Le banche dati di faglie sismogenetiche dell’INGV: DISS e EDSF

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

http://diss.rm.ingv.it/share-edsf/

Roberto Basili, Istituto Nazionale di Geofisica e Vulcanologia, Roma

Le banche dati di faglie sismogenetiche dell'INGV: DISS e EDSF

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  - faglie sismogenetiche e faglie capaci a confronto
  - esplorare la terza dimensione delle faglie: esempi
  - come si usano le faglie sismogenetiche nella stime di pericolosità
  - importanza della terza dimensione
- struttura generale del DISS
- esempio di navigazione del DISS
- struttura generale dell'EDSF
- esempio di navigazione dell'EDSF

Ringraziamenti
ai componenti del DISS Working Group: Salvatore Barba, Pierfrancesco Burrato, Umberto Fracassi, Vanja Kastelic, Gabriele Tarabusi, Mara M. Tiberti, Gianluca Valensise, Paola Vannoli
e inoltre a
Michele M. C. Carafa, Patrizio Petricca

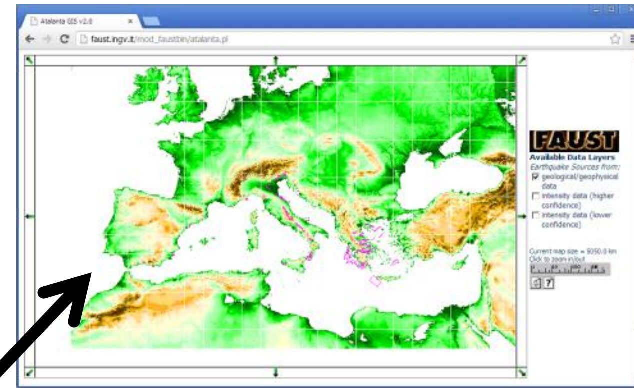
Motivazione e contesto scientifico

ITALIA

EUROPA

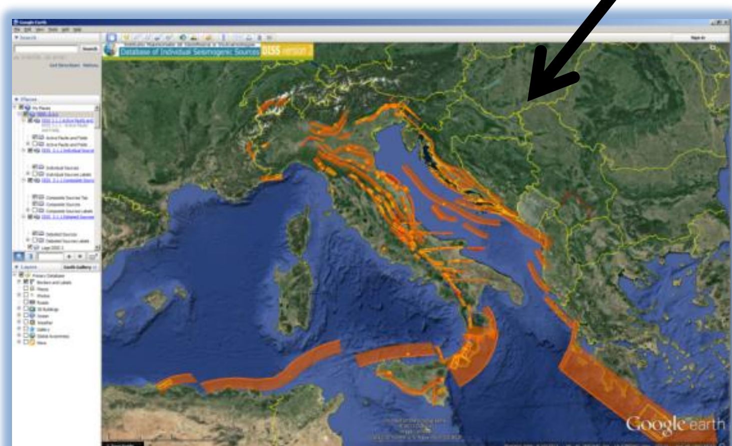
DISS 1.0 **2000**

DISS 2.0 **2001**

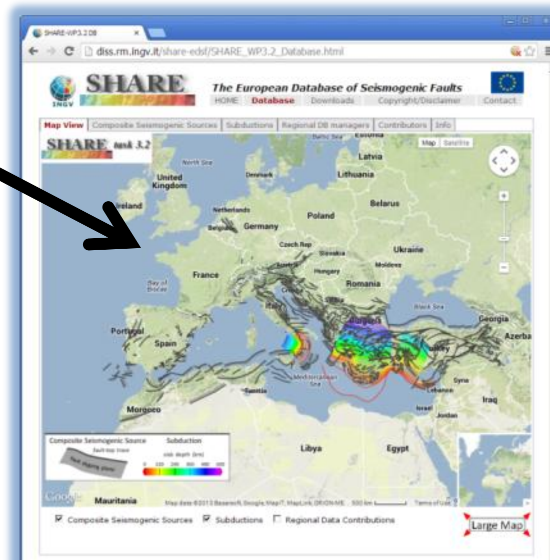


2002 FAUST

DISS 3.x.y **2005**



2013 EDSF



Motivazione e contesto scientifico

Accordo quadro INGV-DPC 2012-2021

http://www.ingv.it/

[*DISS è una delle banche dati prioritarie citate nell'accordo quadro decennale tra INGV e Dipartimento della Protezione Civile*]

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...*]

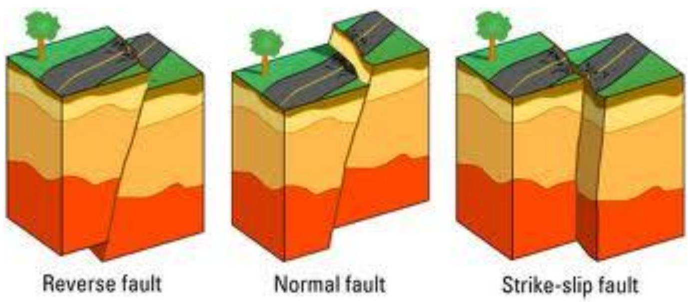
GEM: *The Faulted-Earth Project*

http://www.globalquakemodel.org/

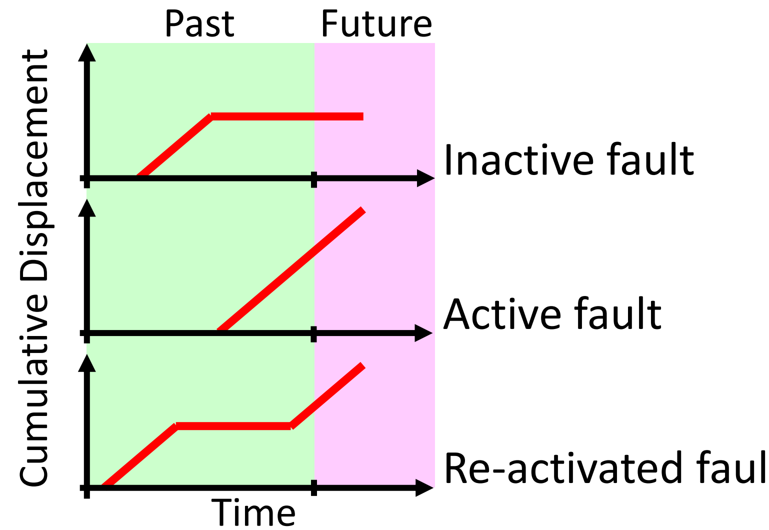
[... *build a global active fault and seismic source database with a common set of strategies, standards and formats...*]

Concetti fondamentali: tipi di faglie

faglia

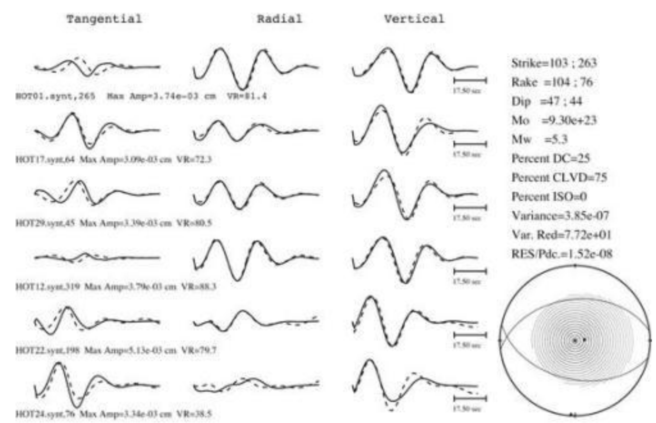


faglia attiva



faglia capace

faglia sismogenetica



Concetti fondamentali: tipi di pericolosità

Hazards Associated with Active Faults

ground shaking

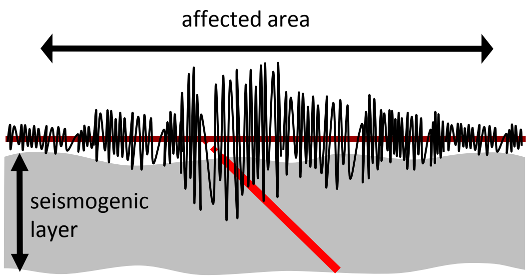
occurs always but is transient

affects the widest area

is responsible for most of the damage

may trigger other geological effects (*liquefactions, landslides, secondary ruptures*)

requires mapping at 1:200k-1M



surface deformation

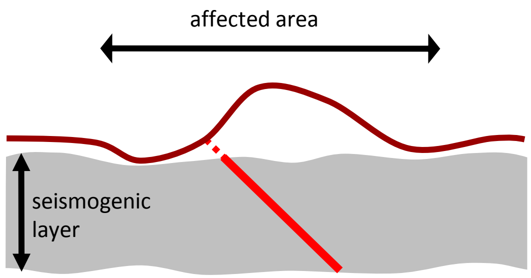
occurs always and is permanent

affects a wide area (*fault size x2*)

produce limited damage (*critical facilities*)

may trigger other geological effects (*stream avulsions, slope instabilities, secondary ruptures, tsunamis*)

requires mapping at 1:200k-1M



surface rupture

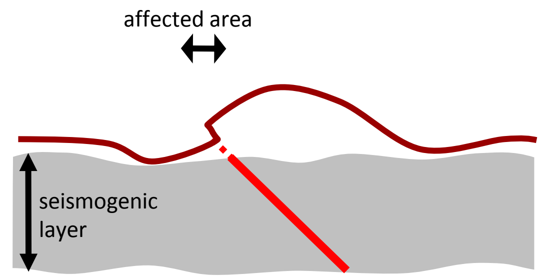
occurs when faults “daylight” and is permanent

affects a limited area (*smaller than fault length*)

may produce significant damage

may trigger other geological effects (*water ponding, damming*)

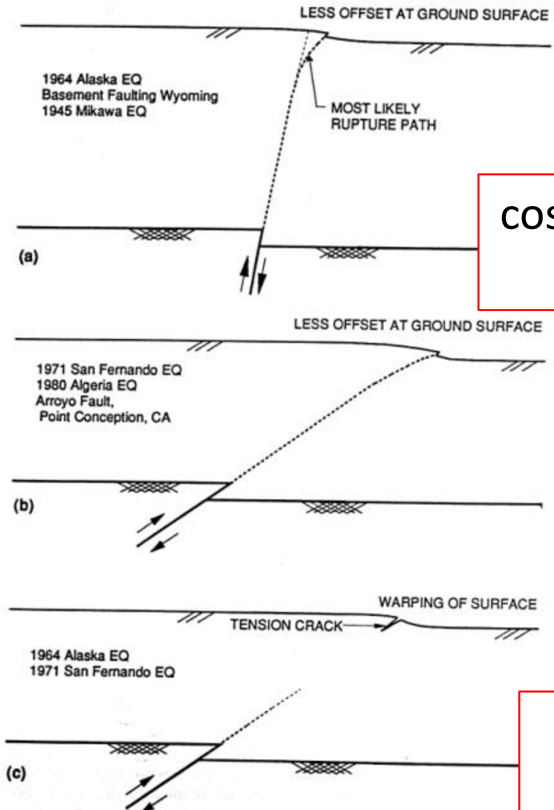
requires mapping at 1:1k-10k



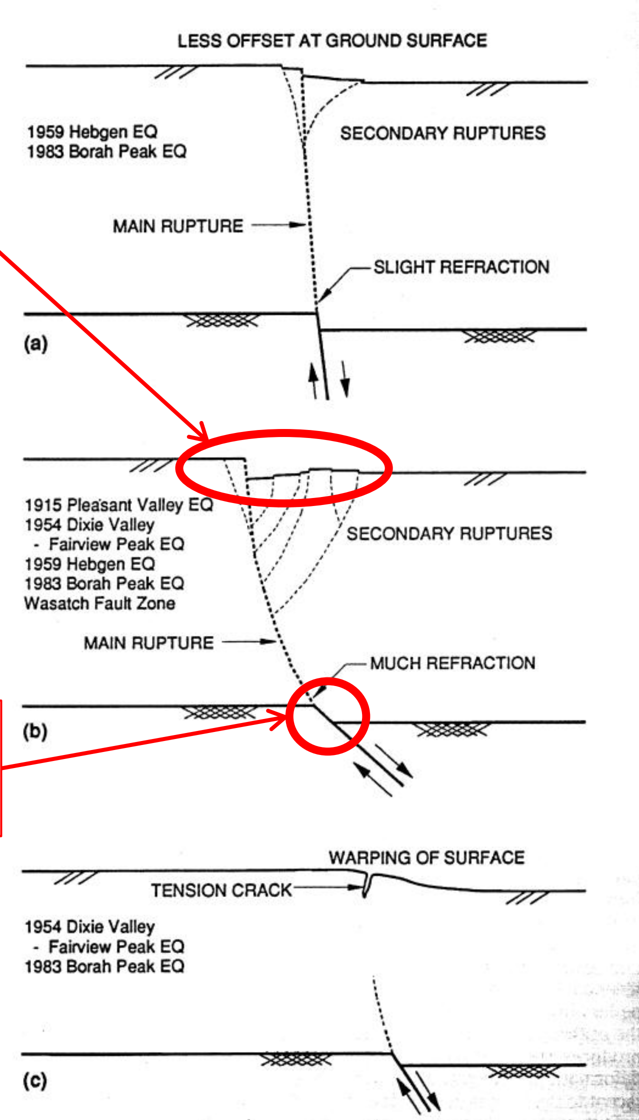
These three processes are the primary cause for damage to buildings and infrastructures. A survey of 50 major earthquakes occurred between 1989 and 2003 (Bird and Bommer, 2004) shows that the primary cause for building collapse is ground shaking in 98% of the cases, followed by liquefaction (32%), slope failure (28%), tsunami (10%), and fault rupture (10%).

Concetti fondamentali: rottura e propagazione in faglie sismogenetiche

Reverse



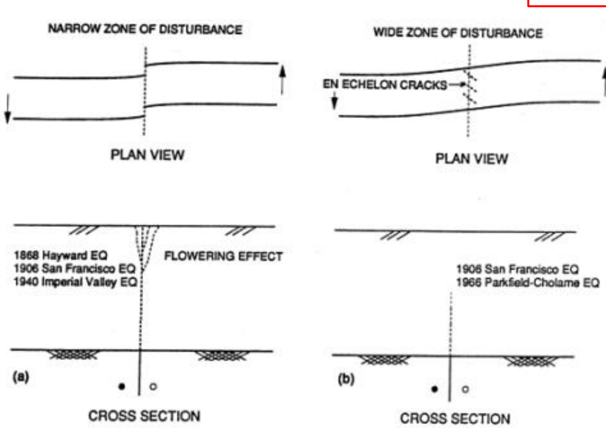
Normal



cosa si può osservare in superficie

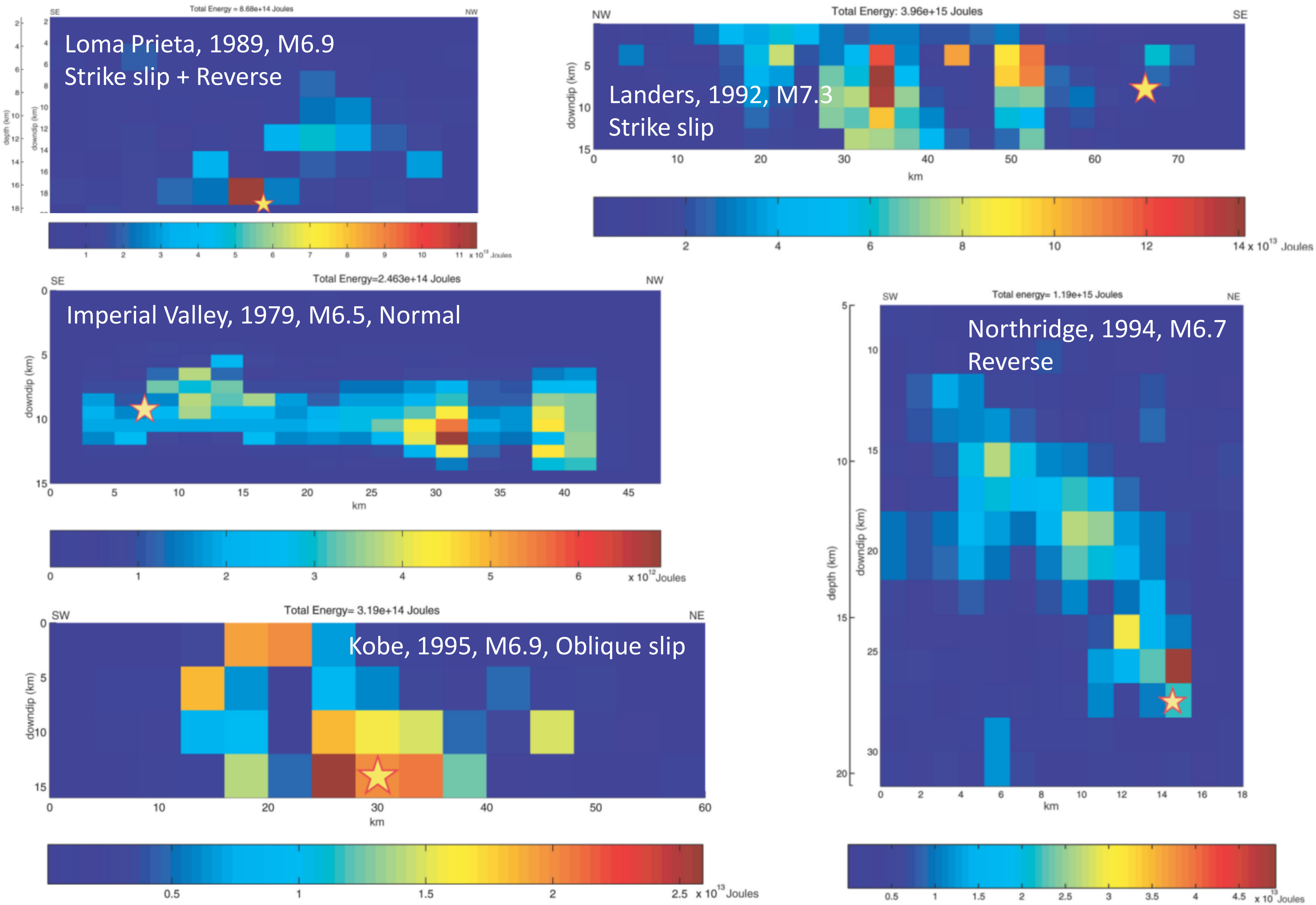
cosa serve per la pericolosità

Strike slip



Bray et al., 1994, J. Geotech, Eng.

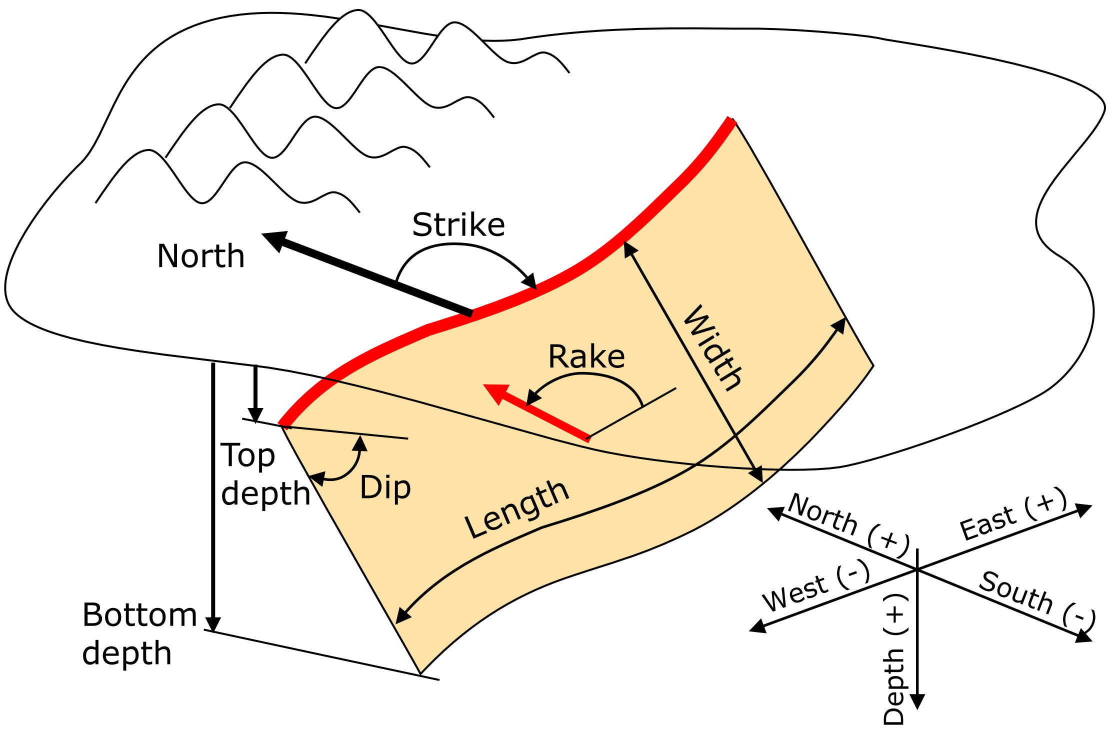
Concetti fondamentali: radiazione di energia sismica



McGarr and Fletcher, 2002, BSSA

Concetti fondamentali: parametri di una faglia sismogenetica

Modello di faglia sismogenetica generalmente usato negli studi di pericolosità sismica



Geometry
Location: Lat, Lon, Depth
Size: Length, Width
Orientation: Strike, Dip

Behavior
Rake
Slip Rate
Earthquake Magnitude
Activity Rate

Concetti fondamentali: definizioni di faglie sismogenetiche

Variety of fault-source models used in PSHA

Fault source name	Definition	Recurrence model	Hazard model
Hazard fault	Mmax ruptures total length Smaller events allowed on fault	GR	USGS, US
Fault section	Ruptures of any size result from combination of 1+ sections	GR	SCEC, California
Behavioral segment	Earthquake rupture spans 1+ segments	SP	AIST, Japan
Fault segment	Max rupture = total length No smaller events allowed on fault	SP	GNS, New Zealand
Composite seismogenic source	Unspecified number of ruptures of any size up to Mmax	GR	SHARE, Europe

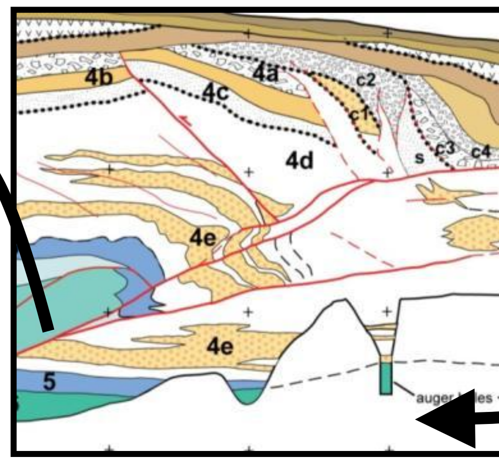
GR: Gutenberg-Richter; SP: strictly periodic

Concetti fondamentali: faglie sismogenetiche e faglie capaci a confronto

Mappatura di faglie attive: idea comunemente accettata

Ricerca di affioramenti

Analisi dell'affioramento

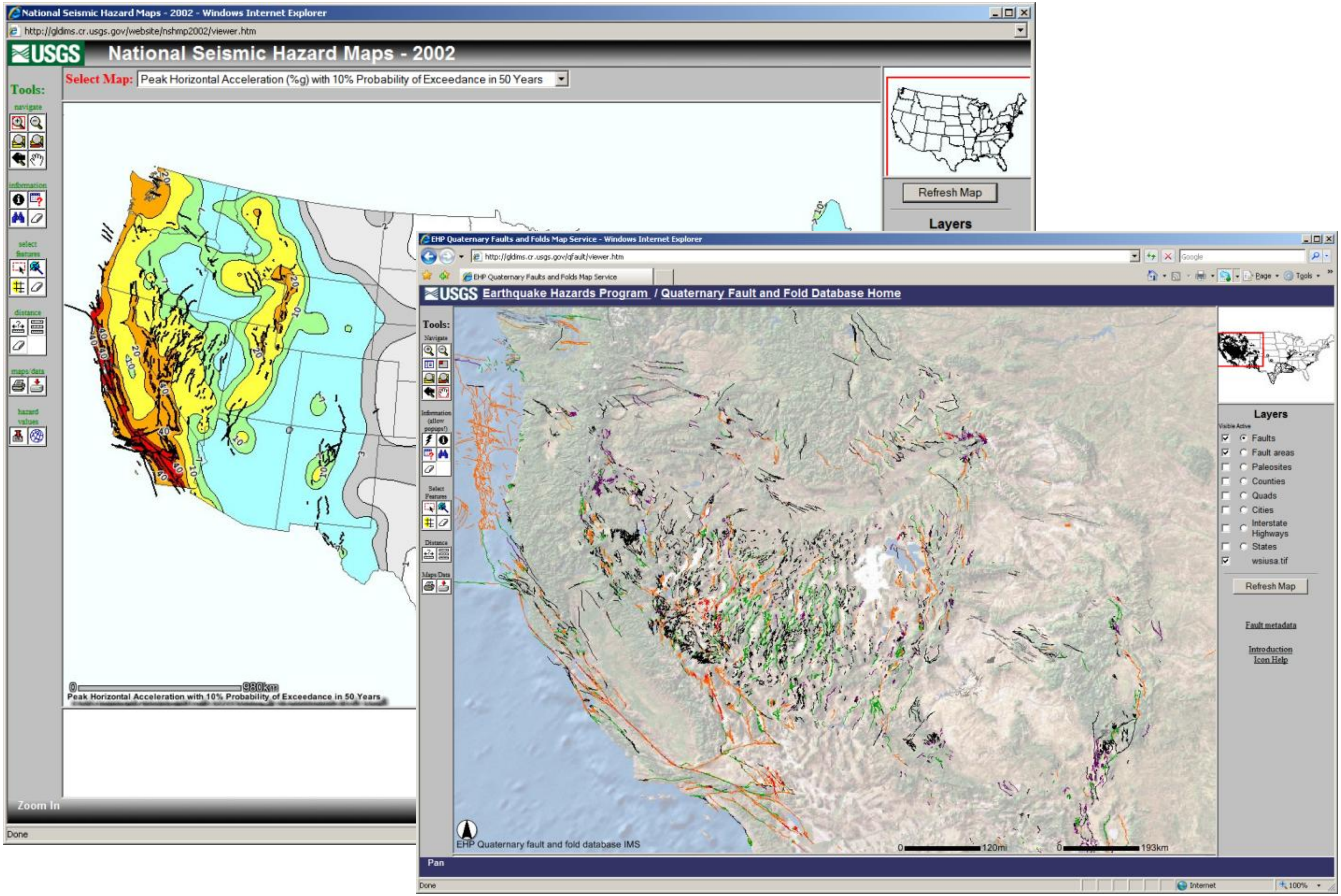


Ricostruzione geometrica/cinematica

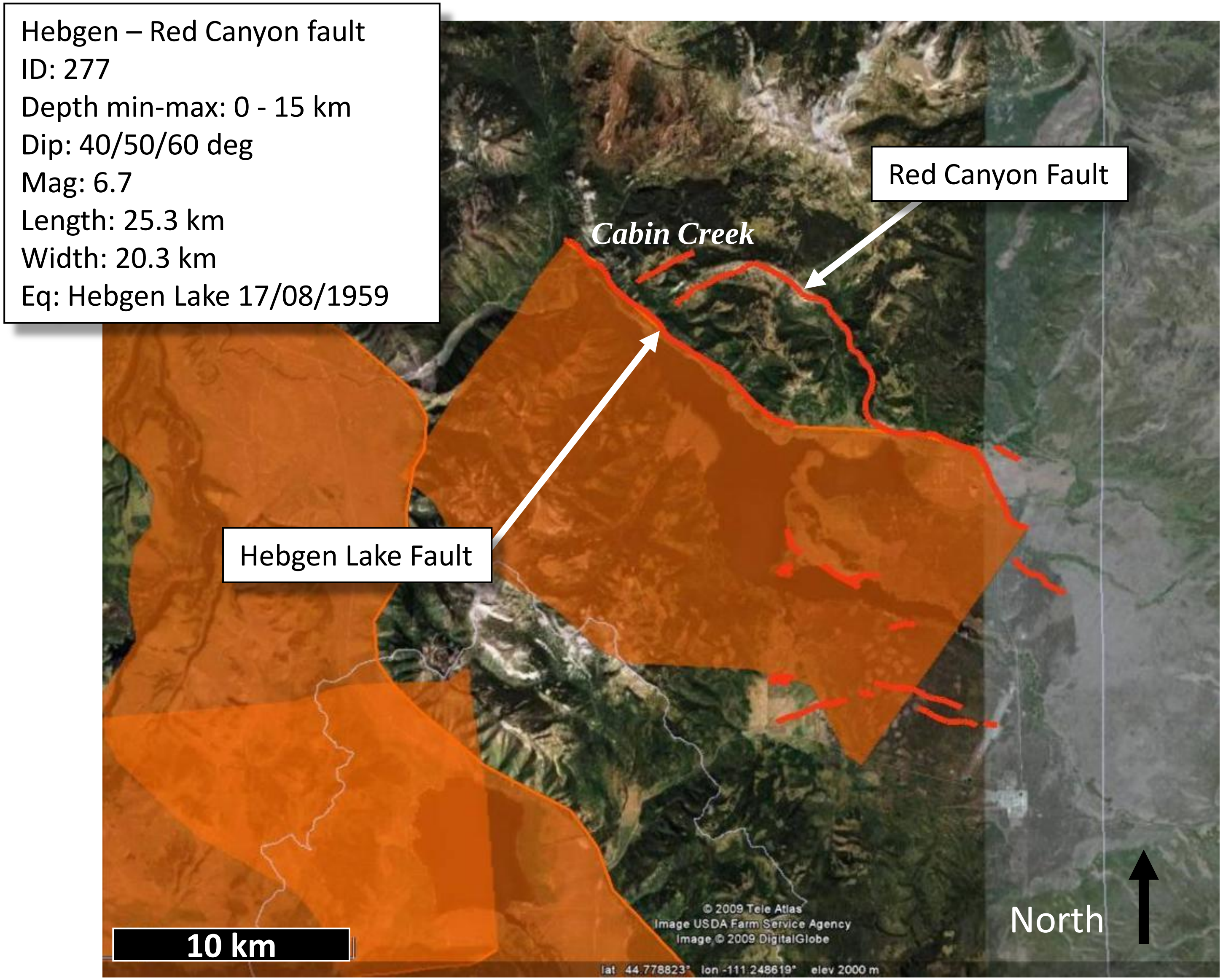
Immagazzinamento
nella banca dati

Esiste una corrispondenza diretta tra mappe di faglie attive e modelli di faglie sismogenetiche per le analisi di pericolosità?

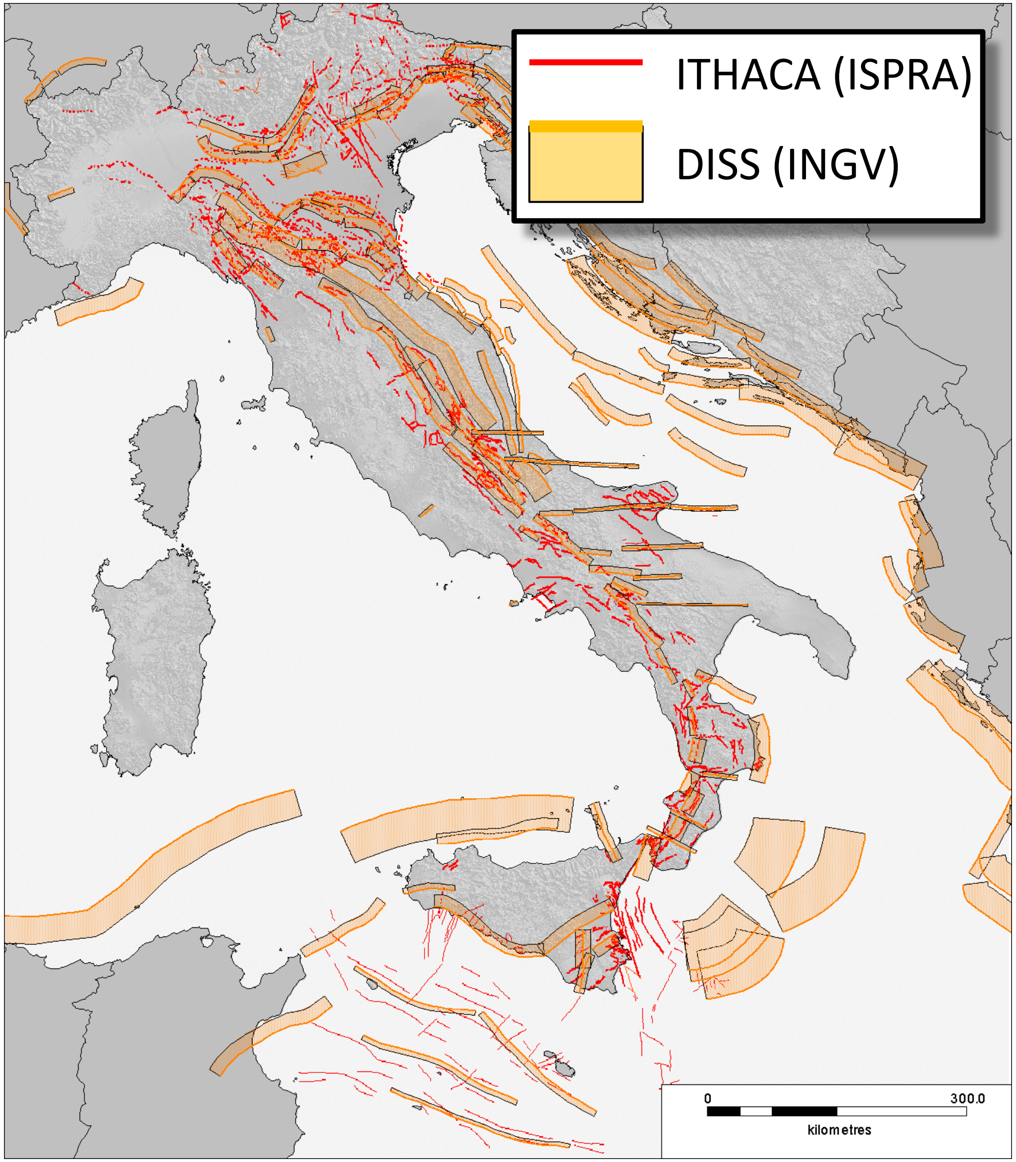
Concetti fondamentali: faglie sismogenetiche e faglie capaci a confronto



Concetti fondamentali: faglie sismogenetiche e faglie capaci a confronto

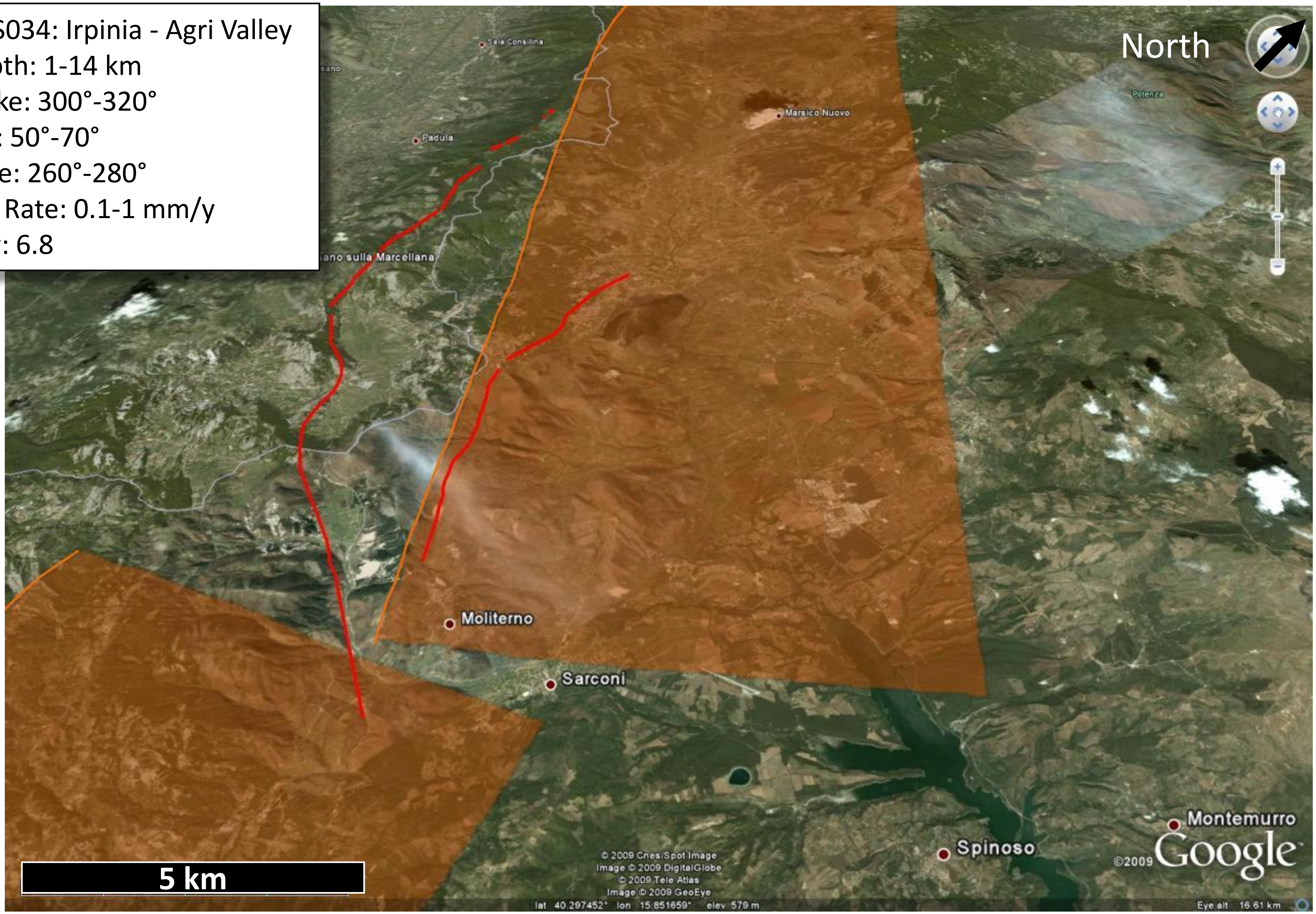


Concetti fondamentali: faglie sismogenetiche e faglie capaci a confronto



Concetti fondamentali: faglie sismogenetiche e faglie capaci a confronto

ITCS034: Irpinia - Agri Valley
Depth: 1-14 km
Strike: 300°-320°
Dip: 50°-70°
Rake: 260°-280°
Slip Rate: 0.1-1 mm/y
Mw: 6.8



Concetti fondamentali: esplorare la terza dimensione delle faglie

La faglia alto-tiberina

Grant agreement no.: 259256
Principal Investigator: Cristiano Collettini
Host Institution: Istituto Nazionale di Geofisica e Vulcanologia, Roma
Budget: 1.514.400 Euro
Starting date October 2010, duration 5 years.

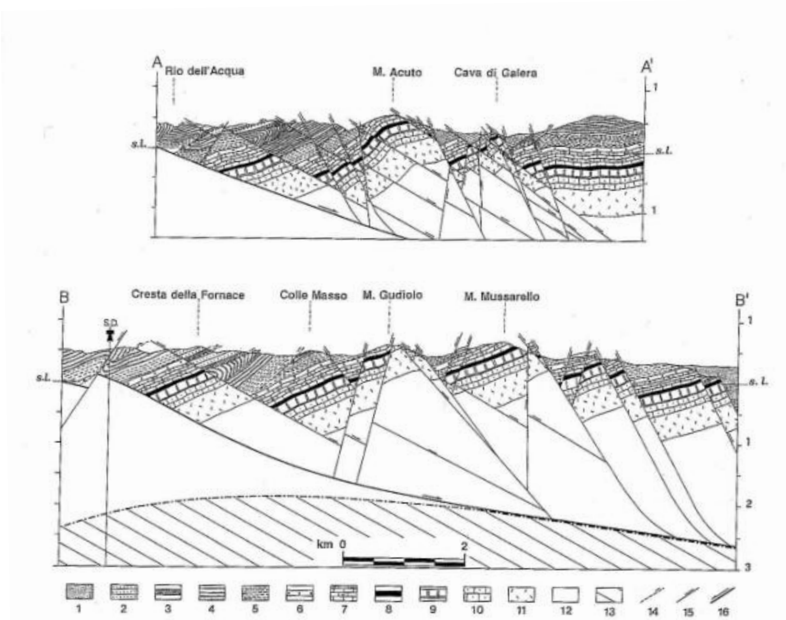


Fig. 7 - Sezioni geologiche attraverso l'area in studio (tracce in Tav. 1). 1: depositi continentali plio-quaternari della Valle del Tevere; 2: *Arenarie del Falterona - Cervarola*; 3: *Argille Varicolori*; 4: *Marnoso-Arenacea*; 5: *Marnosa Umbra*; 6: *Scaglia cinerea* e *Bisciaro*; 7: *Scaglia* (*bianca, rossa e variegata*), 8: *Marne a Fucoidi*; 9: *Maiolica*; 10: successione giurassica dal tetto del *Calcare Massiccio* alla base della *Maiolica*; 11: *Calcare Massiccio*; 12: *Anidriti di Burano*; 13: *Verrucano*; 14: sovrascorrimenti; 15: faglie dirette; 16: traccia dello scollamento basale delle faglie distensive.

Brozzetti, 1995

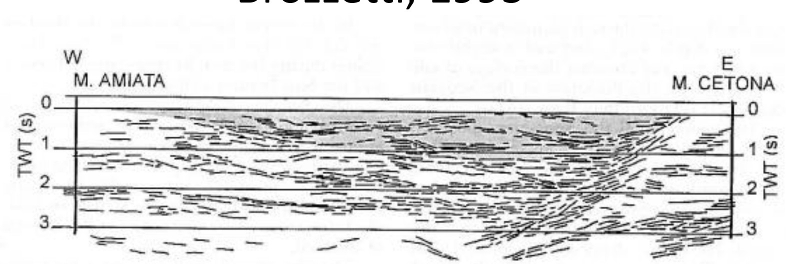
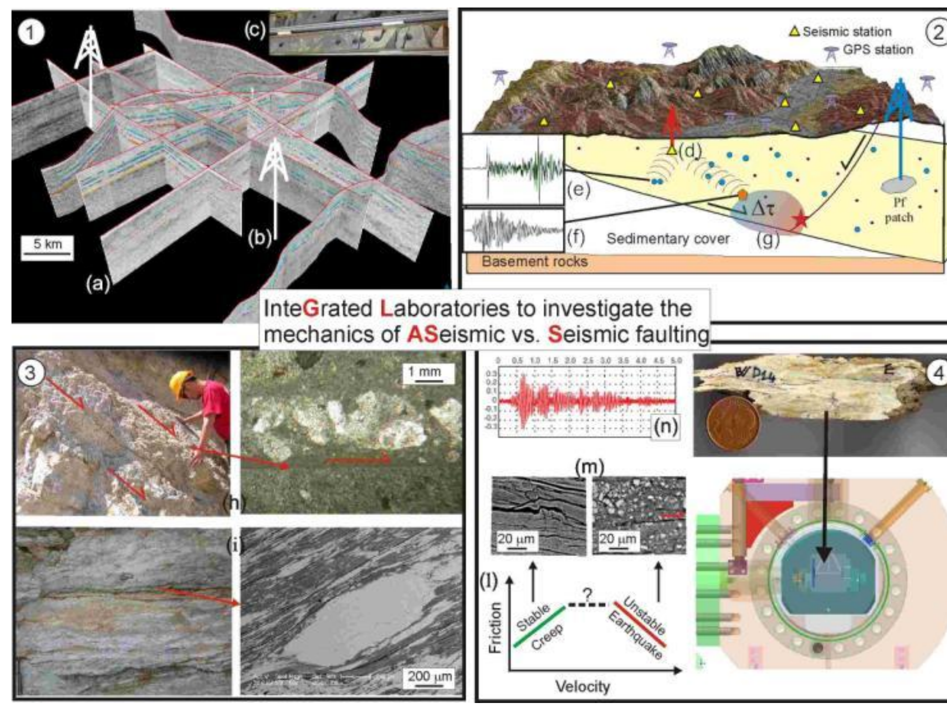


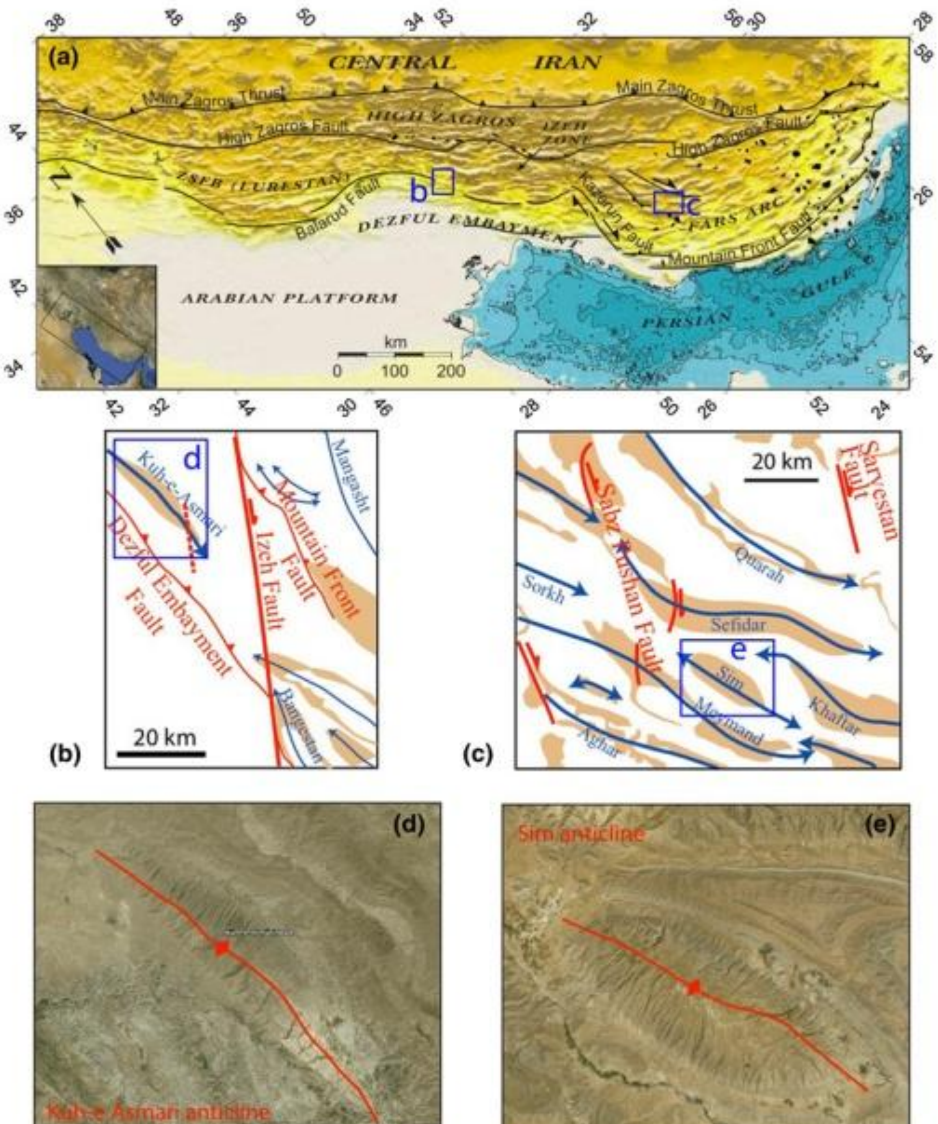
Fig. 2 - Seismic reflection line crossing in a SW-NE direction the Southernmost sector of the Radicofani basin (In gray are the Neogene sediments).

Barchi et al, 1998

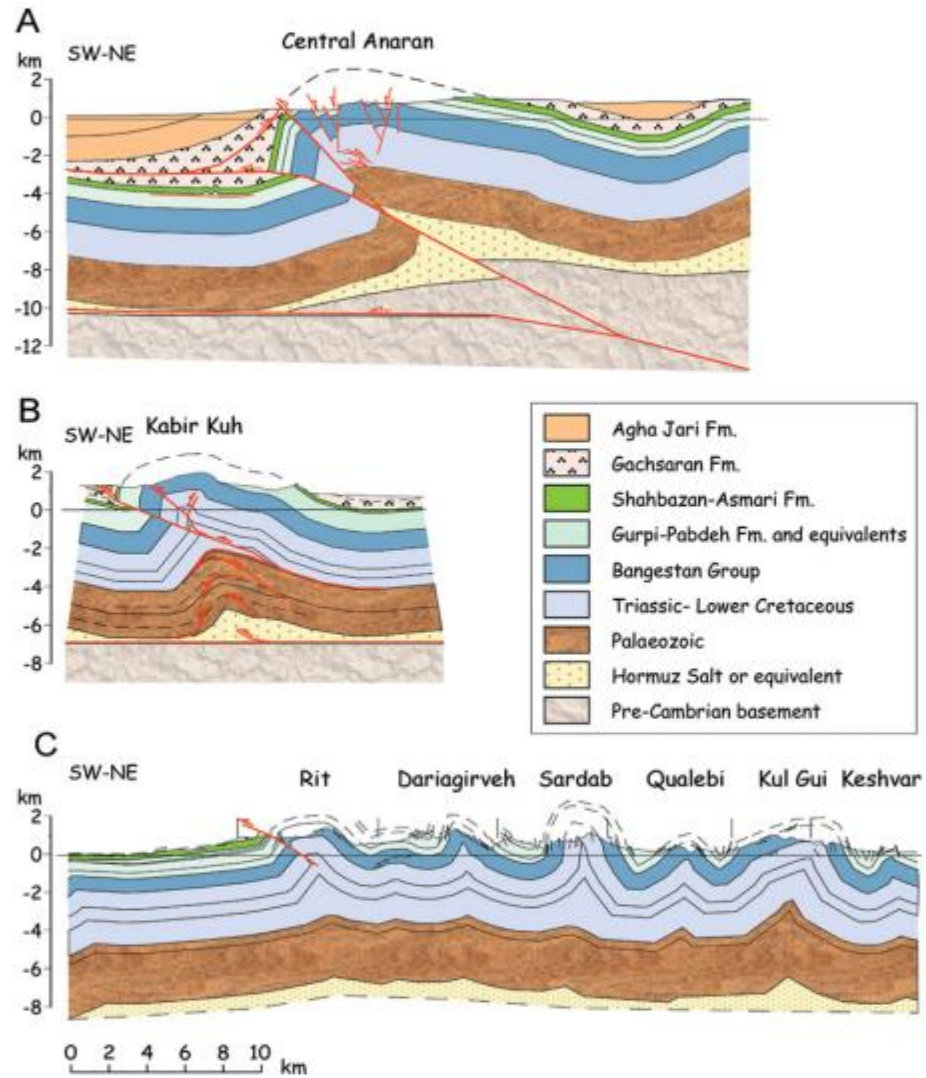


Concetti fondamentali: esplorare la terza dimensione delle faglie

Faglie inverse in Iran



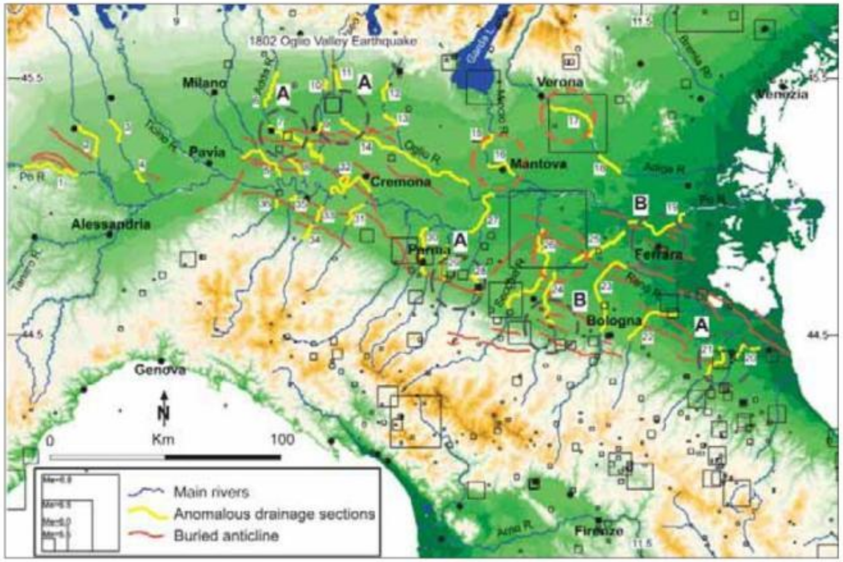
Carminati et al., 2013, Int. J. Earth Sc.

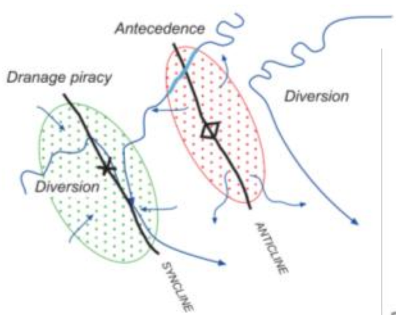


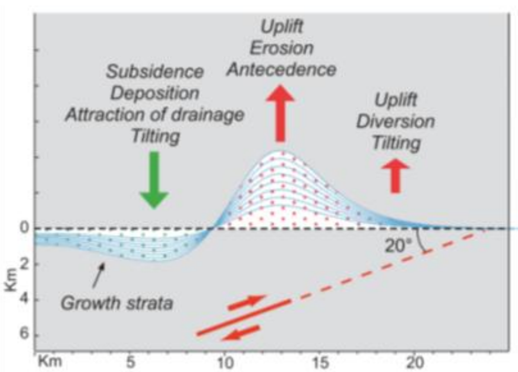
Verges et al., 2011, Geol. Mag.

Concetti fondamentali: esplorare la terza dimensione delle faglie

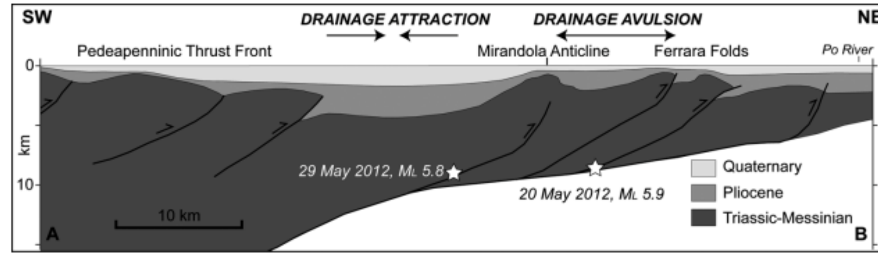
La faglia di Mirandola e il terremoto del 2012

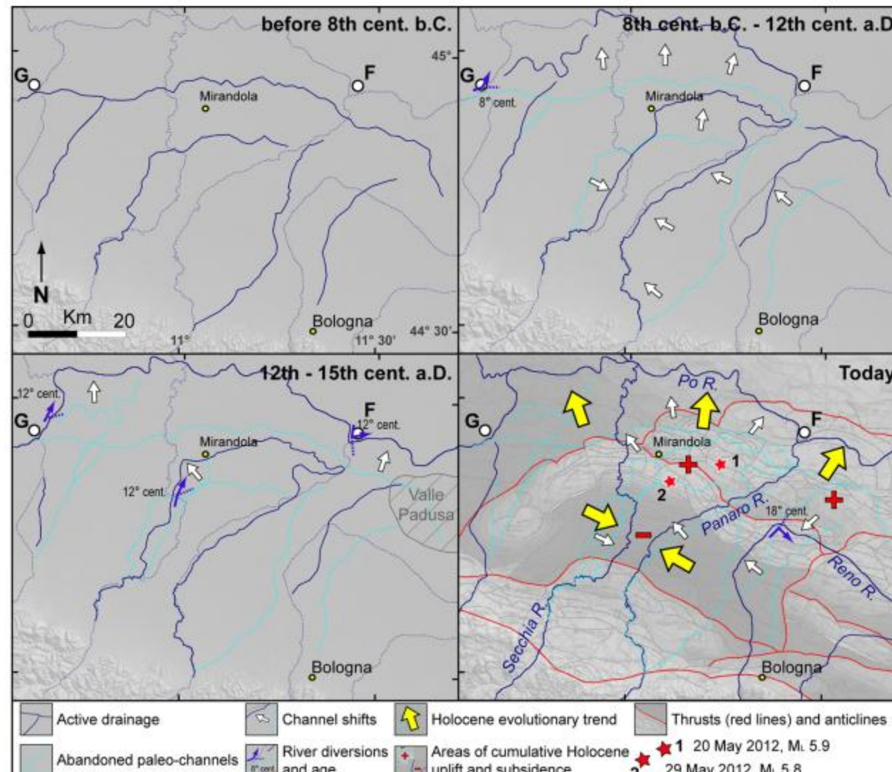






Burrato et al., 2003, AoG

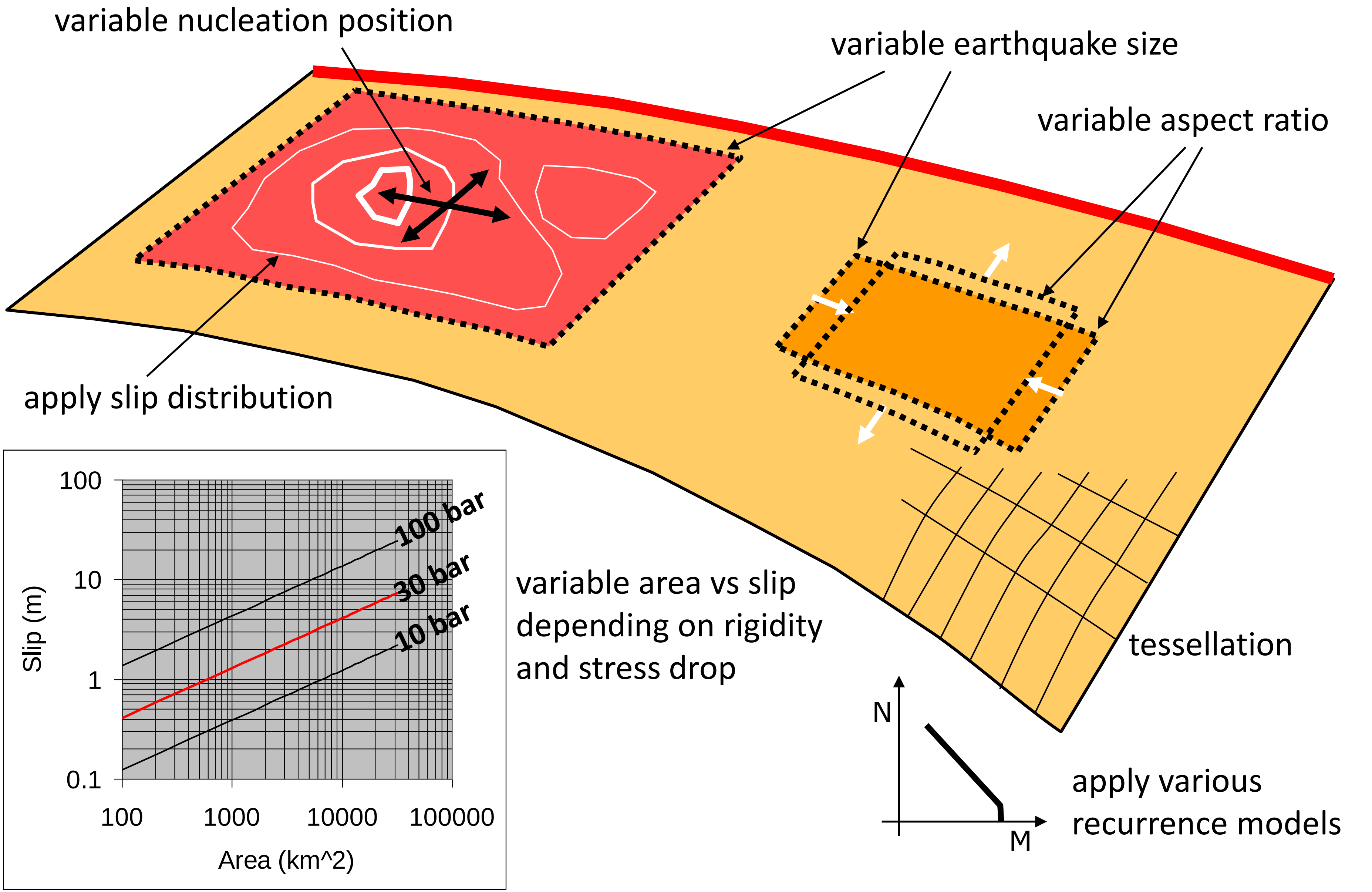




Burrato et al., 2012, AoG

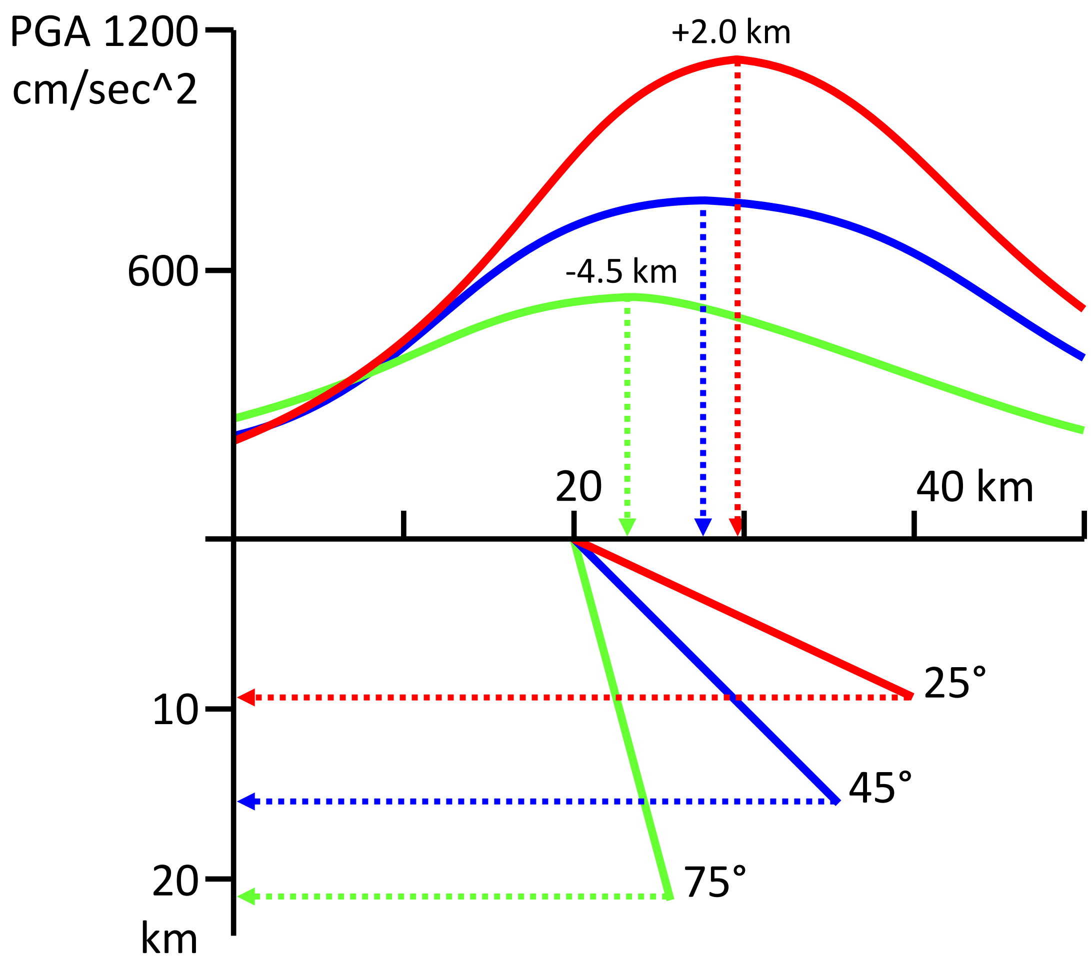
Roberto Basili, Istituto Nazionale di Geofisica e Vulcanologia, Roma

Concetti fondamentali: come si usano le faglie sismogenetiche



Concetti fondamentali: importanza della terza dimensione

Effect of dip angle uncertainty: **Ground Motion**

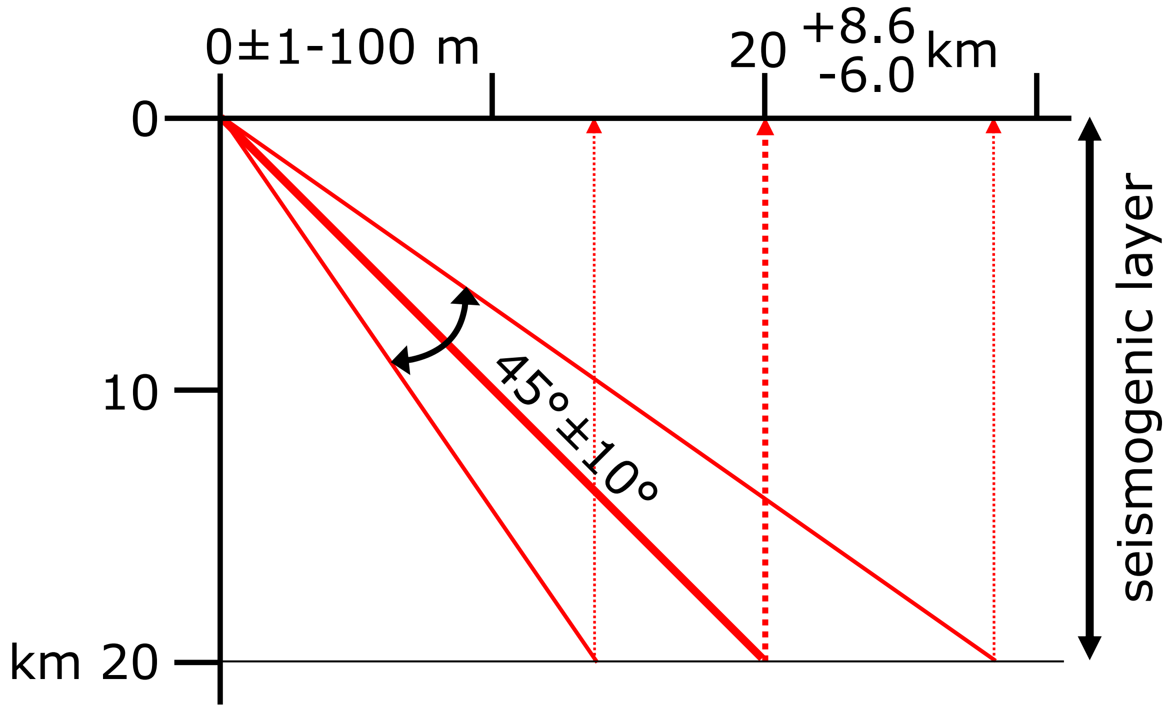


Fault: L=47 km; W=22 km; Mw 7.1

Concetti fondamentali: importanza della terza dimensione

Effect of dip angle uncertainty: **Geometry**

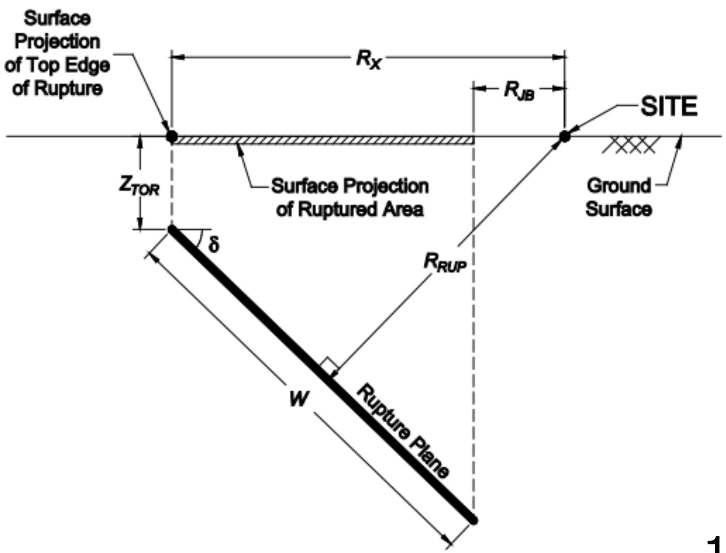
Dip angle uncertainties affect fault–distance metrics in GMPEs and activity rates

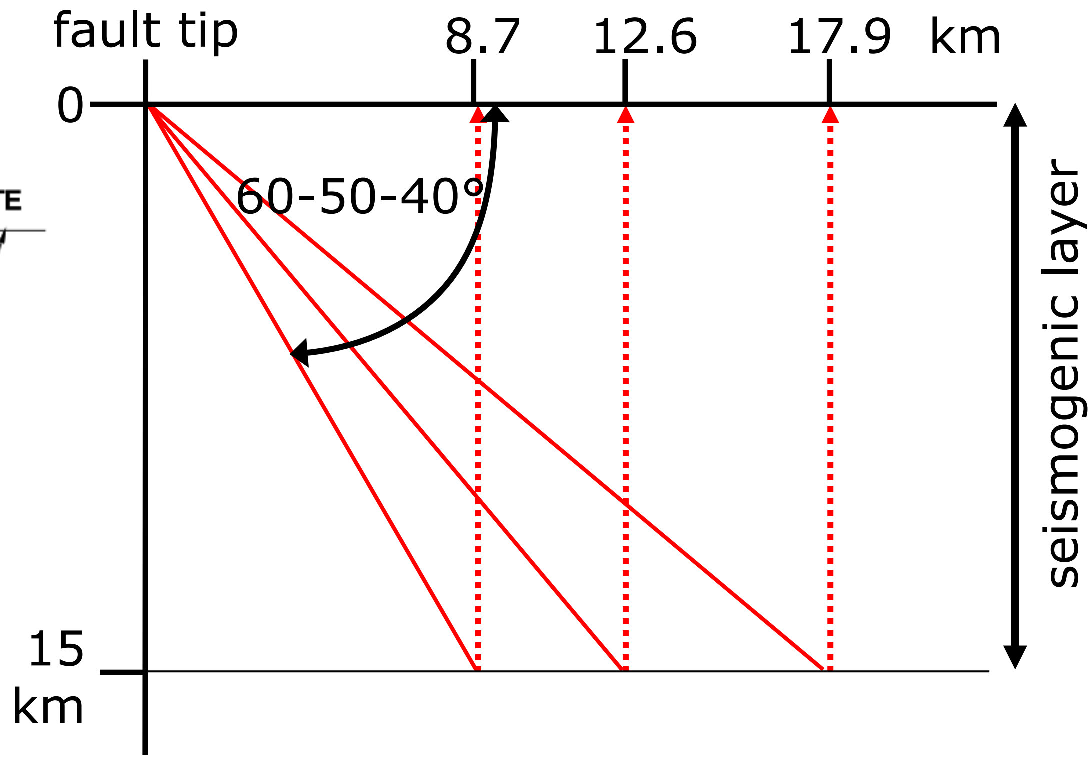


Dip (deg)	HW (km)	HWErr (km)	DDW (km)	DDWErr (km)	Mw	MwErr
55	14.0	-6.0	24.4	-3.9	7.2	-0.1
45	20.0	0.0	28.3	0.0	7.3	0.0
35	28.6	8.6	34.9	6.6	7.5	0.2

Concetti fondamentali: importanza della terza dimensione

Effect of dip angle uncertainty: **Fault-site distance**





$Z_{TOR} = 0$

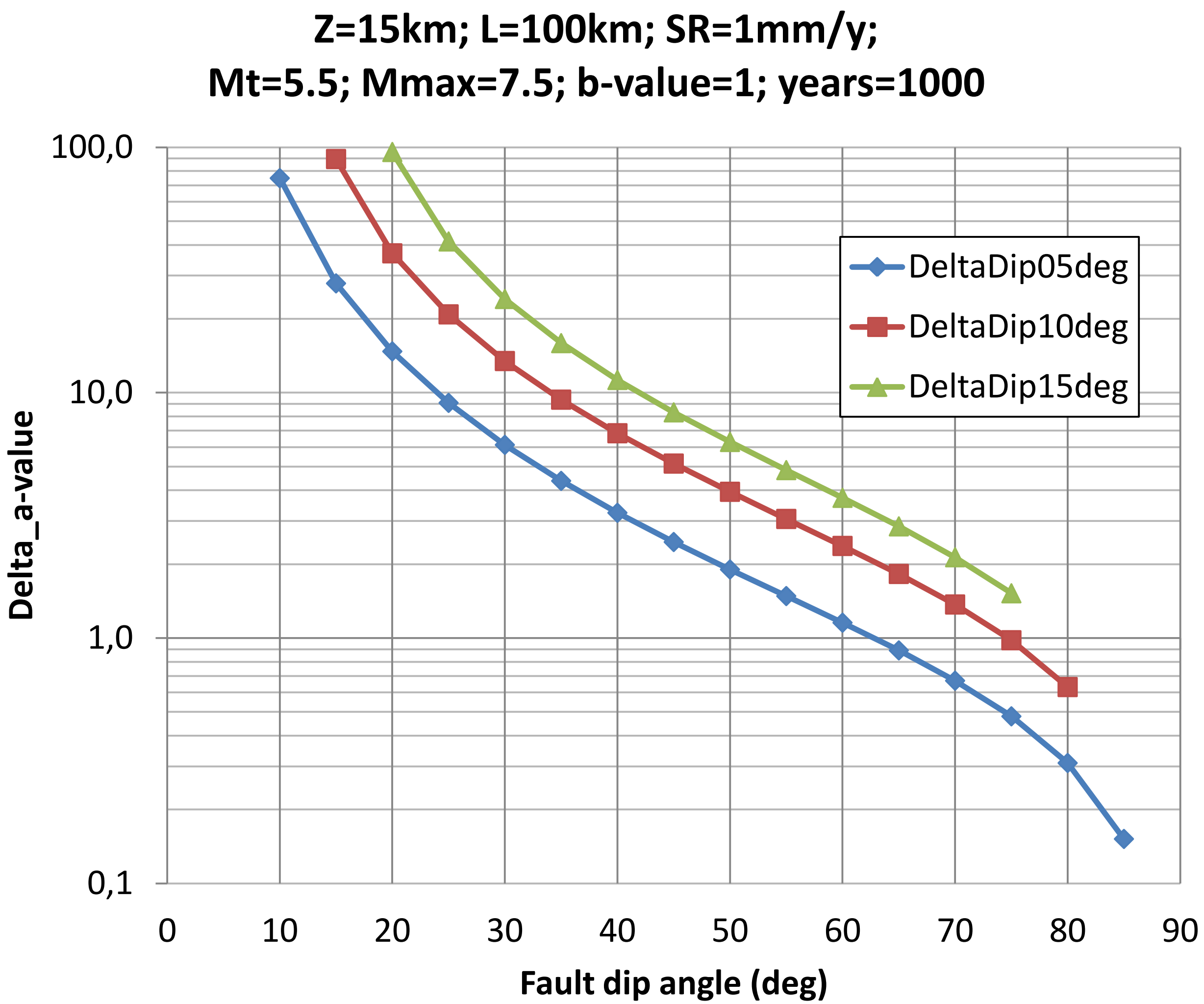
$R_{JB} = +5.3$ or -3.9

$R_{RUP} = +2.5$ or -2.0

Open-File Report 2008–1128
Intermountain West
Allowed for distribution of dips on normal faults (40°, 50°, and 60° with 0.2, 0.6, 0.2 weights, see Appendix G) as recommended by Western States Seismic Policy Council

Concetti fondamentali: importanza della terza dimensione

Effect of dip angle uncertainty: **Activity Rates**

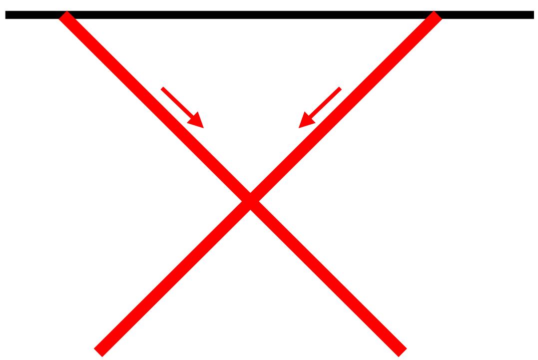


Concetti fondamentali: importanza della terza dimensione

Effect of dip angle uncertainty: **Geometry**

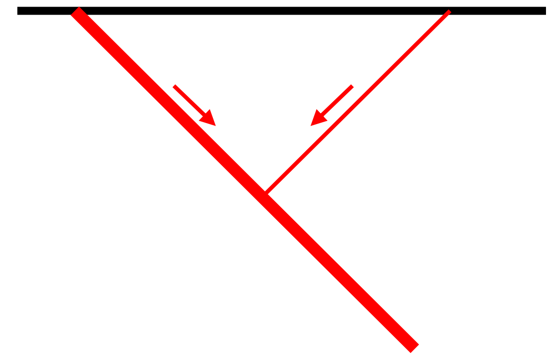
cross-cutting faults are

mechanically unrealistic

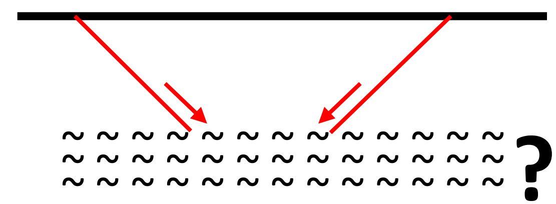


if the case is not treated this may lead to double the activity rates thereby overcooking the hazard

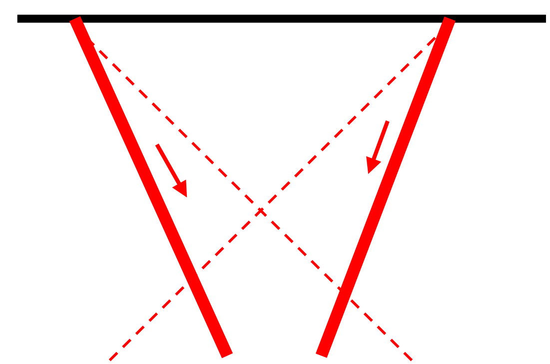
the fault system is partly a secondary structure



the fault system is shallower than thought

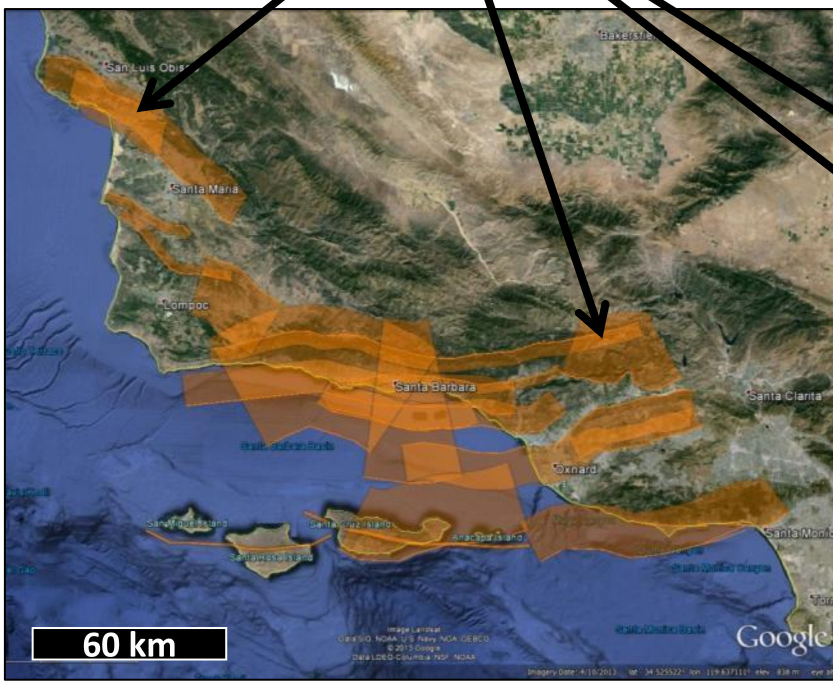


the fault system dip angles are steeper than thought

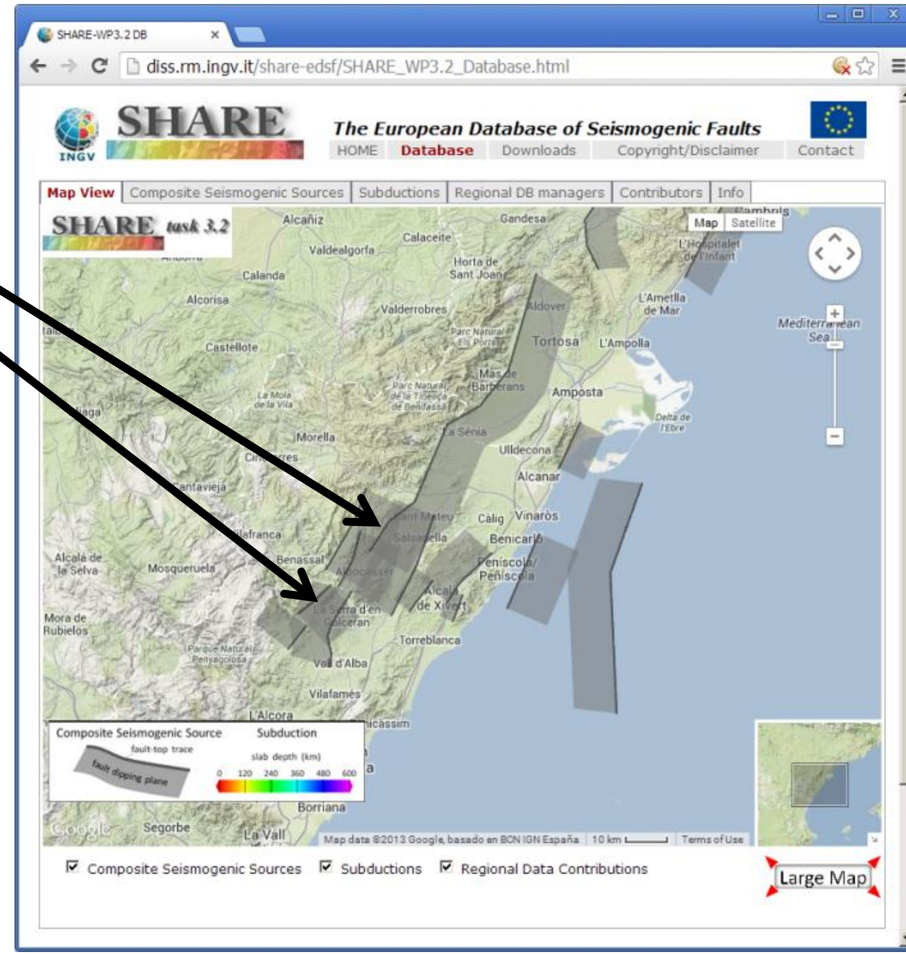


Concetti fondamentali: importanza della terza dimensione

Zone di sovrastima del tasso di attività

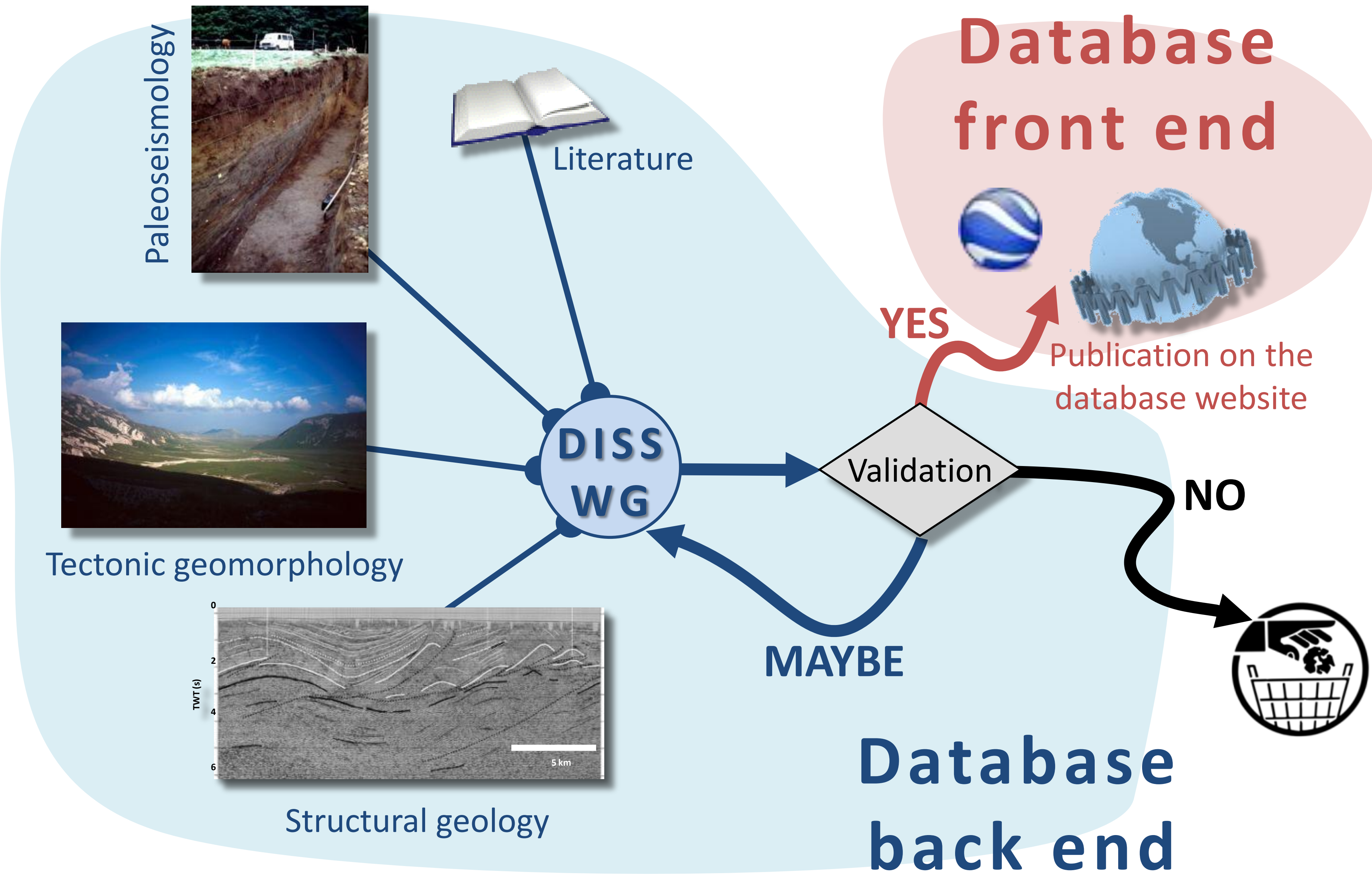


California: fonte UCERF -> USGS



Spagna: fonte QAFI -> SHARE

DISS: struttura e contenuti <http://diss.rm.ingv.it/diss/>



DISS: struttura e contenuti <http://diss.rm.ingv.it/diss/>

The database **FRONT-END** (Web GIS, Google Earth) contains four main layers in common with the BACK-END:

- *Individual Seismogenic Sources*
- *Composite Seismogenic Sources*
- *Debated Seismogenic Sources*
- *Subductions*

Each record of the DATABASE is formed by:

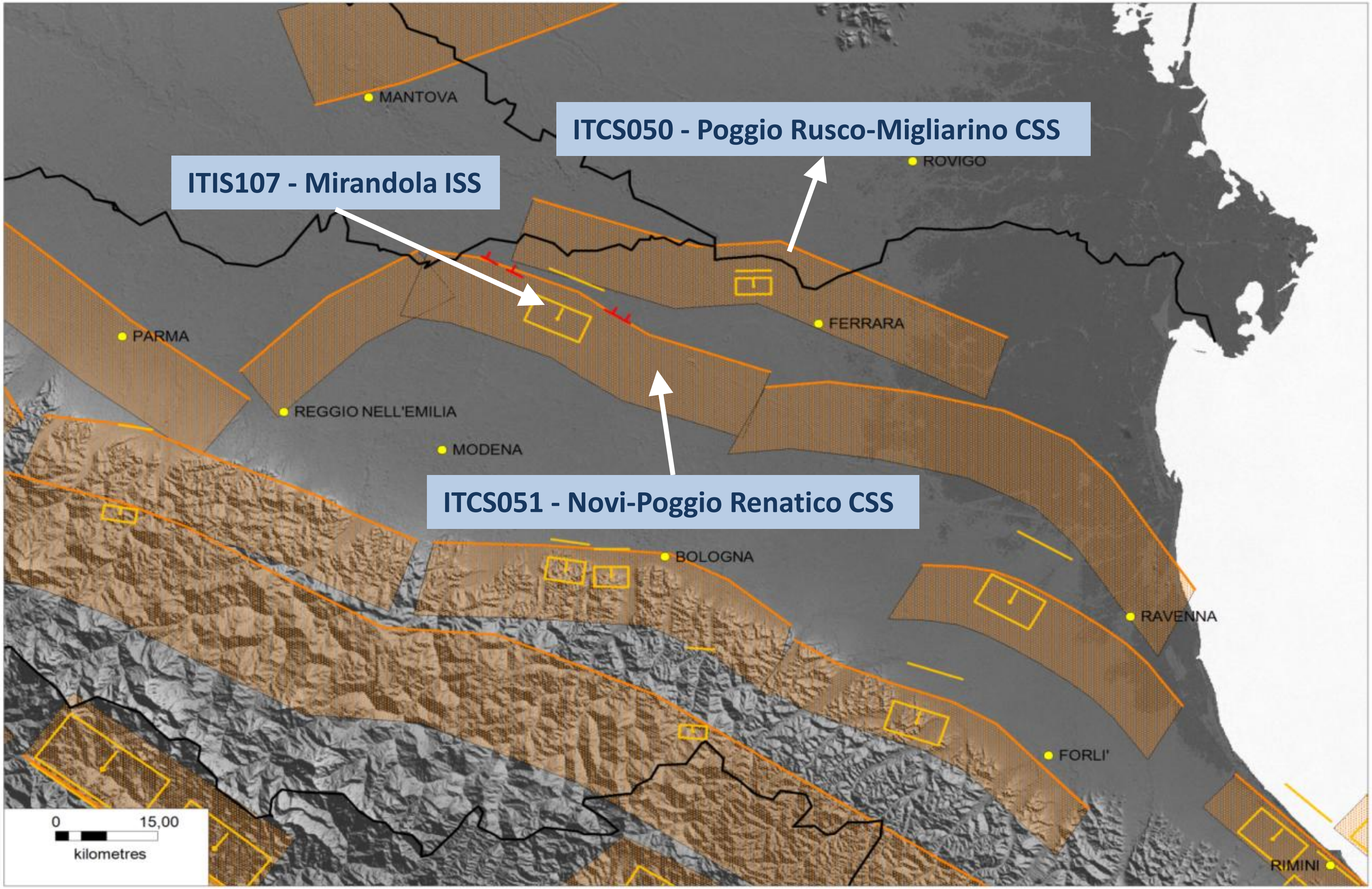
1. a geographic feature;
2. a set of alphanumeric attributes;
3. optional geographic features with attributes (active fault traces and active fold axes);
4. a commentary;
5. a set of pictures, each supplemented by a title and a caption;
6. a list of pertinent references.

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

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

DISS: esempio di navigazione <http://diss.rm.ingv.it/diss/>

Sorgenti individuali e sorgenti composite in Pianura Padana



DISS: esempio di navigazione <http://diss.rm.ingv.it/diss/>

Esempio di un record completo del database: la sorgente individuale di Mirandola, ITIS107

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 recent tectonic activity of the buried Ferrara Arc, highlighted by tl exerted on the evolution of the drainage network and by the geom syntectonic growth strata.

In the area located between the Pede-Apenninic Thrust front and fronts of the Northern Apennines an active compressional tectoni documented by borehole breakout data with N-S oriented maximu focal mechanism and GPS data.

The Pede-Apenninic Thrust Front is traditionally considered an ac sequence thrust of the Northern Apennines belt, with a continuou Apennines foot-hills defined by geologic and geomorphic evidence Boccaletti et al., 2004). However, recent papers proposed that th feature of the pede-Apennines foot-hills is not the expression of a shallow thrust fault (Picotti and Pazzaglia, 2008). According to th of the regional deformation would be taken by a deep, blind thrus responsible of the large scale geomorphology of the Northern Ape

The ongoing activity of the more external Northern Apennines thru in the plain is still a matter of debate, probable due to the unfavor between tectonic activity (expressed as vertical deformation due t anticlines) and the rates of sedimentation. As a consequence, on geophysical and geological subsurface data are able to show the of the buried structures.

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

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

In particular, activity of the Mirandola Source was responsible for in the sincline and diversion around the anticline of the Secchia a rivers, whose paleo-courses show consistent evolution with migra areas of relative subsidence. The use of high resolution stratigrap highlighted the geometry of growth strata in sintectonic strata, an calculate the relative uplift rates of the growing anticline during th Quaternary, obtaining 0.16 mm/a of relative uplift rate for the last

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

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.

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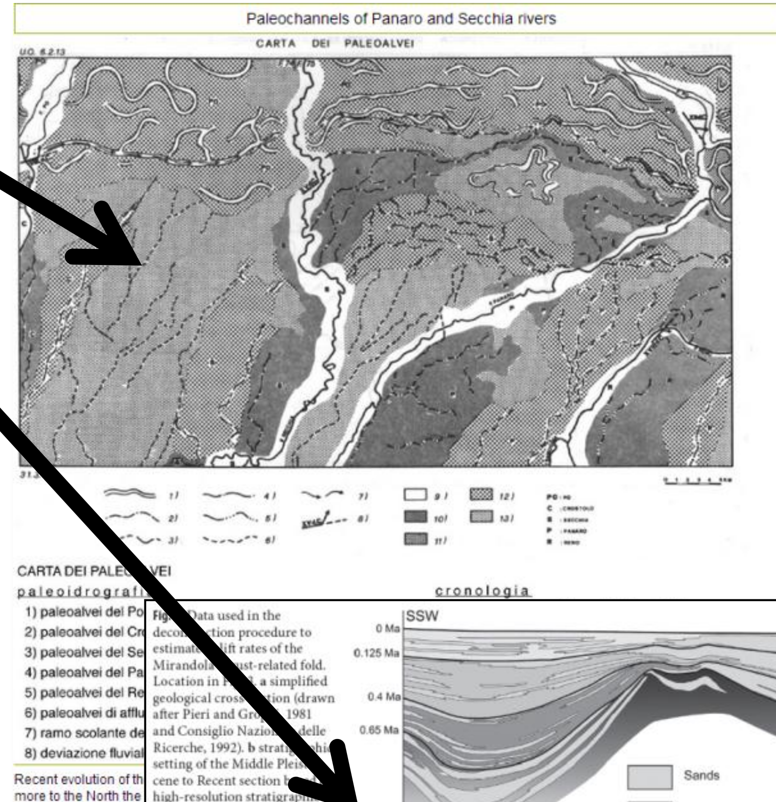
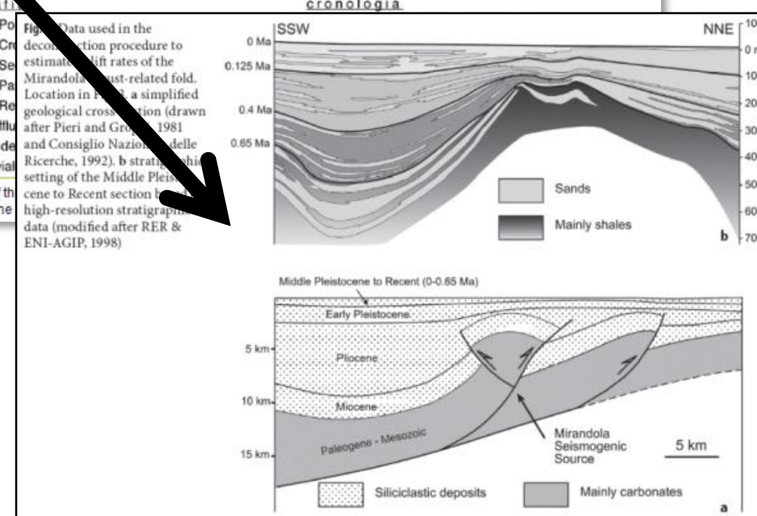
Esempio di un record completo del database: la sorgente individuale di Mirandola, ITIS107

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	





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Esempi di sorgenti composite: informazioni generali e parametriche, ITCS050 e 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;

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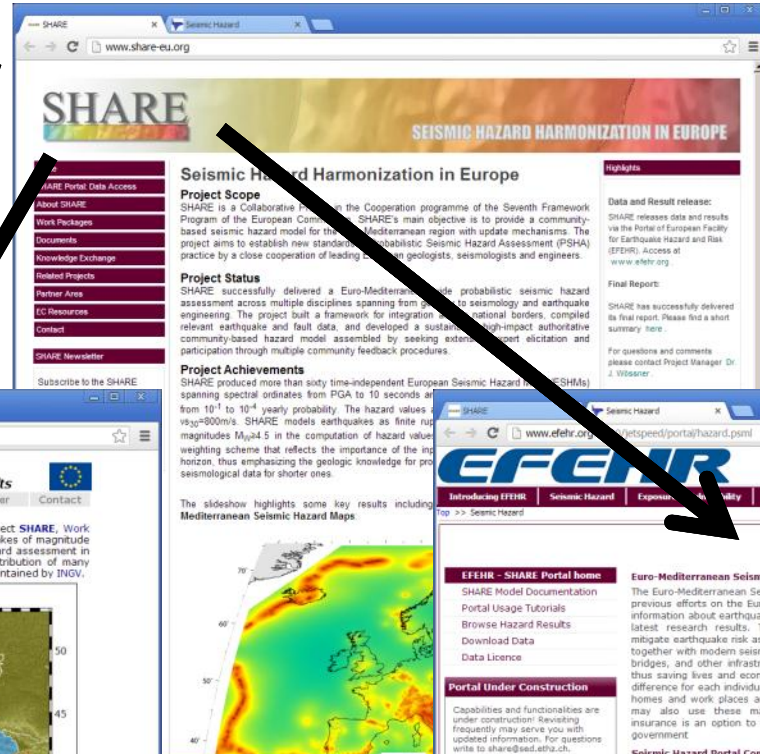
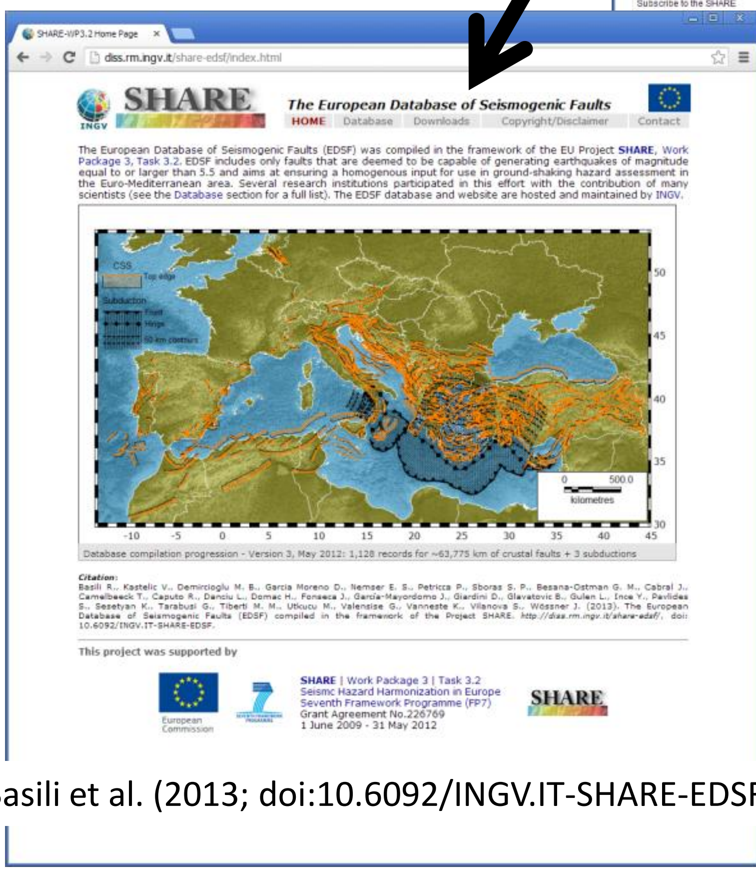
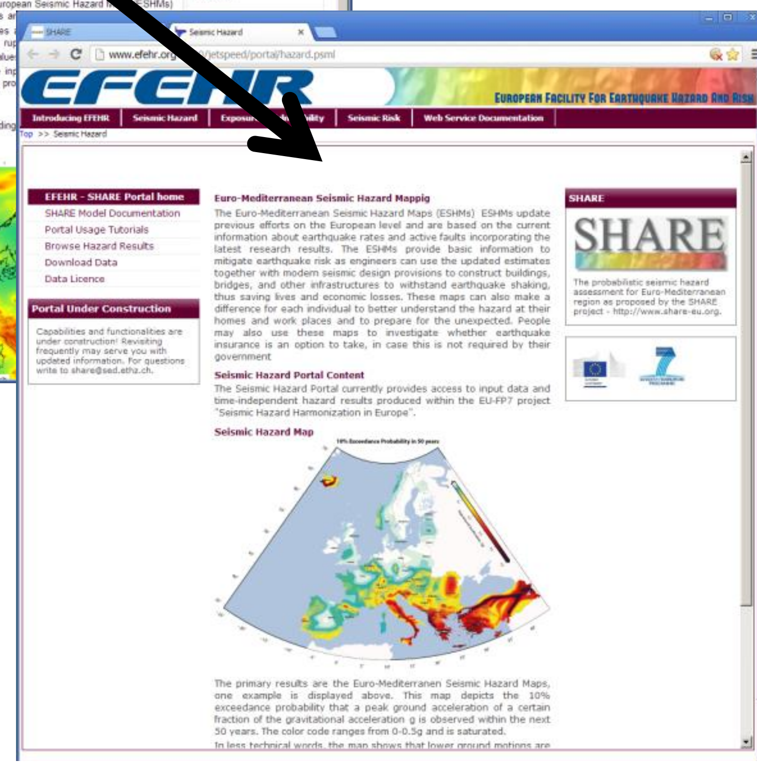
http://www.share-eu.org/



Banca dati delle faglie sismogenetiche

Mappe di pericolosità





Basili et al. (2013; doi:10.6092/INGV.IT-SHARE-EDSF)

Giardini et al. (2013; doi:10.12686/SED-00000001-SHARE)

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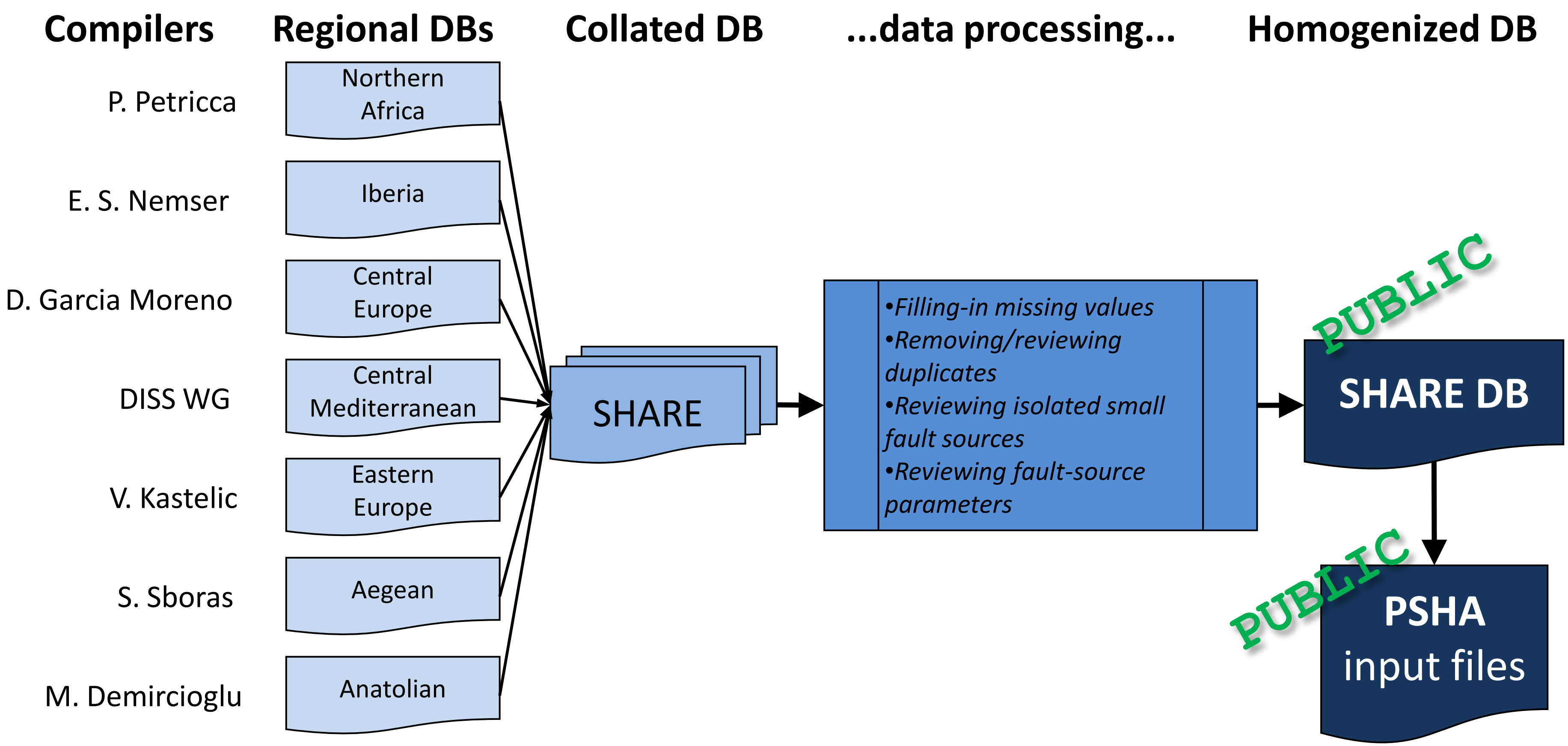

Contributors: 109 scientists from 49 different institutions plus a number of regional initiatives from DISS WG (Italy), EMME Project (Turkey), GreDASS (Greece), QAFI (Spain and Portugal)

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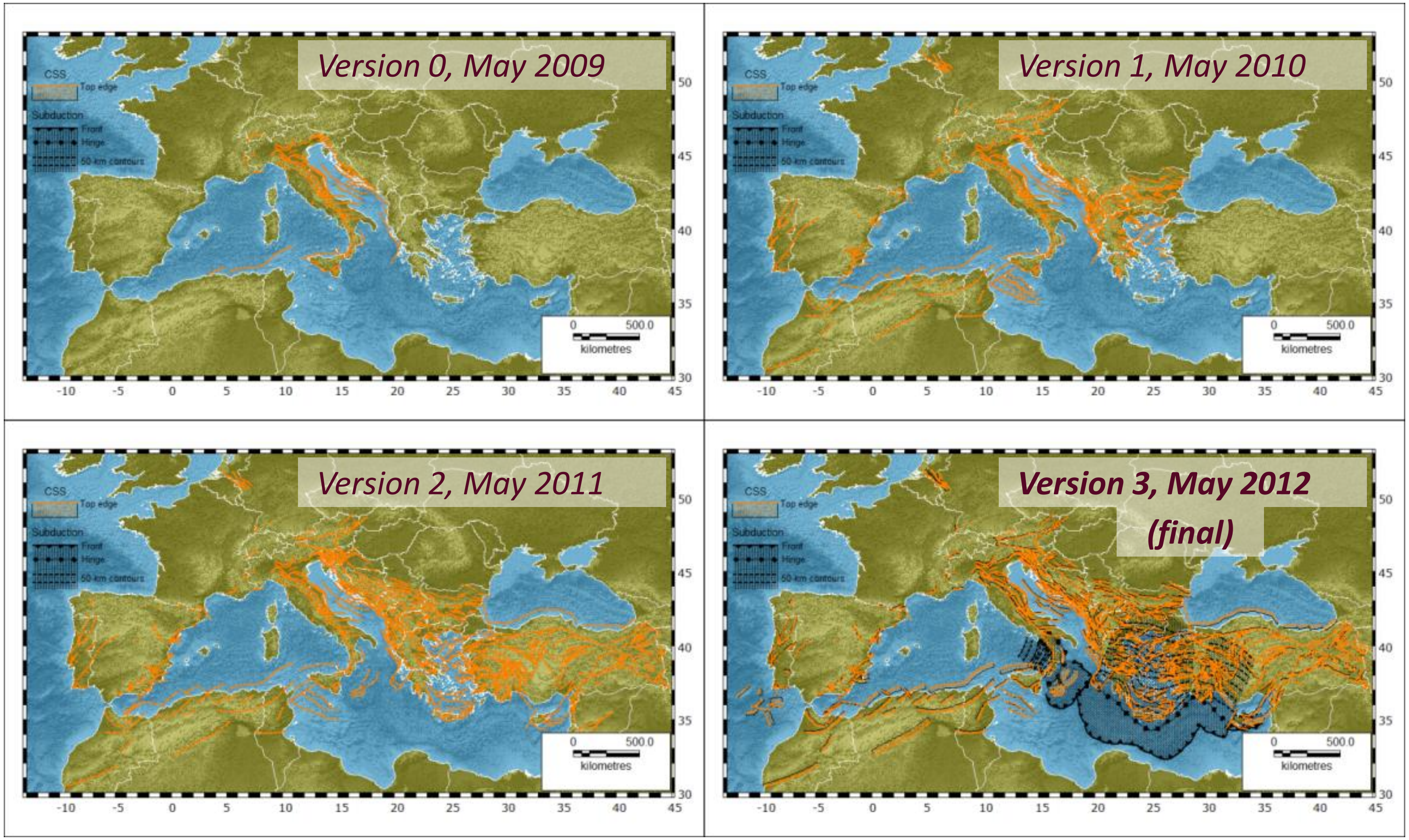
Database compilation progression



1,128 records for ~63,775 km of crustal faults + 3 subductions

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