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NEOTECTONIC STRUCTURE OF THE LAKONIKOS GULF

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ABSTRACT

Detailed single-channel seismic reflection survey has been carried out in the Lakonikos Gulf, Southern Peloponnese, aiming to a better understanding of the neotectonic structure of the Lakonikos Basin. Our survey showed that, contrary to the model of a simple N-S asymmetric graben previously considered, a tectonic horst occurs within the tectonic graben of Lakonikos. A subsidence of more than 1000m is produced by the N-S marginal faults, whereas, the N-S faults creating the central horst structure within the Lakonikos graben are high-angle reverse faults, which have uplifted the sea bottom together with the Pleistocene and Holocene sediments by about 100m. Several E-W vertical transcurrent faults, with strike-slip motion deform the N-S structures. The central tectonic horst structure is very recent as the observed deformation of the Upper Pleistocene and Holocene sediments indicated and a transtensional geodynamic regime is suggested.

KEY WORDS: seismic reflection survey, neotectonic structure, Lakonikos Gulf, Southern Peloponnese, Greece

1. INTRODUCTION

In contrast to the other segments of the Alpine Tethyan system, the Hellenic arc represents a segment where subduction of the African plate is still taking place. Latest Neogene extension and subsidence in the area of the Hellenic arc is expressed by the creation of several neotectonic basins. The geodynamic models proposed for the creation of these basins consider, in general, a tensional regime with the formation of tectonic grabens by normal faulting (McKenzie, 1978; Mercier, 1979). More complex geodynamic models have been also proposed including mega-shearing and torsion instead of pure tension (Mariolakos & Papanikolaou, 1982,1987).

In 1987-1989 the University of Athens together with the National Center for Marine Research with financial support from the Earthquake Planning and Protection Organization carried out detailed marine seismic survey in the frame of the research project on the neotectonic structure of the Hellenic arc. Emphasis was given to the study of the submarine basins around the Central and Southern Peloponnese. A dense grid of single-channel reflection profiles was obtained using 10-40-inc^3 air-gun source and 2-9 KJoules Sparker system (model SIG)on R/V Aegaeon. Positioning was achieved by using radar fixes every 5 minutes with precision ±50m. In addition, high-resolution echo sounder along the same profiles was used to enable the construction of precise bathymetric maps.

This detailed geophysical survey resulted in the distinction of the neotectonic structures of the Messiniakos (Papanikolaou et al, 1988a, 1988b, Pavlakis et al, 1989) and Argolikos (Papanikolaou et al, 1994) gulfs of the Southern Peloponnese. More recently some results on the Lakonikos (Papanikolaou et al, 1997) and Kyparrisiakos (Foundoulis et al, 2000) gulfs have been also presented. Present paper concerns the neotectonic structure of the Lakonikos gulf.

2. THE MORPHOLOGY OF THE LAKONIKOS GULF

The bathymetry of the gulf (Fig.1) shows an asymmetric basin elongated in the N-S direction with the axis of the basin running close to the eastern coastline. The asymmetry of the basin is marked by the difference in the slope morphology, which shows abrupt slopes along the eastern margin and more gentle slopes along the western margin of the gulf.

The morphology of the gulf bottom is rather complicated without a flat lying basinal part but instead it shows a strongly deformed area of 10-15 km width with uplift in the central part of the gulf. This feature defines the difference in geomorphology of the Lakonikos Gulf in comparison with that of the adjacent Messiniakos and Argolokos gulfs (Fig. 2a, b, c). The uplifted area is bordered both to the east and to the west by narrow channels

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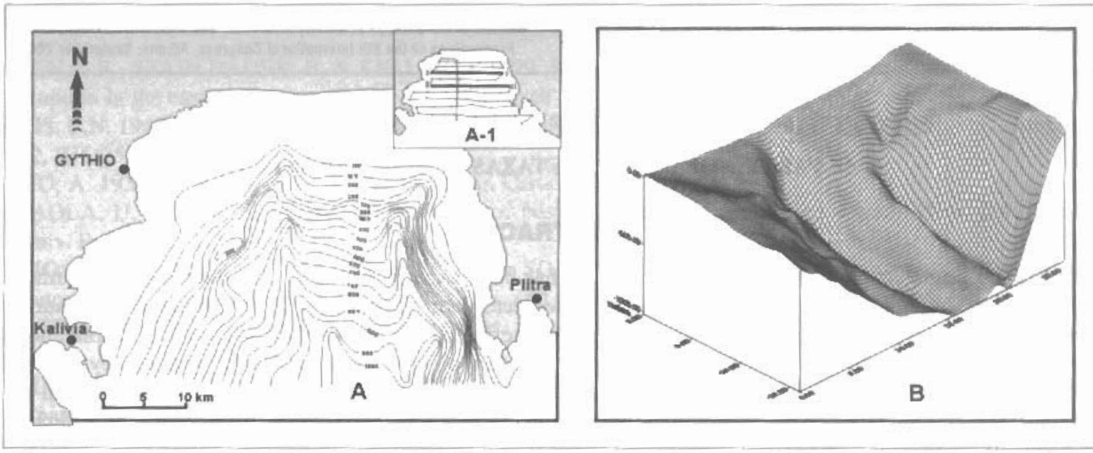

Fig. 1: Bathymetric map of the Lakonikos Gulf with contour interval 50 m (A) and the 3D bathymetric model of the gulf (B). Sketch map (A-1) shows the grid of the seismic reflection profiles within the gulf.

(2-3 km width) running in the N-S direction. The overall geomorphological structure is limited below the continental shelf area.

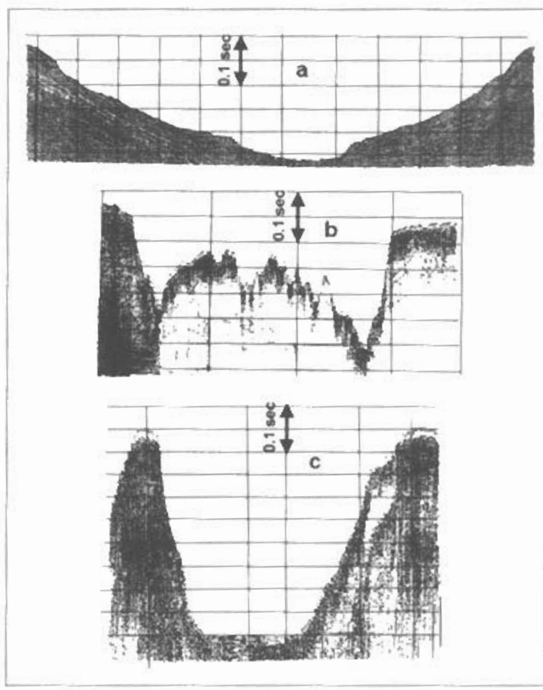

Fig. 2: Representative profiles of Messiniakos (a), Lakonikos (b) and Argolokos (c) gulfs showing their different geomorphological structure.

The morphological slope map (Fig. 3) shows that the only subhorizontal seabottom areas are, in fact, the continental platform with depth below 120m. It is also remarkable that the western half of the gulf is dominated by 5-20% slope values whe

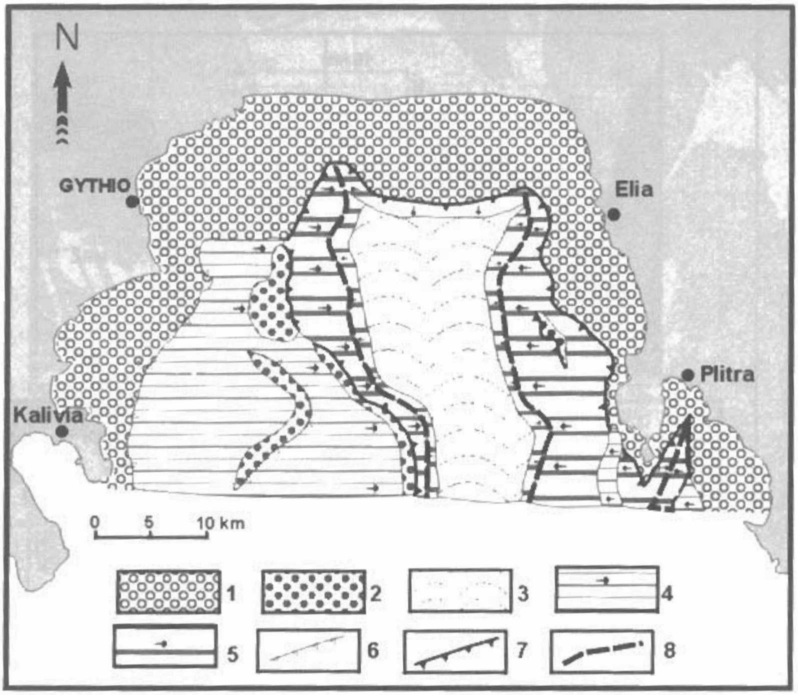

Fig. 3: Morphological slope map of the Lakonikos Gulf.
1: Very small slopes (less than 3%) on the continental platform, 2: Small slope values (1-5%) on the continental slope, 3: Area of intense relief of the sea bottom, 4: Moderate slope values (5-20%), 5: High slope values (more than 20%), 6: Minor slope discontinuity (> 5%), 7: Major slope discontinuity (> 15%), 8: Submarine channels

3. THE NEOTECTONIC STRUCTURE OF THE LAKONIKOS BASIN

The neotectonic structure of the gulf can be studied on the basis of fault and corresponding block geometry and kinematics with consideration of the geometry, orientation and throw of the faults on one hand and geometry, type of movement (vertical, horizontal or rotational) and relative motion in regards to the adjacent neotectonic blocks on the other (Papanikolaou et al., 1994).

Fault characteristics can be obtained from seismic profiles on the basis of local stratigraphy and the use of marker horizons. An average velocity of 1750 $msec^{-1}$ for Holocene sediments and 2000 $msec^{-1}$ for the other post-alpine formations were used in order to estimate the fault throw and reflection depth. Three stratigraphic units can be distinguished in the Lakonikos Gulf according to their reflection character (Fig.4). The Holocen unit, with an almost constant thickness about 20-25 m, can be observed on seismic reflection profiles all over the basin. The thickness of the Middle-Upper Pleistocene unit, which conformably underlies the Holocene, does not exceed 200m. The third unit, observed below is interpreted as Pliocene-Lower Pleistocene sediments, which also occur onshore around the gulf in the adjacent tectonic blocks. The deep-seated alpine basement cannot be distinguished on seismic profiles due to the limited penetration possibilities of the effected seismic survey. In several cases the contact between the lower and the middle unit was used for estimating the fault throw and minimum relative vertical motions.

The study of planar geometric features, such as the depth of continental platform, provides a good measure of the Holocene deformation. The depth of the edge of the continental platform of the Lakonikos basin ranges mostly between 95 and 113 m, which indicates the range of the vertical movement of the tectonic blocks during the Holocene (Fig.5). In some blocks the change of depth is gradual due to the tilting of the blocks. The continental platform of the Lakonikos Gulf is developed all around the basin and its structure is not as complicated as that described in the adjacent Messiniakos and Argolikos basins (Papanikolaou et al., 1988a, Pavlakis et al., 1989, Papanikolaou et al., 1994).

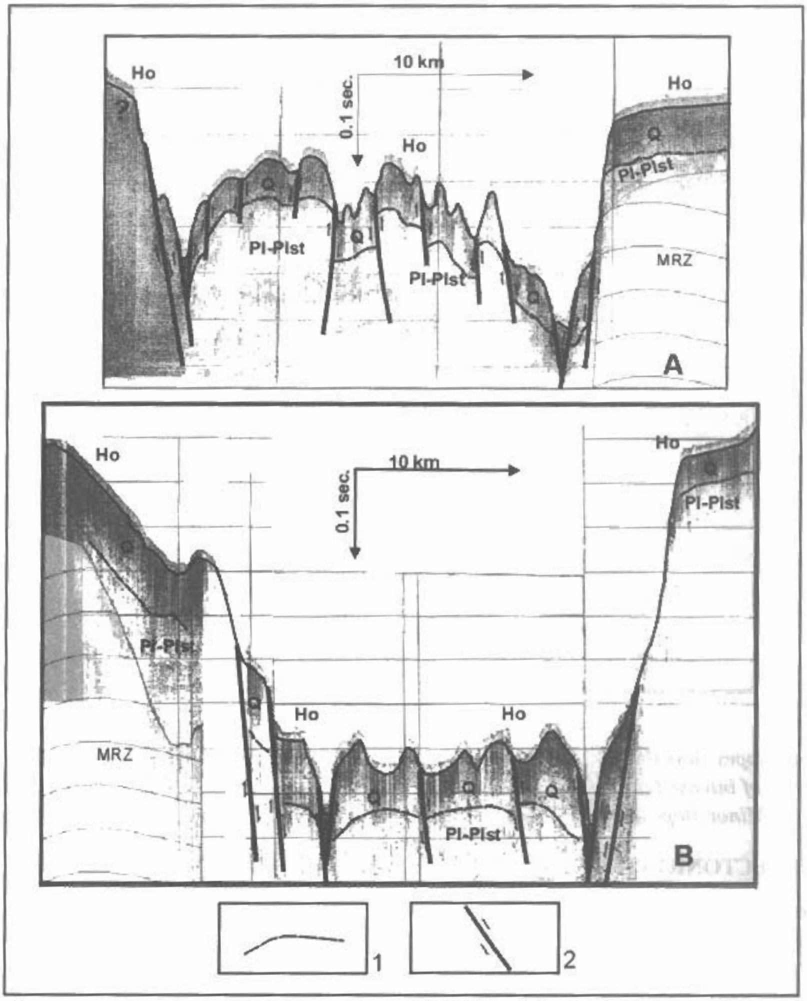

Fig. 4: Representative seismic reflection profiles I-I (A) and II-II (B) with elements of seismostratigraphy and structure of the Lakonikos Gulf

1: Surfaces (marker horizons), 2: Faults with arrows indicating sense of movement. Seismostratigraphy: Ho - Holocene, Q - Middle-Upper Pleistocene, Pl-Plst - Pliocene - Lower Pleistocene. Location of profiles I-I and II-II see on Fig. 1, A-1.

3.1 The fault geometry and kinematics

The faults detected within the Lakonikos Gulf can be distinguished in three groups (Fig.5): (i) the normal faults with N-S direction (from NNW-SSE to NNE-SSW), which control the geometry of the basin. Some secondary N-S normal faults, disrupt the main structures, (ii) the high-angle reverse faults of N-S direction, which produce an uplift of the central part of the basin, (iii) the transcurrent faults with E-W direction, which show a pronounced strike-slip component and cut across the whole structure of the basin by creating parallel E-W segments.

The overall neotectonic subsidence of the central part is estimated more than 1000 m although the total fault throw cannot be estimated because of the absence of the alpine basement in the seismic profiles. Based on the displacement of the lower and the middle units it is about 300-600 m along the eastern margin and about 150-250 m along the western margin of the neotectonic graben.

The reverse high-angle faults create the central horst structure within the Lakonikos graben (Papanikolaou et. al., 1997). They have uplifted the sea bottom together with the Pleistocene and Holocene sediments by about 100-150 m in comparison to the adjacent channels. Additionally they create microblocks and internal deformation of sediments observed inside the horst structure (see Fig.4).

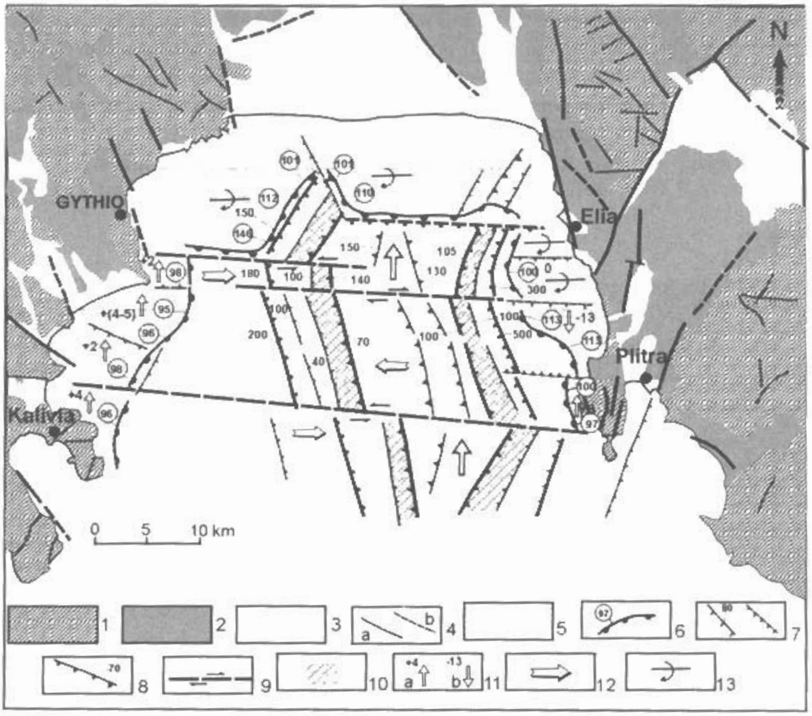

Fig. 5: Simplified neotectonic map of the Lakonikos Gulf
Neotectonic structure onshore (according to Lekkas et al., 1998). 1: Alpine formations, 2: Pliocene-Lower Pleistocene, 3: Upper Pleistocene-Holocene, 4: Faults of uncertain kinematics, detected (a) or probable (b), Neotectonic structure offshore. 5: Continental platform, 6: Edge of the continental platform with depth indications in m.'s, 7: Normal faults with indication of their throw in m.'s, certain (a) or probable (b), 8: Reverse faults with indication of their amplitude in m.'s, 9: Transcurrent faults with indication of their strike-slip motion, 10: Areas of narrow grabens, bordering the recent horst structure within the Lakonikos basin, 11: Motions of blocks of the continental platform with indication of the uplift (a) and subsidence (b) rate in m.'s, 12: Horizontal escape of blocks, 13: block tilt with indication of sense of tilt.

The above N-S trending complex tectonic structure is disrupted by E-W transcurrent faults, whose horizontal motion is indicated by the offset of fault segments, the offset of the edge of the continental platform and the abrupt change of several morphological and tectonic features. In all cases the horizontal motion is much higher than the vertical and may reach several km. Although both senses of horizontal motion are presented, the prevailing motion is sinistral.

3.2 The geometry and kinematics of blocks

In the case of the Lakonikos Gulf all the categories of block motion (relative uplift, relative subsidence, tilt around horizontal or inclined axis, horizontal escape) are present (Fig.5). The western margin is characterized by relatively small block uplift up to 2-5 m judging from the difference of the depth of the edge of the continental platform. Some blocks at the northern margin appear to be tilted around E-W horizontal axis. Tilt and subsidence of about 13 m are characteristic for some neotectonic blocks along the eastern margin, with exception of an uplift up to 3 m, which is observed on the tectonic horst of the Xilis cape block, west of Plytra.

4. CONCLUSIVE REMARKS.

The most significant feature of the Lakonikos basin is the creation of the remarkable central tectonic horst within the general tectonic graben. The tectonic horst structure is very recent as the observed deformation of the Upper Pleistocene and Holocene sediments indicates (see Fig. 4). Based on the distribution of the 20-25 m thickness deformed Holocene sediments, and the throw amplitudes of the reverse faults, an average uplift velocity of 15-30 mm/year during the last 4-5 thousand years can be estimated.

A transtentional geodynamic regime could be suggested for the offshore structure. The detected onshore active faults of the Southern Peloponnese (Angelier, 1978, Kowalczyk & Winter, 1979) indicated that in the Early Quaternary the Southern Peloponnese was incorporated into an area of compressional stress. Our point is that the geometry and kinematics of the N-S reverse faults, as well as the E-W transcurrent faults, with predominance of left-lateral strike-slip motion, result in a NE-SW recent local compression stress field in the area of the Lakonikos Gulf.

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