TopoMed: Plate boundary reorganization in the western Mediterranean

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Introduction

This Collaborative Research Project (CRP) – with six Individual Projects (IPs) - addresses the process of plate boundary reorganization in the western Mediterranean region. The opening of the Algero-Provencal Basin (between Spain, Corsica-Sardinia and NW Africa) by roll-back of the African lithosphere, led to collision of the migrating arc-trench system with the NW African (Maghrebian) margin, in the M. Miocene (Fig. 1). We investigate the hypothesis that this event prompted the subsequent and probably still ongoing evolution of the Calabrian Arc in the east, and possibly that of the Gibraltar Arc in the west.

Furthermore, recent activity along the North African margin indicates the possibility that a new subduction zone is being formed, accommodating the continuing ~ N-S motion between Africa and Eurasia (Europe). The Mediterranean region offers unique opportunities to study this key element in Earth dynamics (the Wilson cycle!) in a natural setting. **TopoMed** integrates geophysical, geological and geodetical data acquisition and analysis, imaging, and advanced modelling to investigate the past and future evolution of this plate boundary reorganization. Special focus is on the relationship between the deep lithospheric and mantle scale processes and their (near-) surface expressions.

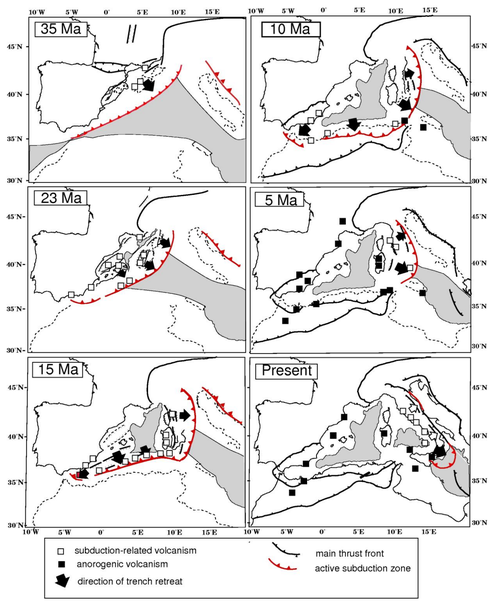


Fig. 1 – Evolution of the convergent plate boundary in the western Mediterranean

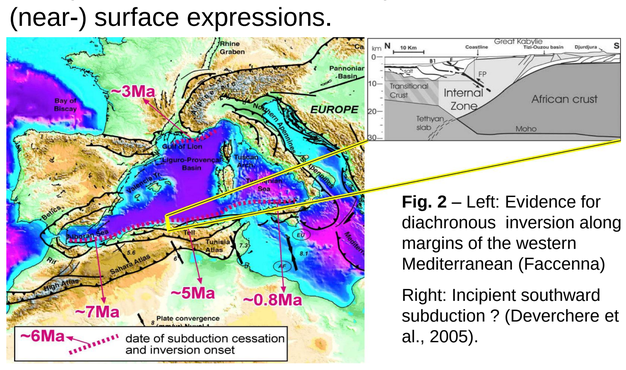


Fig. 2 – Left: Evidence for diachronous inversion along margins of the western Mediterranean (Faccenna)

Right: Incipient southward subduction ? (Deverchere et al., 2005).

Gibraltar Arc – Gulf of Cadiz – Sea of Alboran - Morocco

How did the Gibraltar arc evolve and is it still active? This question is important in view of the possible seismic hazards involved (Lisbon 1755 earthquake!). IPs Germany, Ireland, Portugal and Spain encompass extensive data acquisition campaigns, successfully carried out in close internal TopoMed collaboration and partly in connection with the PICASSO-project (NSF). Methodologies range from magnetotellurics, via controlled source seismology and random noise surface wave tomography to deployment of ocean bottom seismometers and structural modelling. Special attention is given to detailed mapping of geomorphological features in the Gulf of Cadiz.

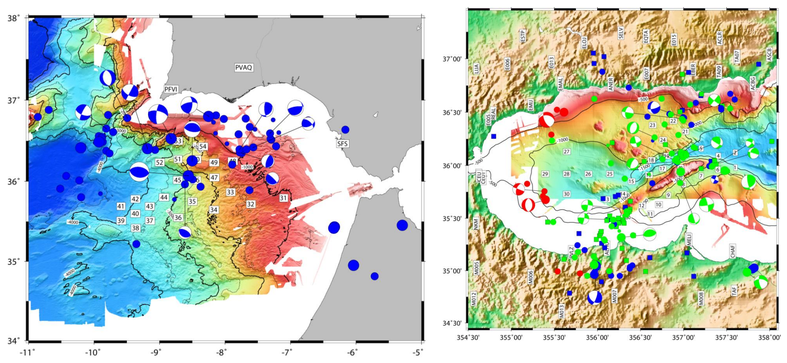


Fig. 3 - Deployments of OBS and preliminary located earthquakes. Color coding for focal depth in the Alboran Sea: blue < 10 km, 10 km <=green<50 km, red >= 50 km,(IP Germany)

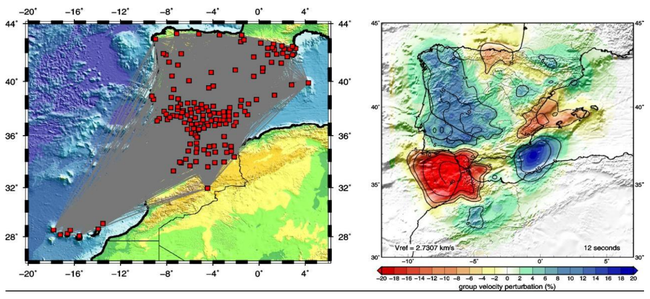


Fig. 4 – Random noise surface wave tomography . Group velocity perturbation map obtained from inversion of the interstationgroup velocity measurements. The perturbations are computed with respect to the map average velocity mp and expressed in percentage. (IP Portugal)

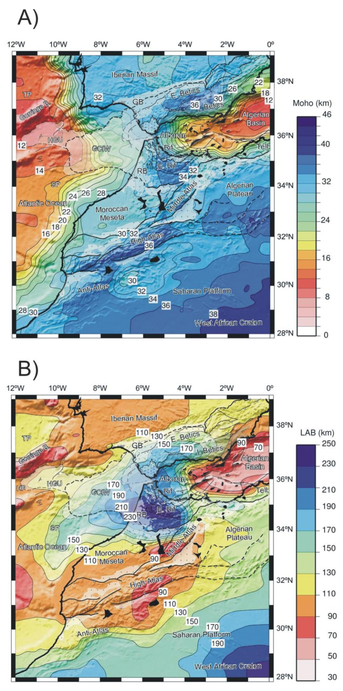
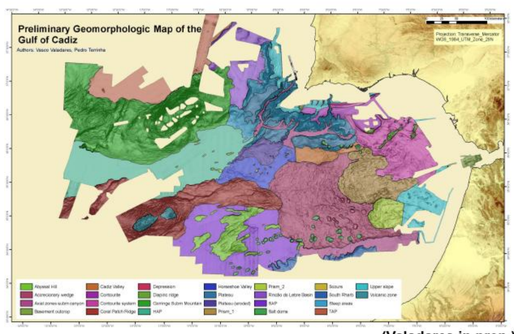


Fig. 5: A) Moho depth map corresponding to our preferred model superimposed to the structural map with the main tectonic units and volcanism. Isolines every 2 km. B) Lithosphere-asthenosphere boundary depth map corresponding to our preferred model superimposed to the structural map with the main tectonic units and volcanism.. Isolines every 20 km (IP Ireland/Spain).



(Valadares in prep.)

Fig. 6 – Preliminary geomorphological map of the Gulf of Cadiz (IP Portugal)

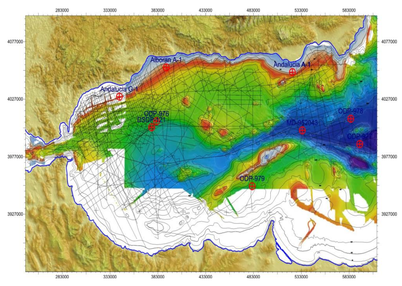


Fig. 7 - Seismic profiles data-set in the Alboran Sea (IP Spain)

Calabrian Arc

Also here the question is (Messina earthquake 1908!): Is the arc still active ?

Detailed studies in IP Italy addressed the structure and evolution of the arc's accretionary complex and the location and geometry of active faults absorbing convergence. Some results: -

Kinematic reconstructions suggest that the outer deformation front has migrated towards SE at a rate of 2 cm/yr in the last 5 Myr.; - east of the toe of the Malta escarpment a STEP-fault accommodating roll-back is identified.

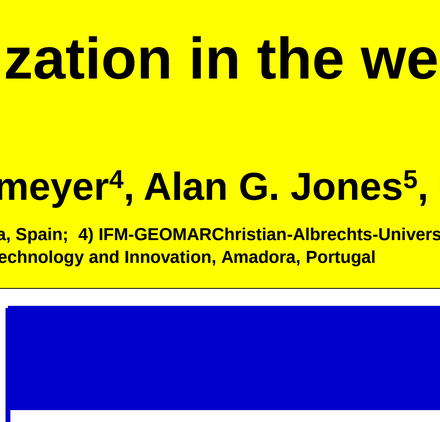


Fig. 8 (Left) - Geodynamic setting of the study area. The Eurasia/Africa plate convergence rate is indicated by the red arrow. The geological model is modified from Morelli A., and Barrier E., 2004, Commission for the geological Map of the World, coord. by Cadet J.-P. and Funiciello R.
The NW ward dipping subducting slab of the African plate is represented by the yellow isodepth lines in the Tyrrhenian Sea.

Fig. 9 (Right) – Shaded relief bathymetric map (GEBCO data) with the location of the geological and geophysical data available in the working area. The three key areas studied during the second year of the TopoMed project are represented by the black boxes. Newly acquired data (MCS and CHIRP seismic data) are represented by the red and green lines.

Subduction initiation in southern Tyrrhenian Sea ? Role of STEP-fault?

Seismic activity in the southern Tyrrhenian Sea points to incipient southward subduction, possibly induced by the STEP- fault related weakness zone .
IPs Italy and NL jointly address this possibility, combining observations and modelling

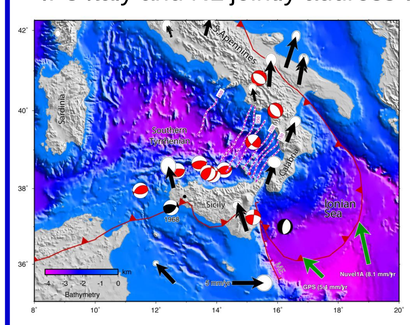


Fig. 10 (Left) - Seismic activity in southern Tyrrhenian Sea indicates incipient southward subduction. *GPS from D'Agostino and Selvaggi, 2004.*

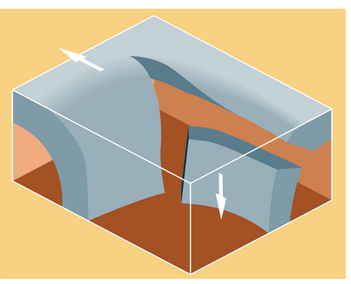


Fig.11- (Right) -This is a region of presumed (former) STEP-fault activity. Numerical modelling indicates that this weakness zone allows for subduction initiation (see Fig. 12).

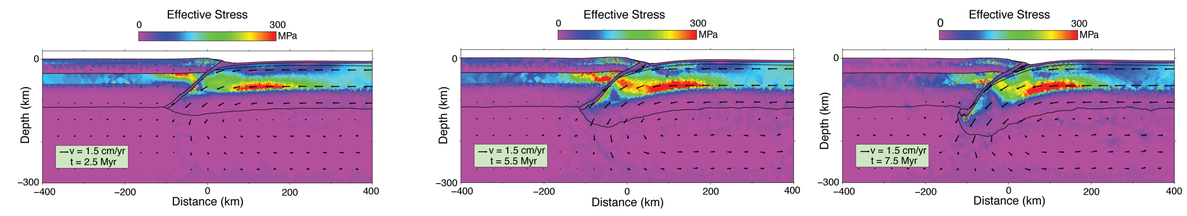
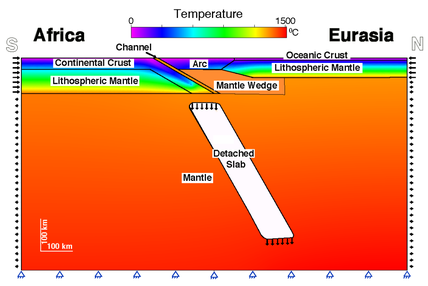


Fig. 12 - Numerical models indicate that a STEP fault in a convergent setting may lead to subduction initiation (IP NL, Baes et al..))

Algerian margin: Arc-continent collision and subduction polarity change ?

What happens after collision of the migrating trench and arc with the north Afrcican margin (~ Langhian) ?

Observational evidence obtained by French associated partners (see Fig. 2) is combined with numerical modelling (IP NL). Results shed light on conditions required for subduction polarity reversal and temporal evolution of the process (cf. Fig. 2)



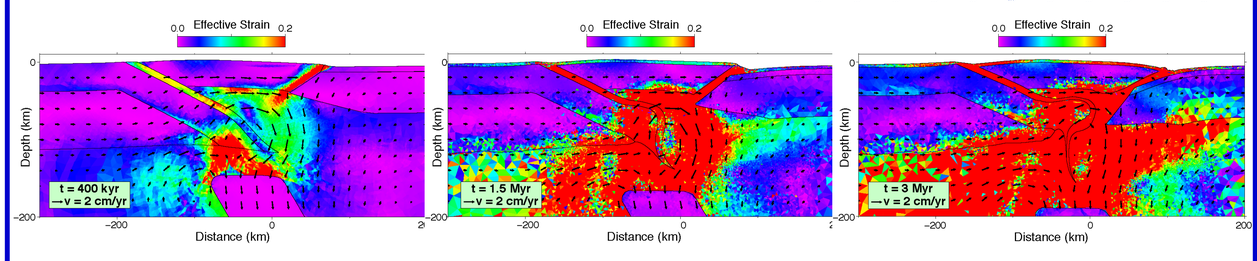


Fig. 13 - Numerical models for subduction polarity reversal after arc-continent collision (IP NL, Baes et al..)

Conclusions

- Progress in data acquisition components of TopoMed is very good.

- Numerical modelling of pertinent plate boundary processes has provided insight in the possibilities of incipient subduction.

- Analysis of observational results and integration of Individual Projects are underway

- The western Mediterranean truly is a unique natural laboratory for studying plate boundary reorganization.