THE DIGITAL BACKBONE OF THE DATABASE OF INDIVIDUAL SEISMOGENIC SOURCES – DISS, VERSION 3

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Motivation

INGV-DPC Agreement 2012-2021

http://www.ingv.it/

[DISS is included in the short list of top priority Databases]

EU Project SHARE: *WP3*

http://www.share-eu.org/

[... expand DISS to the Euro-Mediterranean area and establish common standards for the definition and characterization of seismogenic sources...]

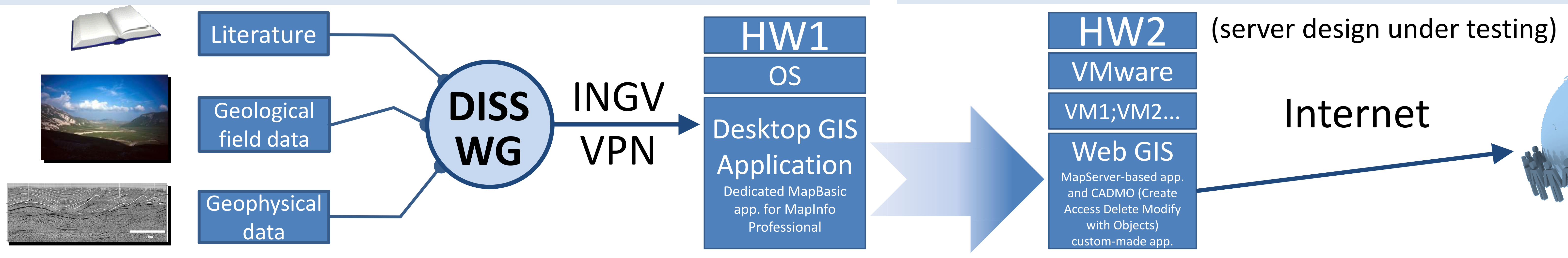
GEM: *The Faulted-Earth Project*

http://www.globalquakemodel.org/

[... build a global active fault and seismic source database with a common set of strategies, standards and formats, to be placed in the public domain...]

BACK-END: LIMITED ACCESS

FRONT-END: PUBLIC ACCESS



The database BACK-END (desktop GIS) contains all support data that are used for constraining the fault sources model:

- *data from scientific papers, reports, theses, original work, georeferenced raster maps and sections, vector data, etc.*

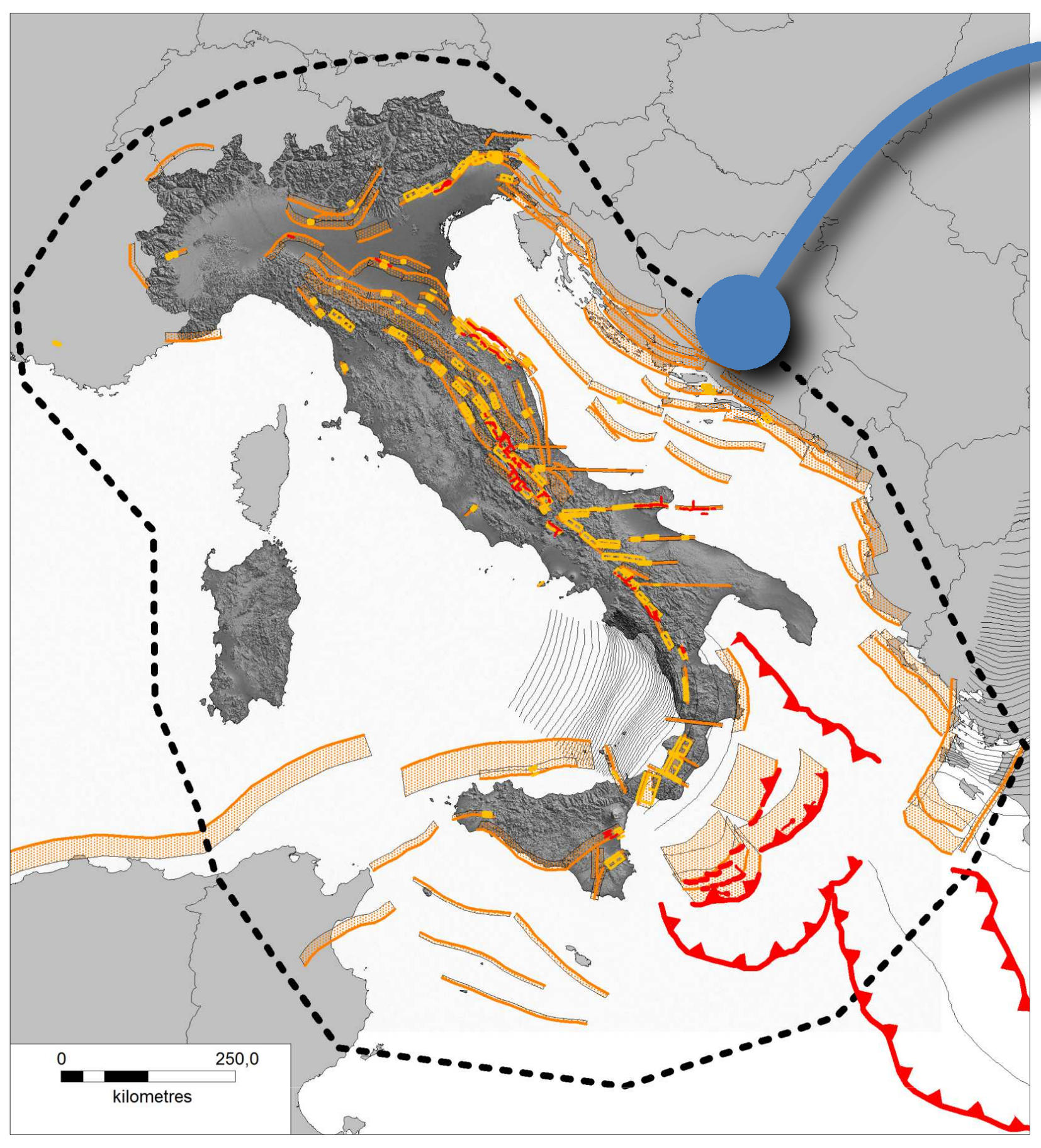
- *Compilations of active faults traces and tectonic structures*
- *Paleoseismological point data*
- *Borehole breakouts and focal mechanisms*
- *Oil-exploration wells*
- *Geological sections and seismic profiles*
- *Scientific papers*

The database FRONT-END (Web GIS, Google Earth) contains three main layers:

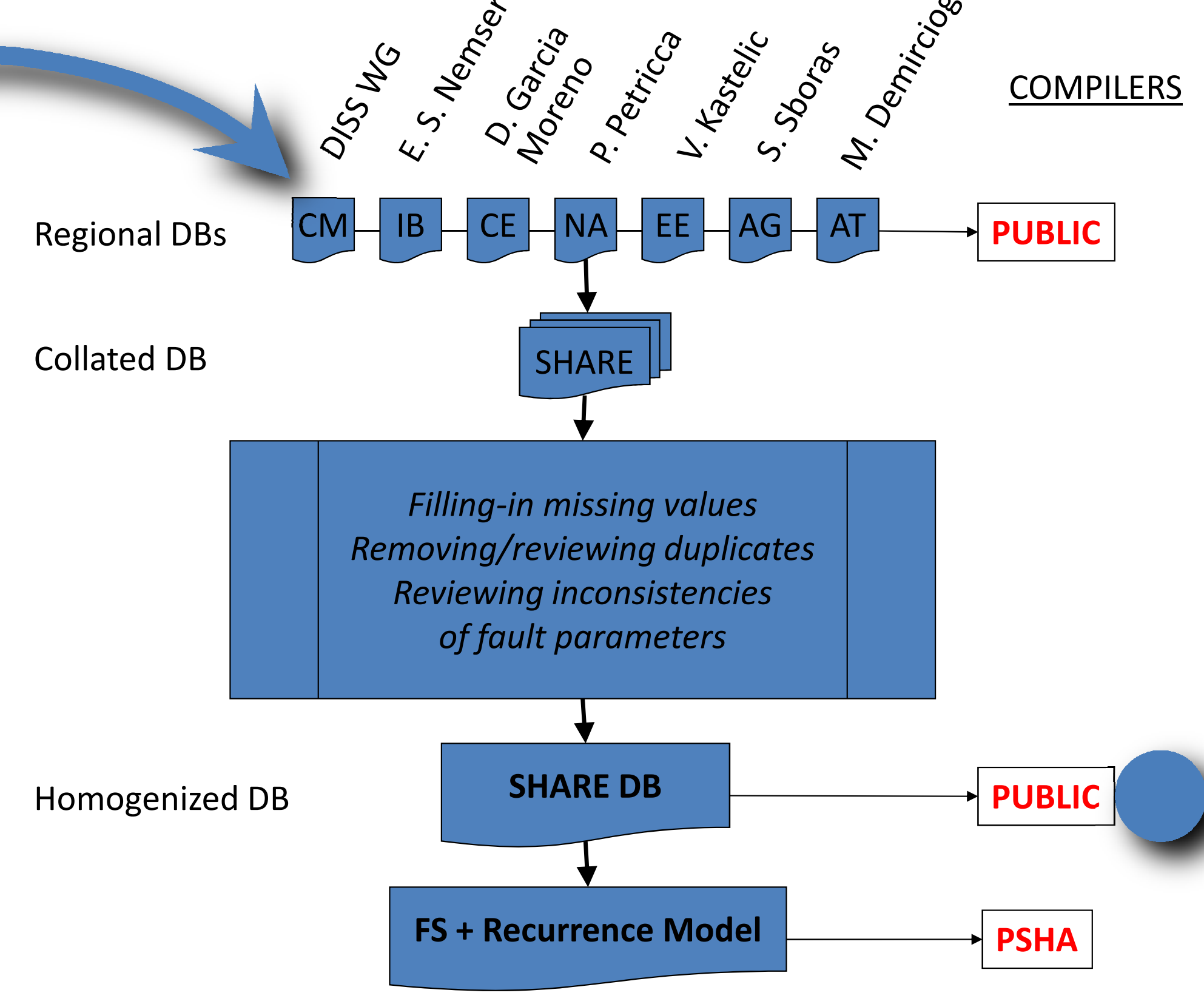
- *Active fault and fold axis traces*
- *Crustal fault sources*
  - *Individual Seismogenic Sources*
  - *Composite Seismogenic Sources*
  - *Debated Seismogenic Sources*
- *Subductions*

DATABASE CONTENT

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

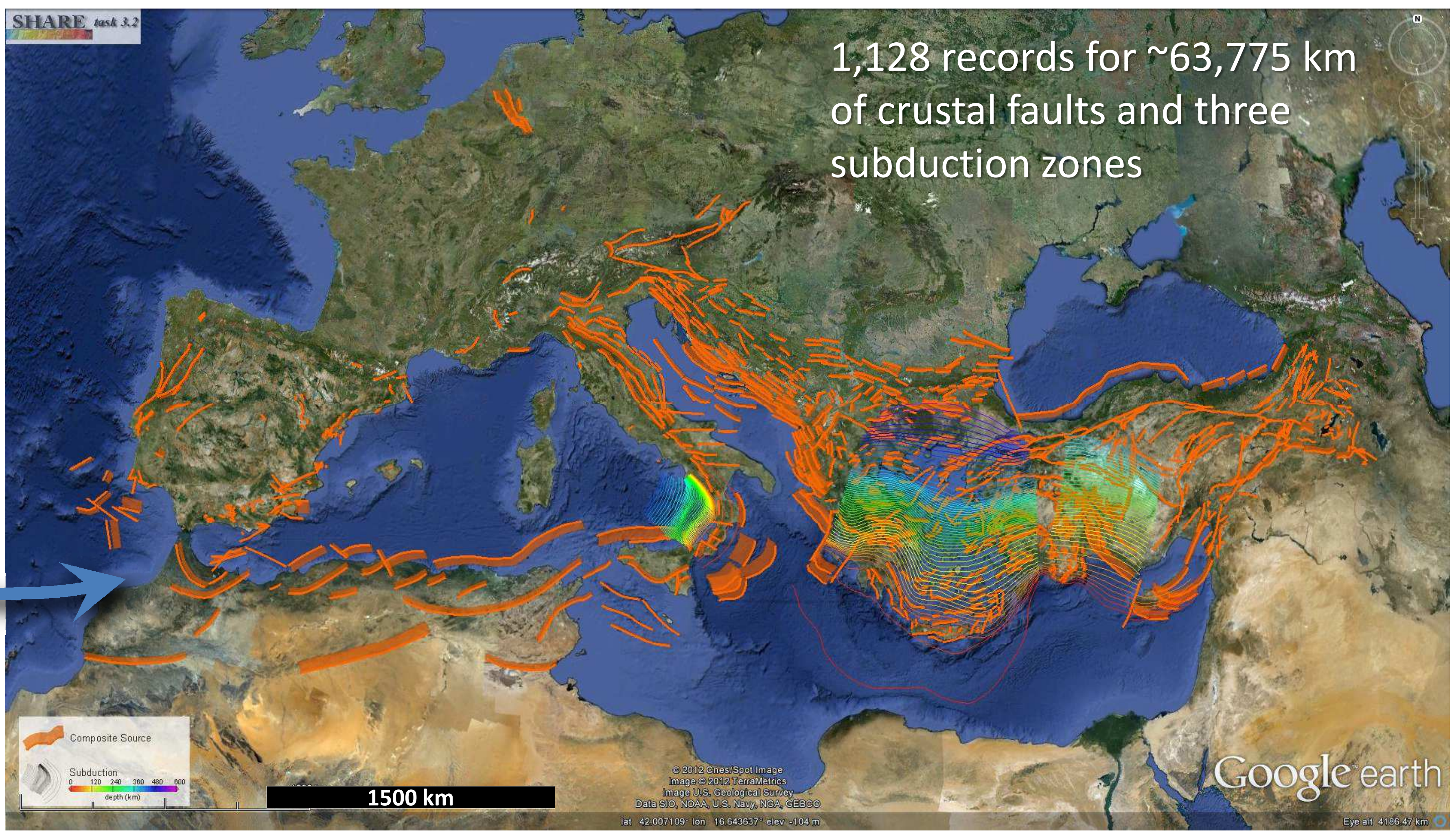


EU Project SHARE DB - http://diss.rm.ingv.it/SHARE/



Filling-in missing values
Removing/reviewing duplicates
Reviewing inconsistencies
of fault parameters

CONTRIBUTORS - 83 scientists from 36 different institutions plus a number of regional initiatives from: DISS WG (Italy), EMME (Turkey), GreDASS (Greece), IBERFAULT (Spain and Portugal).



1,128 records for ~63,775 km of crustal faults and three subduction zones

SEISMOGENIC SOURCES: EXAMPLE

The database structure is designed to include not only the parameters of each seismogenic source but also the data, often from published literature, behind them. These support data are illustrated in a "commentary", a set of "figures", and a list of pertinent "references".

Example of a complete entry of the fault sources database: the ITIS107 - Mirandola Individual seismogenic source.

General Information

DISS–ID	ITIS107	**Name**	Mirandola
Compiled By	Burrato, P., E. Carminati, C. Doglioni and D. Scrocca	**Latest Update**	19-Sep-2007
Display map ...			

Parametric Information

Location [Lat/Lon]	44.84 / 11.14	OD	Based on geological and geomorphological observations.
Length [km]	8.7	OD	Based on geological and geomorphological observations.
Width [km]	5.8	OD	Based on geological and geomorphological observations.
Min depth [km]	3.9	LD	Based on geological and seismological data.
Max depth [km]	7.6	LD	Based on geological and seismological data.
Strike [deg]	113	OD	Based on geological and geomorphological observations.
Dip [deg]	40	LD	Based on surface displacement modeling constrained by subsurface data.
Rake [deg]	90	EJ	Inferred from geological data, constrained by orientation of T axes.
Slip [m]	0.45	ER	Calculated from Mo using the relationship from Hanks and Kanamori (1979).
Slip rate [mm/y] min...max	0.25...0.5	OD	Based on growth strata analysis.
Recurrence [y] min...max	900...1800	EJ	Inferred from slip rate and average displacement.
Magnitude [Mw]	5.9	ER	Inferred from slip rate and average displacement.

LD=Literature Data; OD=Original Data; ER=Empirical Relationship; AR=Analytical Relationship;EJ=Expert Judgement;

Information About The Associated Earthquakes

Latest Earthquake	Unknown	See "Commentary" for information.
Penultimate Earthquake	Unknown	See "Commentary" for information.
Elapsed Time [y]	-9999	See "Commentary" for information.

Active Faults

ID	Name	References
78	Mirandola	Castaldini et al. [1979]
79	Canalazzo di Finale Emilia	Castaldini et al. [1979]
80	Concordia	Castaldini et al. [1979]

Commentary

COMMENTS

We propose the existence of the Mirandola Source based on the evidence of the recent tectonic activity of the buried Ferrara Arc, highlighted by the control exerted on the evolution of the drainage network and by the geometry of syntectonic growth strata.

In the area located between the Pede-Apenninic Thrust front and the buried external fronts of the Northern Apennines an active compressional tectonic regime is documented by borehole breakout data with N-S oriented maximum horizontal stress, focal mechanism and GPS data.

The Pede-Apenninic Thrust Front is traditionally considered an active out-of-sequence thrust of the Northern Apennines belt, with a continuous trace along the Apennines foot-hills defined by geologic and geomorphic evidence of activity (e.g., Boccaletti et al., 2004). However, recent papers proposed that the geomorphic feature of the pede-Apennines foot-hills is not the expression of a continuos shallow thrust fault (Picotti and Pazzaglia, 2008). According to this view, most of the regional deformation would be taken by a deep, blind thrust ramp responsible of the large scale geomorphology of the Northern Apennines foot-hills.

The ongoing activity of the more external Northern Apennines thrust fronts buried in the plain is still a matter of debate, probable due to the unfavorable balance between tectonic activity (expressed as vertical deformation due to growing anticlines) and the rates of sedimentation. As a consequence, only high resolution geophysical and geological subsurface data are able to show the most recent growth of the buried structures.

Besides, in the Po Plain differential compaction of unconsolidated sediments mimicks the vertical tectonic movements induced by thrust activity (i.e. the relative sinclinal subsidence and anticlinal uplift).

The geometry of the Mirandola Source and its kinematics were characterized by a combined study that used the modeling of drainage anomalies and the backstripping of high-resolution stratigraphic data (Ciucci et al., 2002; Burrato et al., 2003; Scrocca et al., 2007).

In particular, activity of the Mirandola Source was responsible for attraction in the sincline and diversion around the anticline of the Secchia and Panaro rivers, whose paleo-courses show consistent evolution with migration towards areas of relative subsidence. The use of high resolution stratigraphic data highlighted the geometry of growth strata in sintectonic strata, and allowed to calculate the relative uplift rates of the growing anticline during the late Quaternary, obtaining 0.16 mm/a of relative uplift rate for the last 125 ka.

We propose the following geometrical parameters for the source: the strike (N113°) is chosen according to the local strike of the buried Ferrara Arc; the fault dips 40° towards the South, according to subsurface seismic profiling; the rake is assumed to be 90° (pure thrusting), based on geodynamic considerations constrained by modeling of the drainage anomalies; the down-dip width is obtained by seismic profiles and is also constrained by modeling of the drainage anomalies; the minimum and maximum depth (3.9 and 7.6 km respectively) are constrained by subsurface geology; the length (8.7 km) is obtained by modeling of the drainage anomalies.

The Mirandola Source is not associated to any historical and/or instrumental earthquake, and as such it may represents a seismic gap. Given its dimension this source is able to generate earthquakes of Mw 5.9. The low slip rate suggests long recurrence interval for the potential earthquake.

OPEN QUESTIONS

1) Considering that the Mirandola Source is not associated with any earthquake, is it possible that the current Italian seismic catalogue missed an earthquake generated by this source?

2) What is the recurrence interval for the earthquakes generated by the Mirandola Source?

SUMMARIES

Castaldini et al. (1979)
In the framework of a reconstruction of neotectonic events, these workers examine the evolution of the drainage system of this reach of the Po Plain. The analysis considers the full length of the Holocene but special emphasis is given to the past three thousand years of progressive shift and sudden diversions of the main streams of the area. In particular, Castaldini et al. (1979) point out that the Secchia and Panaro rivers are first attracted towards each other and towards the axis of the so-called Bologna-Bomporto-Reggio Emilia syncline, then pushed sideways respectively towards the NW and E as they cross the alignment Carpi-Crevalcore. Castaldini et al. (1979) also describe important diversions that occurred after the VIII century B.C., particularly affecting the Po river turning North at Guastalla ("rotta di Guastalla"), the Secchia river turning East just North of Modena, and again the Secchia river turning northwest a few km South of Mirandola. Finally, Castaldini et al. (1979) describe surface faults in the area Mirandola-Concordia based on correlations of the stratigraphy of water wells, in the area of Canalazzo di Finale Emilia based on observations of open ground cracks aligned along a WNW trend, and near Correggio based on observations of fractures in walls and road pavements. This last fault is also seen in satellite imagery.

Veggiani (1985)
In the context of a reconstruction of paleo-channels of the Po river and of its main tributaries, this worker proposes a scheme for the evolution of the Secchia, Panaro, Crostolo and Reno rivers during the past 3,000 years. In particular, Veggiani (1985) proposes a dated sequence of progressive shifts of the Secchia and Panaro rivers up to their present position.

Cassano et al. (1986)
These investigators provide a comprehensive summary of subsurface and surface data along several transects crossing the Po Plain from the Southwest to the Northeast. Their interpretation of Section 9 shows a major anticline driven by a low-angle north-verging blind thrust culminating between Mirandola and Medolla.

Burrato et al. (2003)
These workers analyse in detail the fluvial system of the Po Plain and identify several areas where significant drainage anomalies (e.g., river diversions and shifts in channel patterns) with wave-length comparable to that of tectonic structures of crustal significance are suggestive of the presence of active blind thrust or reverse faults. As second step of their approach the authors compare the position of the drainage anomalies with the location of known buried anticlines, to corroborate the hypothesis of the tectonic nature of the anomalies. Following the observation that some of the anomalies are associated also with historical earthquakes, they propose that these blind thrusts may be potential sources of rather infrequent large earthquakes beneath the Po Plain. Burrato et al show that the Secchio and Panaro rivers exhibit significant anomalies in their trend as they cross an anticline reported in the official geological map. They interpret the fluvial anomaly as having tectonic origin.

Pictures

Title	View
Paleochannels of Panaro and Secchia rivers	🔍
Surface ruptures associated with anticline	🔍
Depth of fresh water-salt water interface	🔍
Cross-section across Mirandola anticline	🔍
Vertical movements in Mirandola region	🔍
Paleochannels of Po River and main tributaries	🔍
Geologic cross-section across Mirandola anticline	🔍

References

Argnani, A., G. Barbacini, M. Bernini, F. Camurri, M. Ghielmi, G. Papani, F. Rizzini, S. Rogledi and L. Torelli 2003 Gravity tectonics driven by Quaternary uplift in the Northern Apennines: insights from the La Spezia-Reggio Emilia geo-transect. Quatern. Int., 101-102, 13-26.

Barozzi, P., and L. Colombi 1992 Profilo CROP-01/01A, sezioni sismiche e geologiche e ipotesi di tracciato del profilo nella Pianura Padana. in: R. Capozzi and A. Castellarin (eds), Studi preliminari all'acquisizione dati del profilo CROP 1-1A La Spezia-Alpi Orientali. Studi Geologici Camerti, spec. vol. 92/2, 161-170.

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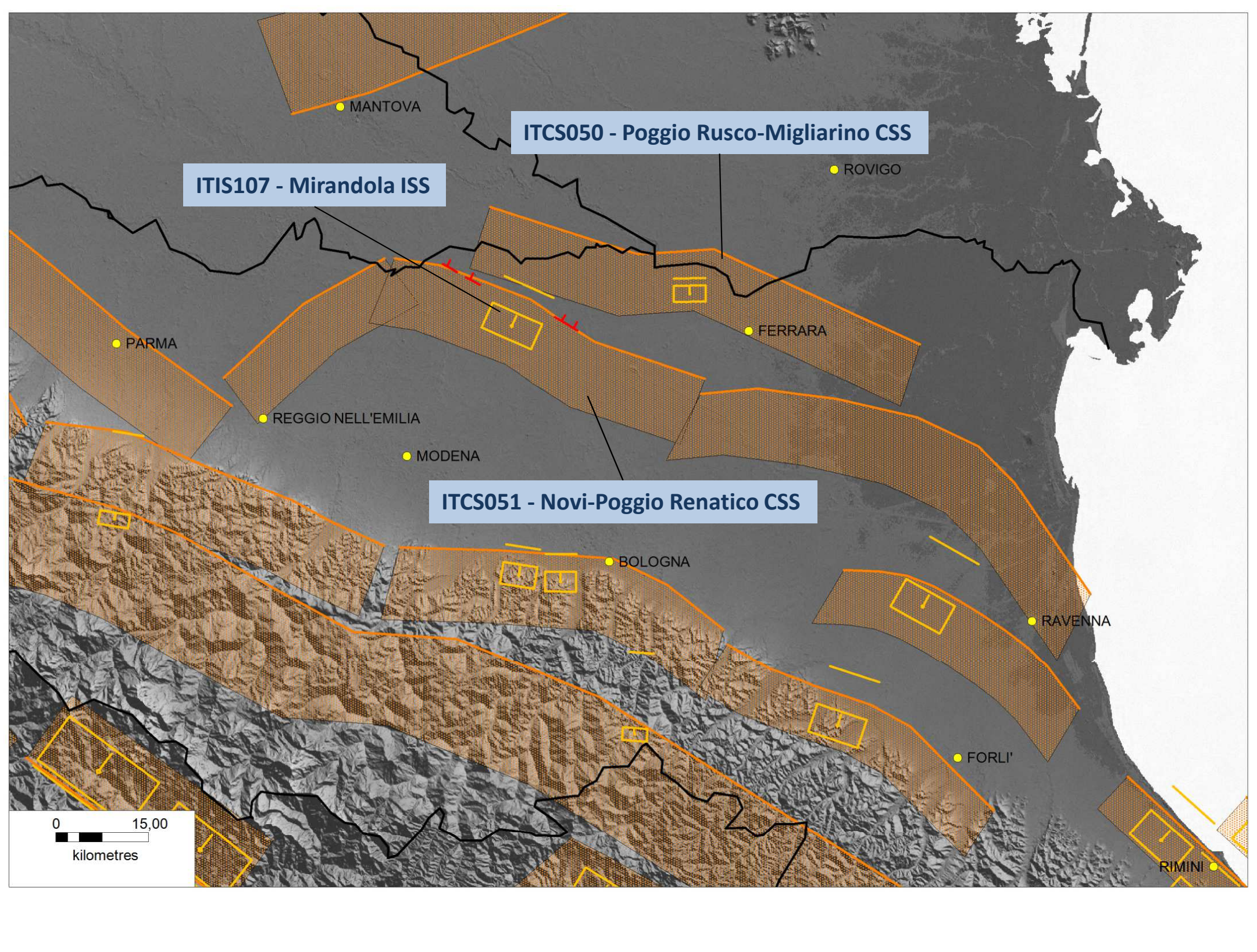

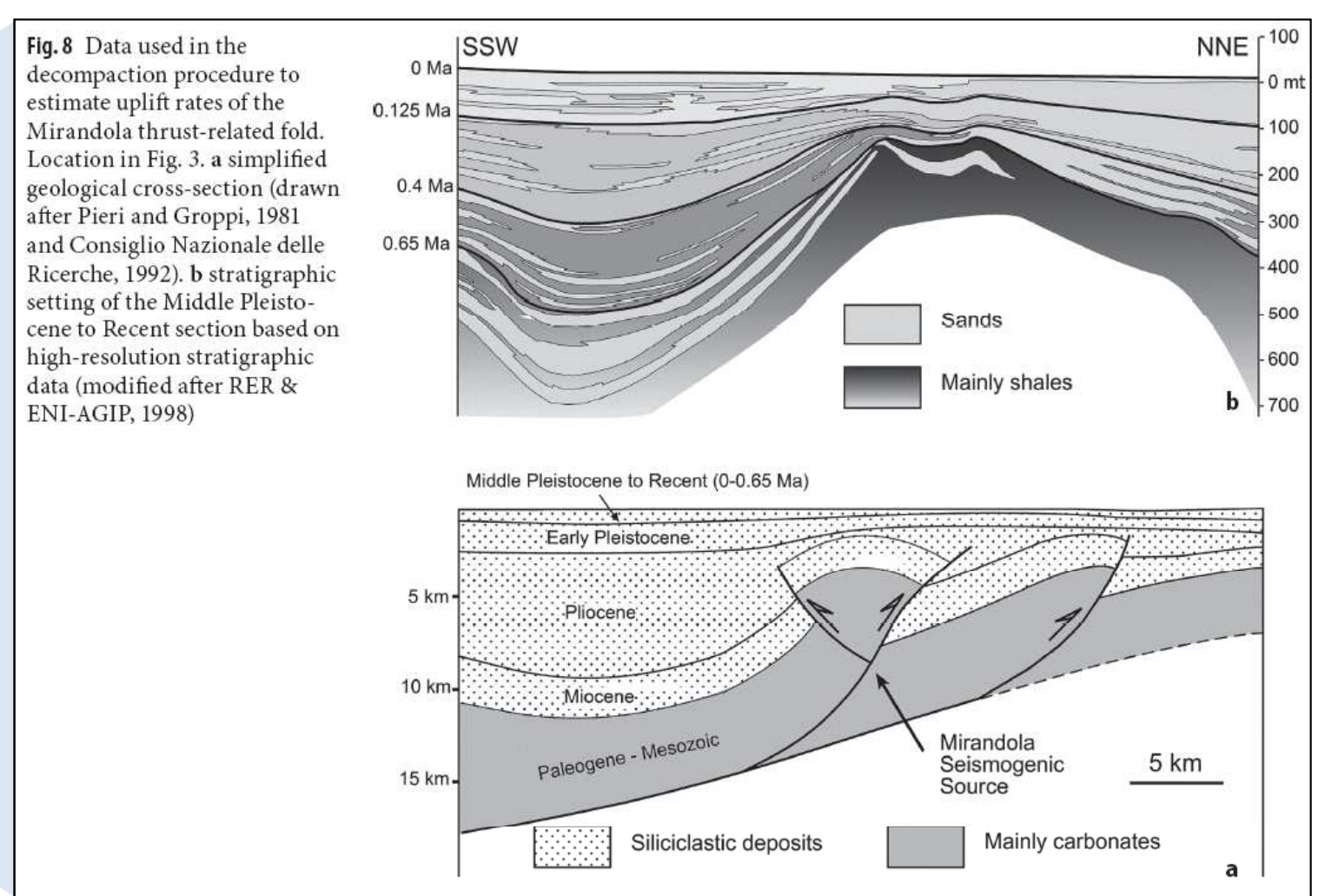

Fig. 8 Data used in the decompaction procedure to estimate uplift rates of the Mirandola thrust-related fold. Location in Fig. 3. **a** simplified geological cross-section (drawn after Pieri and Groppi, 1981 and Consiglio Nazionale delle Ricerche, 1992). **b** stratigraphic setting of the Middle Pleistocene to Recent section based on high-resolution stratigraphic data (modified after RER & ENI-AGIP, 1998)

Examples of entry of the fault sources database: general and parametric information from ITCS050 and ITCS051.

General Information

DISS–ID	ITCS050	**Name**	Poggio Rusco-Migliarino
Compiled By	Burrato, P., and S. Mariano	**Latest Update**	07-Sep-2007
Display map ...			

Parametric Information

Min depth [Km]	1.0	OD	Based on geological data from various authors.
Max depth [km]	8.0	OD	Based on geological data from various authors.
Strike [deg] min...max	85...115	OD	Based on geological data from various authors.
Dip [deg] min...max	25...55	OD	Based on geological data from various authors.
Rake [deg] min...max	80...100	OD	Based on geological data from various authors.
Slip Rate [mm/y] min...max	0.1...0.5	EJ	Derived from geological data concerning adjacent structures.
Max Magnitude	5.5	OD	Based on the strongest earthquake occurred in the region.

LD=Literature Data; OD=Original Data; ER=Empirical Relationship; AR=Analytical Relationship;EJ=Expert Judgement;

General Information

DISS–ID	ITCS051	**Name**	Novi-Poggio Renatico
Compiled By	Burrato, P., and S. Mariano	**Latest Update**	30-Aug-2007
Display map ...			

Parametric Information

Min depth [Km]	3.0	OD	Based on geological data from various authors.
Max depth [km]	10.0	OD	Based on macroseismic and geological data from various authors.
Strike [deg] min...max	95...125	OD	Based on geological data from various authors.
Dip [deg] min...max	25...45	OD	Based on geological data from various authors.
Rake [deg] min...max	80...100	OD	Based on geological data from various authors.
Slip Rate [mm/y] min...max	0.25...0.5	OD	Based on geological data from Scrocca et al. (2007).
Max Magnitude	5.9	OD	Derived from maximum magnitude of associated individual source(s).

LD=Literature Data; OD=Original Data; ER=Empirical Relationship; AR=Analytical Relationship;EJ=Expert Judgement;

REFERENCES

BASILI R., VALENSISE G., VANNOLI P., BURRATO P., FRACASSI U., MARIANO S., TIBERTI M.M. & BOSCHI E. (2008) - *The Database of Individual Seismogenic Sources (DISS), version 3: summarizing 20 years of research on Italy's earthquake geology*, Tectonophysics, 453, 20-43.
BASILI R., KASTELIC V., VALENSISE G., & DISS WORKING GROUP 2009 (2009) - *DISS3 tutorial series: Guidelines for compiling records of the Database of Individual Seismogenic Sources, version 3*, Rapporti Tecnici INGV, no. 108, 20 p., http://portale.ingv.it/produzione-scientifica/rapporti-tecnici-ingv/archivio/rapporti-tecnici-2009/.
BASILI R., GARCIA MORENO D., KASTELIC V., NEMSER E.S., PETRICCA P., SBORAS S. & VALENSISE G. (2010) - *Developing seismogenic source models based on geologic fault data in the Euro-Mediterranean area: SHARE mission accomplished?* Proc. 32nd General Assembly of the European Seismological Commission, Montpellier, 6-10 September 2010.
BURRATO P., POLI M.E., VANNOLI P., ZANFERRARI A., BASILI R. & GALADINI F. (2008) - *Sources of Mw 5+ earthquakes in northeastern Italy and western Slovenia: an updated view based on geological and seismological evidence*. Tectonophysics, 453, 157-176.
DISS WORKING GROUP (2010) - *Database of Individual Seismogenic Sources (DISS), Version 3.1.1: A compilation of potential sources for earthquakes larger than M 5.5 in Italy and surrounding areas.* http://diss.rm.ingv.it/diss/, © INGV 2010 - Istituto Nazionale di Geofisica e Vulcanologia - All rights reserved.
GRUPPO DI LAVORO MPS (2004) - *Redazione della mappa di pericolosità sismica prevista dall'Ordinanza PCM 3274 del 20 marzo 2003*. Final report for Dipartimento della Protezione Civile, INGV, Milano-Roma, April 2004, 65 pp. + 5 appendixes (available at: http://zonesismiche.mi.ingv.it/elaborazioni/).
HALLER K.M. & BASILI R. (2011) - *Developing Seismogenic Source Models Based on Geologic Fault Data*. Seismological Research Letters, 82(4), 515-521, doi: 10.1785/gssrl.82.4.515.
KASTELIC V. & CARAFA M.M.C. (2012) - *Fault slip rates for the active External Dinarides thrust-and-fold belt*. Tectonics, (in press), doi: 10.3301/IJG.2012.03.
VALENSISE G. & PANTOSTI D. (eds) (2001) - *Database of Potential Sources for Earthquakes Larger than M 5.5 in Italy*. Annali di Geofisica, vol. 44, Suppl. 1, with CD-ROM.
VANNOLI P., BURRATO P., FRACASSI U. & VALENSISE G. (2012) - *A fresh look at the seismotectonics of the Abruzzi (Central Apennines) following the 6 April 2009 L'Aquila earthquake (Mw 6.3)*. Italian Journal of Geosciences, 131, doi: 10.3301/IJG.2012.03.

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