



HAL
open science

The M6 1799 Vendée earthquake (France) : a multidisciplinary investigation of the active fault

Caroline Kaub, Laurent Bollinger, Laurent Geoffroy, Julie Perrot, Pascal P. Le Roy, Christine Authemayou

► To cite this version:

Caroline Kaub, Laurent Bollinger, Laurent Geoffroy, Julie Perrot, Pascal P. Le Roy, et al.. The M6 1799 Vendée earthquake (France) : a multidisciplinary investigation of the active fault. Rencontres scientifiques et techniques RESIF 2019, Nov 2019, Biarritz, France. hal-02446624

HAL Id: hal-02446624

<https://hal.science/hal-02446624>

Submitted on 21 Jan 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

The M6 1799 Vendée earthquake (France) : a multidisciplinary investigation of the active fault

Session 2

Kaub C.^{1*}, Bollinger L.², Geoffroy L.¹, Perrot J.¹, Le Roy P.¹, Authemayou C.¹

¹UMR 6538 Laboratoire Géosciences Océan, Institut Universitaire Européen de la Mer, rue Dumont D'Urville, Plouzané, 29217 France

²Département Analyse Surveillance Environnement, CEA, DAM, DIF, 91297 Arpajon, France

* Now at caroline.kaub@gmail.com



1. Context of the M6 1799 Vendée intraplate earthquake

The coastal Vendée (France) is located to the south of a main structure of the Armorican Massif, the 600-km-long South Armorican crustal Shear Zone (SASZ) (1) [fig. 1]. This "stable continental region" (2) is affected by a system of dominantly NW-SE trending shear zones and faults, inherited from a long and polyphased tectonic history since Variscan times.

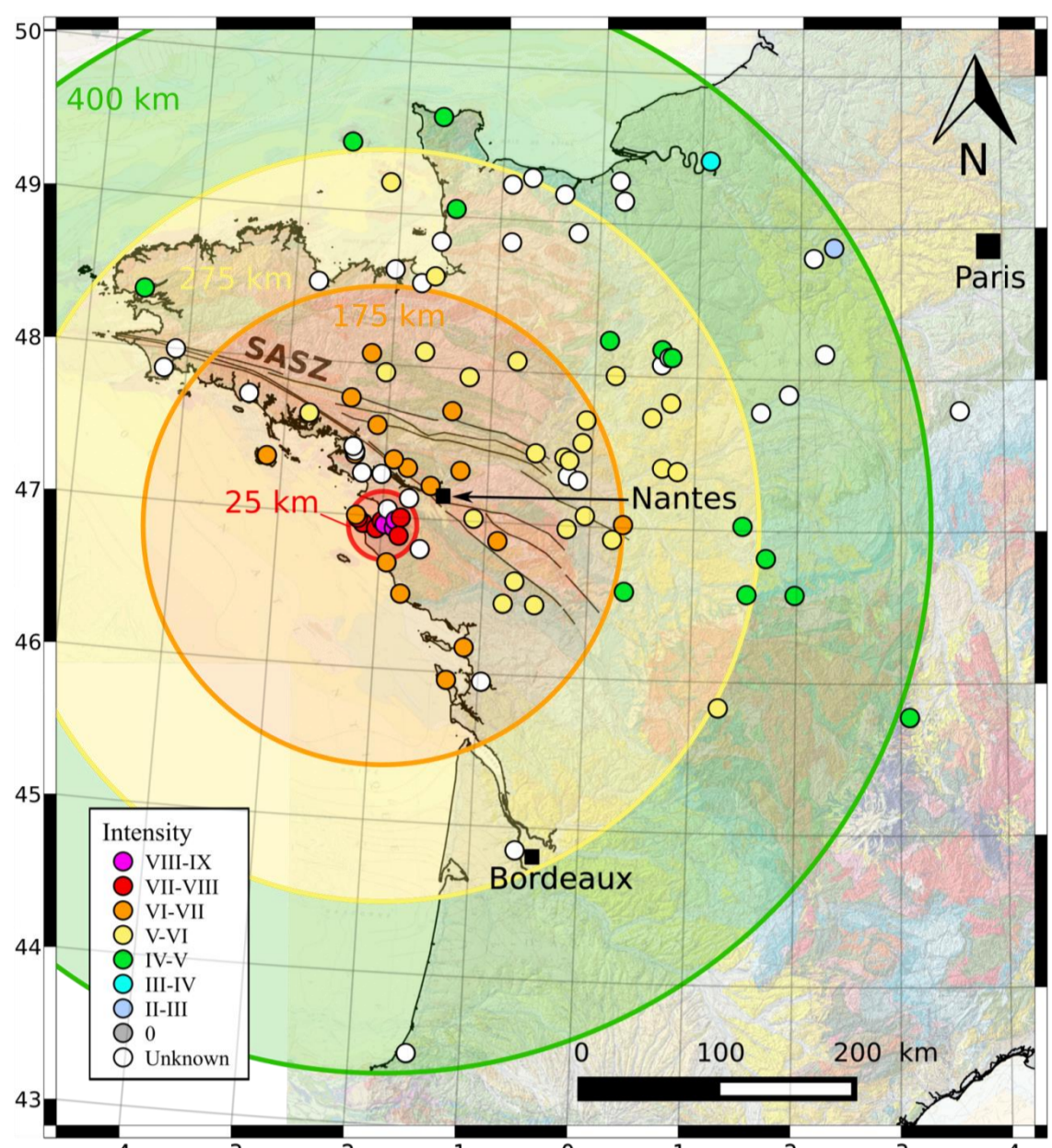
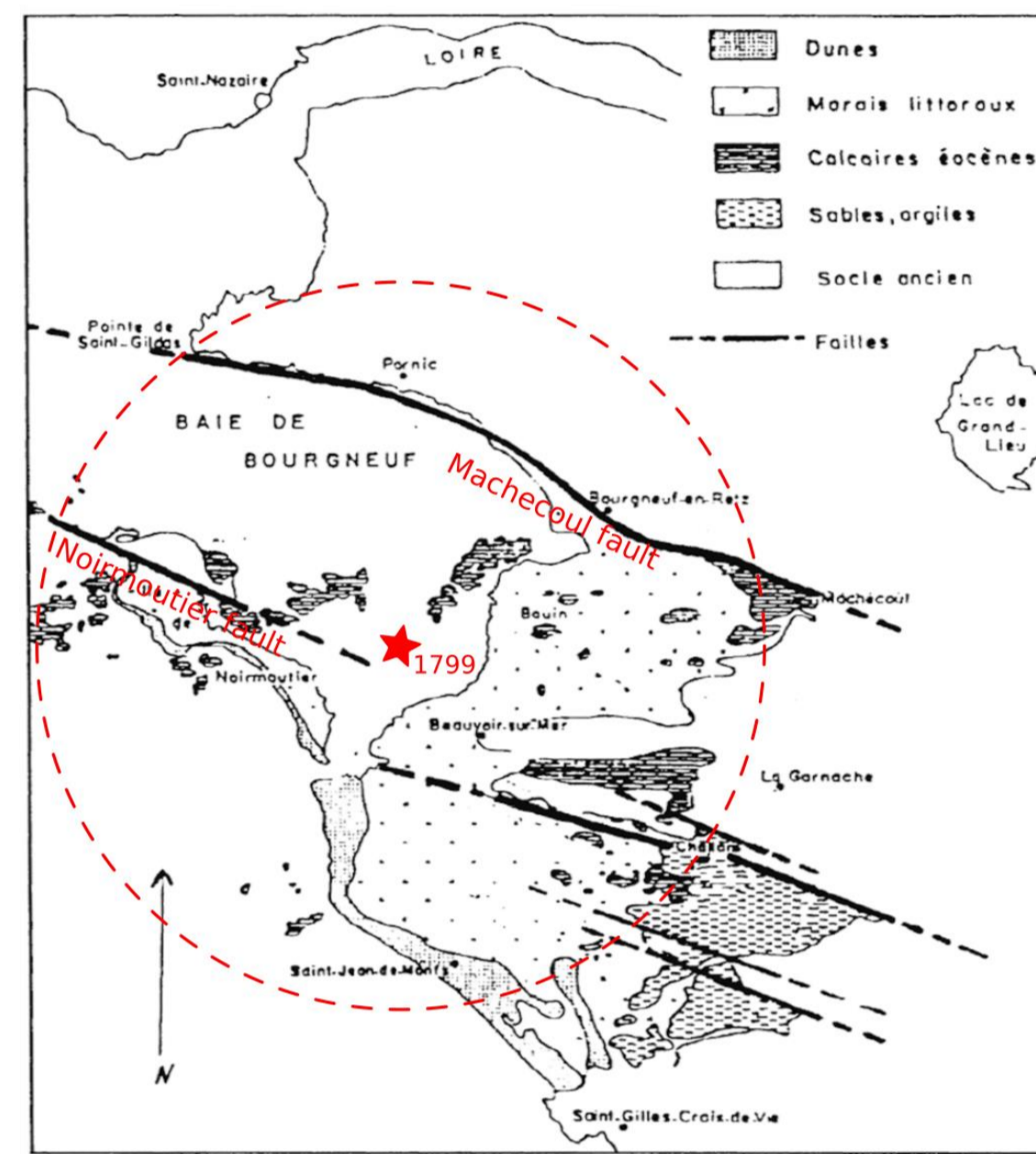


Fig. 1: Macroseismic intensity of the M6 1799 earthquake.

Can we connect this main earthquake to a specific fault ?

Fig. 2: Main faults of the Marais Breton and Baie de Bourgneuf and epicentral location (3), modified from (6).



2. An onshore/offshore multidisciplinary approach

Investigation of the epicentral area of the 1799 earthquake to identify active faults potentially responsible for this event and quantify their recent activity combining outcomes from [fig. 3] :

- 40 km² of new HR bathymetry (Geoswath interferometric sonar - RET22) and topography (RGEALTI, IGN) data
 - Machecoul fault morphology
- 700 km of new seismic profiles (Sparker source single channel streamer, CHIRP echo sounder - RET21 & 2)
- Existing onshore drill database (BSS, (7)) to stress Neogene depot centers in the Marais Breton.
- Available onshore gravity data (BGI, (8)) to calculate Bouguer anomaly and 2D modeling near the MF
 - basin geometry & sediment infilling.
- 10 stations temporary seismological experiment (MACHE) to complement 4 years of regional catalog
 - current seismicity

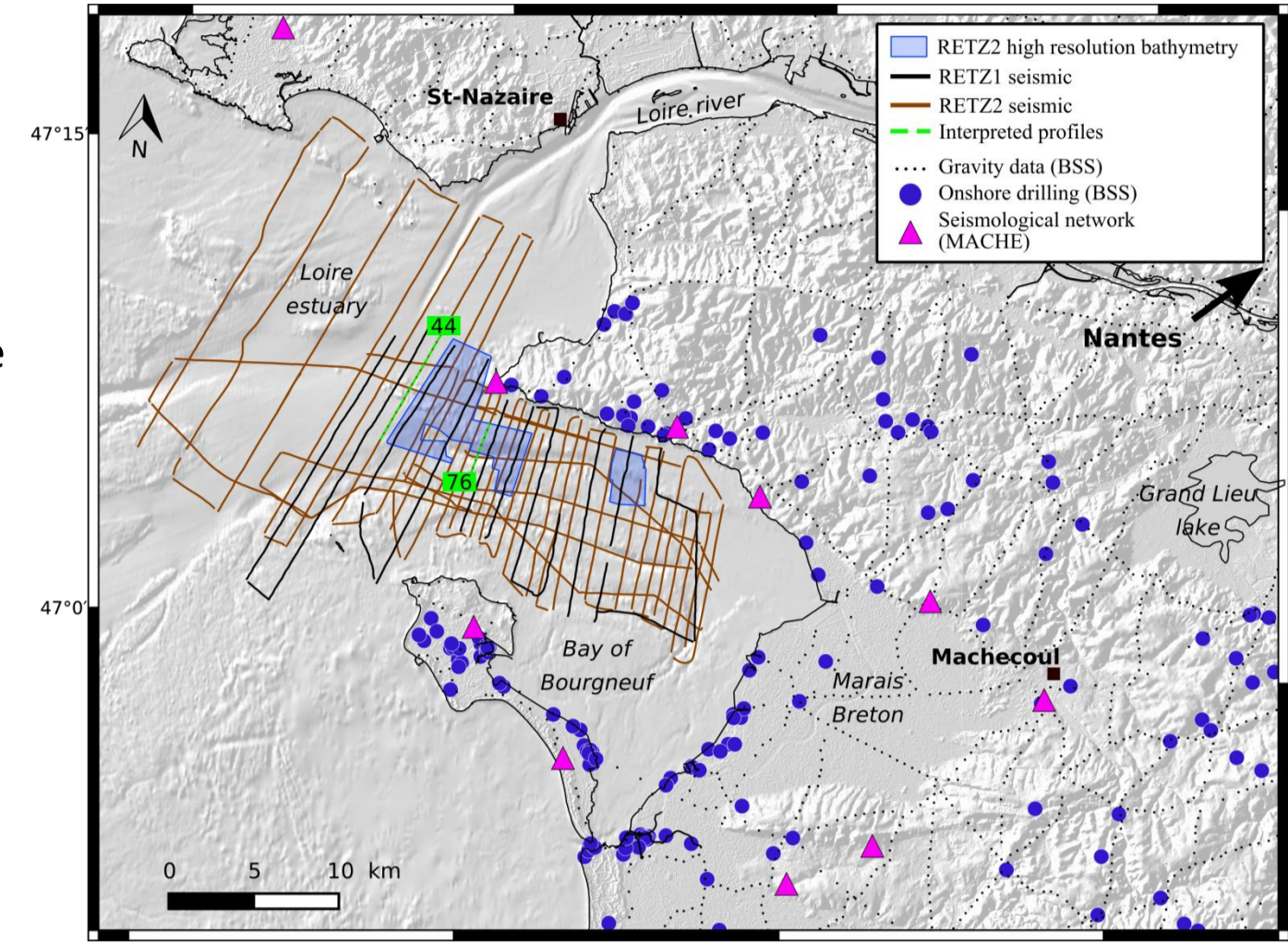
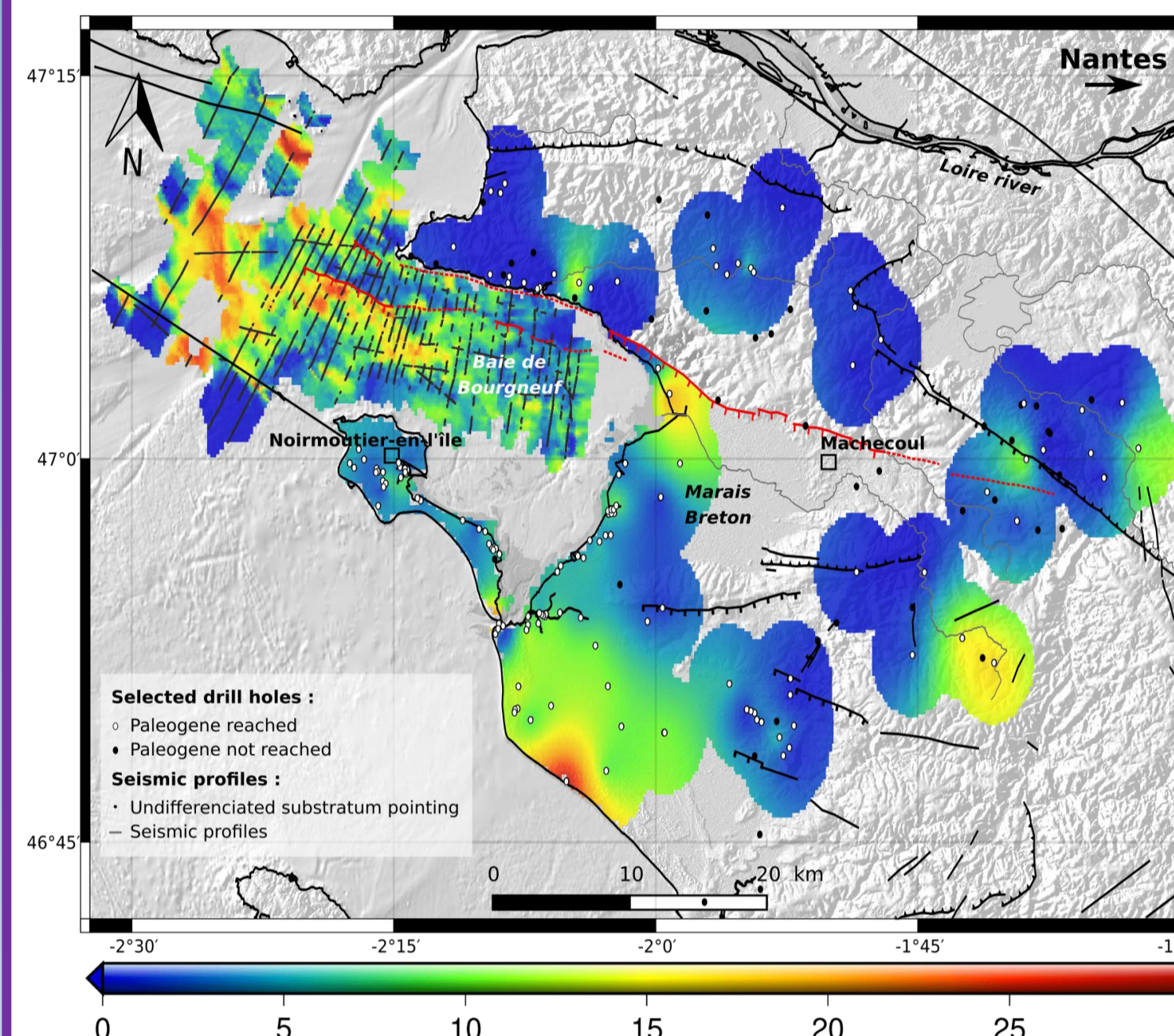


Fig. 3: Location map of all the techniques.

4. Basin infilling



- 5 mGal negative Bouguer anomaly in the Marais Breton
 - Shallow sedimentary basin

Plio-quaternary depocenter repartition study :

- Poorly represented onshore, widely offshore [fig. 7]
- Thickness gradient both toward the MF and westward along the MF
- No syntectonic deformation figures observed on seismic reflexion profiles [fig. 6]
 - Pre-existing topography passively filled during the Neogene or tectonic control of the sedimentation by the MF ?

Fig. 7: Neogene to Quaternary sedimentary thickness (m).

3. Machecoul Fault trace and morphology

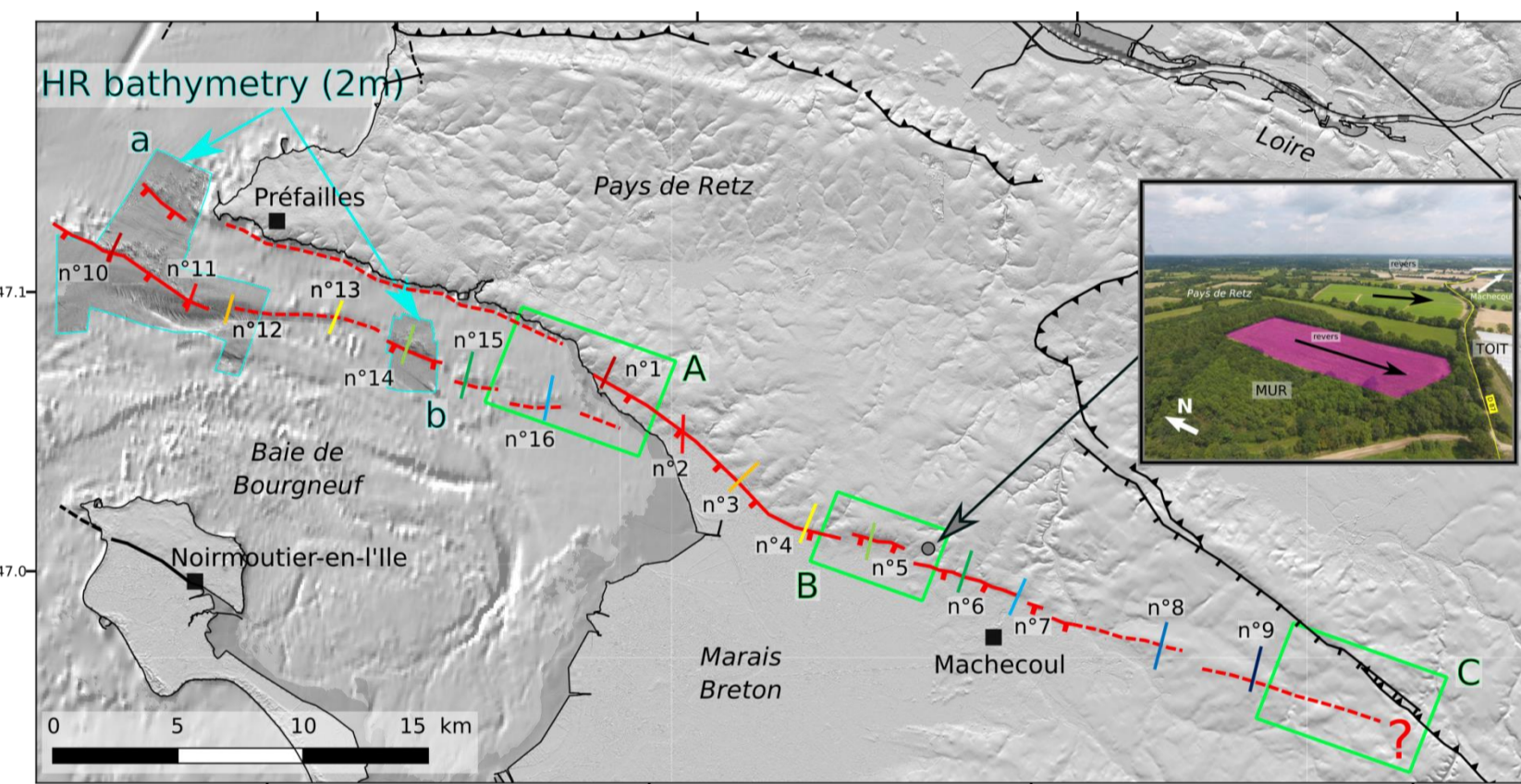


Fig. 4: Onshore-offshore extension of the Machecoul fault signature.

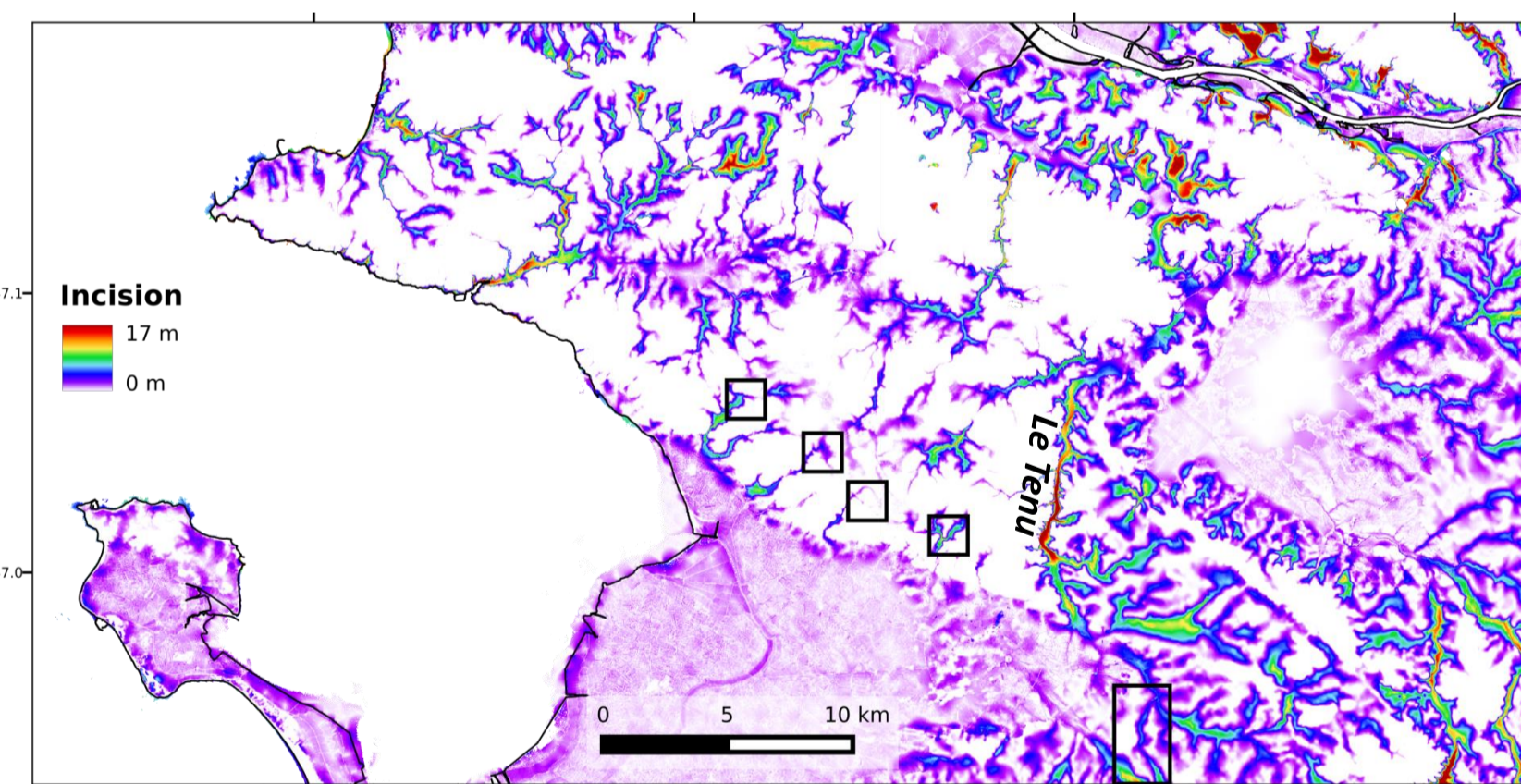


Fig. 5: Incision and captures of the footwall and hanging wall.

Complex fault system geometry [fig. 4 & 6] :

- Onshore morphological trace very **tenuous**, disappearing gradually eastward
- Slope break highly **anthropized**
- Relay structures**
- Offshore signature expressed up to the seafloor, with two parallel faults and upward flexured HW [fig. 6]
- Segmentation** : several N110 trending segments ranging from 2.5 to 12.5 km length onshore, and a maximum 7.5 km length offshore
- SW dipping normal faults system** : no accurate estimation of onshore dip, around 60° dip for the main segment offshore [fig. 6]

Mophometric analysis [fig. 5] :

- Low incision and residual relief of the FW
 - preserved Pliocene paleosurface ?
- Epigenic river (Le Tenu) : FW **uplift** ?
- 4 minor captures in the FW [fig. 5]
- 1 main capture in the HW [fig. 5]

- 2 km wide offshore sub-basin

This pattern of active fault and basin orientation is observed all along the north French Atlantic coast and could be connected to tectonic activity since early Cenozoic (9).

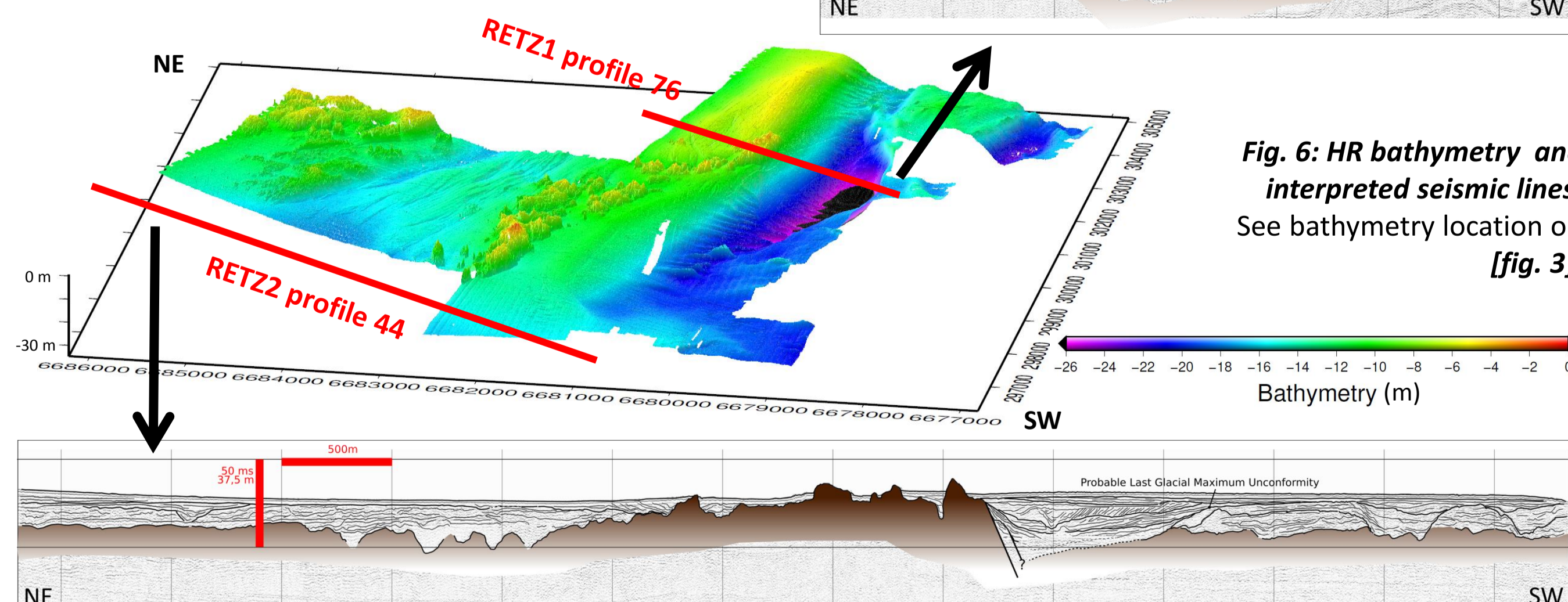


Fig. 6: HR bathymetry and interpreted seismic lines. See bathymetry location on [fig. 3].

5. Seismicity

CHALLANS EARTHQUAKE SEQUENCE (2012)

- 27 April 2012 and located in the Marais Breton [fig. 8]
- Approximately 30 events in 17 days, with M_c ranging from 0.5 to 2.2, and a range depth of 20-25 km
- Largest event occurred on 28 April 2012
- No focal mechanisms

MACHE NETWORK (2016 - 2017)

- 58 events located in 22 months with a M_L ranging from 0.3 to 3 [fig. 8]
- Diffuse microseismicity
- Majority of the activity in the HW
- Depth of earthquakes between 5 and 22 km, at least (both intermediate and deep seismicity)
- 8 normal and strike-slip focal mechanisms [fig. 8]
- Stress inversion : NW-SE $\sigma_{Hmax} = \sigma_1$ or σ_2 and well constrained σ_3

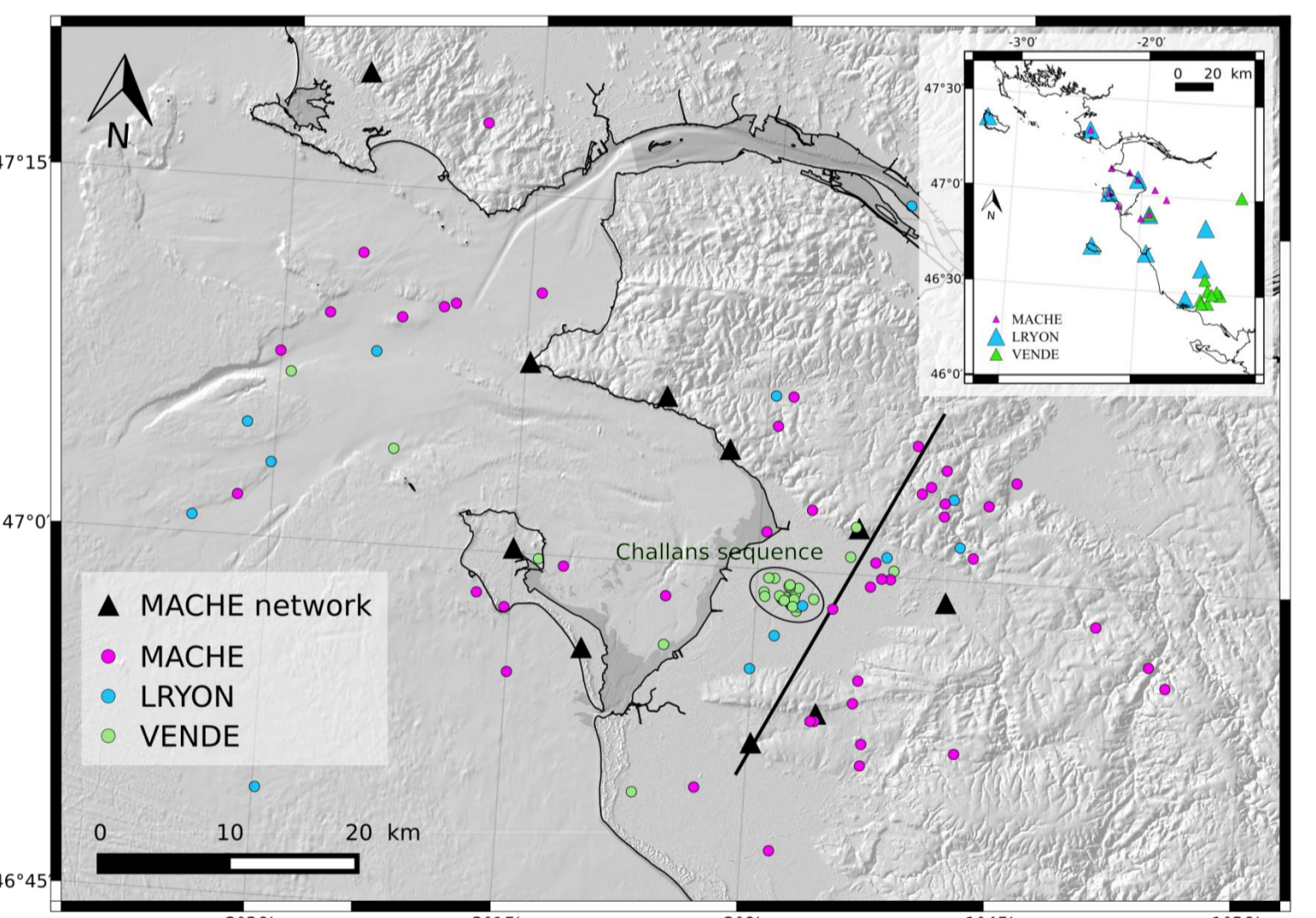
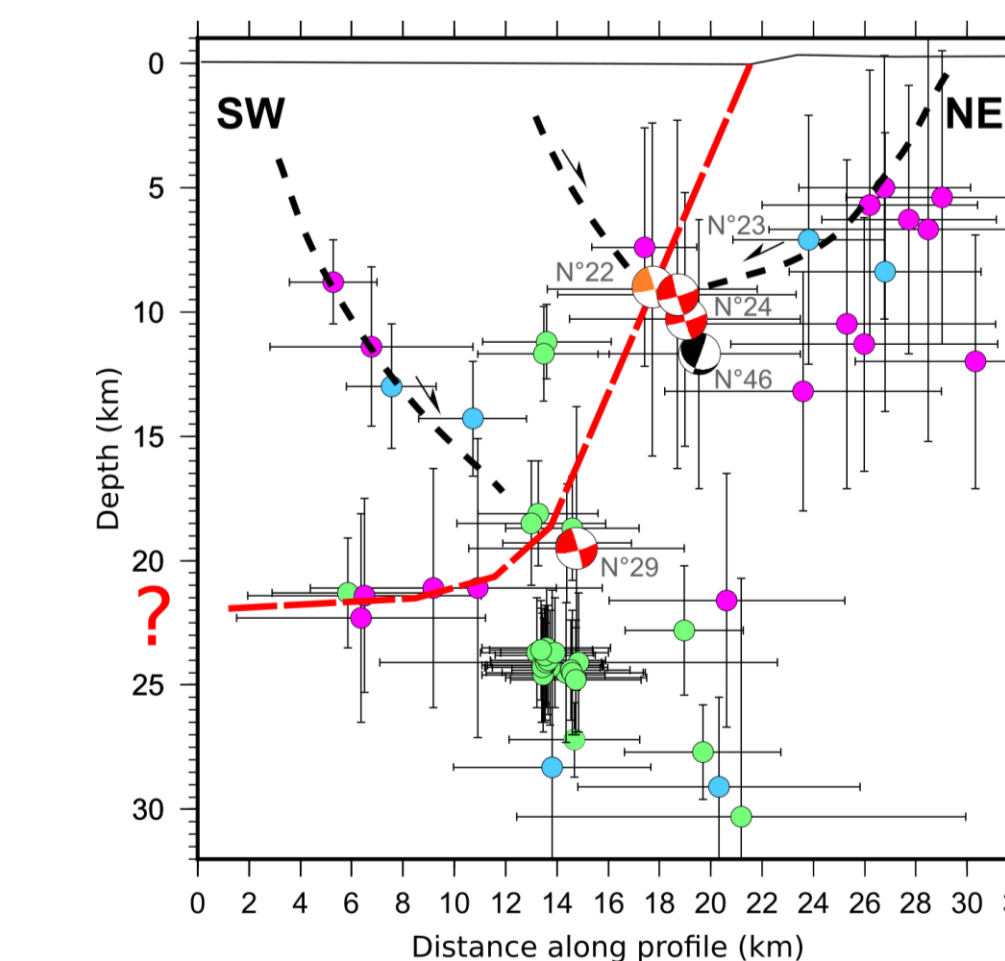


Fig. 8: Seismicity characterized by 3 different network of 10 stations (2011-2017).

6. Conclusions

- Complex fault geometry : segmentation, relay structures onshore and offshore.
- Apparent tectonic control of Plio-Quaternary depocenters : recent reactivation of an old structure.
- The Machecoul fault is probably an active fault : non-negligible microseismic activity in Marais Breton.
- Possible implication of the Machecoul fault in the 1799 event :
 - Noirmoutier fault dips to the SW and is therefore an unlikely source for the 1799 earthquake (6), requiring a macroseismic epicenter several kilometers further South West
 - Foreshock felt only in Machecoul city could indicate a rupture on a fault nearby
 - Machecoul fault segment length compatible with a M6 event
 - Thick seismogenic depth compatible with macroseismic hypocentral estimations (3, 4, 5)
 - MACHE focal solutions compatible with quaternary deformation (10)

References :

(1) Bitri, A. et al. (2003). C. R. Geosciences. (2) Johnston, A. C. et al. (1994). The earthquakes of stable continental regions. (3) BRGM-EDF-IRSN <http://www.sisfrance.net/> (4) Stucchi et al. (2013) Jour. Seism., 17(2) :523-544 (5) Manchuel, K. et al. (2017). Bull. Earthqu. Eng. (6) Limasset et al. (1992) Ann. Bret. Pays Ouest, vol. 99, 97-116 (7) BRGM <http://infoterre.brgm.fr/page/banque-sol-bss> (8) BGI <http://bgi.obs-mip.fr/fr> (9) Delanoë Y., 1988. Géol. de la France. (10) Baize, S. et al. (2013). Bull. Soc. Géol. France, 184(3) :225-259.

Acknowledgements : Baltzer A. for bathymetry data exchange of the Loire estuary & Tiberi C. and Plasman M. for their expertise with gravity processing and interpretation.