The July, 7th 2011 M_L 5.4 earthquake offshore western Corsica (Western Mediterranean)

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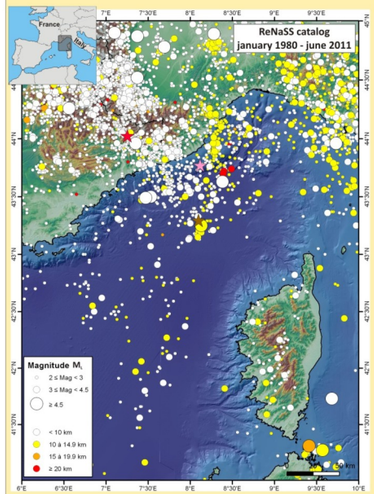
A moderate earthquake (M_L 5.4) occurred 80 km westward Corsica in a very low seismicity area of the Ligurian Sea. This event is the major one of a sequence of five moderate earthquakes that has been set there since July 2011.

SEISMOTECTONIC SETTING

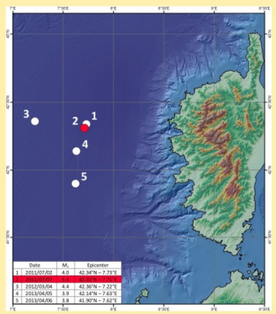
The Ligurian sea is a back arc basin opened from late Oligocene to early Miocene times behind the northward Apulian subduction zone. Presently, it is one of the most seismic area in the Western Mediterranean.

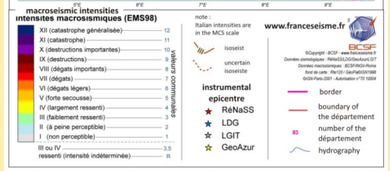


Instrumental seismicity map : the stars correspond to historical earthquakes
-> red : 1564-07-20, I VIII MCS;
-> pink : 1887/02/23, Mw 6.7-6.9;
-> brown : 1963-07-19, Mw 6.0.

The contrast is sharp between the northern and the southern margin of the Ligurian oceanic basin. To the north, there is a dense microseismic activity, some strong historical earthquakes are recorded (e.g. 1887/02/23 Mw 6.7-6.9) and large cumulated deformations are located at the ocean-continent transition zone since 5 Myr and attest for the inversion of the northern Ligurian passive margin. While to the south, the seismicity is quiet with no historical earthquake and without morphotectonic evidence of active deformation.

Nevertheless, five recent moderate earthquakes attest that part of the deformation at the western Mediterranean-Alpine area could be accommodated along faults active at the western side of the Corsica-Sardinia block.





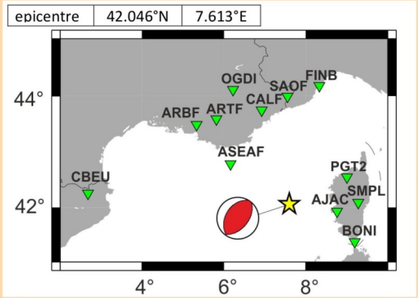
The sequence of five moderate earthquakes occuring western Corsica in 2011-2013. The 7th July 2011 is the strongest event recorded in this area since 1963. It was largely felt by the population of Corsica, Sardinia and along the French-Italian Riviera.

EARTHQUAKE ANALYSIS

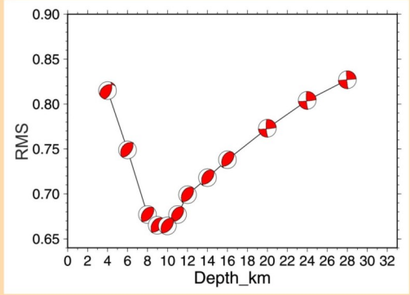
We have studied the July 7th earthquake using regional broadband records from France, Italy and Spain. The waveform inversion is performed using the FMNEAR method (Delouis, 2014) with imposed frequency band chosen as low as possible, to be less dependent on the velocity model. The source is represented by a pure double couple point source. The focal mechanism is purely reverse and the optimal depth is 10 km.

Mean regional velocity model used in this study. Qp and Qs are quality factors for the P- and S-waves respectively

Thickness (km)	Vp (km/s)	Vs (km/s)	density	Qp	Qs
0 - 1.5	3.5	2.01	2.1	200.	100.
1.5 - 3	4.5	2.61	2.3	400.	200.
3 - 5	5.5	3.24	2.5	500.	250.
5 - 8	6.0	3.53	2.7	600.	300.
8 - 12	6.5	3.82	2.9	800.	400.
12 - 15	7.0	4.12	3.0	900.	450.
15 - 17	7.5	4.41	3.1	1000.	500.
> 17	8.0	4.62	3.3	1000.	500.

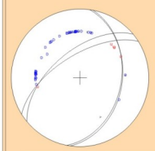


FMNEAR solution	strike	dip	rake
Plane 1	40	50	96
Plane 2	211	40	83



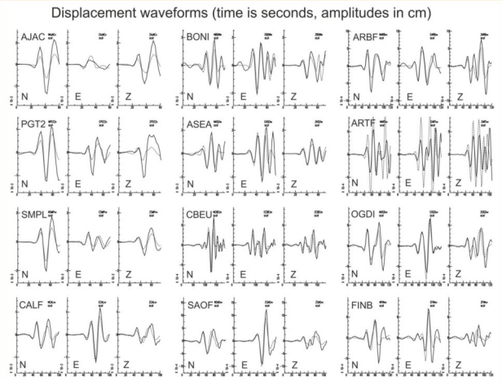
Exploration of focal depth. The inversion is run several times with varying fixed depth and the RMS waveform misfit is plotted as a function of depth. Also displayed, the focal mechanism found for each tested depth. In this exploration procedure, the observed and computed signals are aligned on the first P arrival and no cross-correlation is permitted

The focal mechanism computed from waves polarities display a mainly reverse faulting with a minor strike-slip component.



Focal mechanism computed from P, SV and SH polarities at regional distances (100-600 km) obtained with a velocity model made of two gradients : one in the crust and the other in the mantle.

Polarities solution	strike	dip	rake
Plane 1	11	40	58
Plane 2	231	57	114



Frequency band is 0.02 - 0.05 Hz, except for ARTF, ASEA, BONI which are filtered between 0.04 and 0.08 Hz due to the presence of low frequency noise.

Waveform fit: observed and computed waveforms are drawn in continuous and dashed lines respectively.

Chamot-Rooke N., Gaulier J.M. and F. Jestin (1999). In the Mediterranean Basins : Tertiary extension within the Alpine orogen, Durand B. et al. (Eds), Geological Society of London Special Publication, 156, 37-62.

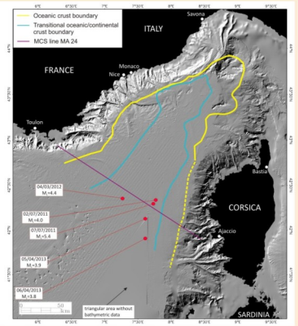
Rollet N., Déverchère J., Beslier M.O., Guennoc P., Réhault J.P., Sosson M. and C. Truffert (2002). Tectonics, 21, 3, doi:10.1029/2001TC900027.

Letort J., Vergoz J., Guilbert J., Cotton F., Sebe O. and Y. Cano (2014). Moderate earthquake teleseismic depth estimations: new methods and use of the comprehensive nuclear-test-ban treaty organization network data. Bull. Seism. Soc. Am., 104, 2, doi: 10.1785/0120130126

Delouis, B. (2014). FMNEAR: determination of focal mechanism and first estimate of rupture directivity using near source records and a linear distribution of point sources. In press at Bulletin of the Seismological Society of America.

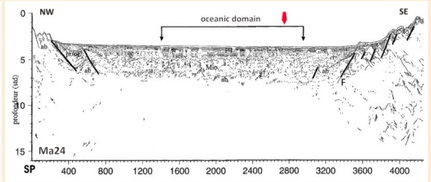
MORPHOTECTONIC ANALYSIS

The epicentre of the July 7th, 2011 earthquake is 2700 m under sea level. As the four other events of the 2011-2013 sequence, it is located in the oceanic domain of the Ligurian Sea close to the transitional domain with the thinned continental crust. In the epicentral area, the moho is at a depth range of 12-15 km (Chamot-Rooke et al., 1999).
For the july 7th, earthquake, we compute a focal depth at 10 km, therefore the faulting occured in the oceanic crust or in a very thinned continental crust. Nevertheless, based on a ceptral analysis together with teleseismic data, Letort et al. (2014) proposed a much deeper hypocenter, around 26 km depth, and concluded that this earthquake occured in the continental crust.



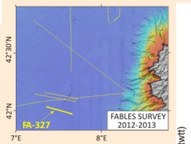
Boundary of the continental, transitional and oceanic domain in the Ligurian Sea (modified from Rollet et al., 2002).

In the epicentral area, the bathymetry displays a very flat morphology and no scarp of tectonic origin has been pointed out at the resolution of the data.



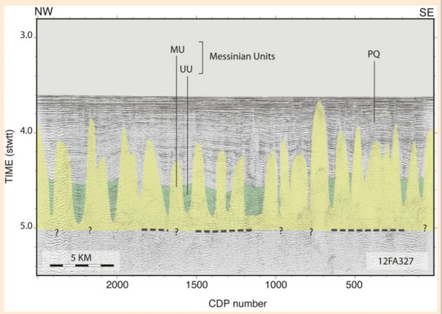
Interpretation of the MCS line MA24 (Malis survey; Rollet et al., 2002). F: normal fault, ab: accoustic basement, Mio: Miocene sediments, pq: Plio-Quaternary sediments, sel: salt layer, ue: Upper evaporites (~5.3 Ma).

Offshore western Corsica, only inherited normal faults are reported. These faults are related to the Oligo-Miocene rifting episode and are assumed to be inactive during Plio-Quaternary times. The red arrow corresponds to the approximate projection of the July 7th epicentre.



Location of MCS profiles acquired offshore western Corsica during the FABLES survey.

In 2012, the FABLES geophysical survey crosses the epicentral area.The MCS profils display subhorizontal sedimentary layers dismembered by messinian salt diapirsm. From the sea floor until 3 km depth (maximum penetration depth), no inherited fault is evidenced.



Interpretation of the MCS profile 12FA-327: PQ, Plio-Quaternary sediments; MU, Mobile Unit (salt); UU, Upper Unit.

CONCLUSION

We analysed the July 7th, 2011 earthquake offhore western Corsica and its geological setting :

-> The reverse faulting along a NE-SW striking fault plane is consistent with previous significant earthquakes (e.g. 1963-07-19, Mw 6.0) and with the regional deformation field.

-> The focal depth is controversial. We favour a ~10 km depth from the regional waveforms modeling and a faulting in the Ligurian oceanic crust. In any case, if the focal depth is as deeper as 26 km, according to the teleseismic waveforms modeling, the faulting would be in the oceanic mantle.

-> From the morphotectonic analysis the activated structure remains unknown and correspond certainly to a deep inherited fault rooted in the oceanic crust with no expression in the shallow sedimentary cover.