## THE GROSMARIN EXPERIMENT

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The Ligurian margin is a passive margin, seismically active and subjected to gravitative movements. The data provided from different disciplines indicate that the active deformation in this sector is among the strongest ever experienced in Western Italy and Southern France.

The current geodynamics of the basin is not completely understood yet, and somewhat under interest and debate of the scientific community. The latest results on the recent evolution of the Alps-Mediterranean system, which acknowledge a halting of the collision at the level of Alps and a transfer of the active collision to the Algerian margin (Jolivet and Facenna, 2000; Nocquet and Calais, 2004; Wortel and Spakman, 2000) suggest that the area under study experience extension, but studies made at a local level (Bethoux et al., 1992; Eva and Solarino, 1998) would instead show that the area is under compression and hypothesize a closure of the Ligurian basin. The complex origin is not the unique element that renders this sector of peculiar importance. In fact, the interest for the area is reinforced by its seismic activity that, although of low to moderate energy, acts in a sector of high vulnerability. Some historical events involved dramatic social and material damages, like the 1831 and 1854, M=5.5 and M=5.7 respectively, earthquakes or the 1887, M=6.3 event (600

casualties) that also caused tsunami waves observed along the 250 km of the Ligurian coast from Genoa to Cannes, with run-up heights around 1-2 metres (Eva and Rabinovich, 1997). The recent growth of population (that now accounts for more than 2.500.000 inhabitants between Cannes and Genoa), the setting of numerous industries and the tourist business of the area are additional motivation for monitoring the area from the seismic point of view and especially to make specific studies on the seismogenic structures of this sector. Events with magnitude greater than 4.5 to 5.0 are in fact recorded every 5 years (Courboulex et al., 2007), but apart from these strong events, the area undergoes a rather weak microseismicity that often remains undetected and always poorly located by land seismic networks.

Finally, the natural risks associated to this sector are boosted by the presence of steep canyons that incise the offshore margin and favour gravitative slopes. The sediment masses accumulate on top of these canyons and may slip even after an earthquake of moderate magnitude. Within this frame, the identification, the location and the detailed description of both the seismogenic and the gravitative structures, on land and at sea, assume a paramount importance. The GROSMARIN (which stands for GrandROSMARIN) cruise is proposed by UMR Géosciences Azur (with fellow french and italian research groups). Its goals are to better characterize active structures along this zone and to assess the resulting seismic hazard in a sort of continuation with respect to the MALISAR experiment, which has already surveyed some active structures through shallow observations. The GROSMARIN cruise is in fact the necessary counterpart to characterize them at depth. The activity within the project is organized into two steps.

The first part of the experiment, conducted at sea with the R/V's l'Atalante, has consisted in an active survey to (1) study the microseismicity along a part of the northern margin of the Ligurian Basin, offshore France and Italy, roughly extended from Villefranche to Imperia and (2) to realise a 3D tomography by wide-angle seismics. In the eight days between 19 and 27 April 2008 shots every 60 seconds have been made on profiles parallel (about 150 km length) and perpendicular (about 100 km offshore) to the coast.

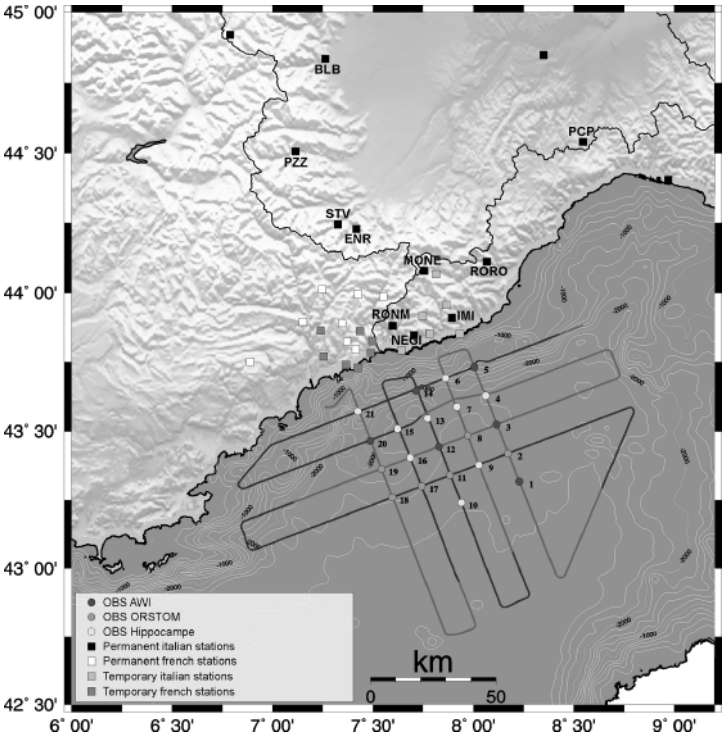


Fig. 1 - Main features of the GROSMARIN project. The circles show the location of the 21 OBS stations. The squares indicate the temporary or permanent seismic stations operating on French and Italian land. The lines show the shooting profiles.

The second part of the experiment is instead based on the recording of natural seismicity and is more tuned to the seismotectonic aspects. In fact, among its goals are the definition and characterization of the relationships between structures on land and at sea, to get a 3D tomographic model updated with respect to the

already existing one (Eva et al., 2001) by local earthquake inversion (Thurber, 1983) to be compared with that obtained by wide-angle seismics and to infer more details (location, geometry, extension) on the seismogenic structures of the Ligurian Sea. In order to get the best data coverage, in the experiment a network of temporary seismic stations has been set. Offshore, 21 OBS's (Ocean Bottom Seismometers) have been deployed, 15 out of which operate for a 5-month period above the active part of the margin. A dense temporary seismic network complements the observation zone on land. In fact, 16 temporary stations have been deployed (see Fig. 1 for details) for the recording of the active data; a part of these instruments will operate until all OBS are removed.

Nowadays the comprehensive database of active data, which will contain the about 500000 seismic recordings, is under compilation and processing. The preliminary analysis of the seismic waveforms show an excellent signal to noise ratio, in particular for the night shots, due to the careful choice of number and types of guns to be used. It is noteworthy to underline that, in optimal conditions, shots have been recorded even by seismic stations not included in the experiment and located much further north of the study area, like those operating in the northern sector of the Piedmont region (Fig. 2).

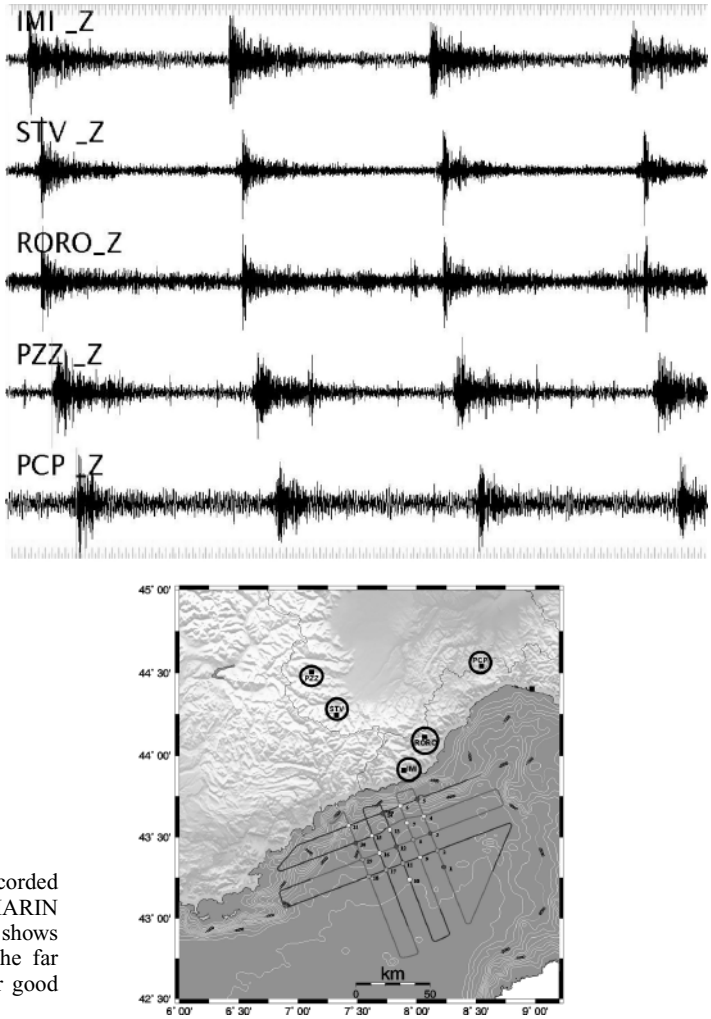


Fig. 2 - Example of waveforms recorded within the active part of the GROSMARIN project. The map on the bottom panel shows the position of the stations. Even the far stations (PZZ, PCP) exhibit a rather good signal to noise ratio.

**Acknowledgements.** This project is strongly linked with those led by the teams of Geosciences Azur and focused on the study of the seismic hazard along the Riviera area (PASSERELLE programme, « Risque-Décision-Territoire » of the ministry of environment ; IRIS project, « ACI risques naturels » programme, CURARE programme) and with those led by INGV (Istituto Nazionale di Geofisica e Vulcanologia) within the DPC (Dipartimento della Protezione Civile) 2007-09 frame under the task S1 (Determination of the seismic potential for the computation of the seismic hazard in Italy). The project is also included in the site characterization that should lead to the installation of a multi-parameter sea bottom observatories (ESONET/NoE).

## References

Bethoux N. , Fréchet J. , Guyoton F., Thouvenot F. , Cattaneo M. , Eva C. , Nicolas M., Granet M.; 1992: A closing Ligurian Sea? Pure and Applied Geophysics., 139, 2, 179-194.

Courboulex F., Larroque C., Deschamps A., Kohrs-Sansorny C., Gelis C., Got J.L., Charreau J., Stephan J.F., Bethoux N., Virieux J., Brunel D., Maron C., Duval A.M., Perez L., Mondielli P.; 2007: Seismic hazard on the French Riviera: observations, interpretations and simulations. Geophys. Journ. Int. 170, 1, 387-400

Eva C., Rabinovich A.B.; 1997: The February 23, 1887 tsunami recorded on the Ligurian coast, Western Mediterranean. Geophys. Res. Lett., 24, 2211-2214

Eva E. and Solarino S.; 1998: Variations of stress directions in the western Alpine arc. Geophys. Journ. Int., 135, 2, 438-449.

Eva E., Solarino S., Spallarossa D.; 2001: Seismicity and crustal structure beneath the western Ligurian derived from local earthquake tomography. Tectonophysics., 339, 495-510

Jolivet, L., Facenna C.; 2000: Mediterranean extension and the Africa-Eurasia collision. Tectonics, 19, 6, 1095-1107.

Nocquet J.M., Calais E.; 2004: Geodetic measurements of crustal deformation in the Western Mediterranean and Europe. Pure and Applied Geophysics, 161, 661-681.

Thurber C.;1983: Earthquake locations and three dimensional crustal velocity structure in the Coyote lake area, central California. J.Geophys. Res., 88, 8226-8236.

Wortel M.R.J., Spakman W.; 2000: Subduction and slab detachment in the Mediterranean-Carpathian region. Science, 290, 1910-1917.