

## Crustal structure of the Libyan margin

Marco Brönnner and Jannis Makris

*Institute of Geophysics, Hamburg University, Germany*

### INTRODUCTION

The Eastern Mediterranean sea is characterized by high seismicity and a complex tectonization which is not fully understood yet. Several geodynamic models have been developed to explain the processes in this region (Makris, 1976; Le Pichon *et al.*, 1982; Mc Kenzie, 1970 and 1972). Still the subduction process south of Crete, the crustal structure below the Mediterranean Ridge and the deep structure of the north African passive continental margin remain poorly understood. The geophysical data – especially for the African margin – are limited to potential fields and some industrial reflection seismic lines, while deep seismic soundings are either very old or completely missing.

From reflection seismic experiments (Chaumillon *et al.*, 1996) at the southern edge of the Mediterranean Ridge (MR) a backthrusting tectonic structure in the sediments was identified in a southward direction. This confirms the MR as an accretionary complex (Le Pichon *et al.*, 1982; Ryan *et al.*, 1982; Mascle *et al.*, 1995), but it is not yet clear if and how far this backthrusting reaches onto the continental margin. Furthermore the question arises about how far the extant compression affects a tectonization of the African margin and of the crust itself.

To investigate questions and better understand the geodynamic processes in the Eastern Mediterranean region two active seismic studies south of Crete and the Mediterranean Ridge were carried out. We used densely spaced Ocean Bottom Seismographs (OBS) with distances of 3.5 to 5 km and shot a 48 lt. airgun array at 120m intervals. Two profiles extended to the Libyan margin of Africa and mapped its crustal structure. The locations of both lines are indicated in figure 1, where the bathymetric-topographic features demonstrate the complexity and lateral variability of the area.

### PRELIMINARY RESULTS

The data were combined to common receiver point gathers (CRP) and corrections derived from navigation and bathymetric data were taken into account. For both lines about 130 CRP sections could be used for evaluation. The data were evaluated with forward modelling by using two point raytracing of traveltimes and amplitudes (Cerveny and Psencik, 1983) For each line we generated a 2D P-wave velocity depth model which resolved the crustal structures along these lines. We identified by different velocities at least four sedimentary layers, upper and lower continental crust and oceanic crust.

Crete-Project '99, Distribution of OBS- and Land-Stations

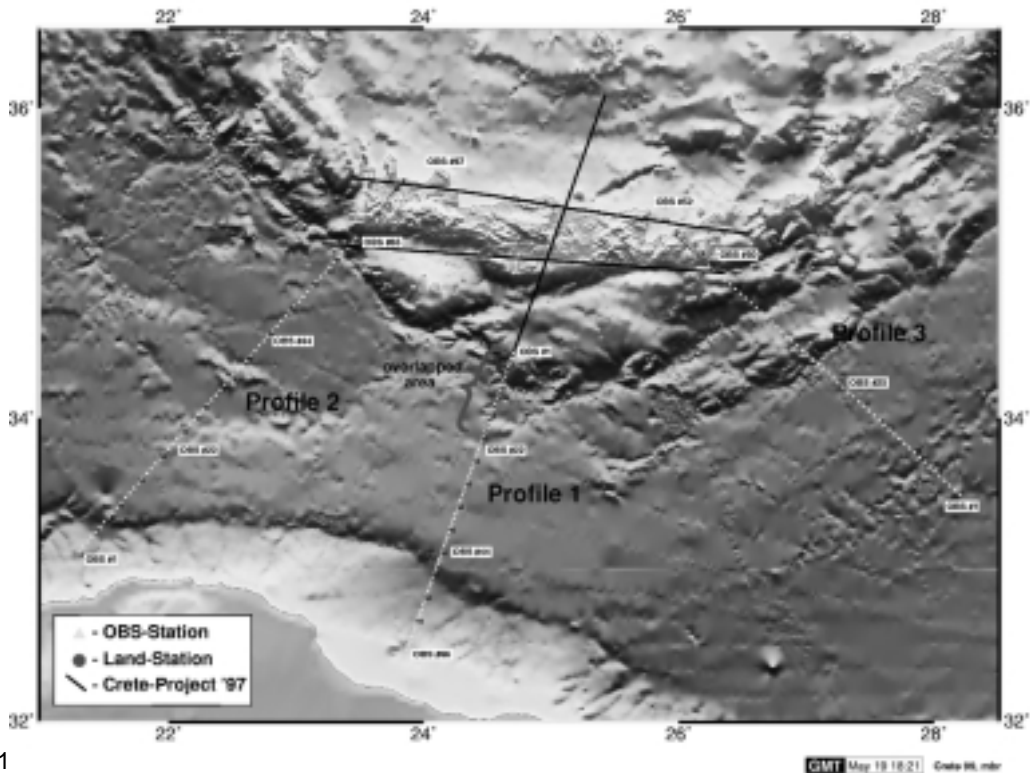


Fig. 1

Profile 1

The first line is N-S oriented and extends from the Cretan continental margin to Tobruk in Libya. The sea bottom varies on this profile from approx. 900 m on the African margin to more than 3400 m depth at the Hellenic Arc. In the middle of the profile – at the Mediterranean Ridge – an almost constant depth of 1800 m is observed. Along the line 66 OBS were deployed with a spacing of 3.5 km, and 2258 airgun shots were fired. For evaluation and computation of a 2D velocity depth model along this line (Fig. 2), 53 CRP sections were applied.

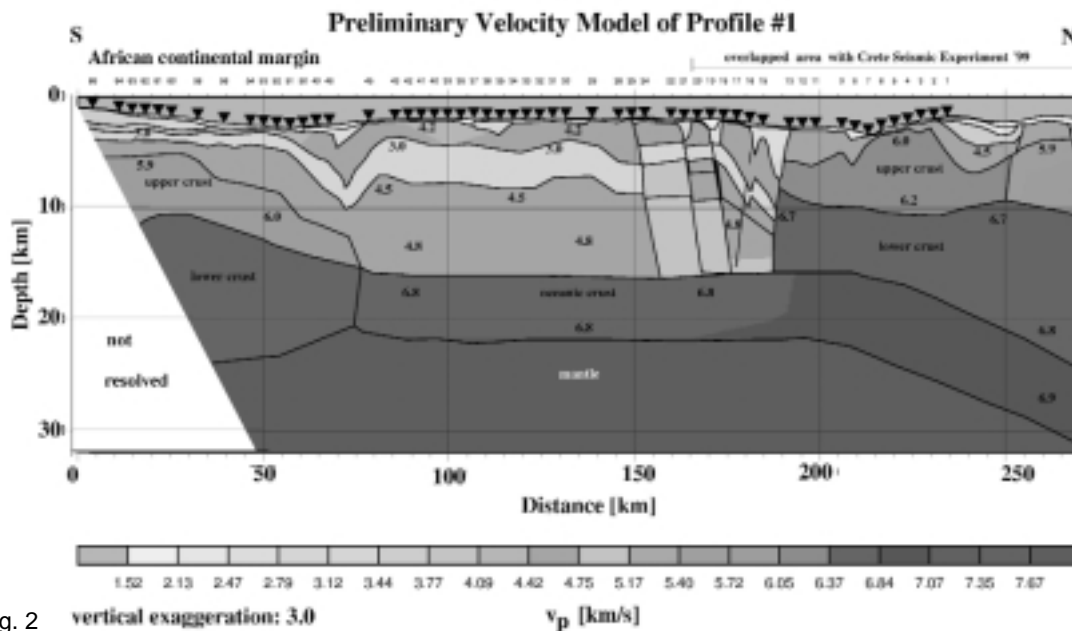


Fig. 2

The African passive continental margin extends to nearly 90 km offshore the coastal line and has an abrupt transition to an oceanic crust buried under 12 to 14 km of Mesozoic and Neogene sediments. The sediments on the Libyan margin along this profile are 4 to 5 km thick and they have at least one major velocity inversion zone. They are depressed to the continent-ocean margin where their thickness is nearly doubled and where they show backthrusting to the south. The depth of water here increases to some 3000 m. The sediments and the crust at this part of the margin are not severely deformed, until well off the transitional area. The continental crust is 23 km thick and thickens towards the coast to a value of approx. 28 km.

**Profile 2**

The second line of NE-SW orientation extends from western Crete towards Bengazi and the Sirte basin. Along this seismic profile strong variations in bathymetry and topography are observed. Onshore Crete the altitude ranges between approx. 20 m and 870 m, south of Crete the depth of water increases rapidly to approx. 3700 m in the Hellenic Arc. Towards the south the seafloor depth ranges between 2500 m and 2000 m and decreases to approx. 1400m towards the African margin. Sixty seven OBS and 17 landstations were deployed. The spacing between the OBS was approx. 4.2 km, the distance between landstations was about 2 km, and 2852 offshore shots were fired. For evaluation and computation of a 2D velocity depth model along this line (Fig. 3), 80 CRP sections were used.

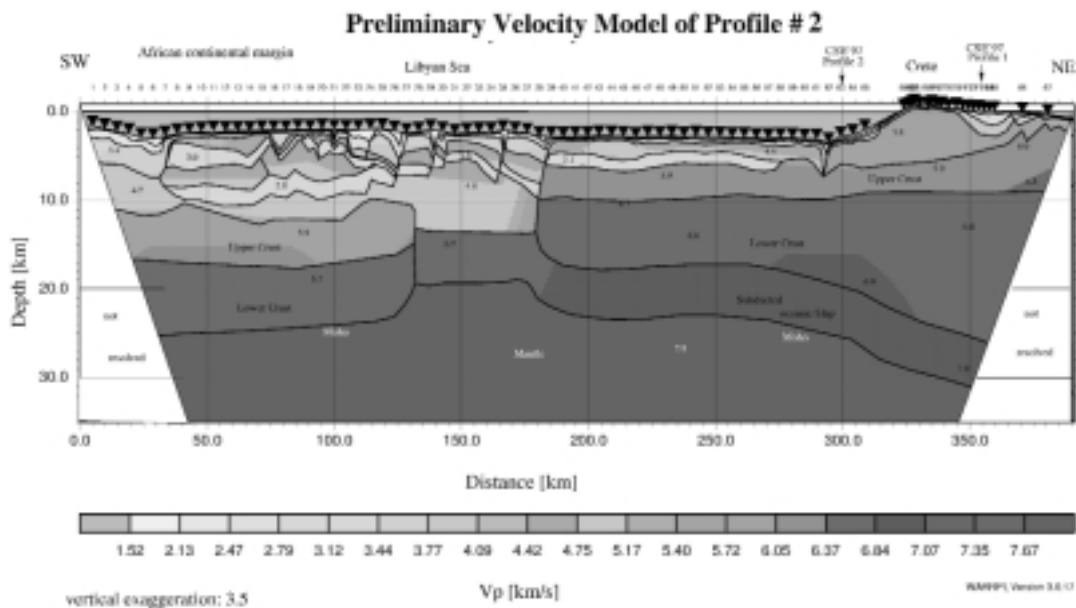


Fig. 3

The continental structure of this area extends to at least 160 km off the Libyan coast and is severely tectonized. Towards the coast a well developed basin was identified following the bathymetric depression. It is limited to the northeast by a major fault. The crust is 22 to 25 km thick including 6 to 7 km sediments under a 2 to 2,5 km waterdepth. Particularly intense is the tectonization of the structures at the continent-ocean margin. Two inversions of the  $v_p$ -velocities were identified, demonstrating the complexity and extended history of this passive margin. The tectonic structures in the sediments are dominated by large and inordinate sequences of overthrust tectonics towards the south, that becomes chaotic at the transition. The following oceanic structure is of limited extend, not more than 50 km wide and covered by 12 to 13 km of strongly tectonized sediments. Subsequently it is in contact to the European continental margin southwest of Crete. The identification of the collision of the African-European continental margins is most advanced in this area, where crustal shortening should produce a continent-continent collision in the near geological future. The complexity and lateral variability of the Mediterranean margin of north Africa are demonstrated in a simplified way for the Libyan coastal areas.

## CONCLUSIONS

The crustal structure of the African margin as it is identified along profile 1 and profile 2 is extremely different. While the passive continental margin at profile 2 shows thick and strong tectonized units of sediments lying on thin continental crust, the African margin – basement and sediments – along profile 1 is barely affected by faulting. This changes abruptly at the transition where huge packages of sediments start to be backthrust towards the African margin. Furthermore at profile 2 we identified two layers with velocity inversion in contrast to only one at profile 1. The upper one can be explained by weak sediments covered by Messinian salt. It can be observed on both profiles up to the European continental margin south of Crete. An explanation for the second, deeper low velocity layer at profile 2, might be given by tectonic deformations and broad overthrusting which is a consequence of continuous crustal shortening. Therefore thicker and stronger tectonized sediments along profile 2 may indicate a more advanced compressional process between Africa and Europe on the western profile, which would also explain the smaller relic of oceanic lithosphere between the African and European continental margins.

Although the crustal structure of the Libyan margin is mapped quite well along these two profiles, a correlation and interpretation of the evolution of the African margin remain highly speculative until more deep seismic studies are performed by active on-offshore experiments.

So far P-wave traveltimes were taken into account to generate present models. A refinement in resolution and a further confirmation of the models will be accomplished by evaluation of converted waves and gravity data.