Δελτίο Ελληνικής Γεωλογικής Εταιρίας τομ. XXX/1, 325-330, 1994
Πρακτικά 7ου Επιστημονικού Συνεδρίου, Θεσσαλονίκη, Μάιος 1994

Bulletin of the Geological Society of Greece vol. XXX/1, 325-330, 1994
Proceedings of the 7th Congress, Thessaloniki, May 1994

LATE QUATERNARY UPLIFT OF THE OLYMPUS - PELION RANGE COASTS (MACEDONIA - THESSALY, GREECE)

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ABSTRACT

Geomorphological and biological evidence at a number of sites along the coast of the Ossa- Pelion Ranges testifies to an about 60cm seismic uplift, which, in one case, was dated at around 1500B.P. Relicts of marine sediments have also been observed in a number of sites along the coast, at heights of about 15m. The preservation of marine fauna and the level of the sub-aerial exposure diagenesis indicate a coastal uplift of Late Quaternary age. This last movement may probably be extrapolated for the whole Olymbus- Pelion chain and indicate that uplift continued during the period of extensional tectonics; however, the observed Late Quaternary small-amplitude motions may not be related to the uplift responsible for the unroofing of the metamorphic rocks of this mountain chain.

ΠΕΡΙΛΗΨΗ

Γεωμορφολογικά και βιολογικά στοιχεία οδηγούν στο συμπέρασμα ότι σε διάφορες θέσεις κατά μήκος της ακτής των βουνών Οσσας και Πηλίου παρατηρείται σεισμική ανύψωση 60περίπου εκ., για την οποία σε μία τουλάχιστον περίπτωση η ραδιοχρονολόγηση με επιταχυντή έδωσε ηλικία 1500 περίπου ετών. Υπολείμματα θαλάσσιων ιζημάτων εντοπίστηκαν επίσης σε ύψος 15 περίπου μέτρων σε διάφορες θέσεις κατά μήκος της ακτής. Η διατήρηση της θαλάσσιας πανίδας και και ο βαθμός της αερόβιας διαγένεσης υποδηλώνουν ανύψωση Ανω Πλειστοκαινικής ηλικίας. Η τελευταία αυτή κίνηση φαίνεται ότι αντιστοιχεί σε ολόκληρο τον ορεινό όγκο Ολύμπου- Πηλίου, και υποδηλώνει ότι η ανύψωσή του συνεχίστηκε και κατά την περίοδο της εφελκυστικής τεκτονικής. Πάντως, οι μικρού εύρους πρόσφατες κινήσεις δεν έχουν κατ' ανάγκην το ίδιο αίτιο με τις ανυψώσεις που προκάλεσαν την αποκάλυψη των μεταμορφωμένων πετρωμάτων των ορεινών αυτών όγκων.

INTRODUCTION

While there is a general agreement that the Olymbus-Ossa -Pelion Ranges (Macedonia-Thessaly, Greece), a 200km long topographic high corresponds to a chain of uplifted and unroofed metamorphic rocks (Vergely and Mercier, 1990; Fig. 1), there is much debate concerning the timing and mechanism of the uplift.

The two extreme, most recent views are, first, that of Vergely and Mercier

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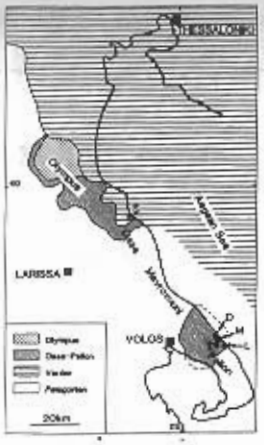

Fig. 1: Location map. Geotectonic zones and tectonic windows in the Olympus, Ossa, Mavrovouni and Pelion Mt Range are shown (after Vergely and Mercier, 1990, simplified). S stands for Stomion, D for Damouchari, M for Mylopotamos, T for Tsangarada and L for Lambinou.

(1990), who suggest a compression- associated opening of the tectonic window between Oligocene and Lower Miocene, before the period of extension that became important since Mid-Late Miocene. And second, that of Schermer (1990), who based on petrologic and structural data suggests a normal-faulting related, more than 6km late unroofing of blueschists in the Mt Olymbus; and of Faugères (1975), who based on morpho- stratigraphic correlations inferred an about 2km uplift and opening of the tectonic window in Pleistocene.

Psilovikos (1981) on the other hand, based on independent geomorphological and morphotectonic observations concluded that Olymbus was progressively uplifted by about 1800- 2400m since Miocene, and that a small part (about 10%) of this uplift occurred in Pleistocene.

Since extension is prevailing in the wider area since Upper Miocene (Vergely and Mercier, 1990; Caputo, 1990), the geomorphological data seem to give credit, at least partly, to theories for extension -associated uplift; however, until now, the direct (mainly stratigraphic) evidence for this uplift was poor (Stiros and Papageorgiou, in press).

The aim of this paper is to show that relicts of marine sediments, of Late Quaternary, probably, age exist at Pelion, while in sites where the lithological conditions permit, exposed notches testify to an about 1500 years old seismic uplift. These results may be extrapolated for the whole Olymbus- Pelion Ranges.

Late Holocene Uplift

The lithological conditions along the coast of Thessaly and Macedonia are not favourable for the formation and preservation of exposed notches or the preservation of fossil marine fauna remains (highly deformed metamorphic, mainly rocks, long coastal strips of alluvium); however, in a few places, where relatively homogeneous carbonate rocks outcrop, a well defined (exposed) fossil notch is observed (Fig. 2).

Fig. 2: The uplifted Late Holocene notch at Mylopotamos (Pelion). The vertex of the notch corresponds to a fossil sea-level, about 60cm higher than the active one.

AMS radiocarbon dating of a fossil sample of *Lithophaga lithophaga* L. collected at Damouchari, near Tsangarada (sample code GifA-92TH4) gave an apparent age of 1925±55 years, which corresponds to a calibrated dating between 250 and 540AD.

In a few other sites, for example at the Stomion lighthouse (Fig. 1),

empty perforations of *Lithophaga lithophaga* are clearly visible. In all these areas a relative land uplift is equally evident, but not datable with physical and palaeontological methods; however, the preservation of perforations in rather smooth and easily erodible rocks is likely to indicate a Late Holocene land uplift as well.

Late Quaternary uplift

Neogene and Quaternary marine sediments have never been identified in the past in the study area; however, at Mylopotamos, near Tsangarada (Pelion Mt), marine sediments have first been reported by Stiros and Papageorgiou (in press) at the height of about 15m, next to the steps leading from the parking platform to the beach.

These relicts, a few centimetres thick and spread over an area of a few metres wide, consist of a cemented yellowish fine grained matrix. From a macroscopic examination, the only associated biological remains found are *Cliona* perforations and *Lithophaga lithophaga* L. in good condition, their holes drilled partly in the Mesozoic carbonates. These data indicate a marine or coastal deposition environment, but permit the estimation of only a minimum relative sea-level change of about 15m.

From a microscopic examination, these relicts can be characterized as beach sediments of shallow offshore environment, composed of lime packstones. Lower energy conditions prevailed during deposition which permitted bioturbation and boring activities by marine organisms. Allochemic components include, first, bioclasts of molluscs, gastropods, *Coralline* algae, bryozoans and echinoderms; and second, lithoclasts of mica schists, quartzites, dolomitic-dedolomitic recrystallized limestones/ marbles, muscovite-epidote schists. The sediments are rich in quarz grains of variable size. Both lithoclasts and quarz grains have been transported to the beach environment by a nearby source area (channelized conglomerates- sandstones). The sediments have been cemented in the marine environment by Mg-calcite cement, in the form of peloids and spar. Peloids are well-sorted and average 50-100μm in diameter. They are cemented by Mg-calcite spar, resulting in a characteristic pelsparite texture. Pelsparitic sediment fills also the cavities created on the surface of the allochems by biological activities. No traces of aragonitic cement have been detected.

The studied coastal sediments have been subaerially exposed soon after their deposition. Due to that, allochems are not cemented in places by marine cement, but by a dense micritic matrix of pedogenic origin, rich in quarz grains (floating texture; Fig. 3). A large suite of vadose and soil features have been observed, including dripstone cement, micritization, dissolution and a general tendency for destruction of the original texture and structure of the pr imary sediments. Some allochems are coated by anisopachous micritic coatings with characteristic pretuberances, while in places they have been slightly assimilated by pedogenic sedimentation. Intergranular voids created by dissolution are filled partially or entirely by microcrystalline sparite. Irregular veins cut the sediments which recall the "alveolar texture", characteristic of pre-existing rootlets (rhizolites). They consist of sparry calcite- filled cylindres, with micritic walls. Open spaces in the centre of the cylindres correspond to preexisted organic material that has been decayed and removed.

The above fabrics-spectrum are characteristic of the classical transitional horizon that intervenes between marine sediments and the overlain soil profile. In terms of soil terminology, the studied sediments correspond to the first

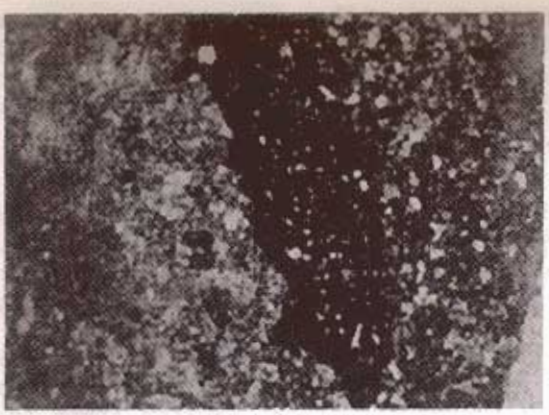

Fig. 3: Contact between a sediment characterized by pelsparitic texture (light colour) and a micritic sediment of pedogenic origin rich in quarz grains (floating texture, darker colour).
Biological remains in these notches (*Lithophaga lithophaga* L., Chtamalus) allow a good definition of the fossil Biological Mean Sea- Level (for a definition see Stiros et al 1992; in press; Laborel and Laborel - Deguen, 1994), about 60cm higher than the active one. Furthermore, the good preservation of the fossil fauna indicates an episodic, conspicuously seismic uplift (idem).

stage of pedologic alteration (immature calcretes). The preservation of infra-littoral fauna (e.g. *Lithophaga lithophaga*) are likely to indicate a quick relative sea-level fall by an amount larger than that of the amplitude of the mid-littoral zone (Stiros et al., 1992); this sea-level change was responsible also for the subaerial exposure of the sediments. During exposure, pedogenic sediments probably precipitated from fresh water flowing over the substrate or when it was ponded in depressions. By progressive subaerial exposure, calcrete facies started to develop. In the studied sediments only fabrics characteristic of the first stages of maturation (formation of irregular coatings, micritization, rhizolites) have been observed; this indicates a limited period of subaerial exposure. Since there is no evidence that the observed sediments were ever capped by a thick layer of sediments, now eroded, the period of their subaerial exposure is indicative of the time lapse since their emergence.

From a comparison with Pleistocene calcrete formations (Pomoni-Papaioannou and Dornsiepen, 1987; Pomoni-Papaioannou and Galeos, 1989) we estimate that the duration of this last period is of the order of a few thousands, or maximum a few tens of thousands years. No palaeontological dating of the sediments is on the other hand possible, while isotope datings are not yet available. However, from the macrospopic examination of the outcrop, the preservation of Lithophaga, and in comparison with other areas, this outcrop can be dated to the Late(?) Quaternary; a result consistent with that of microscopic analysis.

The Mylopotamos outcrop is not an isolated case of relative land uplift of the Aegean coast of Thessaly, for similar evidence comes from a number of other sites as well, Lambinou for instance (Fig. 1), where Pleistocene, apparently, fossil *Lithophaga* have been observed at the height of at least a few metres above the water in the cliffs of a crevasse, about 50m south of the end of the road leading to the coast.

DISCUSSION

From the point of view of regional tectonics, the Olymbus- Pelion Range can be regarded as a chain of uplifted and unroofed metamorphic rocks (Vergely and Mercier, 1990). The data presented above give clear evidence of a possibly Late Quaternary, 15m minimum land uplift in the study area, part of which (at least 60cm) is associated with earthquake(s) that occurred about 1500 years ago.

These data could, in a first approximation, be regarded as representative of the kinematics of the whole Range.

This result is consistent with both the results of Faugères (1975) and Psilovikos (1981) for a Pleistocene uplift of Olymbus Mt, but the time window and the area covered here does not permit to decide which estimate of uplift is more plausible.

Our results also clearly indicate that the uplift of this metamorphic chain continued in a period of extensional tectonics. This is apparently in favour of the extensional theories of uplift and unroofing of blueschists, but does not negate the theory of Vergely and Mercier (1990): there is no reason to believe that the mechanism of an uplift of a few tens of metres is similar with the mechanism of an uplift of a few kilometres.

A possibility is that the observed Late Quaternary vertical motions are associated with shear, for example the strike slip component of the major normal fault that controls the coast of Thessaly and the adjacent part of Macedonia (Mascle and Martin, 1990; Stiros, 1990; 1992); analogous Late Holocene and Upper Quaternary uplift have been observed along the Aegean coast of Cenral and North Euboea as well (Stiros et al., 1991; 1992; in press). Another possibility is that the observed uplift reflects a secondary response to normal faulting, as may also be the case with Euboea (Stiros et al., in press).

Interestingly, the inferred seismic uplift of the coast of the study area occurred during a period during which formed most the observed and dated Holocene shorelines in the Aegean back-arc basin, the Ionian Sea and the Hellenic arc, as well as the Eastern Mediterranean ("Early Byzantine Tectonic paroxysm", according to Pirazzoli, 1986; see also Pirazzoli et al., 1991; 1994). Therefore, the Late Holocene uplift of the Olymbus- Pelion Range may reflect accomodation of strain from the North Aegean Trough in the framework of rearrangement of first order tectonic blocks in an East Mediterranean scale.

AKNOWLEDGEMENTS

This is a contribution to the "Active Geodynamics" (DE-8661704) Project of IGME, and to the DGXII Project of the CEC "Climatic change, sea-level rise and associated impacts in Europe" (Contract EPOCH- CP-90-0015) and the Task-Group "Paleoseismicity of the Late Holocene" of the Inter-Union Commission of the Lithosphere.

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