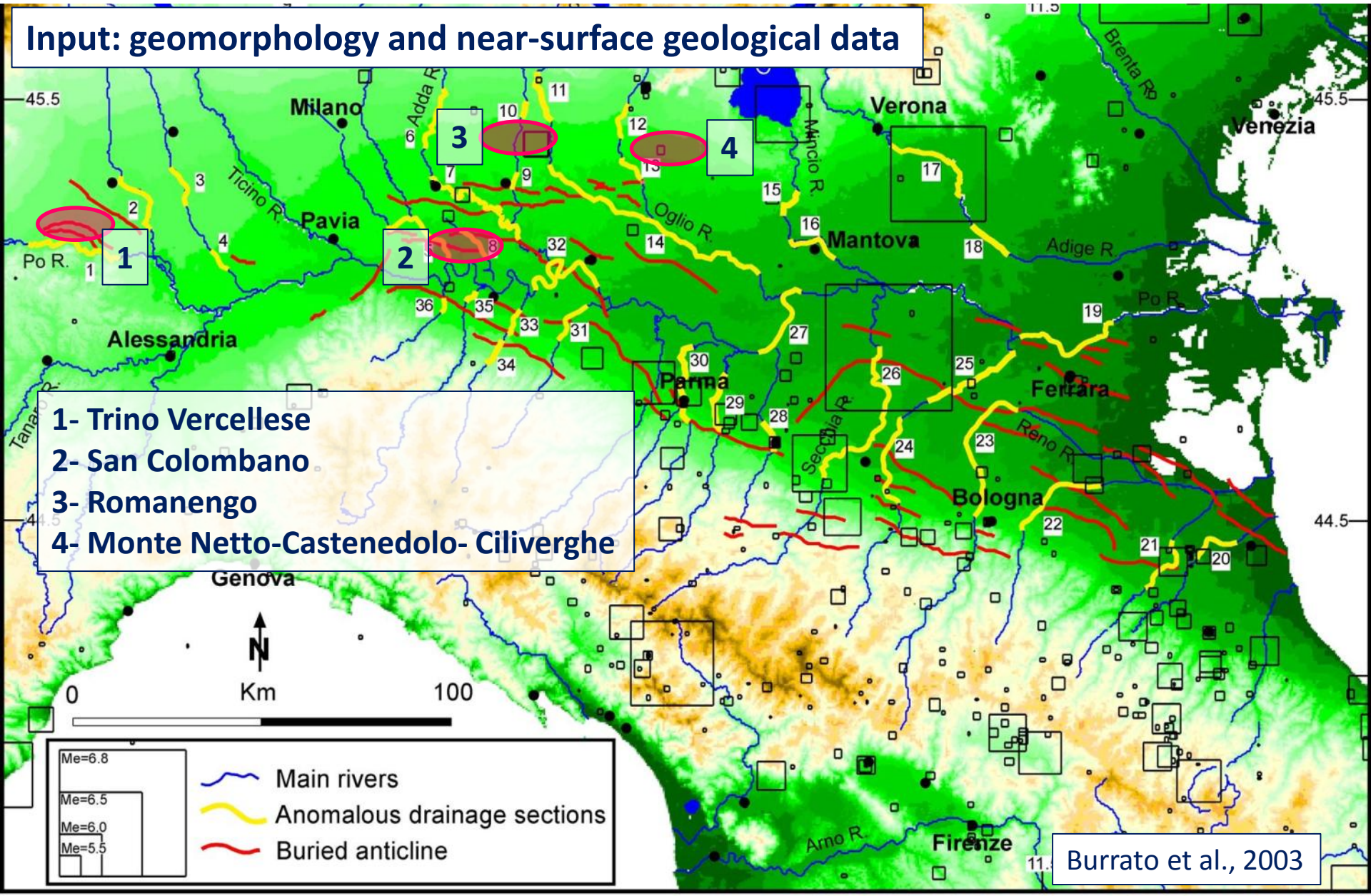
BUILDING A SEISMOGENIC SOURCE MODEL



Bigi et al., 1992 – Modello Strutturale d'Italia
AA.VV.

BUILDING A SEISMOGENIC SOURCE MODEL

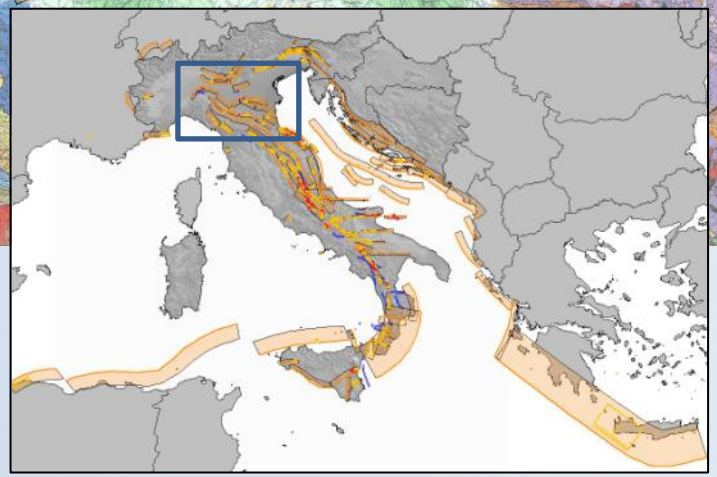
An inventory of river anomalies in the Po Plain, Northern Italy: evidence for active blind thrust faulting



Burrato et al., 2003

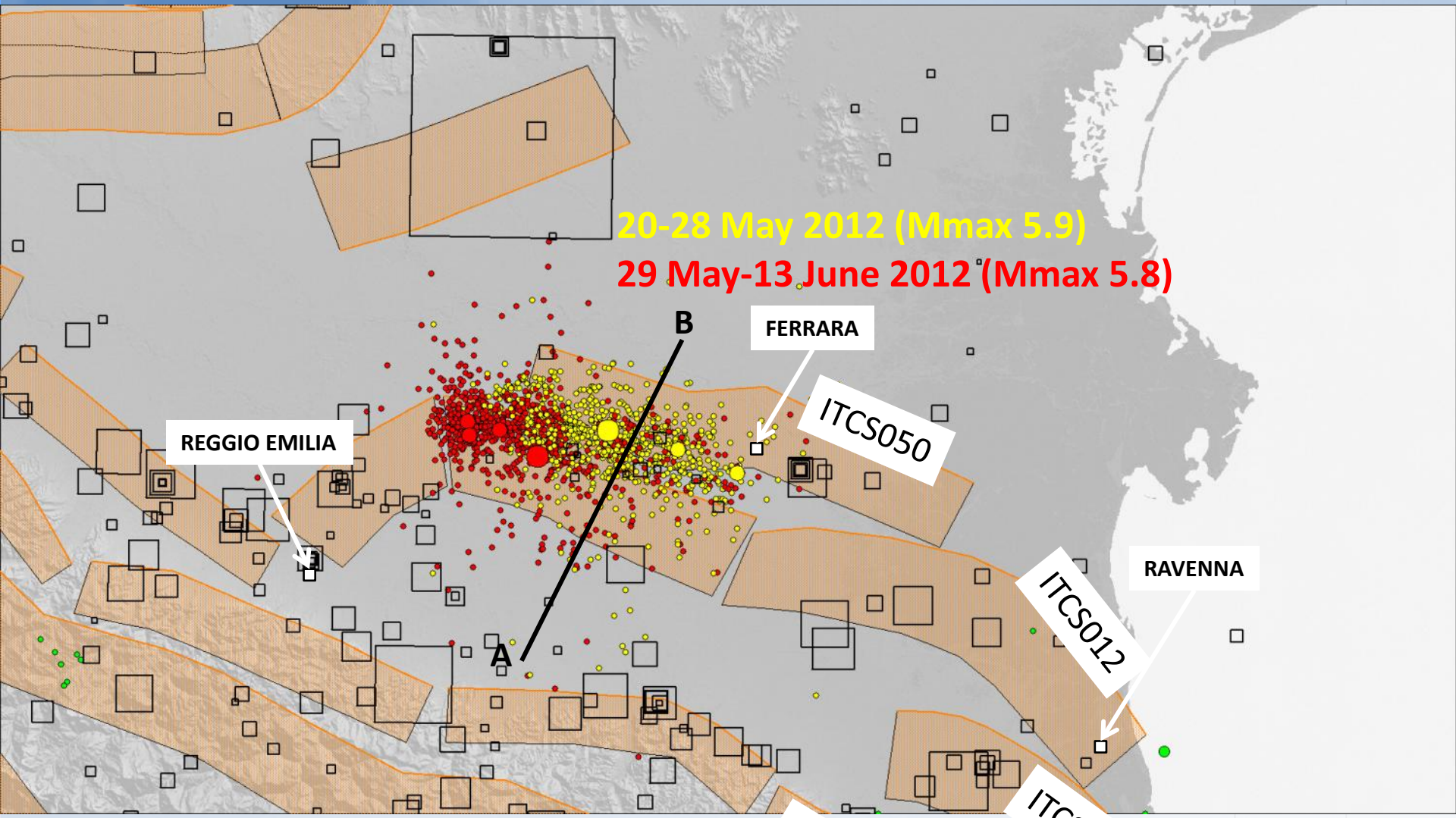
FROM GEOLOGICAL/GEOMORPHOLOGICAL DATA TO *SEISMOGENIC SOURCES*

DISS v. 3.1.1 - http://diss.rm.ingv.it/diss/



- ✓GIS based database
- ✓Web interface
- ✓Google Earth

THE EMILIA SEISMIC SEQUENCE



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DISS - http://diss.rm.ingv.it/diss/

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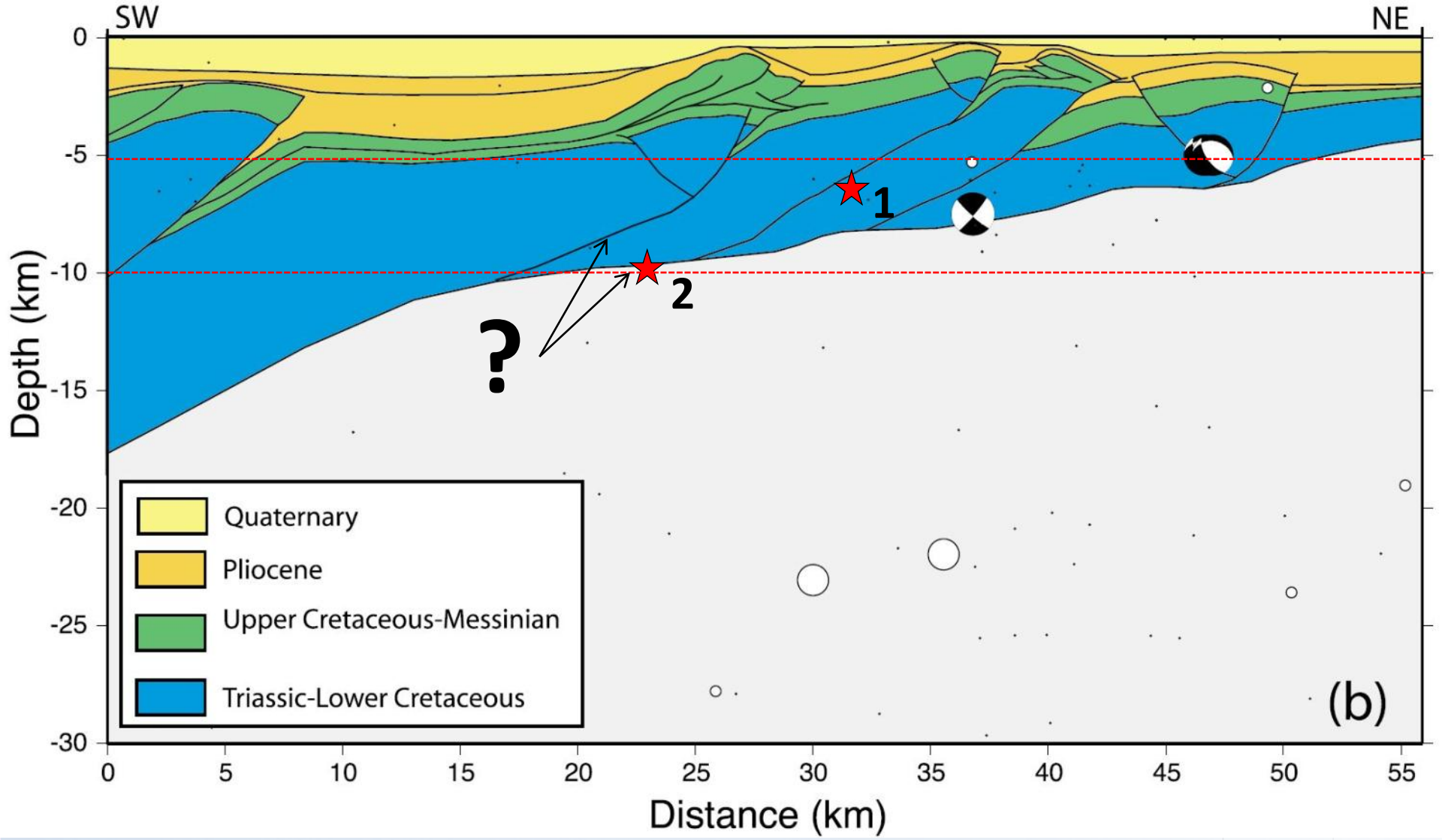
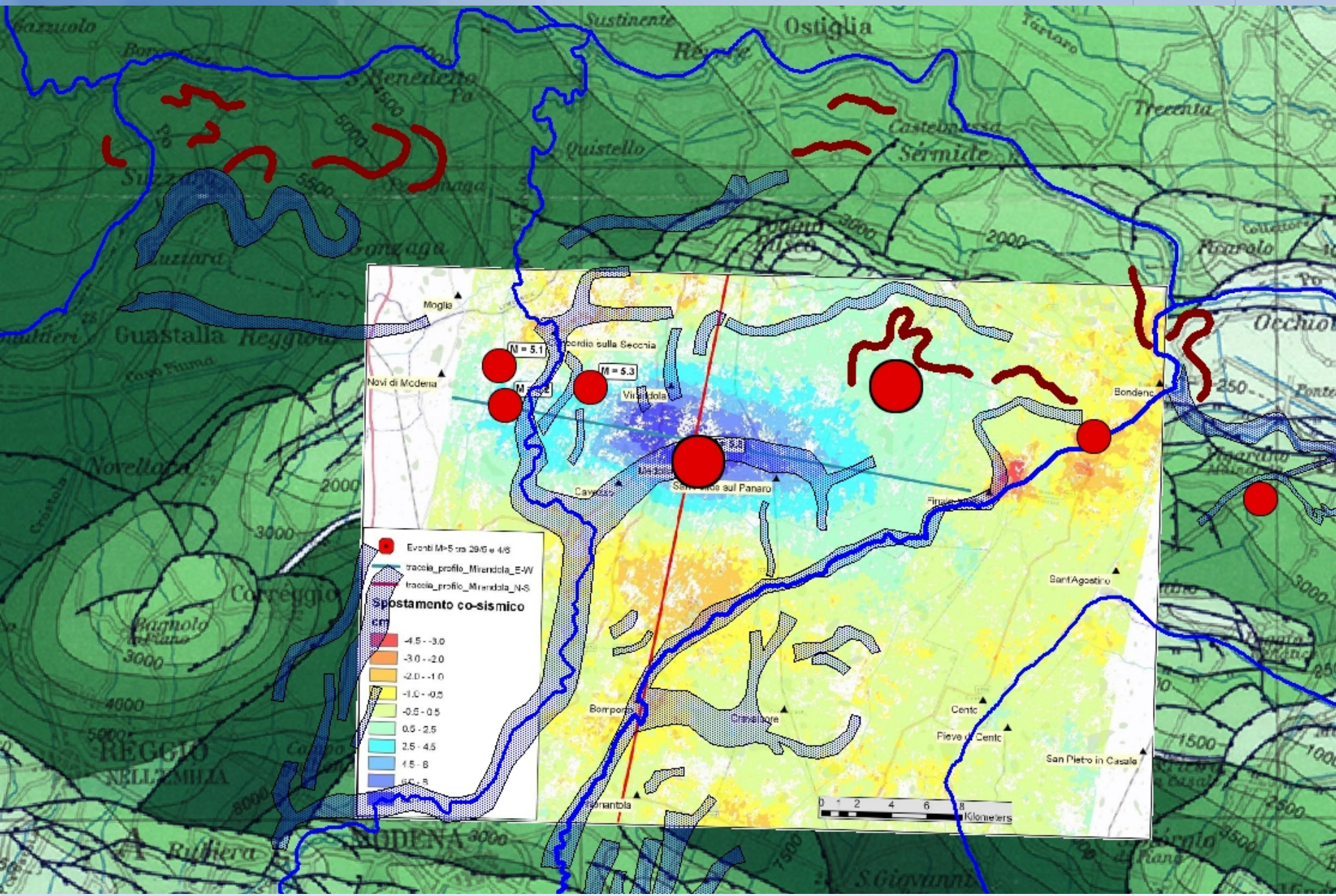


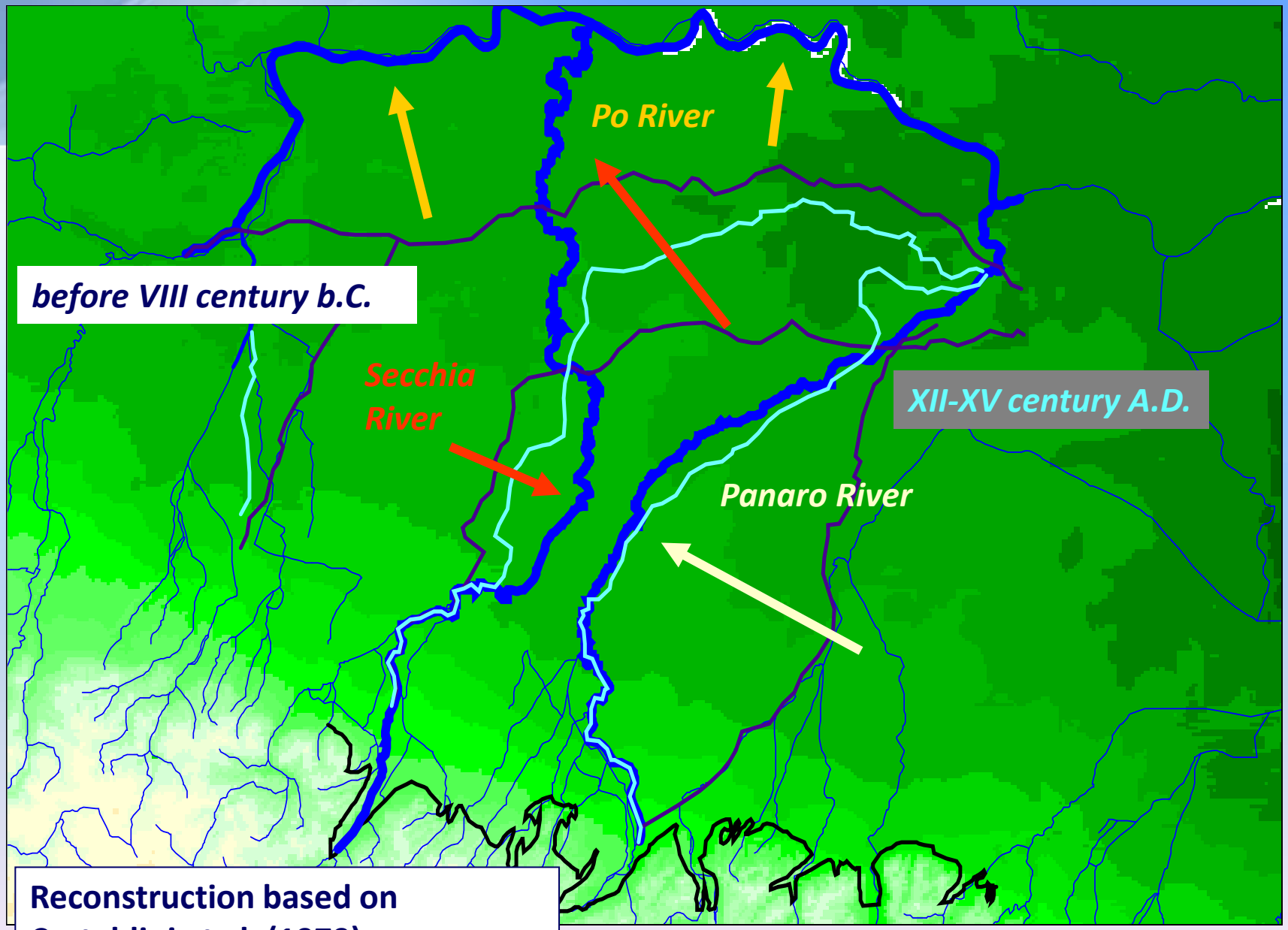
Carminati et al., 2010

COSEISMIC SURFACE DISPLACEMENT



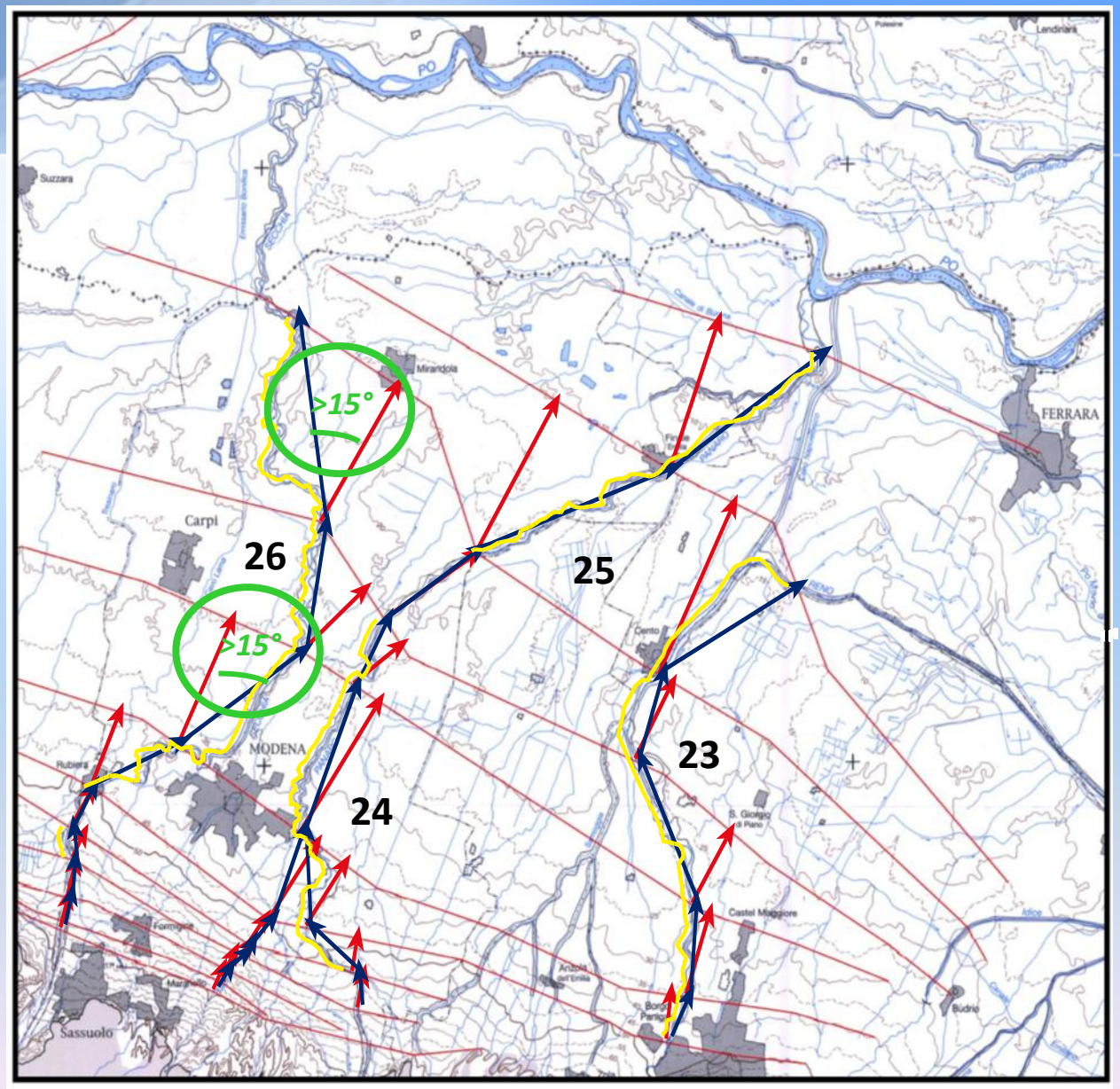
SAR image from: **http://comunicazione.ingv.it/primo-piano/report_sar_ingv_emilia_2.pdf**

DRAINAGE EVOLUTION IN THE EMILIA PLAIN



Burrato et al., 2003

DRAINAGE ANOMALIES IN THE EMILIA PLAIN



Contour-lines (5m)

Topographic gradient

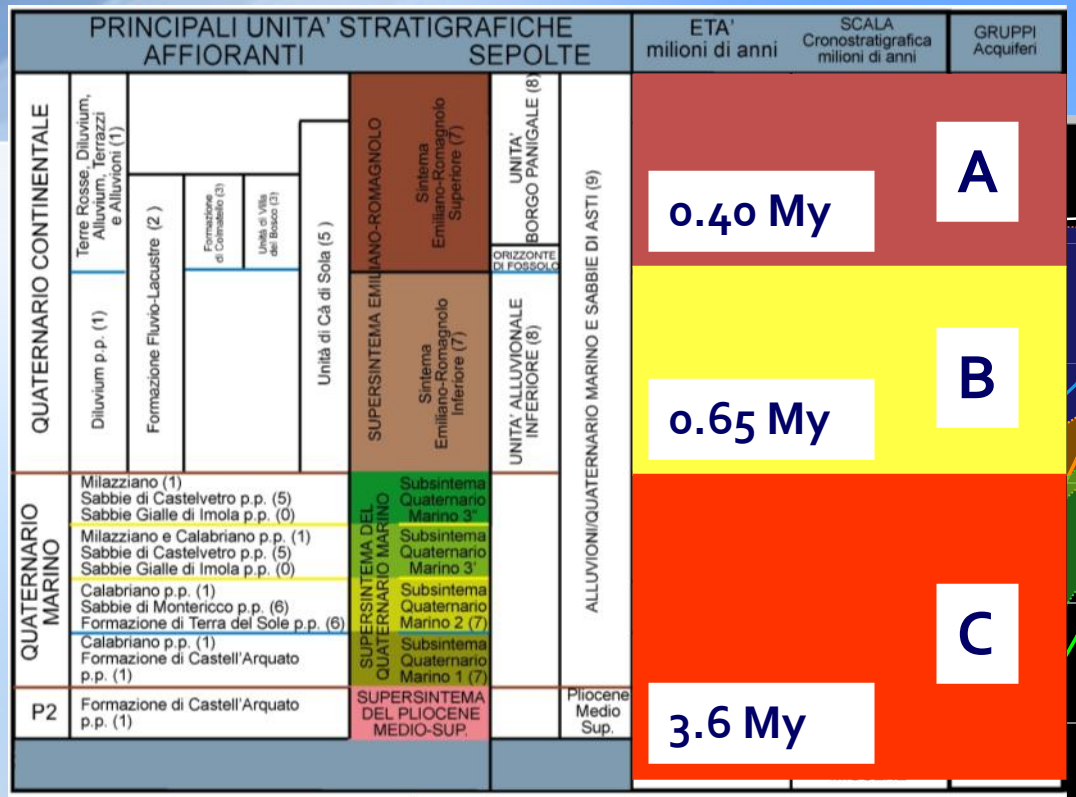
Avg drainage direction

Anomalous reach

base map from: Geomorphological Map of the Po Plain (1997)

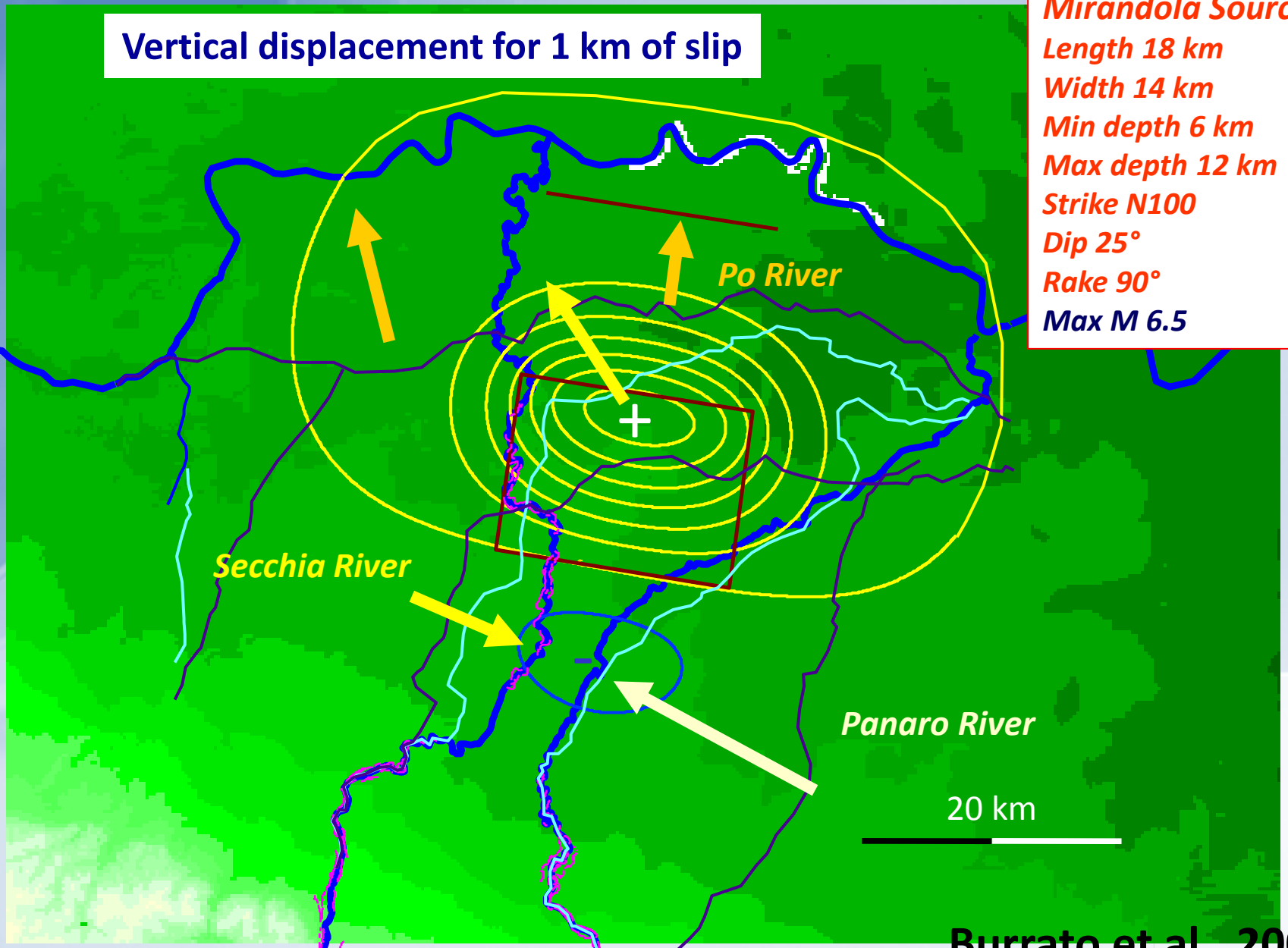
Burrato et al., 2003

GROWTH STRATA ACROSS THE MIRANDOLA ANTICLINE



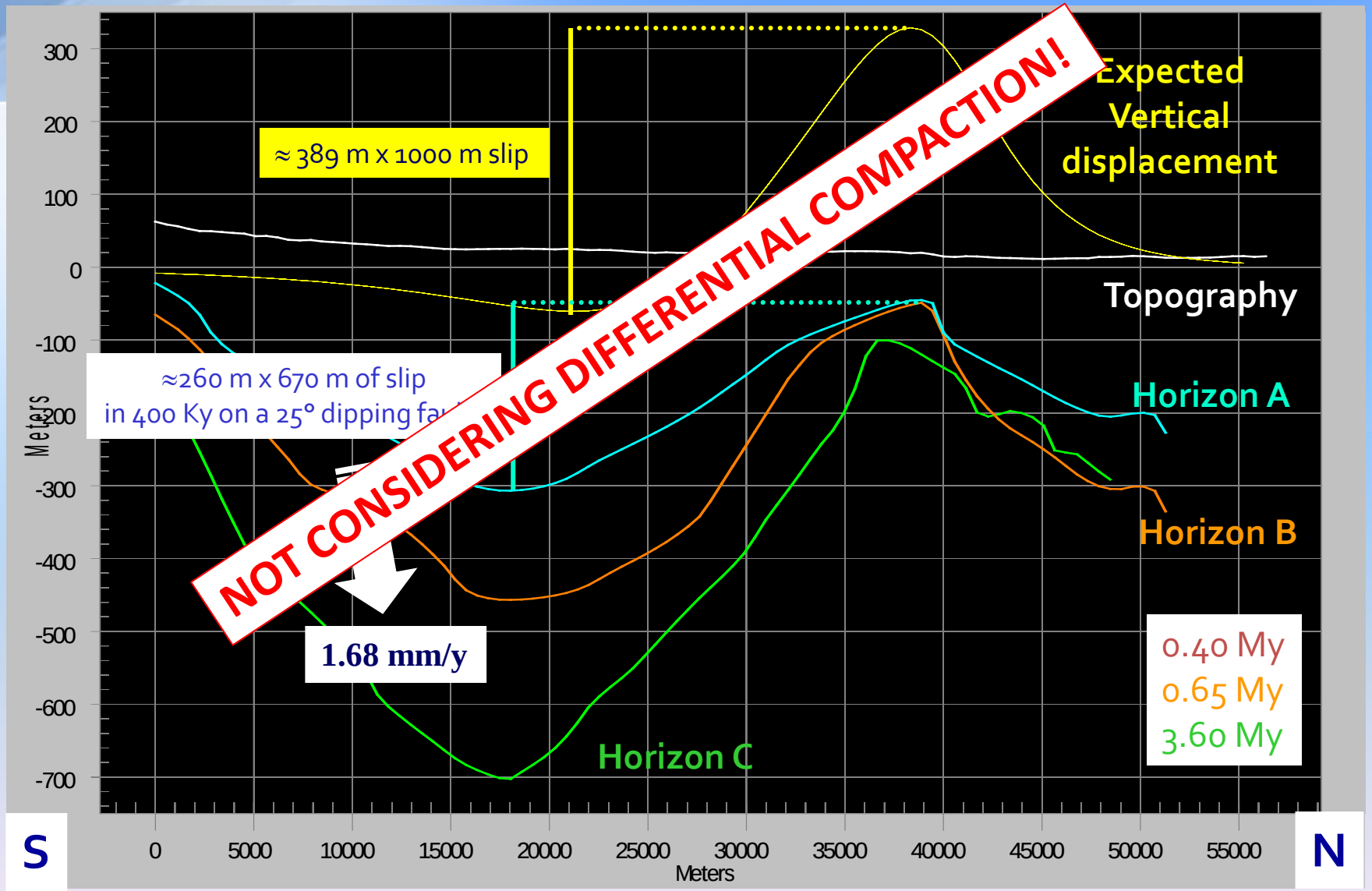
Burrato et al., 2003

DISLOCATION MODELING



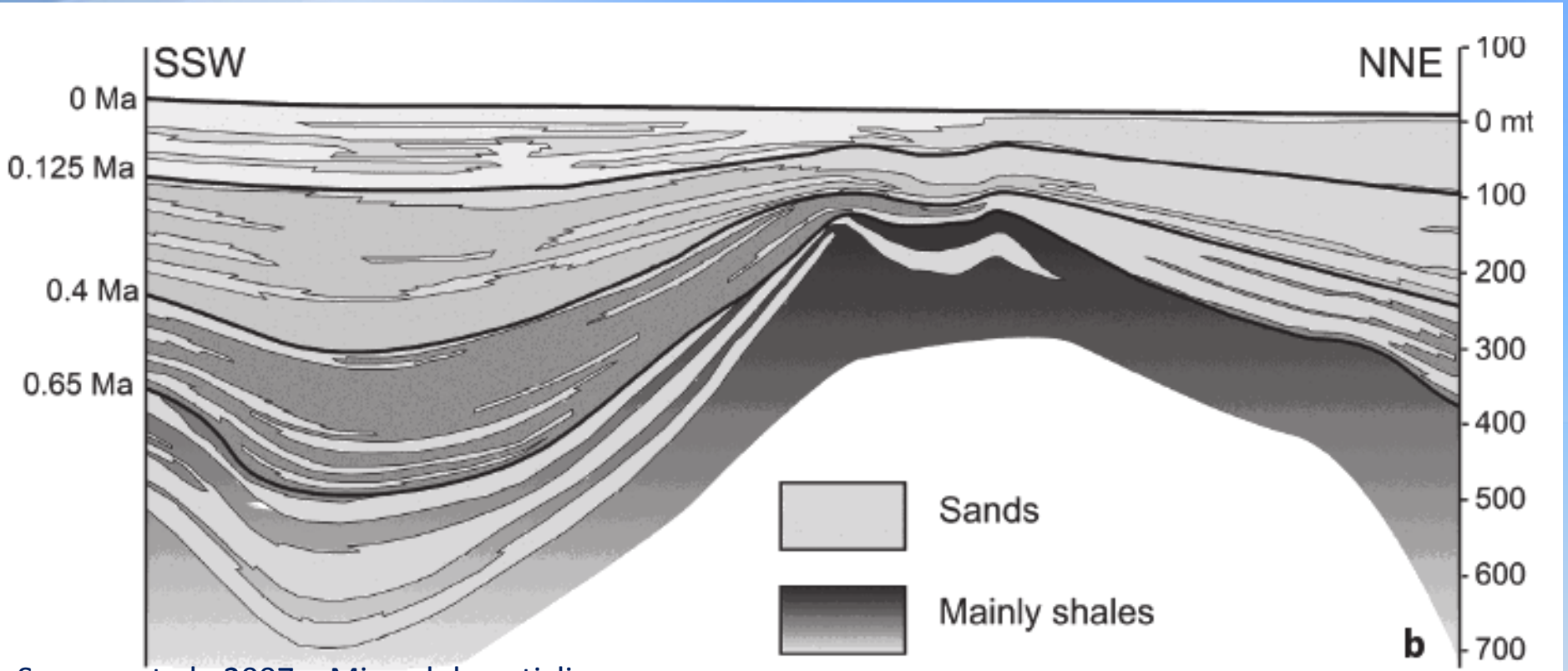
Burrato et al., 2003

CALCULATING SLIP RATE USING DISLOCATION MODELING



Burrato et al., 2003

REFINING SR CALCULATIONS USING HIGH RESOLUTION DATA



Scrocca et al., 2007 – Mirandola anticline

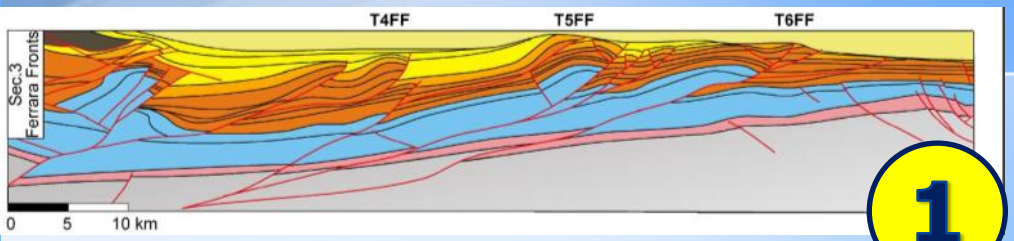
Uplift rate since Pleistocene

1.70 mm/a without considering differential compaction – Burrato et al., 2003

0.53 mm/a using a decompaction workflow – Scrocca et al., 2007

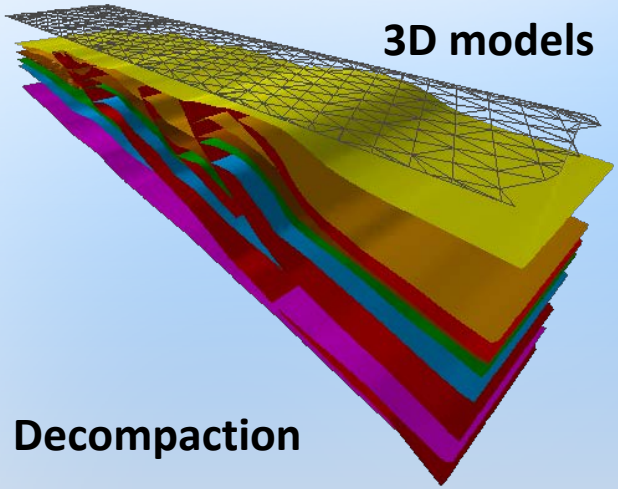
A NEW APPROACH: FROM RAW DATA TO SR

Dataset



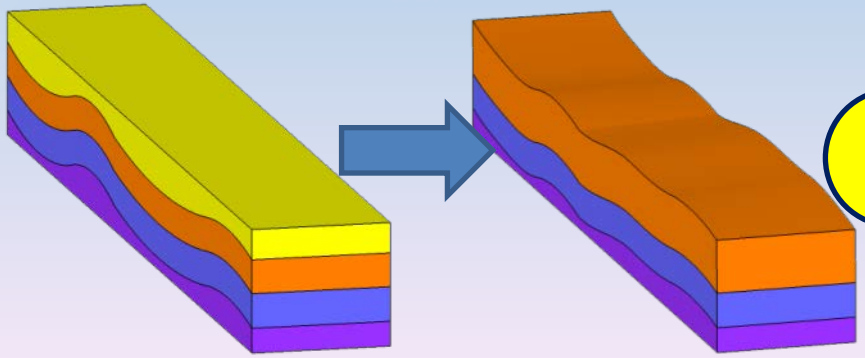
1

3D models



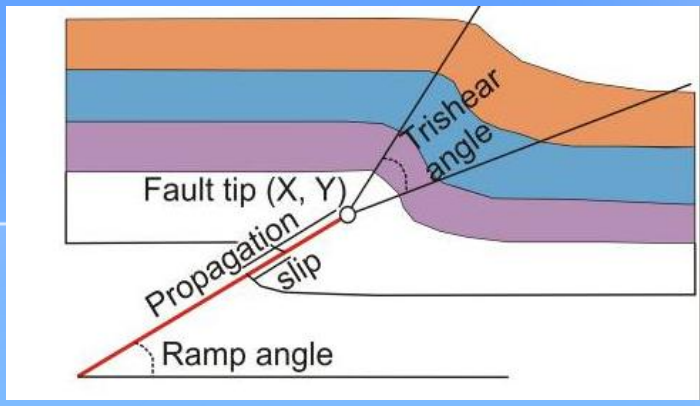
2

Decompaction

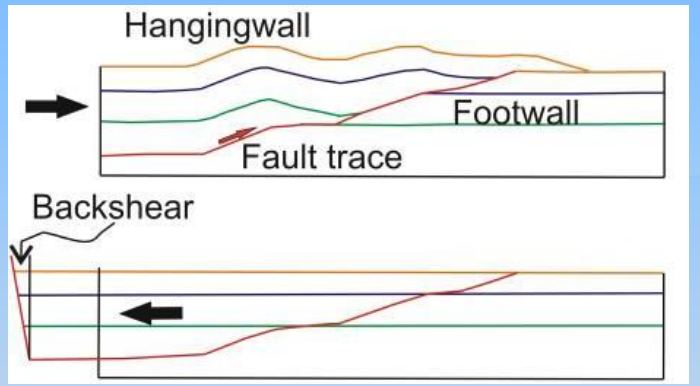


3

Fault propagation folds: trishear

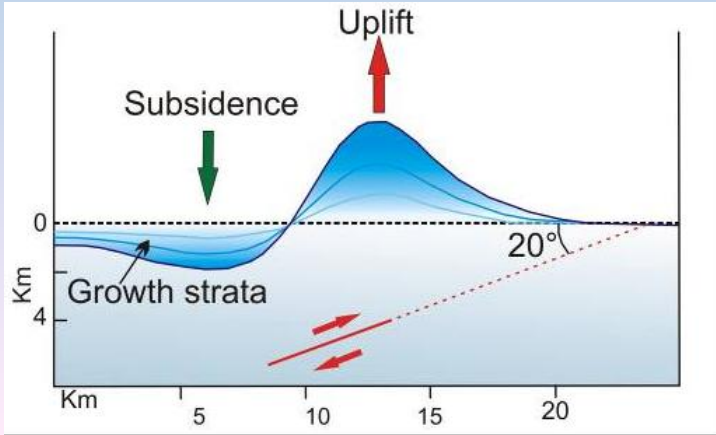


Dislocated horizons: fault parallel flow



4

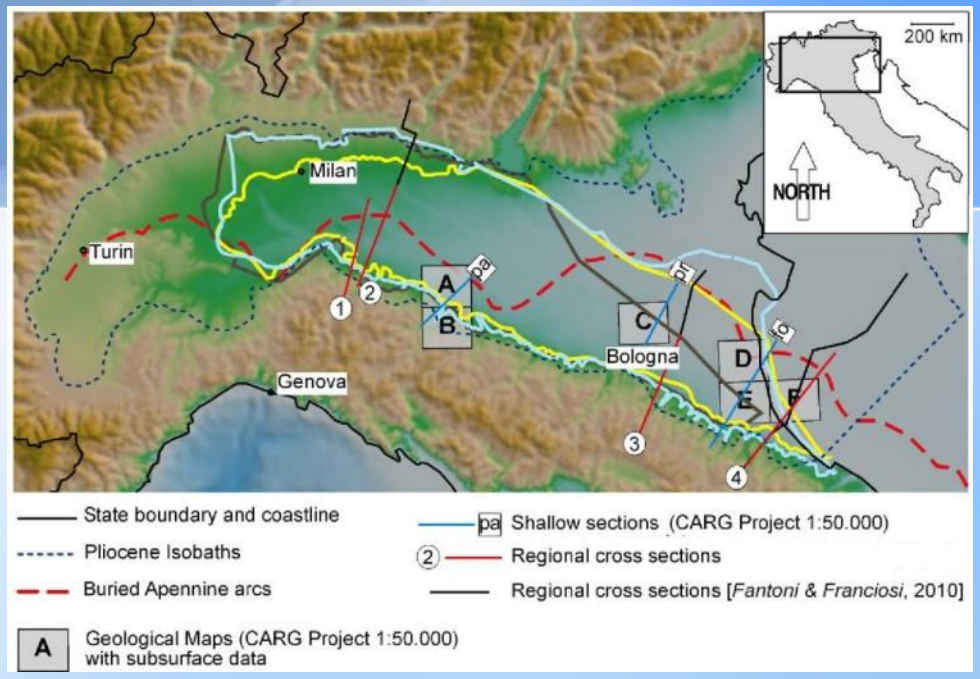
Shallow surfaces: Dislocation modeling

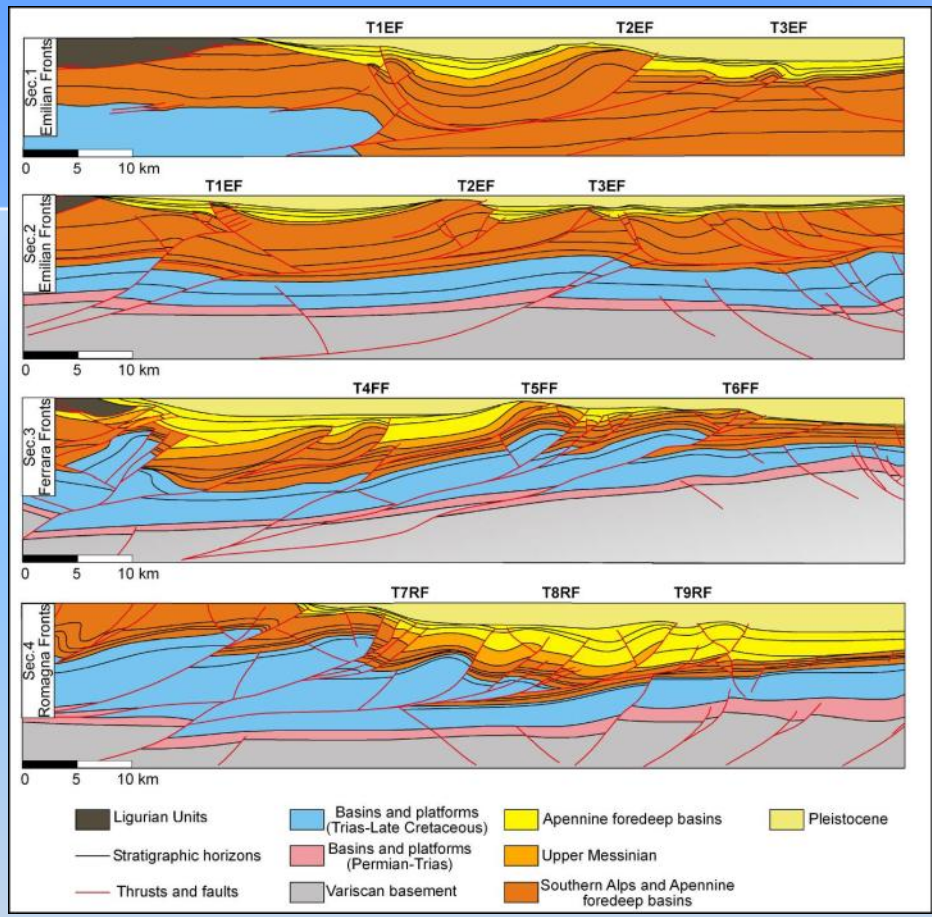


Maesano et al., 2010 - GeoItalia

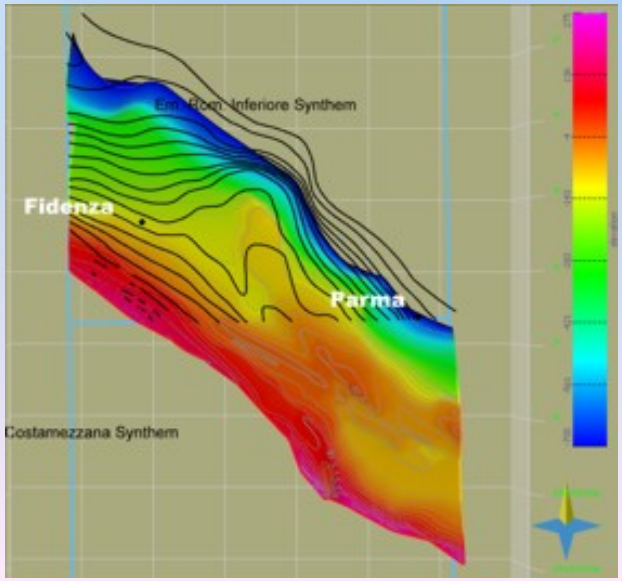
DATASET

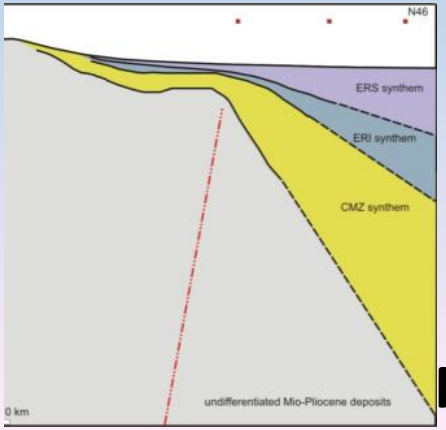
Regional cross sections





Shallow sections – CARG Project-RER



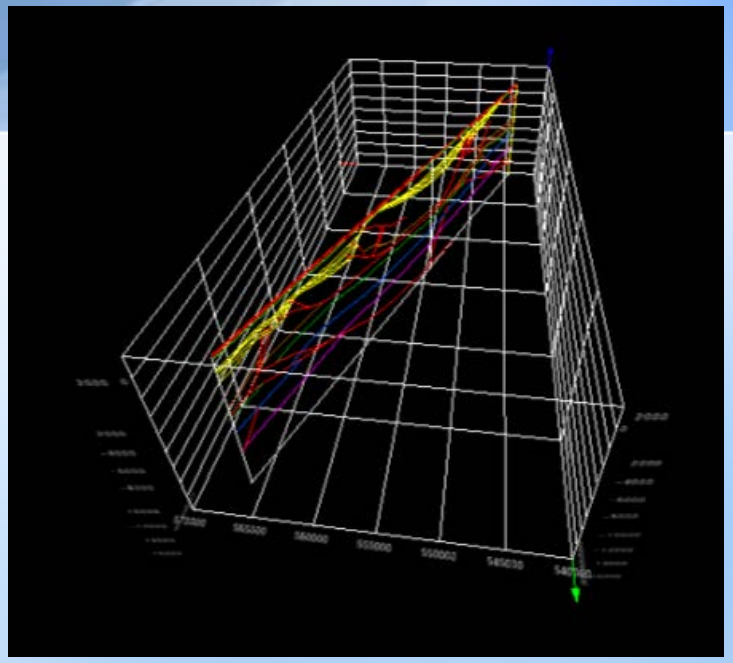


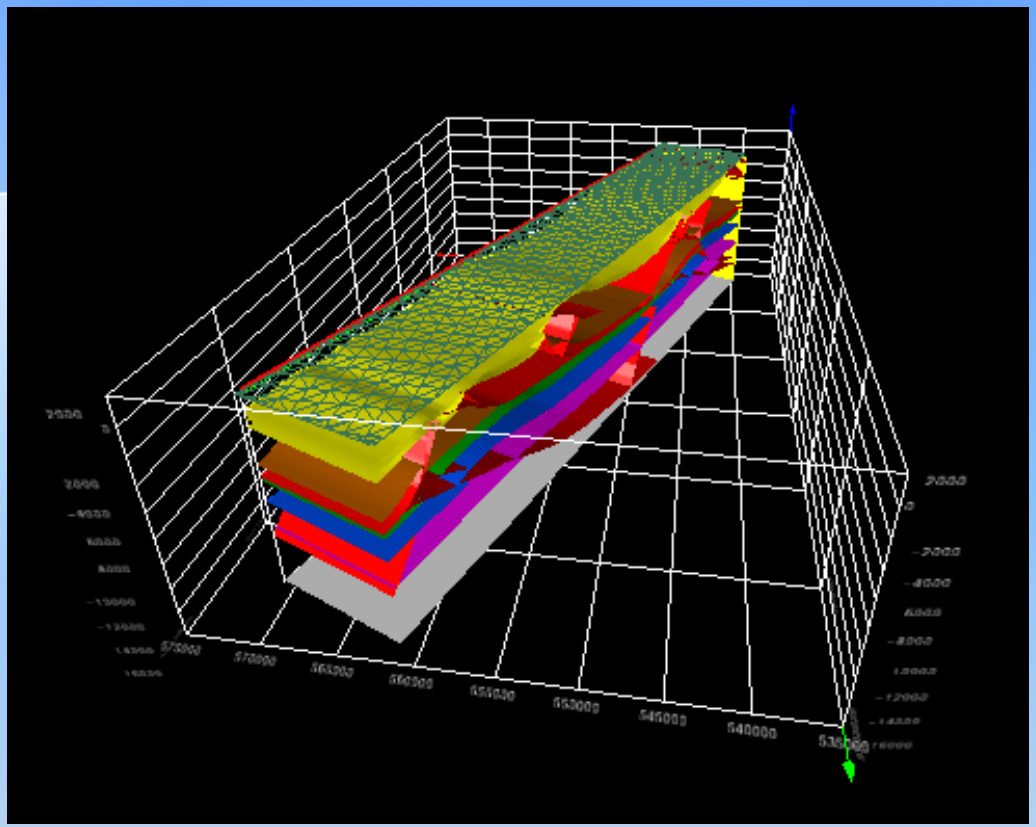
Sections modified from:
Fantoni et al., 2009
Toscani et al., 2006

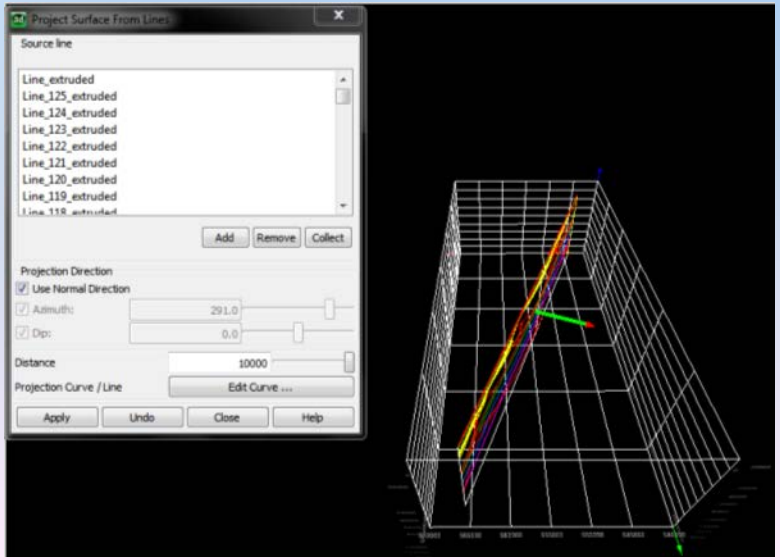
1

Maesano et al., 2010 - GeoItalia

CONSTRUCTION OF 3D MODELS FROM 2D SECTIONS







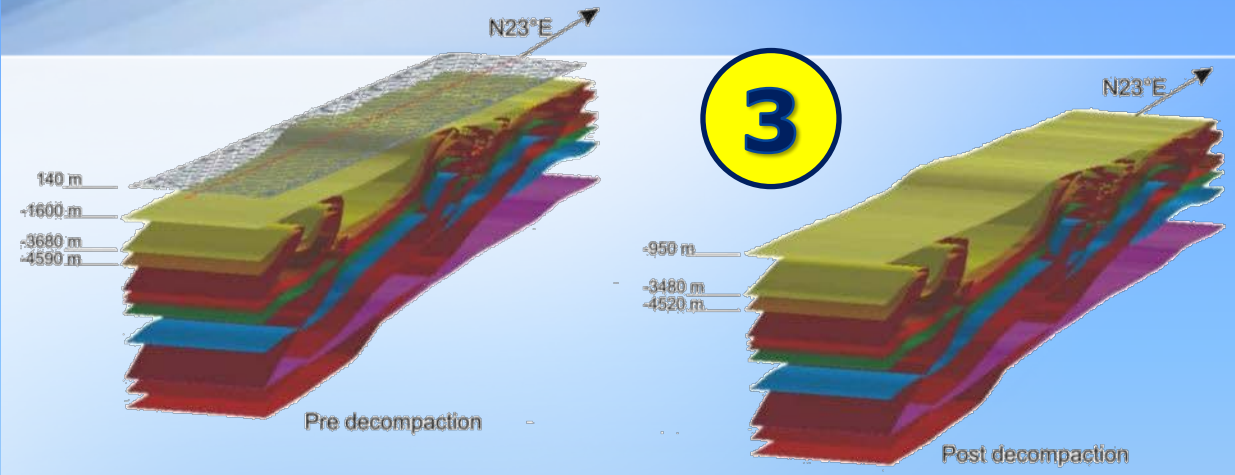
2

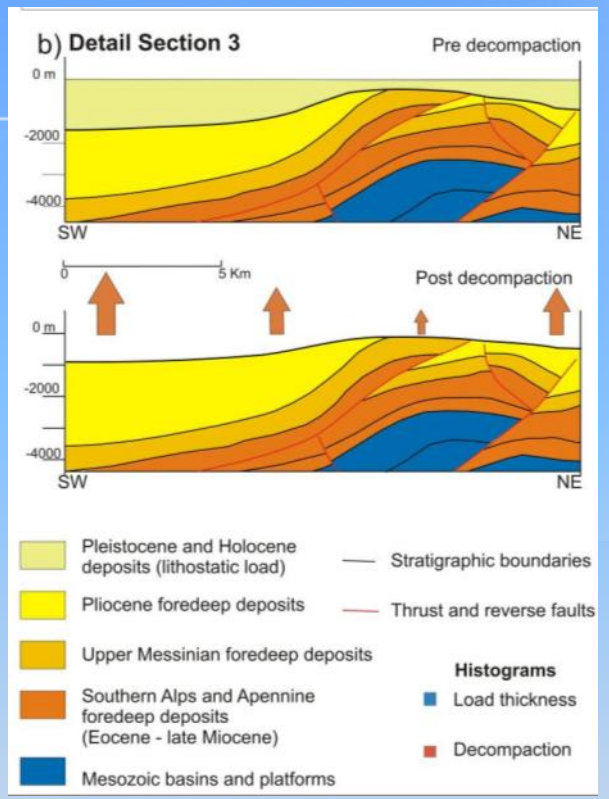
Maesano et al., 2010 - GeoItalia

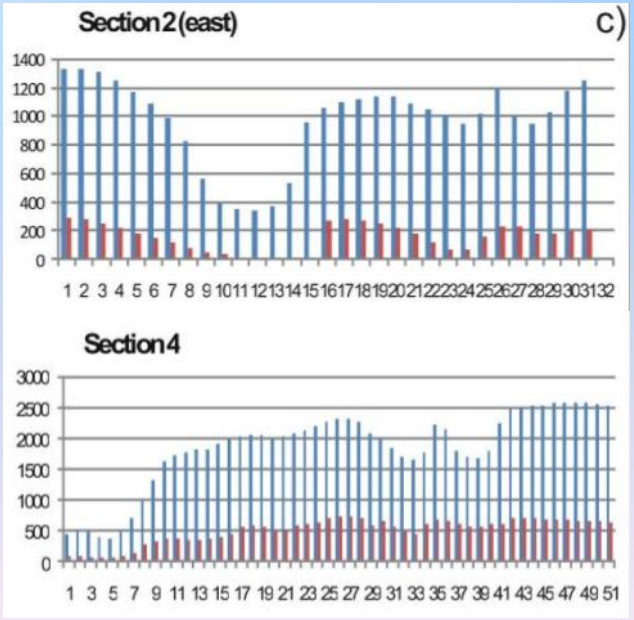
DECOMPACTION

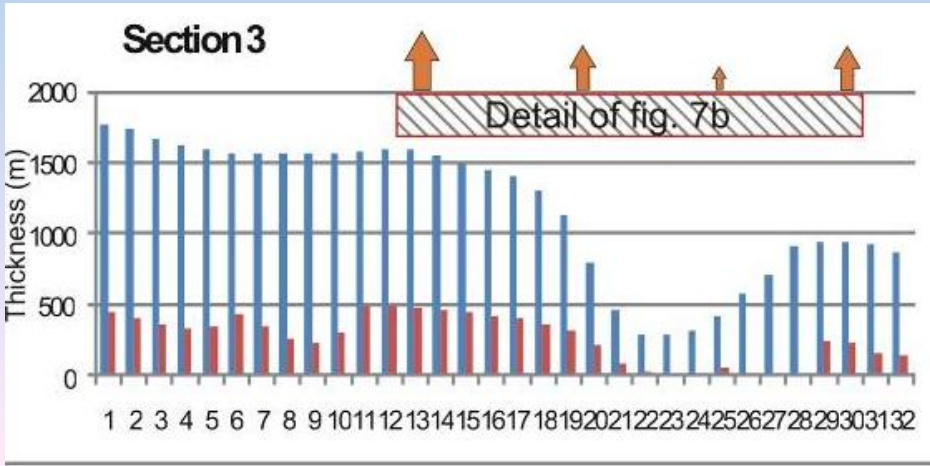
10% thickness changes at anticline axes

Up to **40%** thickness changes in synclines



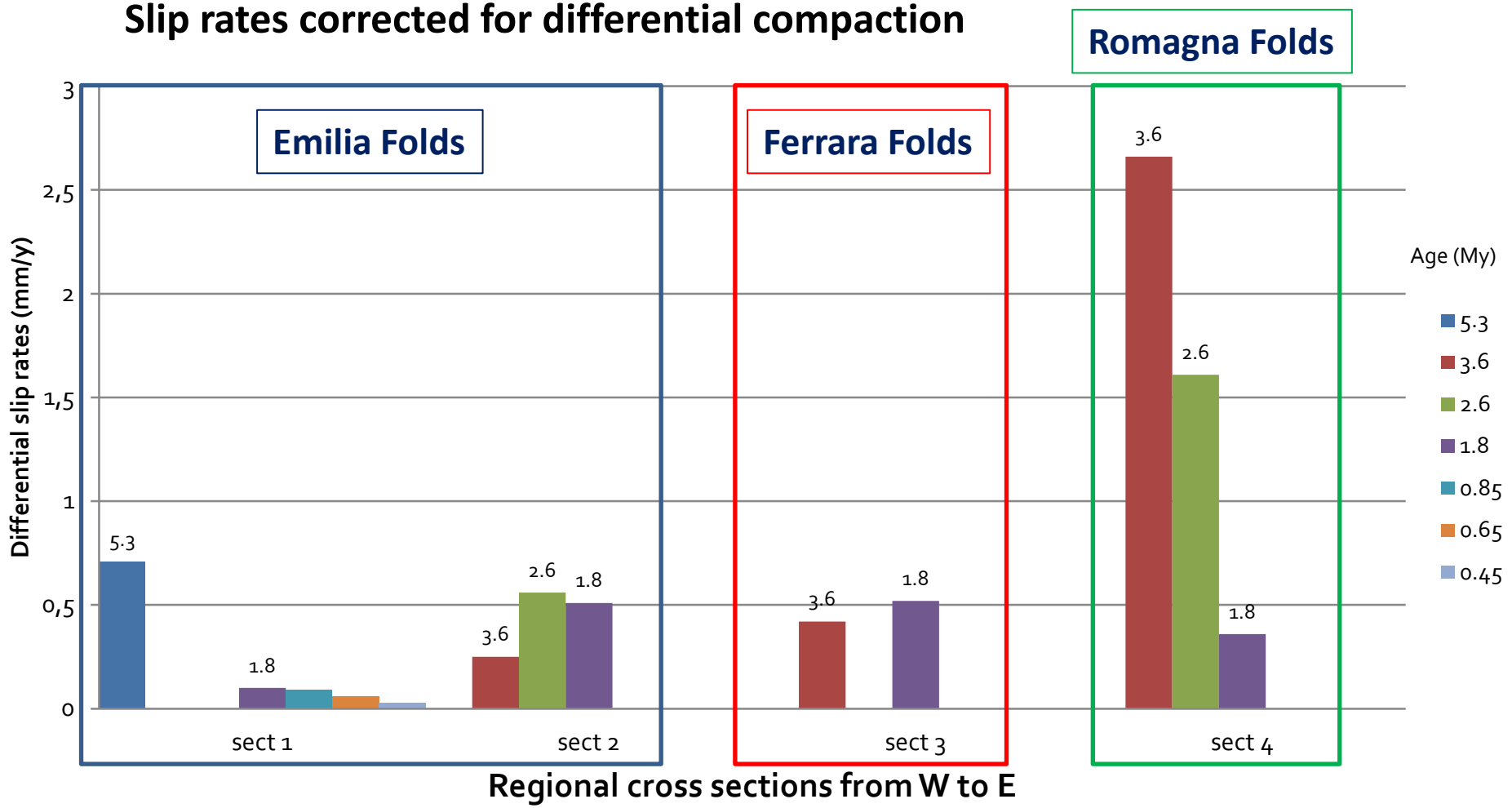






Maesano et al., 2010 - GeoItalia

RESULTS



Maesano et al., 2010 - GeoItalia