STSM – report COST Action ES1301

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Summary

The mission in the Alboran Sea (fig. 1) had many objectives in several fields of marine geology (e.g. active and passed tectonic evidences, fluid escapes, coral mounts). This 5 weeks mission on the SARMIENTO DE GAMBOA vessel was divided in two parts: the LEG-1 from the 22nd April to the 14th May and the LEG-2 from the 15th May to the 24th May.

During the LEG-1, the scientific team achieves the very high resolution cartography of the seafloor in seismically active areas and realized gravity cores in order to observe evidences of recent displacements of the seafloor and to date them. The IFREMER has provided two Autonomous Underwater Vehicules (A.U.V.), IdefX and AsterX. Those engines were equipped with a multibeam Echosounder to picture to the seafloor, and from time to time with a Sub-bottom profiler Parasound. On the high resolution bathymetry, we cartography Quaternary active strike-slip fault zones along a roughly N-S transect (NF, DF, AF, fig. 1). This may demonstrate the distribution of the actual Africa/Eurasia convergence along a discontinuous N-S senestral shear-zone. We also observed the localization of pockmarks along faults which offset the seafloor.

During the second leg and during the day time, we realize dives with the ROV Max Rover from Hellenic Center for Marine Research (HCMR) in order to observe fresh tectonics scarps at the seafloor and related fluid escapes with a camera. With this method, we were unable to observe evidences of active fluid seepages on the Tofiño Bank or active pockmarks located on Quaternary faults.

During both legs, gravity core have been recovered from either part of major fault zones. Further analysis may provide information on the origin of fluids in the sedimentary cover and on vertical offsets from either part of Quaternary fault zones.

We also realized very high resolution seismic surveys with a SPARKER source from a private contractor (Geomarine Inc.) in order to characterize the sedimentary cover. 2D seismic lines have not been fully processed during the cruise and therefore cannot be used to determine the root of pockmarks.

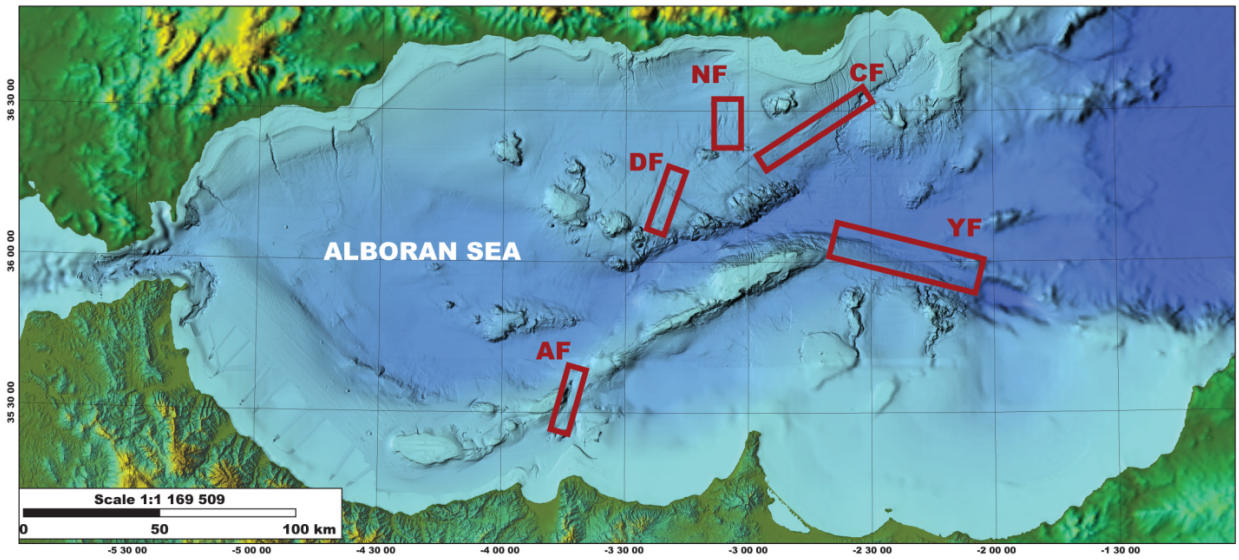

Figure 1 : Map of the Alboran Sea. Red rectangles: locations of studied structures. AF: Al Idrisi Fault; CF: Carboneras Fault; DF: Djibouti Fault; NF: North-South Adra Fault; YF: Yusuf Fault.

Purpose of the STSM

My PhD focus on the relationship between Plio-Quaternary deformation on the southern flank of the Alboran Basin and sedimentary processes. Past missions[1] in the AF area has shown the continuity of active strike-slip structures from the Moroccan land to the Alboran Sea[1]. However the continuity and the termination of the strike-slip faults remained not clear because bathymetry coverage was loose.

In deep marine environment, recent works in Alboran shows that the main sedimentary process is contouritic. Our data show pervasive presence of pockmarks to the top of such seabed features.

Such fluid escapes may have different sources. Miocene muds area a possible source. However, the age and the geographic extend of the Miocene muds are not known with precision. A shallower source may be under-compacted fluids trapped by contouritic sediments. The origin of fluids escapes at the seafloor might show the involvement of weak levels in the sedimentary cover or in the basement.

My goals in the mission were to observe recent tectonic features and related sedimentary features as pockmark at the seafloor in order to characterize the style of the Quaternary Tectonic style. At the regional scale the aim is to understand how the Africa/Eurasia convergence is accommodated by strike-slip structures, and how fluids influence the deformation.

STSM workload

During the first 3 weeks, I worked during the 4h-8h shift, and dedicated my time to two activities. The morning was dedicated to the A.U.V. watch. In partnership with the engineer team, the goal of exercise is to monitor the A.U.V. during the dive and record all anomalies that produce artefacts on the record of the bathymetry in order to make the processing of the data easier.

Along a programmed pathway, the A.U.V. records raw data from the multibeam echosounder. The echosounder send beams toward the seabed with a constant period of time, and records the time of return of the sonic impulse, which is called a ping. The depth of the seabed in the covered area is a function of the velocity of sonic impulse in the water, which is measured by a sound velocity sensor onboard. The A.U.V. also records its position at the moment of acquisition with its internal central inertial. The difference of record between the internal positioning system of the A.U.V and the real position of the A.U.V. is an important source of bias on bathymetric map. This bias is corrected with the Caraibes software (IFREMER). This is the first step of the processing of the bathymetry.

The nightshifts were dedicated to the correction of the bathymetry with the CARIS software. After a straight line, the turn of the A.U.V. is not recorded. The roll, the pitch and the azimuth of the A.U.V are not constant: for example the roll may vary within a 0-0.5° range. This provokes artefacts on the bathymetry. After the filtering of the navigation in the QUARIS software (Fig. 2), my job has consisted of cleaning the bathymetry. The signal reflected by the seafloor is not clean: obstacles in the water column between A.U.V and the seafloor noise makes noises in the data. Also, the diffusion of the beam on flat surfaces triggered false records of the time of return, which artefacts could be removed by filtration or manual picking of false pings. The signal/noise ratio also decreases toward the edges of the area covered, and errors in the measure of the speed in the water column leads to misfits between two lines of bathymetry. The misfit is corrected by hand in some case, or by applying a new speed, in other cases.

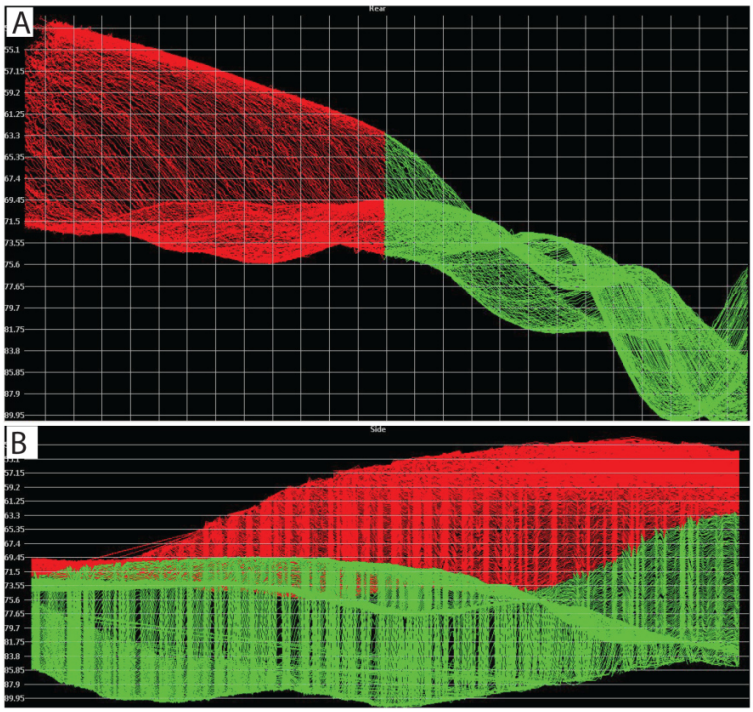

Figure 2: Bathymetry: raw data visualization in the CARIS Software. A : Rear view of a transect; B: Side view

During the second LEG my work consists of watching the during the 2-8am shift and to help to the deployment of the 250m long seismic-streamer.

Preliminary Results

The High Resolution (HR) bathymetry provides us the most

important results during the cruise. ROV dives did not allow to observe recent faults scarps or fluid escape in Quaternary basins or fault zones because the time of observation was too short and deep-sea sedimentary structures (coral mounts, contourites or turbiditic systems) may be active.

The cartography on the HR bathymetry of the part of the N-S Adra fault zone reveals a small basin bounded by Quaternary faults with important vertical component and with an approximatively N-S azimut. The faults limit the northern part of a rhombohedral graben-like basin. To the north of the area, pockmarks are visible at the seabed with a random position. In the basin, the pockmarks are line up along tectonic escarpments and on top of small horsts. In some places, pockmarks are visible with a Matryoshka Doll configuration. This suggests different generation of fluid escapes.

To the south of NF, the Djibouti fault zone (DF) shows 200m wide basin, lining along a deca-kilometric fault zone. The area presents evidences of recent tectonic offsets of the sea-floor. Some structures are oblique with a 60° angle to the NNE-SSW trend of the fault zone.

To the south, we observed similar tectonic structures in the Al-Idrissi Fault zone (AF). Recent small offsets of the seafloor are coherent with the high seismicity in the area. Outcropping fault are oriented as riddle-Shear and evidence of the senestral cinematic along the fault zone. Due to the lake of time Dr. Gràcia decided not to investigate volcanic structures to the south of AF.

From a sedimentary point of view, contouritic deposits influence the morphology of the seafloor. The fault zone crosses the contourite which seems to localize some pockmarks. Here again, it appears that the tectonic influences fluids behavior. However, the trigger of fluid escapes is not clear because we didn't neither observe the active faults nor active fluid escapes with the ROV or with other sensors. Consequently, the relation between pockmarks and active faults should be more investigated. However, the fluid thematic seems restricted to fluid from the most superficial origin, as pockmarks appeared to be contouritic related.

DF, NF, and IF are lining-up and show the same global cinematic. Those are active faults, running from the Adra Area to the Al-Hoceima Area near the Moroccan coast line. This mission confirms the presence at the seafloor of a strike-slip structure crossing the Alboran Sea.

Evidence of Quaternary active faults has been seen in YF and CF. Nonetheless, the last activity on those faults is not dated. The geometry of faults at the seafloor shows evidence of a strong strike-slip component for the recent deformation. In YF, we observe bulges at the seafloor that are likely to be folds associated with the recent strike-slip faults. The folds may be related to the stress loading during the interseismic period. It appears that YF and YF and CF are longer and more continuous than IF, AF and DF. But at this point, it is impossible to demonstrate that the discrepancy come from different mechanical behaviors, or from different stages of maturation of those fault zones.

In conclusion, the mission provides me observations of Quaternary strike-slip faulting in Alboran. But the relation with fluids escapes at the seafloor has to be more investigated. Further analysis of gravity cores could provide indications of the origin of fluids near the surface and therefore might show a relation between fluid escapes at the seafloor and active tectonic. At this point, there are no evidences that deep fluids or hydrothermal processes are involved in the

mechanical behavior at the regional scale. In contouritic environment, the localization of pockmarks along the faults shows that there is a relation between expressed faults at the seafloor and fluid escapes. However, it is impossible to propose a relative dating of those features.
A mechanical analysis of the strike-slip fault patterns at the seafloor must be done to move further on the linkage between fluid expulsions and deeply rooted tectonic processes.

Futur collaboration including publications resulting from STSM

For now, the collaboration with Dr Gràcia is pending to the decision of my PhD advisor.

Confirmation by the host institute of the successful execution of the mission

Please find the confirmation letter as an attachment to an email.

Other comments (if any).

(1) D'ACREMONT,E., GUTSCHER,M.-A., RABAUTE,A., MERCIER DE LÉPINAY,B., LAFOSSE,M., POORT,J., AMMAR,A., TAHAYT,A., LE ROY,P., SMIT,J., DO COUTO,D., CANCOUËT,R., PRUNIER,C., ERCILLA,G. & GORINI,C. (2014) High-resolution imagery of active faulting offshore Al Hoceima, Northern Morocco. Tectonophysics, 160-166.