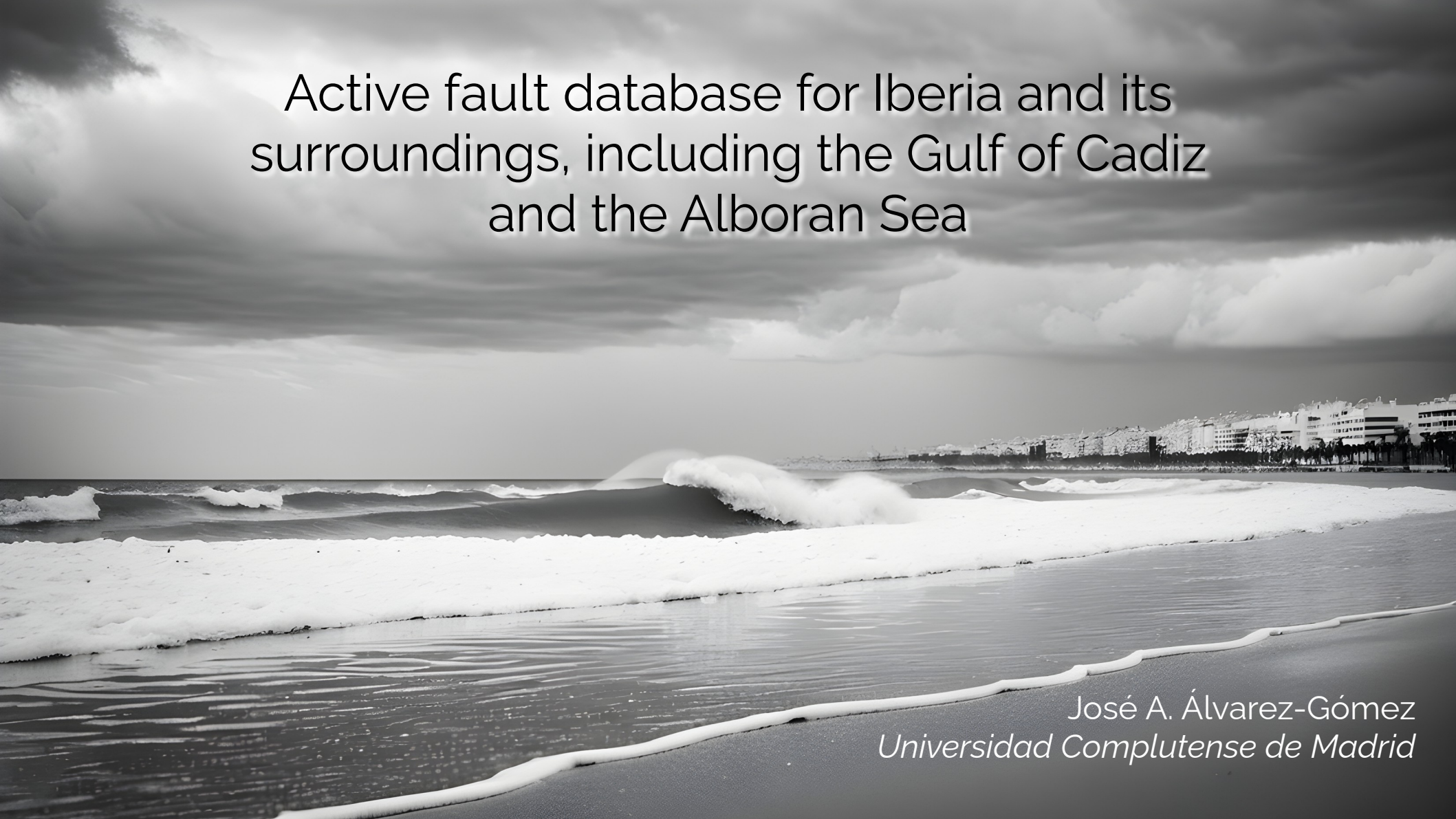
Active fault database for Iberia and its surroundings, including the Gulf of Cadiz and the Alboran Sea



José A. Álvarez-Gómez
Universidad Complutense de Madrid

The Quaternary-active faults database of Iberia (QAFI)

http://info.igme.es/qafi/

The **QAFI** is a community-based active faults database maintained and curated by the Geological Institute of Spain (IGME-CSIC).

Technical editors (ACCESS database):

Santiago Martín Alfageme (QAFI v.2) (IGME-CSIC)
Julián García-Mayordomo (QAFI v.3 and 4) (IGME-CSIC)

Technical editors (Shapefiles):

Raquel Martín-Banda (IGME-CSIC)
Julián García-Mayordomo (IGME-CSIC)

Web application:

Ángel Prieto Martín (IGME-CSIC)

Scientific editors of QAFI v.4:

Julián García-Mayordomo (IGME-CSIC)
Raquel Martín-Banda (IGME-CSIC)
Carolina Canora Catalán (U. Autónoma de Madrid)
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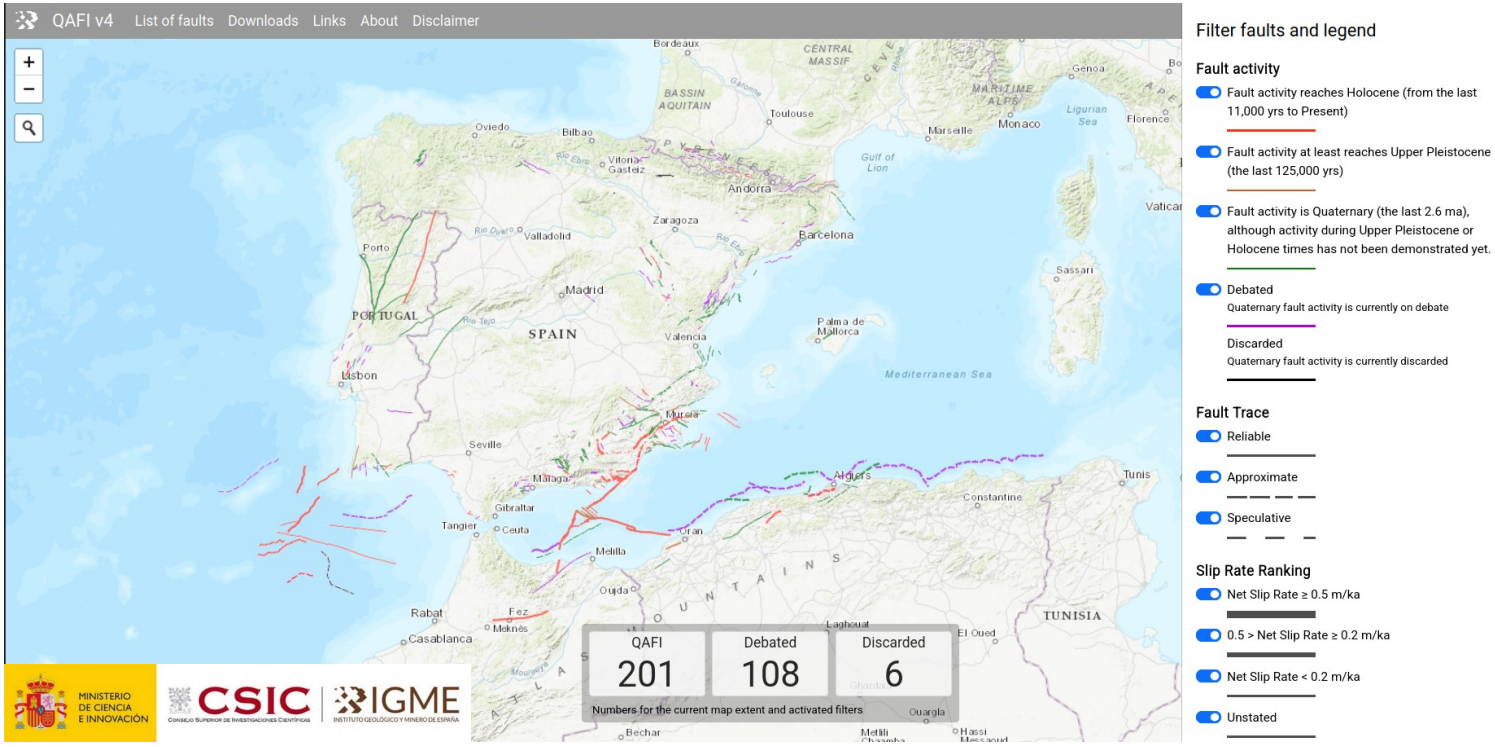


Details of the fault AT004

Marquês de Pombal: AT004

Identification - compilation

Identification

Identification code : AT004
Fault name : Marquês de Pombal
Identification method : Marine geophysical methods
Geological and geographical set : Atlantic Ocean [Offshore Southwest Iberia]

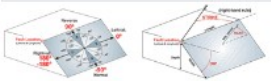
Compilation

Name/s of the compiler/s : Gràcia, E., Bartolomé, R., Martínez, S. and Lo Iacono, C.
Filiation/s : Unitat de Tecnologia Marina - CSIC
Email : egracia@cmima.csic.es
Latest update : 2010-12-30

Location

Geometry and kinematics

Conventions



	Variability/Error	Source	Brief comment
Average strike (°) - 27	± 5	EJ	Based on Martínez Loriente et al (2018) map; after Vanneste (2009) and Gràcia et al. (2010).
Dip (°) - 24	± 5	LD	Depth conversion of a MCS profile (Zitellini et al., 2001; 2004)
Rake (°) - 90	± 10	EJ	Assumed pure reverse
Sense of movement - R		LD	Displacement of reflectors on seismic data (Vanneste, 2009; Gràcia et al., 2010).
Length (km) - 66	± 5	EJ	Based on Martínez Loriente et al (2018) map; after Vanneste (2009) and Gràcia et al. (2010). Towards the south it may connect with the basement Horseshoe Abyssal Thrust (HAT) (Martínez Loriente et al., 2018).
Min depth (km) - 0		LD	Vanneste, 2009; Gràcia et al., 2010.
Max depth (km) - 33	20-50	EJ	Assumed same values as Horseshoe fault (AT001) and San Vicente Fault (see Martínez Loriente et al., 2018). Fault located at contact between very different crusts (continental overthrusting exhumed mantle), depth could be 40-50 km.
Width (km) - 66.588		AK	
Area (km²) - 3792.185		AK	

Quaternary activity

Strength: A+

	Variability/Error	Source	Brief comment
Quaternary activity evidence - Surface expression, offset Quaternary horizons, folds, landslides associated, tectonic control on San Vicente canyon			
		LD	Vanneste, 2009; Gràcia et al., 2010; Ilarra et al., 2020
Age of the youngest deposits or landforms (ka) - MIS affected by the fault - y: 87		LD	Age of the last mass transport deposit associated to the fault. We relate it to the 1755 Lisbon Earthquake (Vanneste, 2009; Gràcia et al., 2010).

Slip rate

Accuracy: Not rated

	Variability/Error	Source	Brief comment
Vertical Slip Rate HSR (mm/kyr) - 0.368	0.064	EJ	Based on MCS profile as shown in Ilarra et al. (2020) Fig. 9 - offset 1.3± ±0.05 (km) or 1150.8 ±50 m (0.1700 m/a ±200) and age from core la mutine (3800 kyr±100).
Horizontal Slip Rate HSR (mm/kyr) - 0		EJ	Assumed pure dip-slip
Net Slip Rate HSR (mm/kyr) - 0.906	0.156	AK	From VSR, Dip and Rake

Paleoearthquakes

	Variability/Error	Source	Brief comment
Net slip per event at the Surface (m) -			Unknown
Number of Seismic Events - 4		LD	We observe a total of 4 successive mass transport deposits associated to this fault (Vanneste, 2009; Gràcia et al., 2010).
Evidence of seismic creep? -			Unknown

Seismic parameters

	Variability/Error	Source	Brief comment
Maximum magnitude (Mw) - 8.1 Reliability: A	8.0-8.5	LD	Lima et al. (2020).
Recurrence interval (years) - 3800 Reliability: Not rated		LD	Based on the average recurrence of successive mass transport deposits associated to the Marquês de Pombal Fault (Vanneste, 2009; Gràcia et al., 2010).
Date of last major earthquake (years) -			Unknown

Associated seismicity

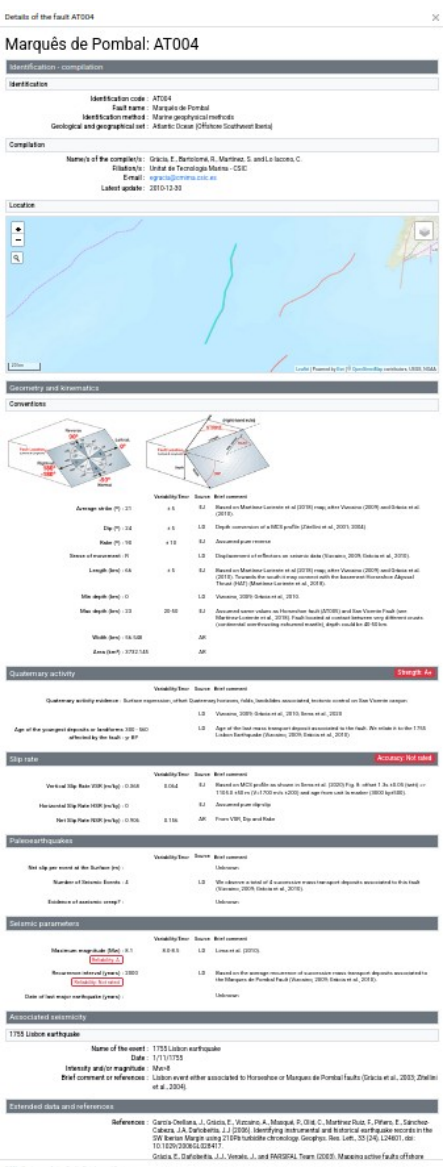
1755 Lisbon earthquake

Name of the event : 1755 Lisbon earthquake
Date : 1/11/1755
Intensity and/or magnitude : Mw=8
Brief comment or references : Lisbon event either associated to Horseshoe or Marques de Pombal faults (Gràcia et al., 2003; Zitellini et al., 2004).

Extended data and references

References : Garcia-Orellana, J., Gràcia, E., Vizcaino, A., Masqué, P., Olid, C., Martínez-Ruiz, F., Piñero, E., Sánchez-Cabeza, J.A. Dañobeitia, J.J (2006). Identifying instrumental and historical earthquake records in the SW Iberian Margin using 210Pb turbidite chronology. Geophys. Res. Lett., 33 (24), L24601, doi: 10.1029/2006GL028417

Gràcia, E., Dañobeitia, J.J., Vernés, J., and PARSEAL Team (2003). Mapping active faults offshore



Marquês de Pombal: AT004

Identification - compilation

Identification

Identification code :	AT004
Fault name :	Marquês de Pombal
Identification method :	Marine geophysical methods
Geological and geographical set :	Atlantic Ocean (Offshore Southwest Iberia)

Compilation

Name/s of the compiler/s :	Gràcia, E., Bartolomé, R., Martínez, S. and Lo Iacono, C.
Filiation/s :	Unitat de Tecnologia Marina - CSIC
E-mail :	egracia@cmima.csic.es
Latest update :	2010-12-30

Location

Details of the fault AT004

Marquês de Pombal: AT004

Identification - compilation

Identification

Compilation

Location

Geometry and kinematics

Conventions

Quaternary activity

Slip rate

Paleoearthquakes

Seismic parameters

Associated seismicity

1755 Lisbon earthquake

Extended data and references

Marquês de Pombal: AT004

Identification - compilation

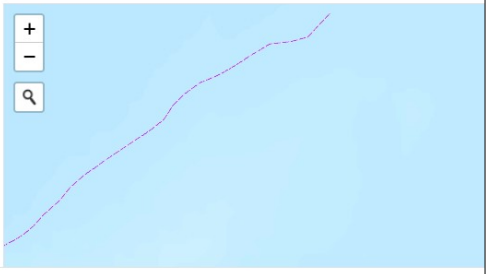
Identification

Identification code : AT004
Fault name : Marquês de Pombal
Identification method : Marine geophysical methods
Geological and geographical set : Atlantic Ocean (Offs

Compilation

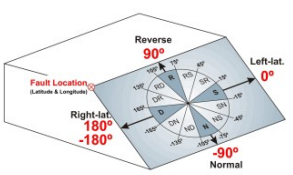
Name/s of the compiler/s : Gràcia, E., Bartolomé,
Filiation/s : Unitat de Tecnologia
E-mail : egracia@cmima.csic.
Latest update : 2010-12-30

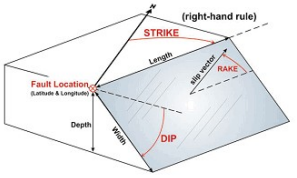
Location



Geometry and kinematics

Conventions





	Variability/Error	Source	Brief comment
Average strike (°) : 21	± 5	EJ	Based on Martínez-Loriente et al (2018) map, after Vizcaino (2009) and Gràcia et al. (2010).
Dip (°) : 24	± 5	LD	Depth conversion of a MCS profile (Zitellini et al., 2001; 2004)
Rake (°) : 90	± 10	EJ	Assumed pure reverse
Sense of movement : R		LD	Displacement of reflectors on seismic data (Vizcaino, 2009; Gràcia et al., 2010).
Length (km) : 66	± 5	EJ	Based on Martínez-Loriente et al (2018) map, after Vizcaino (2009) and Gràcia et al. (2010). Towards the south it may connect with the basement Horseshoe Abyssal Thrust (HAT) (Martínez-Loriente et al., 2018).
Min depth (km) : 0		LD	Vizcaino, 2009; Gràcia et al., 2010.
Max depth (km) : 23	20-50	EJ	Assumed same values as Horseshoe fault (AT005) and San Vicente Fault (see Martínez-Loriente et al., 2018). Fault located at contact between very different crusts (continental overthrusting exhumed mantle), depth could be 40-50 km.
Width (km) : 56.548		AR	

Details of the fault AT004

Marquês de Pombal: AT004

Identification - compilation

Identification

Identification code : AT004
Fault name : Marquês de Pombal
Identification method : Marine geophysical methods
Geological and geographical set : Atlantic Ocean (Offs

Compilation

Name/s of the compiler/s : Gràcia, E., Bartolomé,

Location

Geometry and kinematics

Conventions

(right-hand rule)
STRIKE

Quaternary activity

Strength: A+

		Variability/Error	Source	Brief comment
Quaternary activity evidence :	Surface expression, offset Quaternary horizons, folds, landslides associated, tectonic control on San Vicente canyon			
			LD	Vizcaino, 2009; Gràcia et al., 2010; Serra et al., 2020
Age of the youngest deposits or landforms affected by the fault :	300 - 560 yr BP		LD	Age of the last mass transport deposit associated to the fault. We relate it to the 1755 Lisbon Earthquake (Vizcaino, 2009; Gràcia et al., 2010)

Slip rate

Accuracy: Not rated

		Variability/Error	Source	Brief comment
Vertical Slip Rate VSR (m/ky) :	0.368	0.064	EJ	Based on MCS profile as shown in Serra et al. (2020) Fig. 8: offset 1.3s ±0.05 (twtt) => 1105.0 ±50 m (V=1700 m/s ±200) and age from unit Ia marker (3000 ky±500).
Horizontal Slip Rate HSR (m/ky) :	0		EJ	Assumed pure dip-slip
Net Slip Rate NSR (m/ky) :	0.906	0.156	AR	From VSR, Dip and Rake

Paleoearthquakes

		Variability/Error	Source	Brief comment
Net slip per event at the Surface (m) :				Unknown
Number of Seismic Events :	4		LD	We observe a total of 4 successive mass transport deposits associated to this fault (Vizcaino, 2009; Gràcia et al., 2010).
Evidence of aseismic creep? :				Unknown

Seismic parameters

		Variability/Error	Source	Brief comment
Maximum magnitude (Mw) :	8.1 Reliability: A	8.0-8.5	LD	Lima et al. (2010).
Recurrence interval (years) :	2000 Reliability: Not rated		LD	Based on the average recurrence of successive mass transport deposits associated to the Marques de Pombal Fault (Vizcaino, 2009; Gràcia et al., 2010).
Date of last major earthquake (years) :				Unknown

8) map, after Vizcaino (2009) and Gràcia et al.

ellini et al., 2001; 2004)

data (Vizcaino, 2009; Gràcia et al., 2010).

8) map, after Vizcaino (2009) and Gràcia et al.
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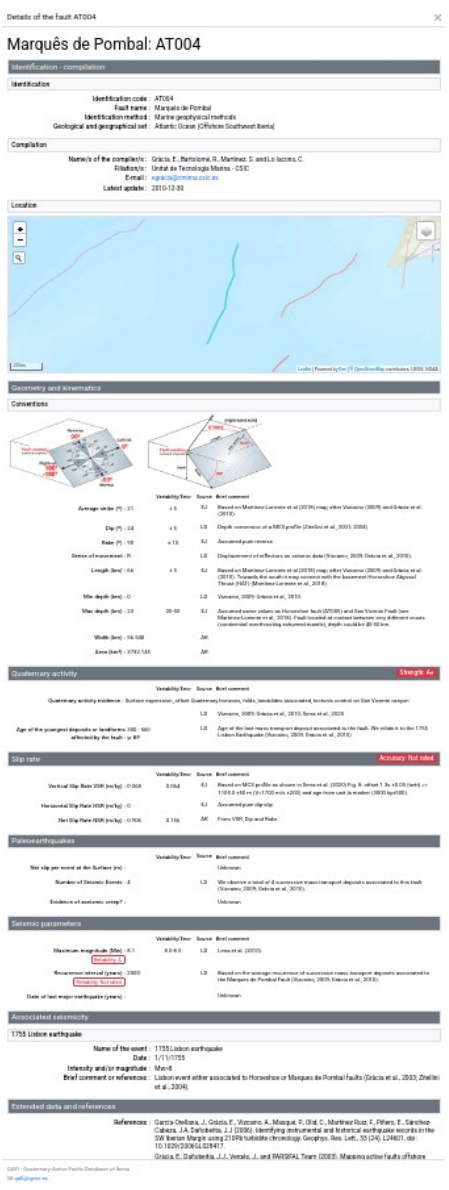

Marquês de Pombal: AT004

Identification - compilation

Identification

Identification code : AT00
Fault name : Marq
Identification method : Marir
Geological and geographical set : Atlan

Compilation

Name/s of the compiler/s : Gràcia

Location

Quaternary activity

Quaternary activity evidence

Age of the youngest deposits or landforn
affected by the faul

Slip rate

Vertical Slip Rate VSR (m/ky

Horizontal Slip Rate HSR (m/ky

Net Slip Rate NSR (m/ky

Paleoearthquakes

Net slip per event at the Surface (m

Number of Seismic Event

Evidence of aseismic creep

Seismic parameters

Maximum magnitude (Mw

Reliability:

Recurrence interval (years

Reliability: Not rate

Date of last major earthquake (years

Extended data and references

References :

García-Orellana, J., Gràcia, E., Vizcaino, A., Masqué, P., Olid, C., Martínez Ruiz, F., Piñero, E., Sánchez-Cabeza, J.A, Dañobeitia, J.J (2006). Identifying instrumental and historical earthquake records in the SW Iberian Margin using 210Pb turbidite chronology. Geophys. Res. Lett., 33 (24), L24601, doi: 10.1029/2006GL028417.

Gràcia, E., Dañobeitia, J.J., Vergés, J., and PARSIFAL Team (2003). Mapping active faults offshore Portugal (38°N-36°N): Implications for seismic hazard assessment along the southwest Iberian Margin. Geology, 31, 83-86.

Gràcia, E., Vizcaino, A., Escutia, C., Asioli, A., Rodés, A., Pallàs, R., García Orellana, J., Lebreiro, S., Goldfinger, C (2010). Holocene earthquake record offshore Portugal (SW Iberia): Testing turbidite paleoseismology in a slow-convergence margin. Quaternary Science Reviews, 29, 1156–1172.

Gràcia, E., Bartolomé, R., Lo Iacono, C., Moreno, X., Martínez-Loriente, S., Perea, H., Masana, E., Pallàs, R., Díez, S., Dañobeitia, J.J., Terrinha, P., Zitellini, N. (2010). Characterizing active faults and associated mass transport deposits in the South Iberian Margin (Alboran Sea and Gulf of Cadiz): On-fault and off-fault paleoseismic evidence. En: Contribución de la Geología al Análisis de la Peligrosidad Sísmica (J.M. Insúa y F.Martín-González, eds.), pp. 163-166. IBERFAULT, Sigüenza (Guadalajara), 27-29 Octubre 2010.

Geissler et al., 2010. Focal mechanisms for sub-crustal earthquakes in the Gulf of Cadiz from a dense OBS deployment. Geophys. Res. Lett., 37, L18309.

Martínez-Loriente, S., Gràcia, E., Bartolome, R., Perea, H., Klaeschen, D., Dañobeitia, J. J., Zitellini, N., Wynn, R. B., & Masson, D. G. (2018). Morphostructure, tectono-sedimentary evolution and seismic potential of the Horseshoe Fault, SW Iberian Margin. Basin Research, 30, 382–400. https://doi.org/10.1111/bre.12225

Serra, C.S, Martínez-Loriente, S., E. Gràcia, Urgeles, R., Vizcaino, A., Perea, H., Bartolome, R., Pallàs, R., Lo Iacono, C., Diez, S., Dañobeitia, J.J., Terrinha, P., Zitellini, N. (2020) Tectonic evolution, geomorphology and influence of bottom currents along a large submarine canyon system: The São Vicente Canyon (SW Iberian margin). Marine Geology, 426, https://doi.org/10.1016/j.margeo.2020.106219.

Stich, D., Mancilla, F., Morales, J., 2005. Crust-mantle coupling in the Gulf of Cadiz (SW Iberia). Geophys. Res. Lett., 32, L13306, doi:10.1029/2005GL023098.

Stich et al., 2010. Moment tensor inversion for Iberia-Maghreb earthquakes 2005-2008. Tectonophysics, 483, 390-398.

Lima,V.V., J. M. Miranda , M. A. Baptista, J. Catalao, M. Gonzalez, L. Otero, M. Olabarrieta, J. A. Alvarez-Gomez, and E. Carreño (2010): Impact of a 1755-like tsunami in Huelva, Spain. Natural Hazards and Earth System Science, 10: 1-10.

Martínez-Loriente, S., Gràcia, E., Bartolome, R., Perea, H., Klaeschen, D., Dañobeitia, J. J., Zitellini, N., Wynn, R. B., & Masson, D. G. (2018). Morphostructure, tectono-sedimentary evolution and seismic potential of the Horseshoe Fault, SW Iberian Margin. Basin Research, 30, 382–400. https://doi.org/10.1111/bre.12225

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Vizcaino, A., 2009. "Processos sedimentaris d'edat Holocena al marge sud-oest de la Península Ibèrica: Aplicació a la paleosismologia marina". Tesis Doctoral, Universitat de Barcelona, 281 pp.

Zitellini, N., Mendes, L., Córdoba, D., Dañobeitia, J.J., Nicolich, R., Pellis, G., Ribeiro, A., Sartori, R., Torelli, L., and BIGSETS TEAM (2001). Source of the 1755 Lisbon Earthquake and Tsunami Investigated. EOS, Transactions of AGU, Vol 82 (26), p. 285-290-291.

Zitellini, N., Rovere, M., Terrinha, P., Chierici, F., Matias, L., and BIGSETS Team, 2004. Neogene through Quaternary tectonic reactivation of SW Iberian Passive Margin. Pure Appl. Geophys., 161, 565-587.

The Quaternary-active faults database of Iberia (QAFI)

SISMOGEN
Transferencia de Conocimiento Geológico al Análisis de la Peligrosidad Sísmica en España

II Reunión Ibérica sobre Fallas Activas y Paleosismología
Iberfault

The **QAFI** is a community-based active fa
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Technical editors (ACCESS database):

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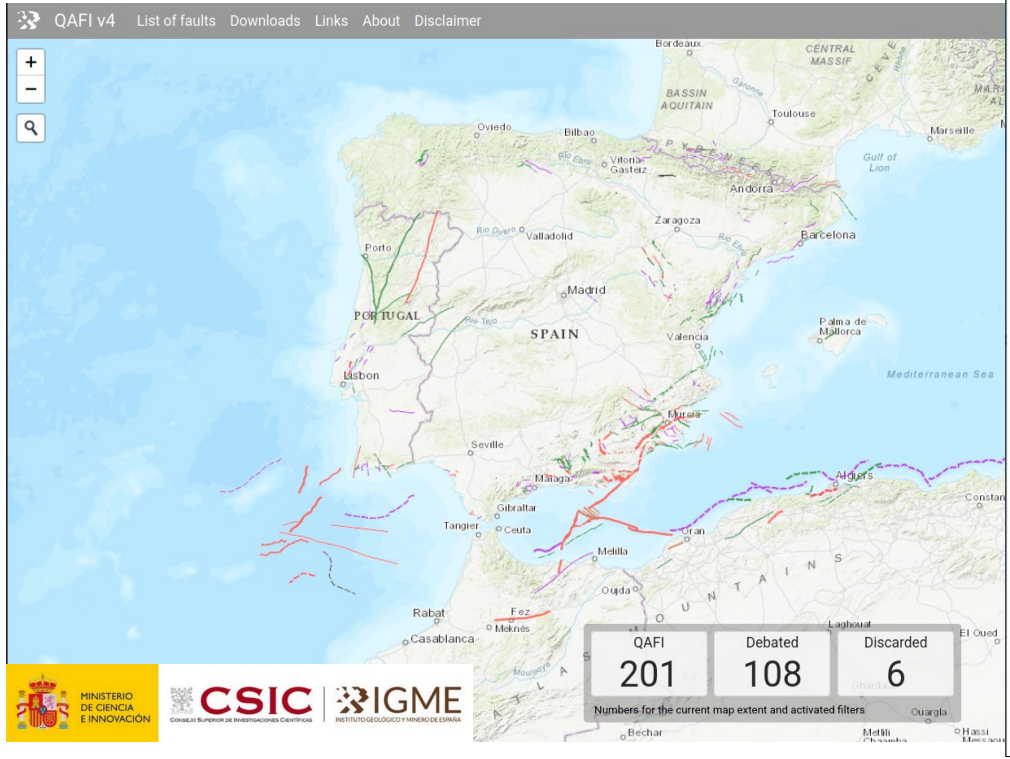


Filter faults and legend

Fault activity

- Fault activity reaches Holocene (from the last 11,000 yrs to Present)
- Fault activity at least reaches Upper Pleistocene (the last 125,000 yrs)
- Fault activity is Quaternary (the last 2.6 ma), although activity during Upper Pleistocene or Holocene times has not been demonstrated yet.
- Debated
  Quaternary fault activity is currently on debate
- Discarded
  Quaternary fault activity is currently discarded

Fault Trace

- Reliable
- Approximate
- Speculative

Slip Rate Ranking

- Net Slip Rate ≥ 0.5 m/ka
- 0.5 > Net Slip Rate ≥ 0.2 m/ka
- Net Slip Rate < 0.2 m/ka
- Unstated

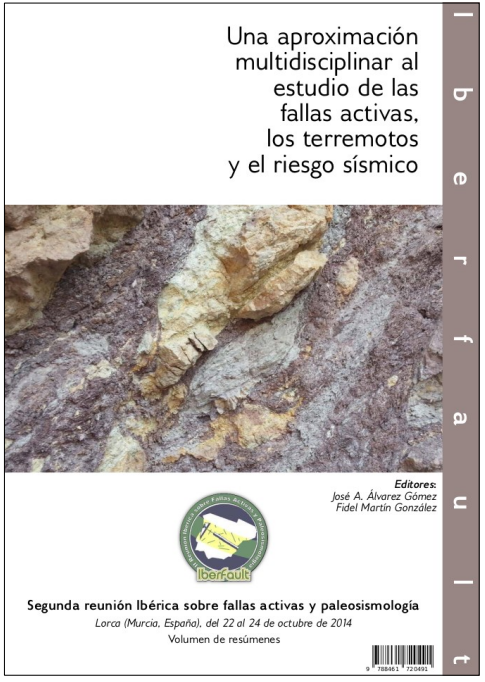
SHARE

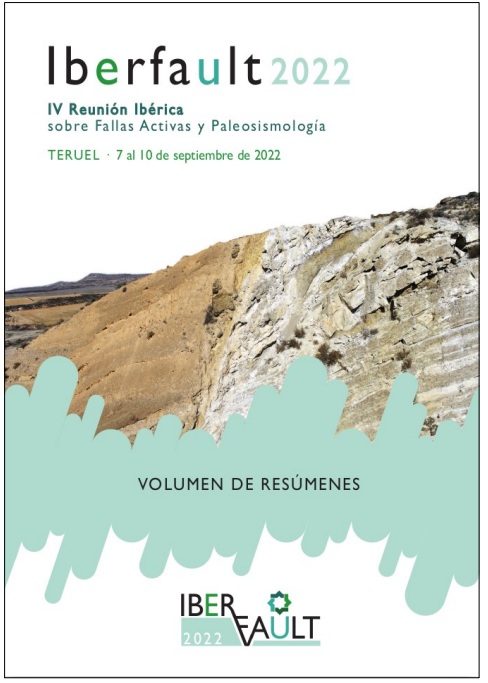
Planetary Geodynamics, Active Tectonics and Related Risks
UCM-910368

FASE-GEO
Caracterización Sismogénica de las Grandes Fallas Activas del Sureste de España Mediante Técnicas Geológicas

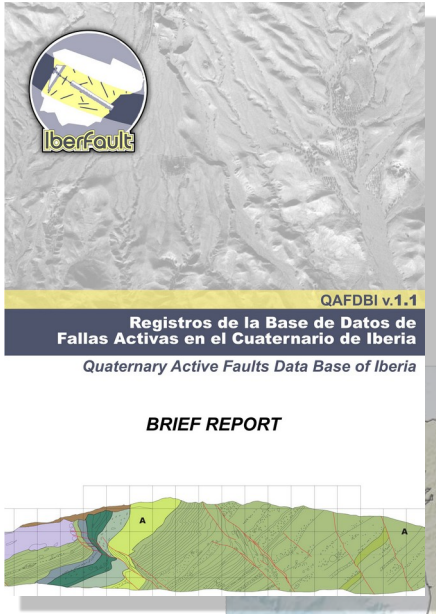
I Reunión Ibérica sobre Fallas Activas y Paleosismología
Iberfault

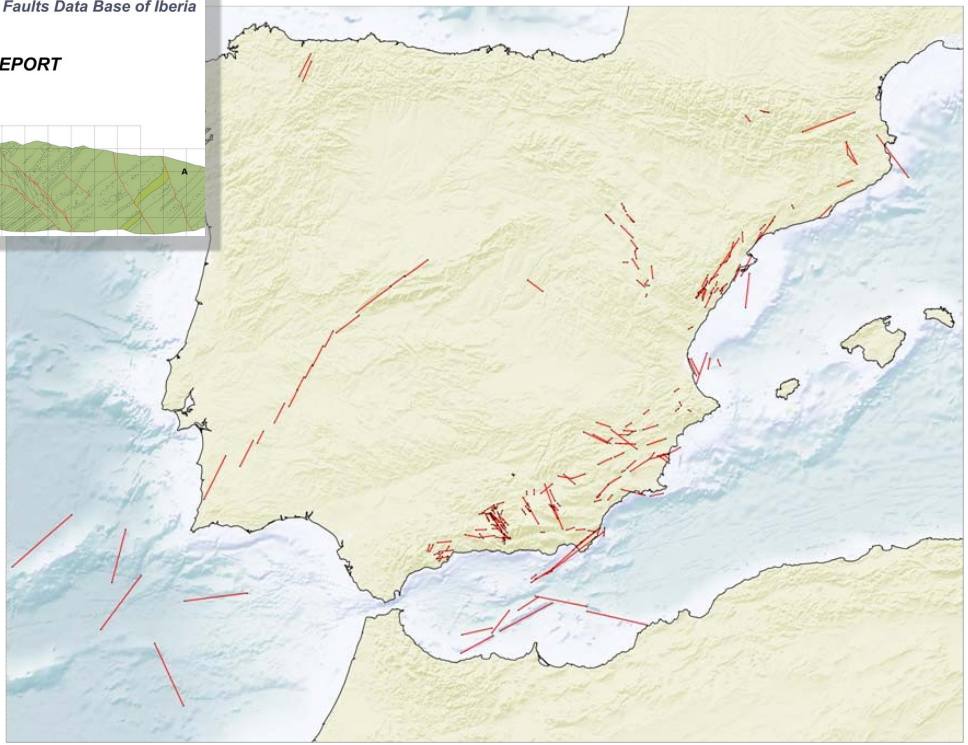
The Iberian active fault and palaeoseismology research community is composed of geologists, geophysicists and geodesists. This community is articulated through specific sessions in several congresses as well as the Iberfault congresses held every 4 years.





QAFDBI v.1.1 (2011)





QAFI v.2.0 (2012)

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Journal of Iberian Geology

Journal of Iberian Geology 38 (1) 2012: 285-302
http://dx.doi.org/10.5209/rev_JIGE.2012.v38.n1.39219

The Quaternary Active Faults Database of Iberia (QAFI v.2.0)

La Base de Datos de Fallas Activas en el Cuaternario de Iberia (QAFI v.2.0)

J. García-Mayordomo[1] *, J.M. Insua-Arévalo[2], J.J. Martínez-Díaz[2], A. Jiménez-Díaz[2], R. Martín-Banda[1], S. Martín-Alfageme[1], J.A. Álvarez-Gómez[3], M. Rodríguez-Peces[2], R. Pérez-López[1], M.A. Rodríguez-Pascua[1], E. Masana[4], H. Perea[5], F. Martín-González[6], J. Giner-Robles[7], E.S. Nemser[8], J. Cabral[5], and QAFI Compilers**

[1]*Instituto Geológico y Minero de España, Madrid, Spain*
julian.garcia@igme.es, r.martin@igme.es, s.martin@igme.es, r.perez@igme.es, ma.rodriguez@igme.es
[2]*Dpt. de Geodinámica, Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, Madrid, Spain.*
insuarev@geo.ucm.es, jmdiaz@geo.ucm.es, ajimenezdiaz@geo.ucm.es, martinjr@geo.ucm.es
[3]*Instituto de Hidráulica Ambiental "IH Cantabria", Universidad de Cantabria, Santander, Spain*
joseantonio.alvarezgomez@unican.es
[4]*Departament de Geodinàmica i Geofísica, Universidad de Barcelona, Barcelona, Spain*
eulalia.masana@ub.edu, hector.perea@fc.ul.pt
[5]*Departamento de Geologia / Instituto D. Luiz, Faculdade de Ciências, Universidade de Lisboa, Portugal*
jcabral@fc.ul.pt
[6]*Área de Geología -ESCET-, Universidad Rey Juan Carlos, Móstoles (Madrid), Spain*
fidel.martin@urjc.es
[7]*Departamento de Geología y Geoquímica. Universidad Autónoma de Madrid. Madrid, Spain*
jorge.giner@uam.es
[8]*Instituto Superior Técnico, Lisboa,*
eliza.nemser@ist.utl.pt
***QAFI Compilers: C. Sanz de Galdeano, J.A. Peláez, F.J. García-Tor*
J.M. Azañón, P. Alfaro, X. Moreno, A. Ferrero-Vega, R. Dias, S. Martín
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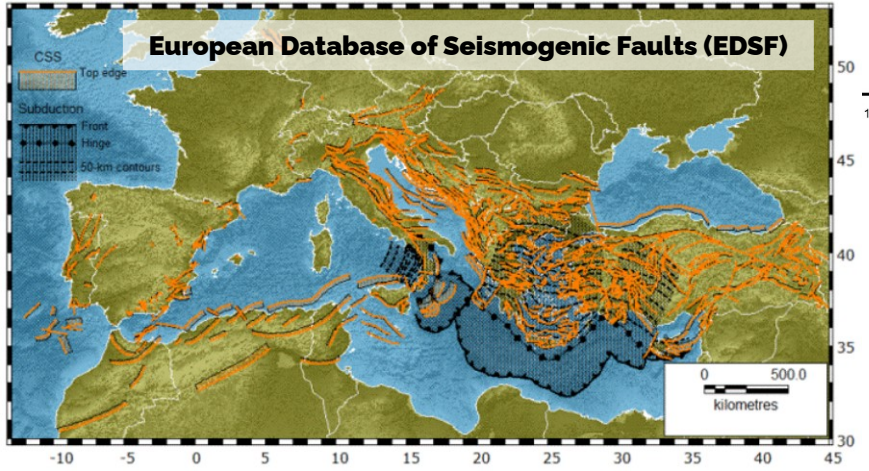
Silveira, E. García-Meléndez, P. Lafuente, J.L. Simón, L.E. Arle

**corresponding author*

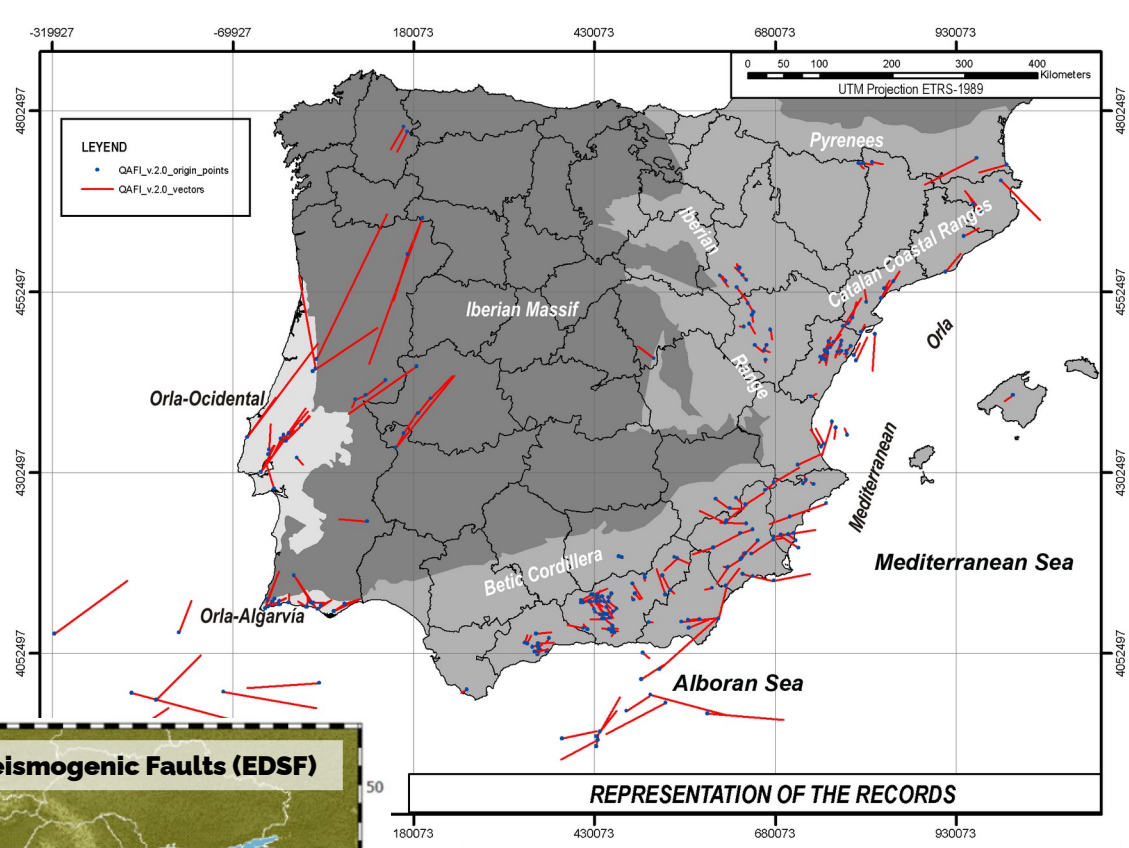
Received: **24/12/2011** / Accepted: 05

Abstract

The Quaternary Active Faults Database of Iberia (QAFI) is an initiative le
(IGME) for building a public repository of scientific data regarding faults ha
(Quaternary). QAFI also addresses a need to transfer geologic knowledge to p
identifying and characterizing seismogenic fault-sources. QAFI is populated b
Earth science researchers, storing to date a total of 262 records. In this article



Basili et al., 2013



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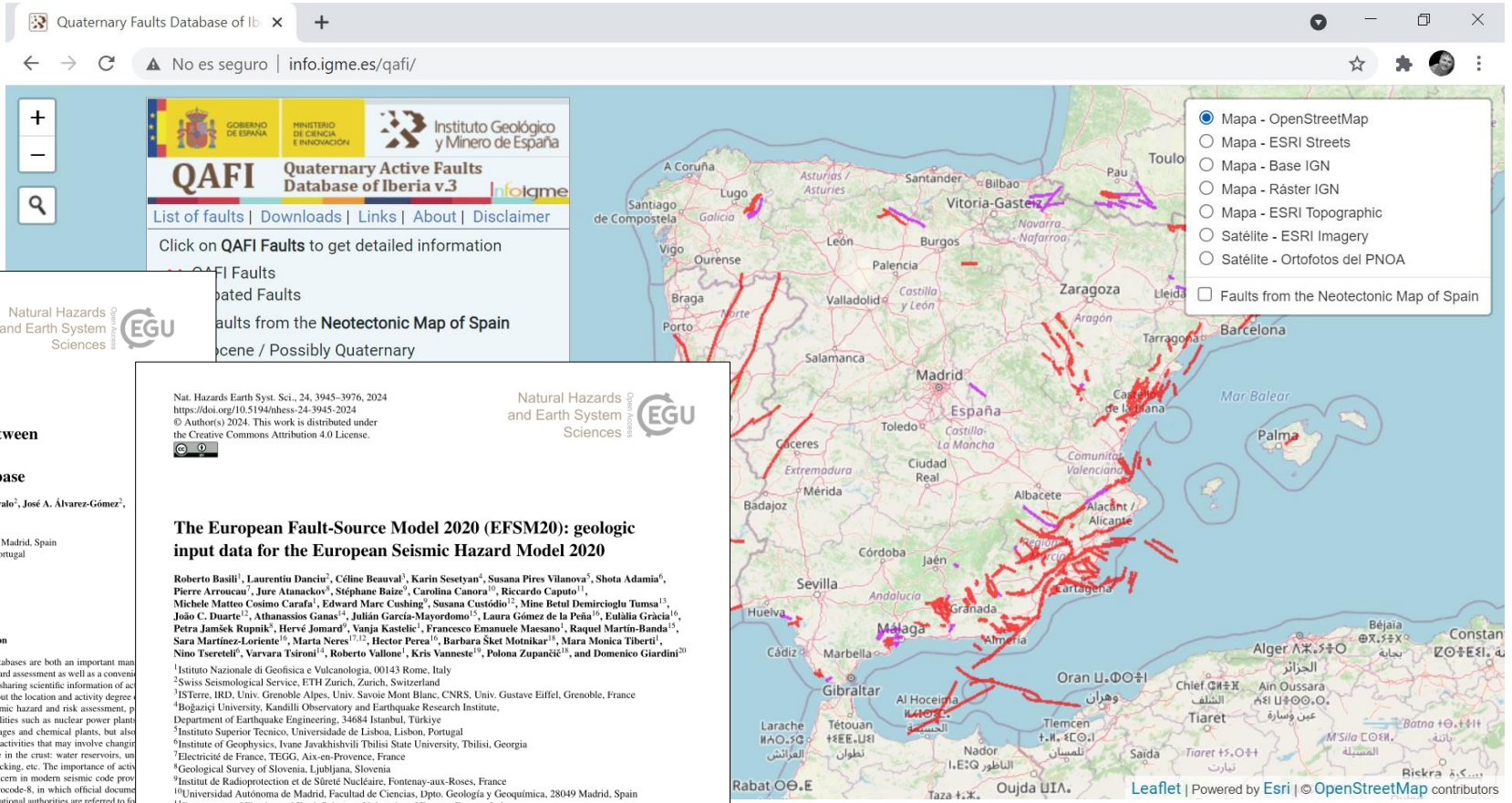
QAFI v.3.0 (2015)



Nat. Hazards Earth Syst. Sci., 17, 1447–1459, 2017
https://doi.org/10.5194/nhess-17-1447-2017

Natural Hazards and Earth System Sciences

Active fault databases: building a bridge between earthquake geologists and seismic hazard practitioners, the case of the QAFI v.3 database

Julián García-Mayordomo[1,2], Raquel Martín-Banda[1,2], Juan M. Insua-Arévalo[2], José A. Álvarez-Gómez[2], José J. Martínez-Díaz[2], and João Cabral[3]

[1]Instituto Geológico y Minero de España, 28003 Madrid, Spain
[2]Department of Geodynamics, Geology Faculty, Complutense University, 28040 Madrid, Spain
[3]Department of Geology, Science Faculty, Lisboa University, 179-016 Lisbon, Portugal

Correspondence to: Julián García-Mayordomo (julian.garcia@igme.es)

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Revised: 7 July 2017 – Accepted: 14 July 2017 – Published: 30 August 2017

Abstract. Active fault databases are a very powerful and useful tool in seismic hazard assessment, particularly when singular faults are considered seismogenic sources. Active fault databases are also a very relevant source of information for earth scientists, earthquake engineers and even teachers or journalists. Hence, active fault databases should be updated and thoroughly reviewed on a regular basis in order to keep a standard quality and uniformed criteria. Desirably, active fault databases should somehow indicate the quality of the geological data and, particularly, the reliability attributed to crucial fault-seismic parameters, such as maximum magnitude and recurrence interval. In this paper we explain how we tackled these issues during the process of updating and reviewing the Quaternary Active Fault Database of Iberia (QAFI) to its current version 3. We devote particular attention to describing the scheme devised for classifying the quality and representativeness of the geological evidence of Quaternary activity and the accuracy of the slip rate estimation in the database. Subsequently, we use this information as input for a straightforward rating of the level of reliability of maximum magnitude and recurrence interval fault seismic parameters. We conclude that QAFI v.3 is a much better database than version 2 either for proper use in seismic hazard applications or as an informative source for non-specialized users. However, we already envision new improvements for a future update.

1 Introduction

Active fault databases are both an important man
for seismic hazard assessment as well as a conveni
displaying and sharing scientific information of act
Knowledge about the location and activity degree
crucial for seismic hazard and risk assessment, pl
for critical facilities such as nuclear power plants
tive waste storages and chemical plants, but also
ning anthropic activities that may involve changir
ural stress state in the crust: water reservoirs, un
gas storage, fracking, etc. The importance of activ
a matter of concern in modern seismic code prov
example in Eurocode-8, in which official docume
by competent national authorities are referred to fo
tification of such faults (e.g. Eurocode-8: Part 5; CE
Active fault databases are also key for tsunami haz
ments (e.g. Álvarez-Gómez et al., 2011) as well a
warning systems, which are largely based on pre
tsunamigenic faulting scenarios derived from infor
such databases (e.g. Gailler et al., 2013).

Since the Quaternary Active Faults Database
(QAFI v.2) was released in February 2012
Mayordomo et al., 2012a), an increasing number
have made use of it. The most relevant use so far h
the creation of the new seismic hazard map of Sp
UPM, 2013), performed considering the foreseer
of Eurocode-8 throughout 2017. QAFI faults we
ered to be complementary information for designin

Published by Copernicus Publications on behalf of the European Geosciences Union.

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Natural Hazards and Earth System Sciences

The European Fault-Source Model 2020 (EFSM20): geologic input data for the European Seismic Hazard Model 2020

Roberto Basili[1], Laurentiu Danciu[2], Céline Beauval[3], Karin Sesetyan[4], Susana Pires Vilanova[5], Shota Adamia[6], Pierre Arroucau[7], Jure Atanackov[8], Stéphane Baize[9], Carolina Canora[10], Riccardo Caputo[11], Michele Matteo Cosimo Carafa[1], Edward Marc Cushing[9], Susana Custódio[12], Mine Betul Demircioglu Tumsa[13], João C. Duarte[12], Athanassios Ganas[14], Julián García-Mayordomo[15], Laura Gómez de la Peña[16], Eulàlia Gràcia[16], Petra Jamšek Rupnik[8], Hervé Jomard[9], Vanja Kastelic[1], Francesco Emanuele Maesano[1], Raquel Martín-Banda[15], Sara Martínez-Loriente[16], Marta Neres[17,12], Hector Perea[16], Barbara Šket Motnikar[18], Mara Monica Tiberti[1], Nino Tsereteli[6], Varvara Tsironi[14], Roberto Vallone[1], Kris Vanneste[19], Polona Zupančič[18], and Domenico Giardini[20]

[1]Istituto Nazionale di Geofisica e Vulcanologia, 00143 Rome, Italy
[2]Swiss Seismological Service, ETH Zurich, Zurich, Switzerland
[3]ISTerre, IRD, Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Univ. Gustave Eiffel, Grenoble, France
[4]Boğaziçi University, Kandilli Observatory and Earthquake Research Institute, Department of Earthquake Engineering, 34684 Istanbul, Türkiye
[5]Instituto Superior Tecnico, Universidade de Lisboa, Lisbon, Portugal
[6]Institute of Geophysics, Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia
[7]Electricité de France, TEGG, Aix-en-Provence, France
[8]Geological Survey of Slovenia, Ljubljana, Slovenia
[9]Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-aux-Roses, France
[10]Universidad Autónoma de Madrid, Facultad de Ciencias, Dpto. Geología y Geoquímica, 28049 Madrid, Spain
[11]Department of Physics and Earth Sciences, University of Ferrara, Ferrara, Italy
[12]Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisbon, Portugal
[13]Turkish Earthquake Foundation, Istanbul, Türkiye
[14]National Observatory of Athens (NOA), Athens, Greece
[15]Instituto Geológico y Minero de España (IGME-CSIC), 28760 Madrid, Spain
[16]Institut de Ciències del Mar-CSIC, Barcelona, Spain
[17]Instituto Português do Mar e da Atmosfera, 1749-077 Lisboa, Portugal
[18]Slovenian Environment Agency, Ljubljana, Slovenia
[19]Royal Observatory of Belgium, Brussels, Belgium
[20]Institute of Geophysics, Department of Earth Sciences, ETH Zurich, Zurich, Switzerland

Correspondence: Roberto Basili (roberto.basili@ingv.it)

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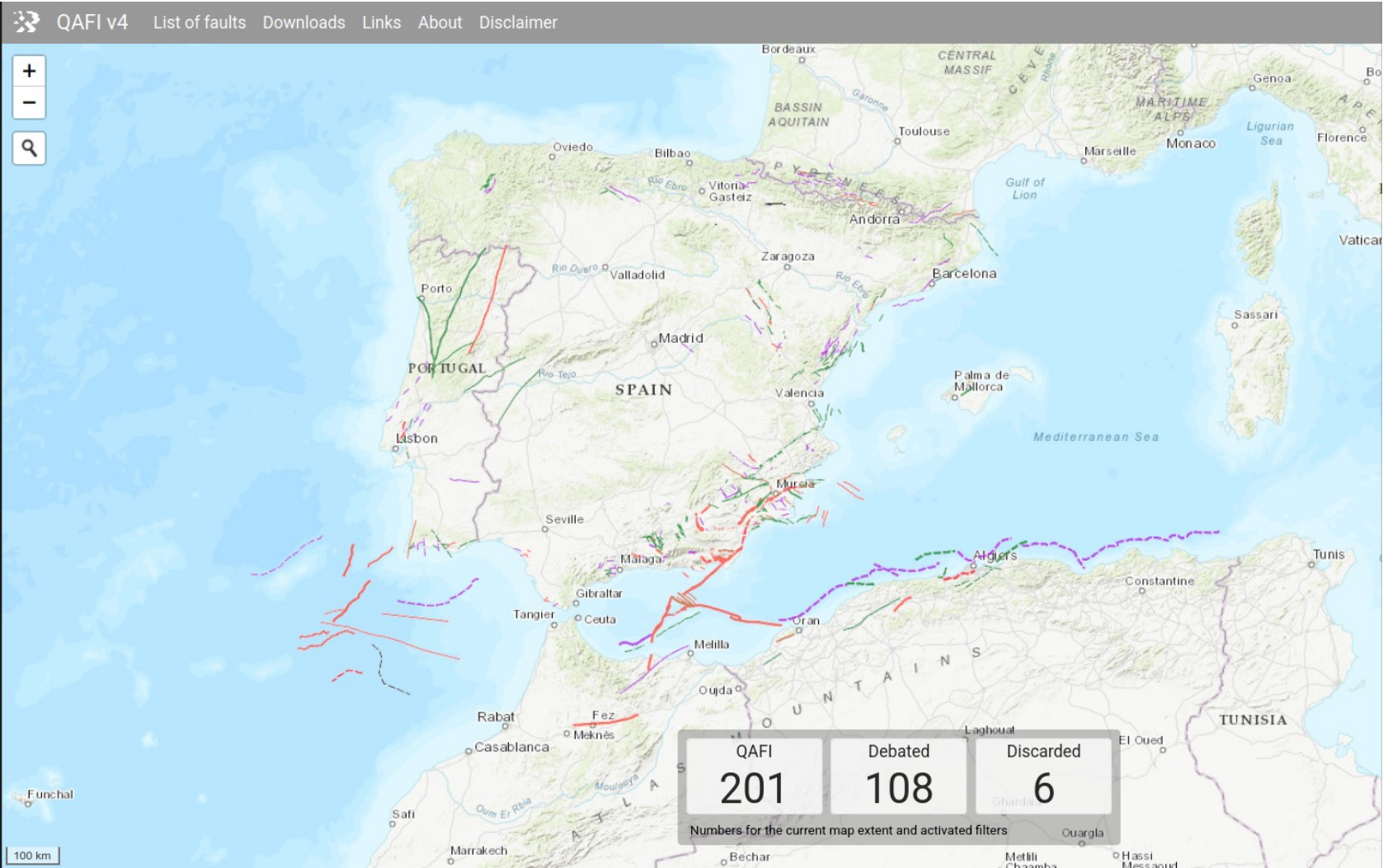
Revised: 16 July 2024 – Accepted: 2 September 2024 – Published: 19 November 2024

Abstract. Earthquake hazard analyses rely on seismogenic source models. These are designed in various fashions, such as point sources or area sources, but the most effective is the three-dimensional representation of geological faults. We here refer to such models as fault sources. This study presents leased European Seismic Hazard Model 2020. The EFSM20 compilation was entirely based on reusable data from existing active fault regional compilations that were first blended and harmonized and then augmented by a set of derived parameters. These additional parameters were devised to en-

QAFI v.4.0 (2022)



Filter faults and legend

Fault activity

- Fault activity reaches Holocene (from the last 11,000 yrs to Present)
- Fault activity at least reaches Upper Pleistocene (the last 125,000 yrs)
- Fault activity is Quaternary (the last 2.6 ma), although activity during Upper Pleistocene or Holocene times has not been demonstrated yet.
- Debated
  Quaternary fault activity is currently on debate
- Discarded
  Quaternary fault activity is currently discarded

Fault Trace

- Reliable
- Approximate
- Speculative

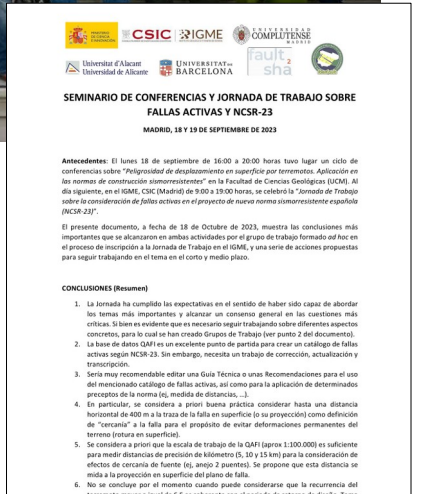
Slip Rate Ranking

- Net Slip Rate ≥ 0.5 m/ka
- 0.5 > Net Slip Rate ≥ 0.2 m/ka
- Net Slip Rate < 0.2 m/ka
- Unstated

Fault2SHA ESC-Working group.
Laboratory on the Eastern Betics Shear Zone

2022 (Alicante).
Workshop on fault modelling in PSHA.

2023 (Madrid). Seminar and workshop on the incorporation of Active Faults into seismoresistant codes.



SEMINARIO DE CONFERENCIAS Y JORNADA DE TRABAJO SOBRE FALLAS ACTIVAS Y NCSR-23

MADRID, 18 Y 19 DE SEPTIEMBRE DE 2023

Antecedentes: El lunes 18 de septiembre de 16:00 a 20:00 horas tuvo lugar un ciclo de conferencias sobre "*Peligrosidad de desplazamiento en superficie por terremotos. Aplicación en las normas de construcción sismorresistentes*" en la Facultad de Ciencias Geológicas (UCM). Al día siguiente, en el IGME, CSIC (Madrid) de 9:00 a 19:00 horas, se celebró la "*Jornada de Trabajo sobre la consideración de fallas activas en el proyecto de nueva norma sismorresistente española (NCSR-23)*".

El presente documento, a fecha de 18 de Octubre de 2023, muestra las conclusiones más importantes que se alcanzaron en ambas actividades por el grupo de trabajo formado *ad hoc* en el proceso de inscripción a la Jornada de Trabajo en el IGME, y una serie de acciones propuestas para seguir trabajando en el tema en el corto y medio plazo.

CONCLUSIONES (Resumen)

1. La Jornada ha cumplido las expectativas en el sentido de haber sido capaz de abordar los temas más importantes y alcanzar un consenso general en las cuestiones más críticas. Si bien es evidente que es necesario seguir trabajando sobre diferentes aspectos concretos, para lo cual se han creado Grupos de Trabajo (ver punto 2 del documento).
2. La base de datos QAFI es un excelente punto de partida para crear un catálogo de fallas activas según NCSR-23. Sin embargo, necesita un trabajo de corrección, actualización y transcripción.
3. Sería muy recomendable editar una Guía Técnica o unas Recomendaciones para el uso del mencionado catálogo de fallas activas, así como para la aplicación de determinados preceptos de la norma (ej, medida de distancias, ...).
4. En particular, se considera a priori buena práctica considerar hasta una distancia horizontal de 400 m a la traza de la falla en superficie (o su proyección) como definición de "cercanía" a la falla para el propósito de evitar deformaciones permanentes del terreno (rotura en superficie).
5. Se considera a priori que la escala de trabajo de la QAFI (aprox 1:100.000) es suficiente para medir distancias de precisión de kilómetro (5, 10 y 15 km) para la consideración de efectos de cercanía de fuente (ej, anejo 2 puentes). Se propone que esta distancia se mida a la proyección en superficie del plano de falla.
6. No se concluye por el momento cuando puede considerarse que la recurrencia del

The QAFI V.5 is now being developed:

- Transformation/adaptation to an official **active fault database** to be used on the **seismoresistant national code**.
- **Comprehensive updating** of known active faults by means of work groups by region.
- Estimation of buffer distances for **Fault Displacement Hazard**.
- **Updating** of the estimations on **recurrence intervals** harmonizing with coherent return periods.

2023 (Madrid). Seminar and workshop on the incorporation of Active Faults into seismoresistant codes.

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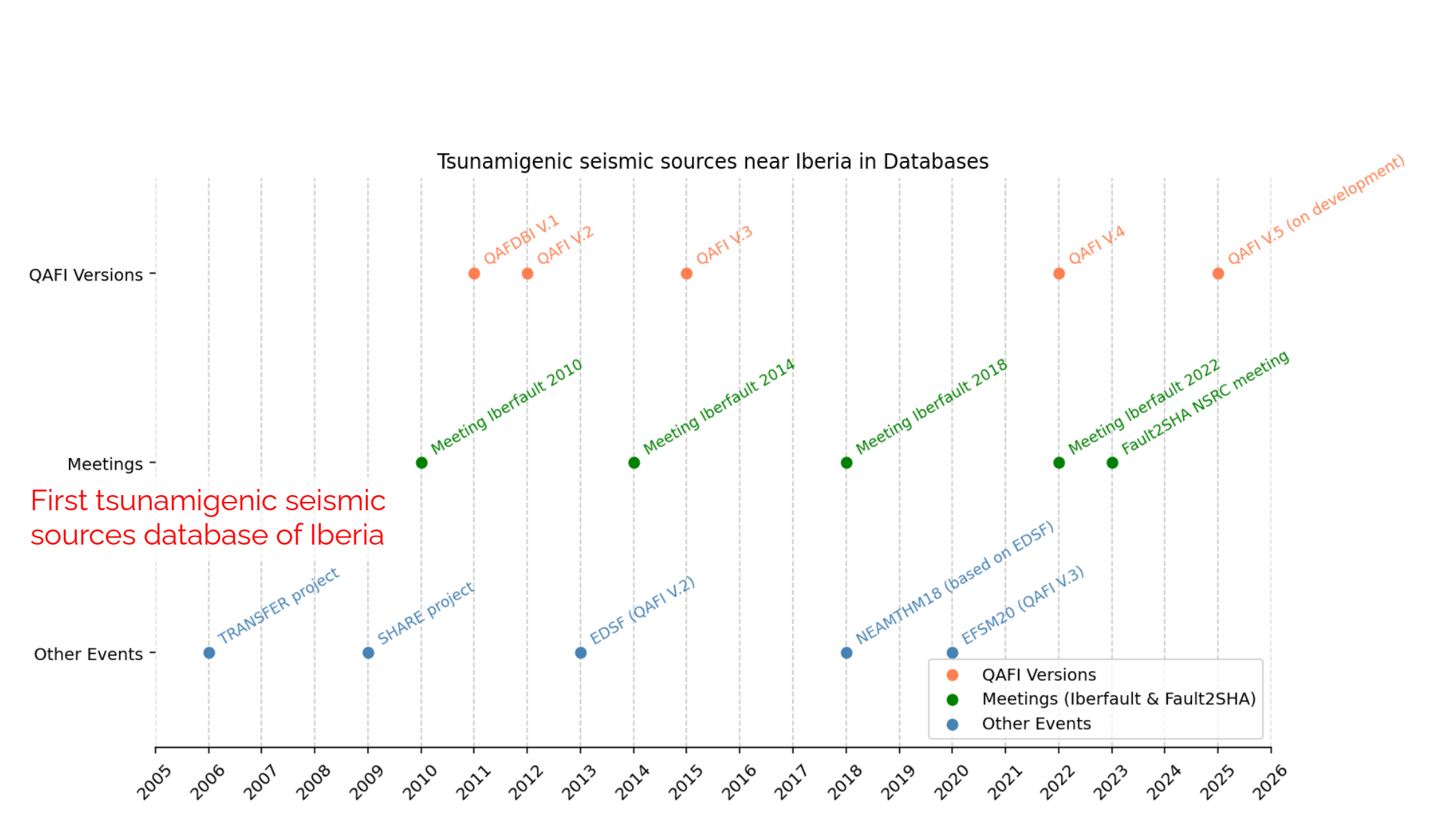
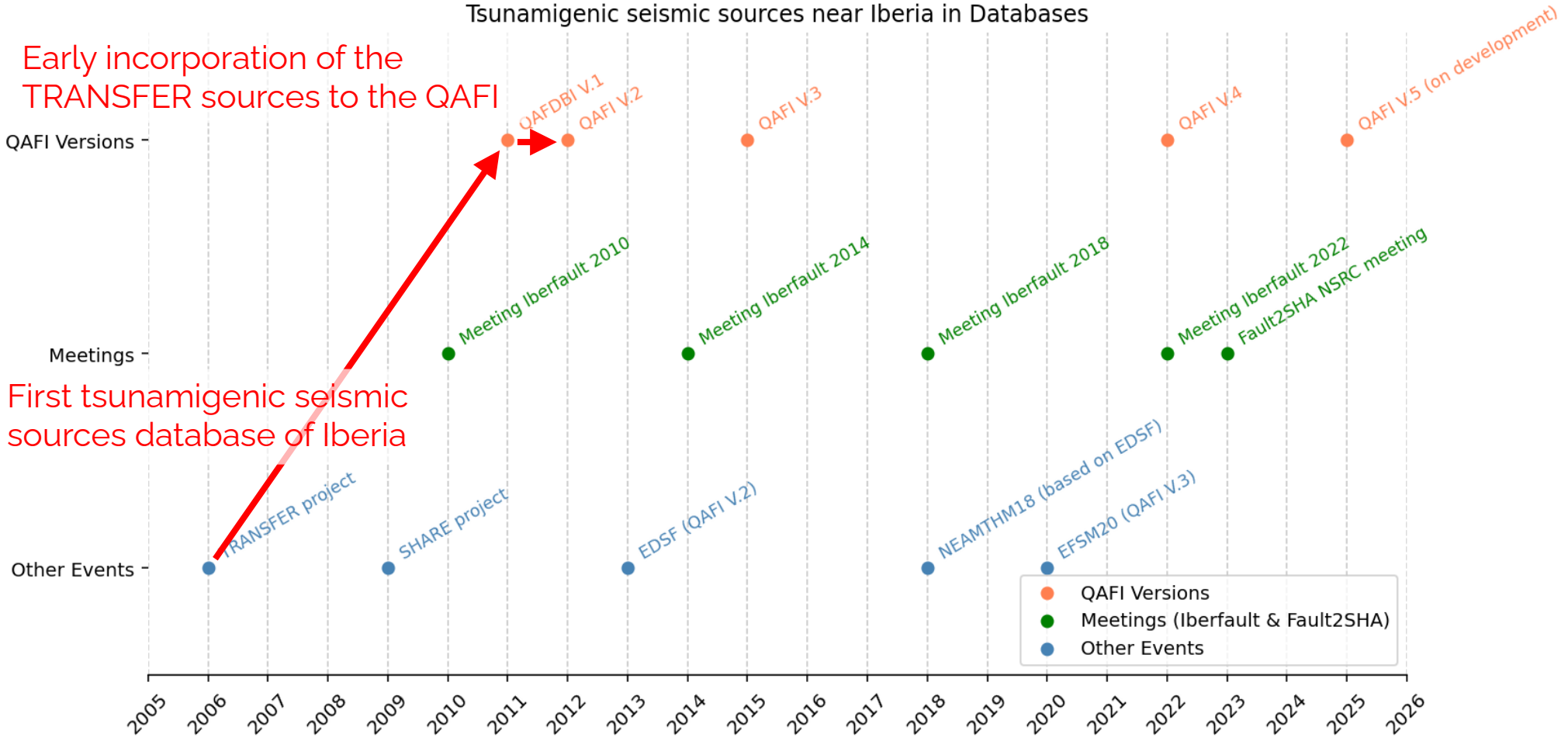
What about tsunamis and submarine faults?



First tsunamigenic seismic sources database of Iberia


Tsunamigenic seismic sources near Iberia in Databases
Early incorporation of the TRANSFER sources to the QAFI
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QAFI V.2
QAFI V.3
QAFI V.4
QAFI V.5 (on development)
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TRANSFER project
SHARE project
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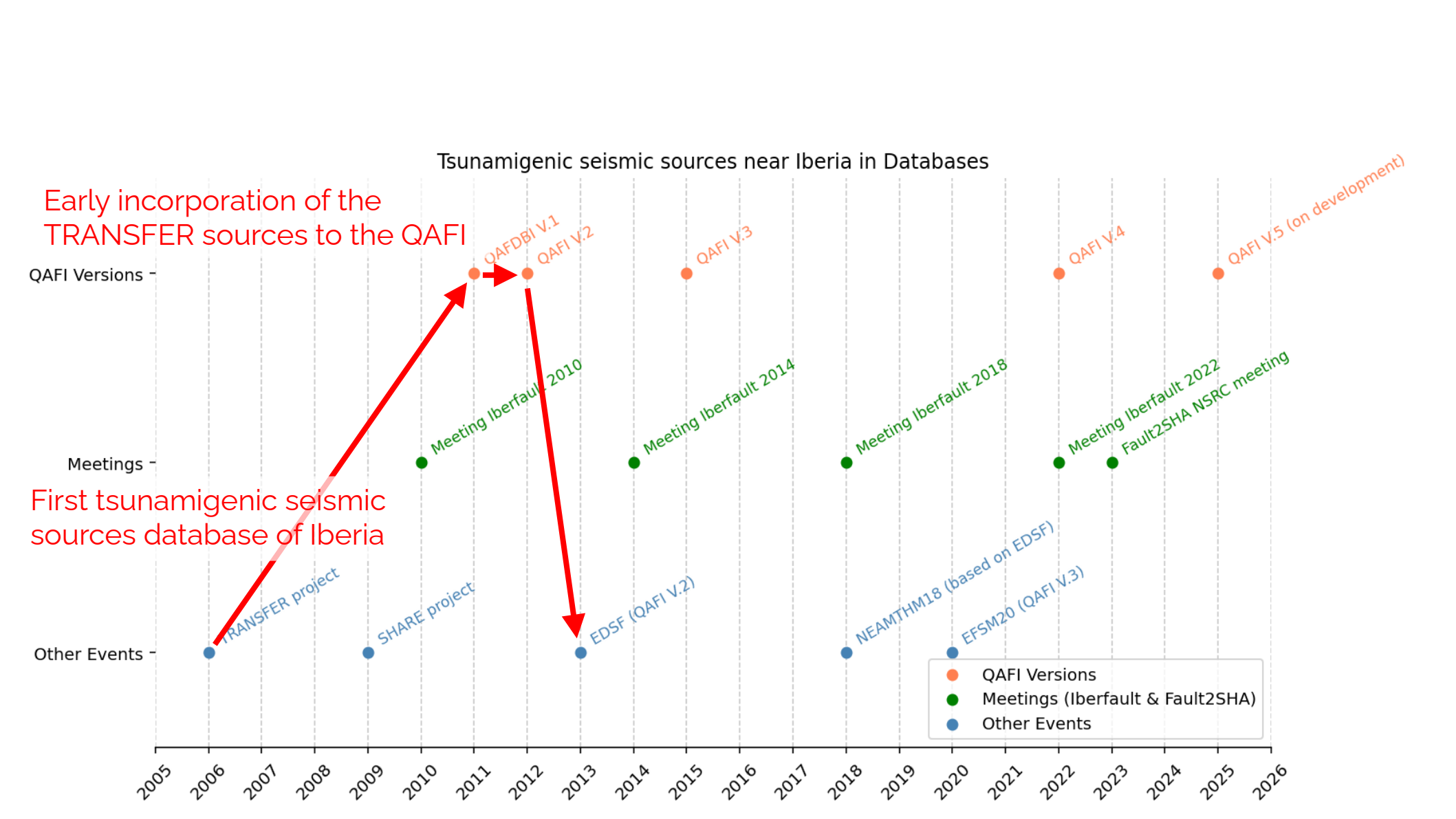
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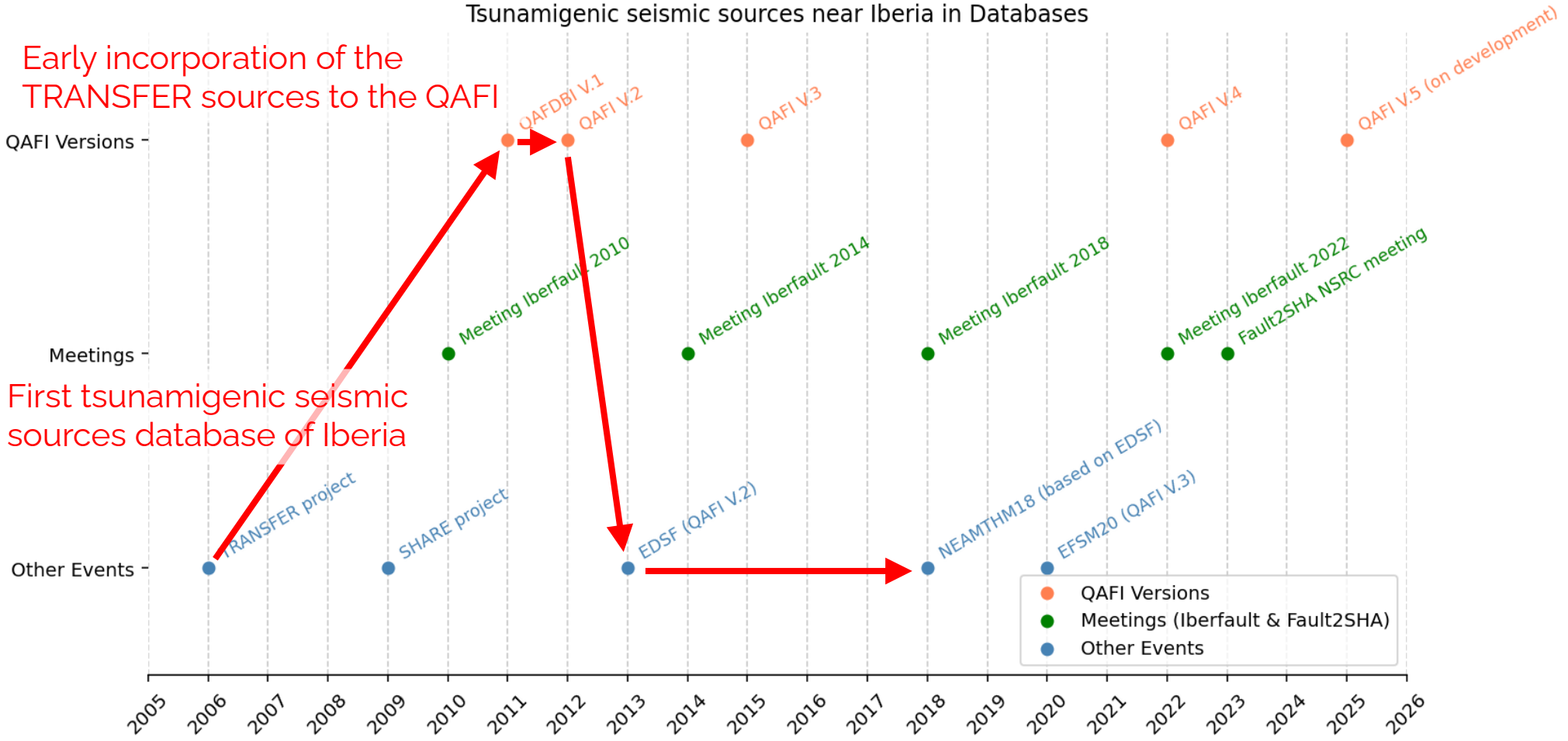
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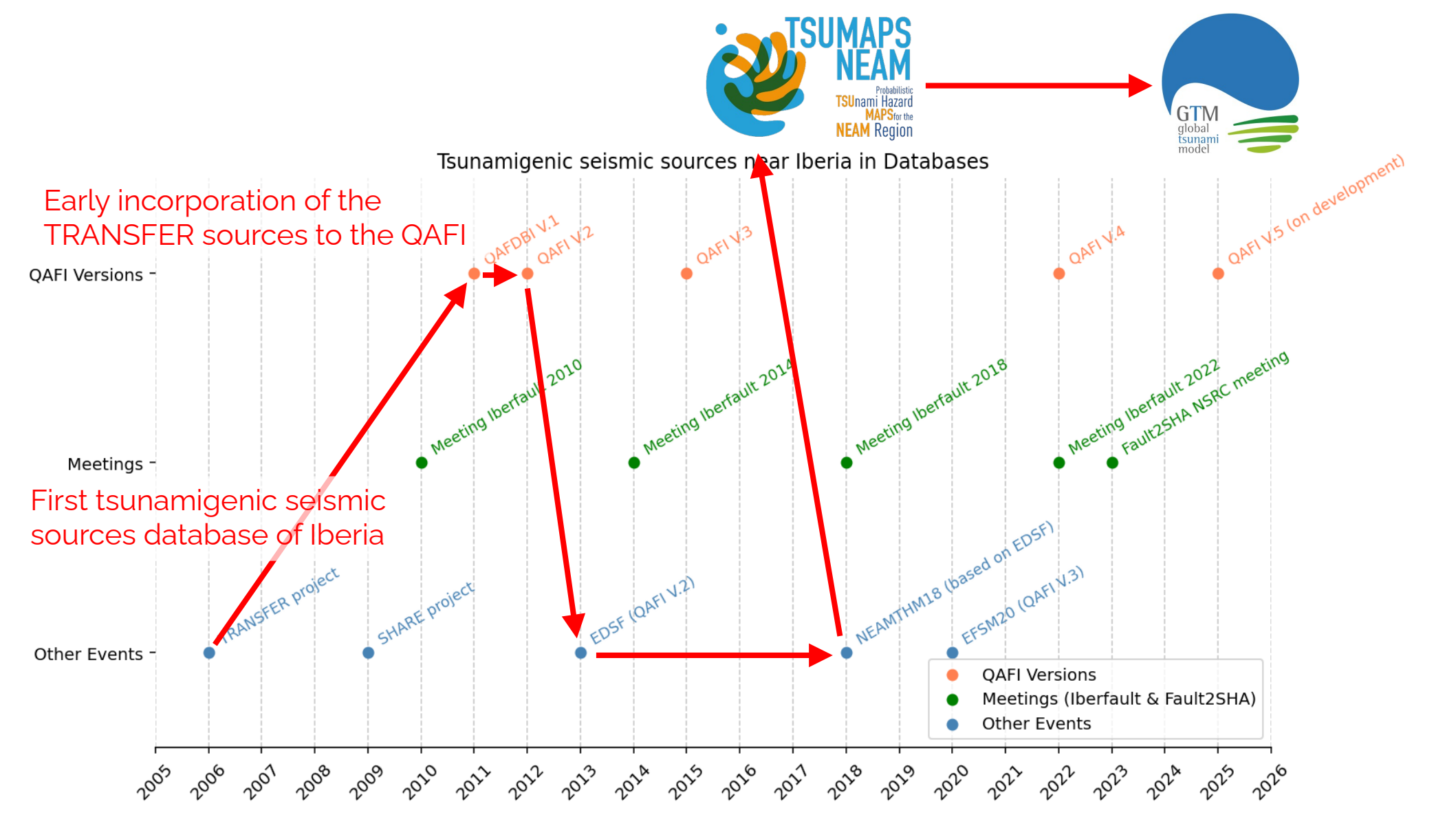
TSUMAPS NEAM
Probabilistic TSUnami Hazard MAPS for the NEAM Region
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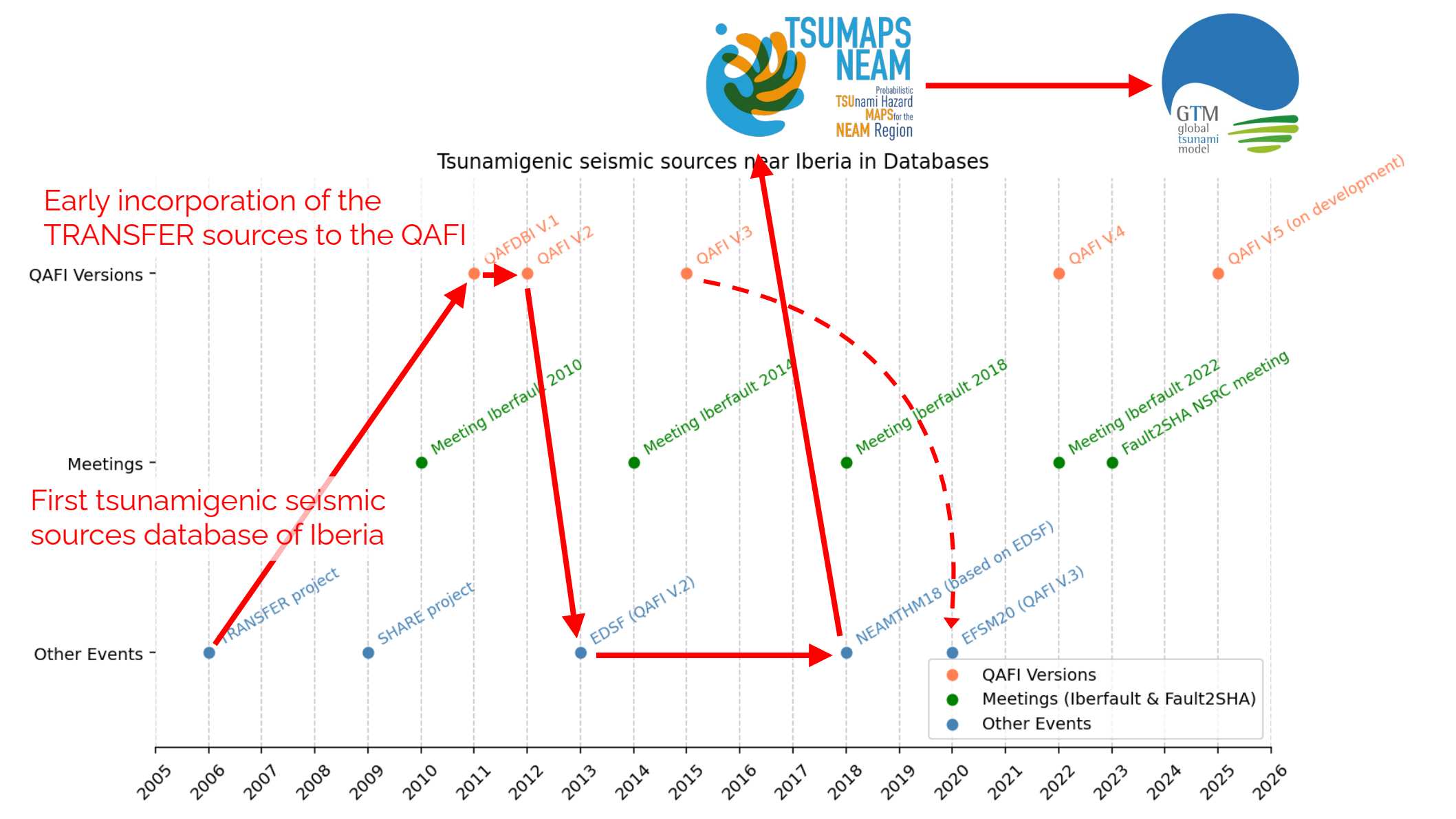
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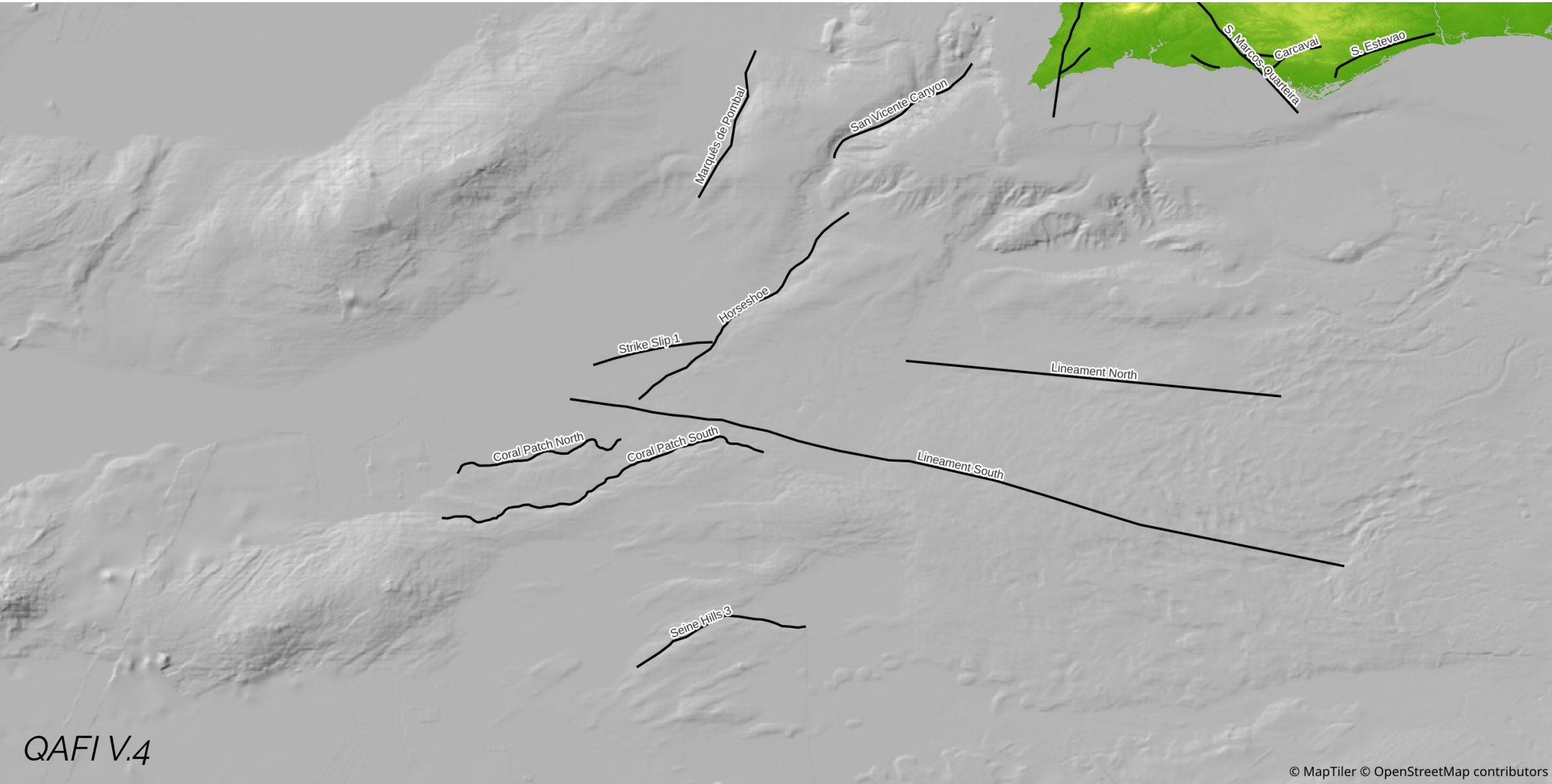
Gulf of Cadiz sources

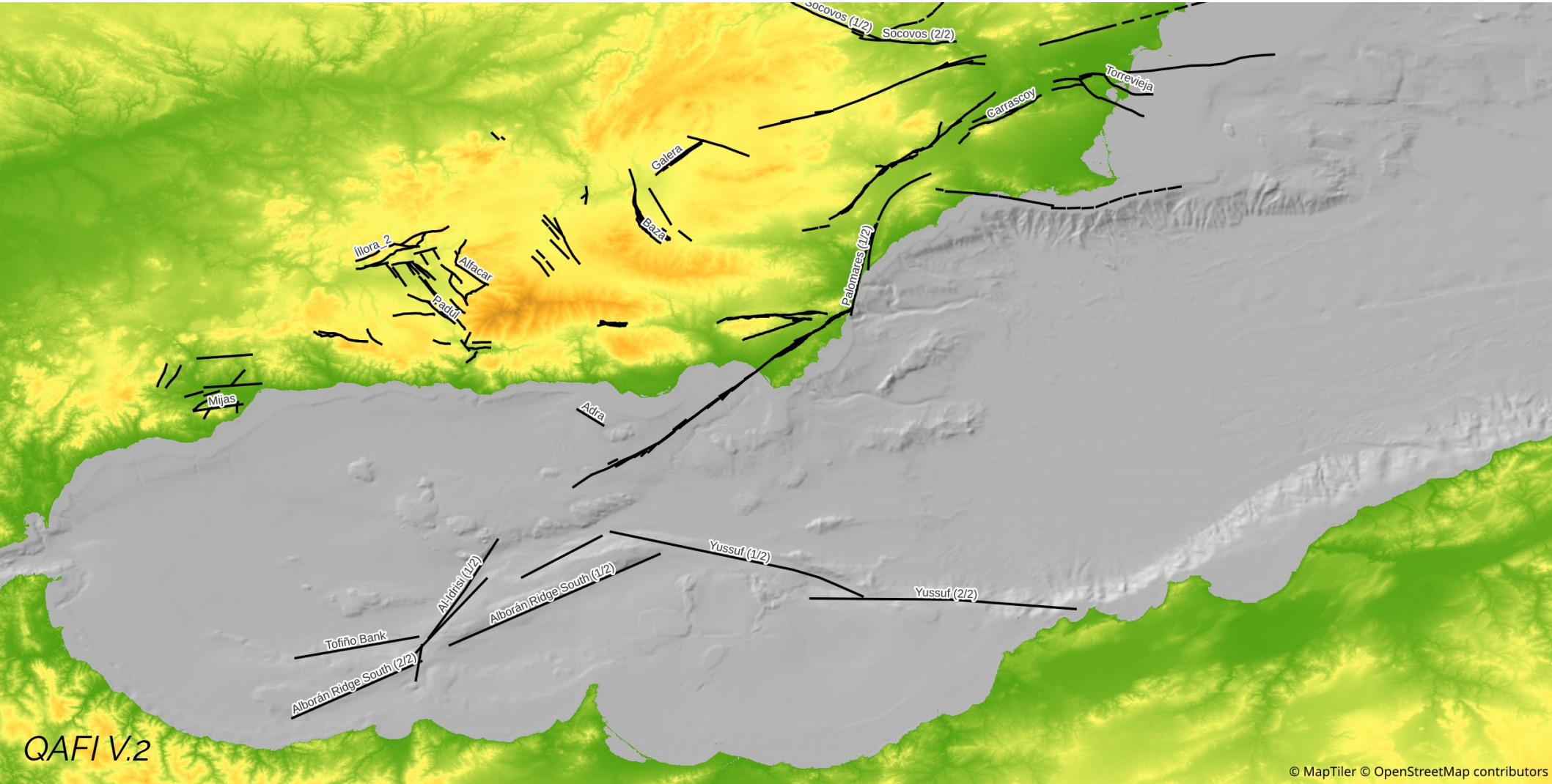
Gulf of Cadiz sources

QAFI V.3

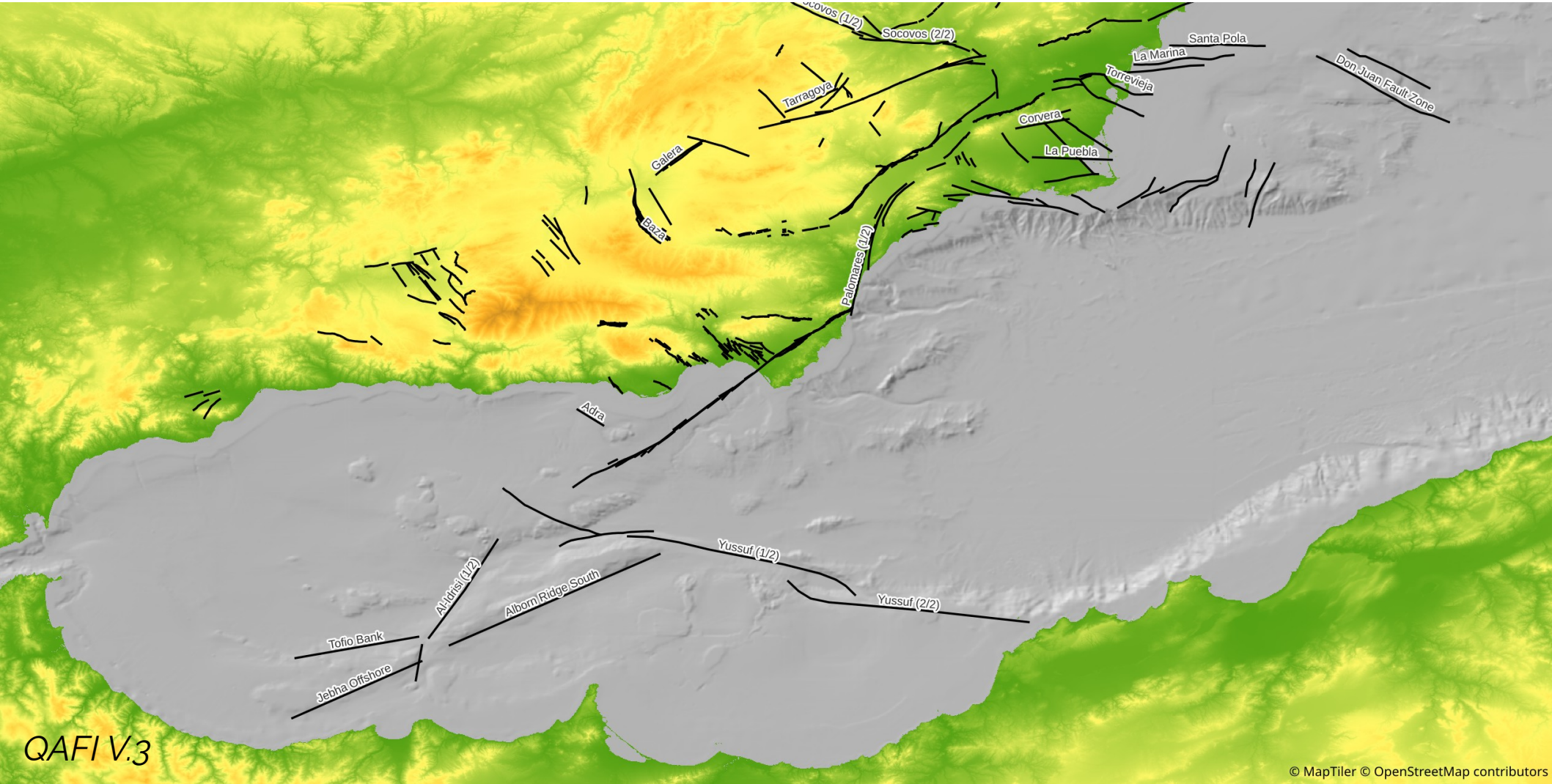
Gulf of Cadiz sources



Alboran Sea sources



Alboran Sea sources



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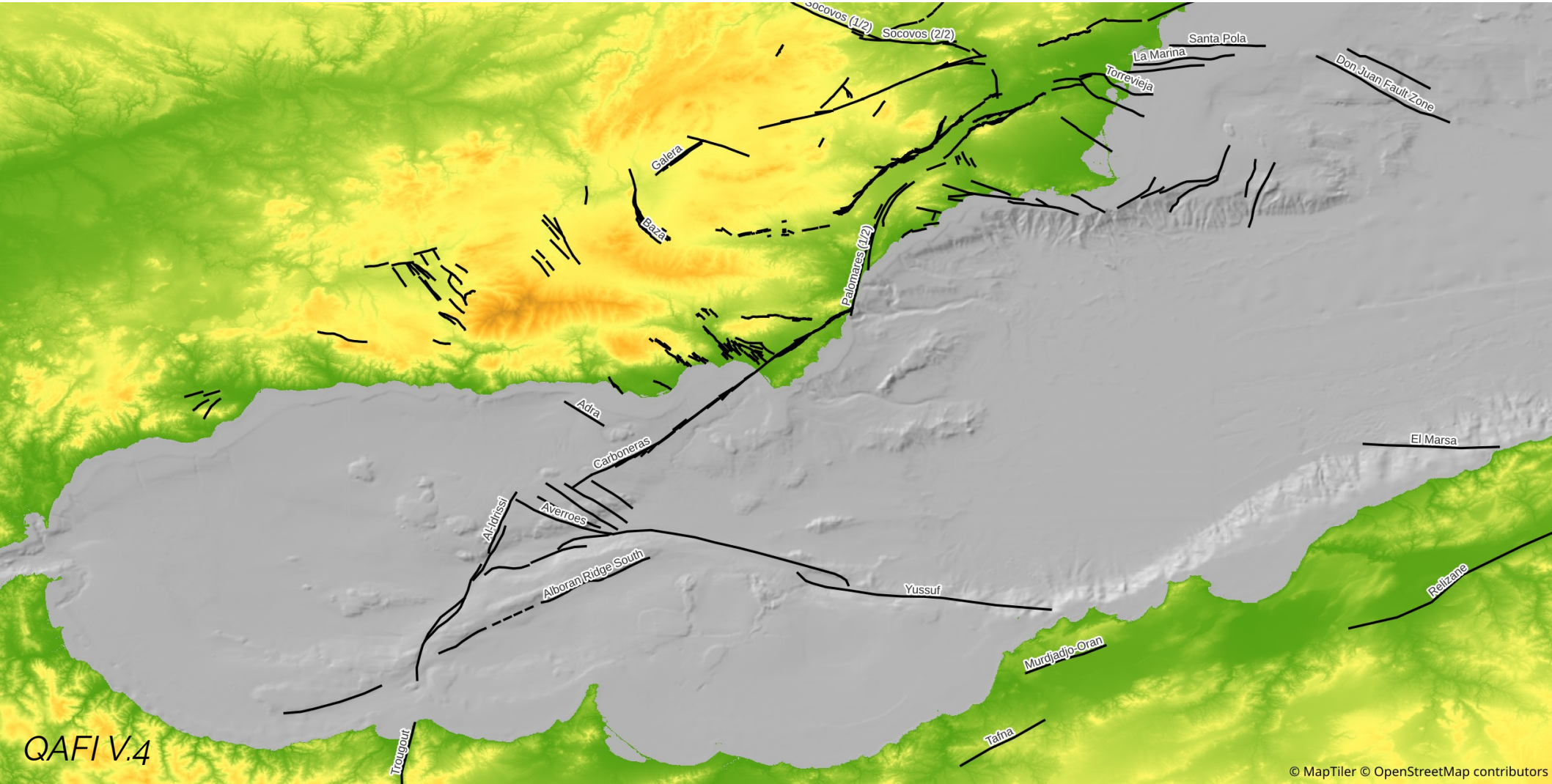

Limitations of the **tsunamigenic seismic sources** on the QAFI database

- Not all the potential seismic sources are included in the database → Epistemologic uncertainty. *We think that the most important ones are included*
- Fault trace uncertain due to technical limitations *enough for tsunami models?*
- Lack of outcrop data → Uncertainties on kinematics (rupture type) *key for tsunamis*
  → Uncertainties on slip rate
- Lack of geodetic data → Uncertainties on slip rate *key for PTHA*
- Seismogenic potential biased → No multi-segment rupture considered *key for max. Mw*
- 3D structure unknown → Real fault dimensions, seismogenic potential and dip uncertain
  key for surface deformation

Ongoing and forthcoming research projects