Δελτίο Ελληνικής Γεωλογικής Εταιρίας τομ. XXX/1, 401-407, 1994
Πρακτικά 7ου Επιστημονικού Συνεδρίου, Θεσσαλονίκη, Μάιος 1994

Bulletin of the Geological Society of Greece vol. XXX/1, 401-407, 1994
Proceedings of the 7th Congress, Thessaloniki, May 1994

PRELIMINARY STUDY OF PALEOSEISMICITY OF THE SOUTHERN LANGADA - VOLVI BASIN MARGIN FAULT ZONE, THESSALONIKI, GREECE

S. Cheng[1], Z. Fang[1], S. Pavlides[2] and A. Chatzipetros[2]

ABSTRACT

Trenching excavation at Gerakarou, northeast of Thessaloniki, Greece, reveals evidence for paleoseismicity of the southern Langada-Volvi basin (Mygdonia basin) margin fault zone. The trench is located across the southernmost fracture line produced during the 1978 Ms = 6.5 earthquake in the macroseismic epicentral area, which at present expresses only as a fissure about 100 m long. Thermoluminescence dating of successive paleosoils interlayered with a late Quaternary colluvium showed that two paleoearthquakes could have happened at c. 7,200 and 14,000 yrs B. P. with another probable one at c. 21,700 yrs B. P. This comes in agreement with the observed fault displacement, which shows an average per event value between 6.5 and 16 cm.

ΣΥΝΟΨΗ

Παλαιοσεισμολογικές έρευνες στη Γερακαρού, βορειοανατολικά της Θεσσαλονίκης, δίνουν ενδείξεις για την παλαιοσεισμικότητα της ρηξιγενούς ζώνης του νότιου περιθωρίου της λεκάνης Λαγκαδά - Βόλβης (Μυγδονία λεκάνη). Η παλαιοσεισμολογική τομή βρίσκεται στη νοτιότερη διάρρηξη που προκλήθηκε από το σεισμό του 1978 (Ms = 6,5) στην περιοχή του μακροσεισμικού επίκεντρου, που σήμερα είναι ορατή σα μία μικρή διάρρηξη με μήκος περίπου 100 μ. Η χρονολόγηση με θερμοφωταύγεια διαδοχικών παλαιοεδαφών που βρίσκονται ενδοστρωματωμένα με ένα κολλούβιο του ανώτερου Τεταρτογενούς, δείχνει ότι δύο παλαιοσεισμοί συνέβησαν πριν από περίπου 7.200 και 14.000 χρόνια, με έναν ακόμα πιθανό σεισμό πριν από 21.700 χρόνια. Αυτά τα στοιχεία συμφωνούν με το παρατηρούμενο άλμα του ρήγματος, που έχει μία τιμή ανά γεγονός ανάμεσα σε 6,5 και 16 εκατοστά.

INTRODUCTION

One of the most seismically active areas in northern Greece is the so called Serbomacedonian seismic zone, which roughly coincides with the well known Serbomacedonian massif. Along this great structure, many active faults exist, which have given birth to some of the greatest earthquakes of northern Greece. Mygdonia basin belongs to this zone; it is an active fault bounded subsidence located northeast of the city of Thessaloniki (fig. 1). The basement rocks consist of old crystalline rocks (Palaeozoic gneisses, Triadic-Jurassic marbles, phyllites, quartzites and mica schists), while some post-orogenic magmatic intrusions of Mesozoic up to Oligocene age also exist. The sedimentation of the basin started at Miocene, when the

1 Institute of Geology, State Seismological Bureau, Beijing 100029, China.
2 Department of Geology, Aristotle University of Thessaloniki, 54006, Thessaloniki, Greece.

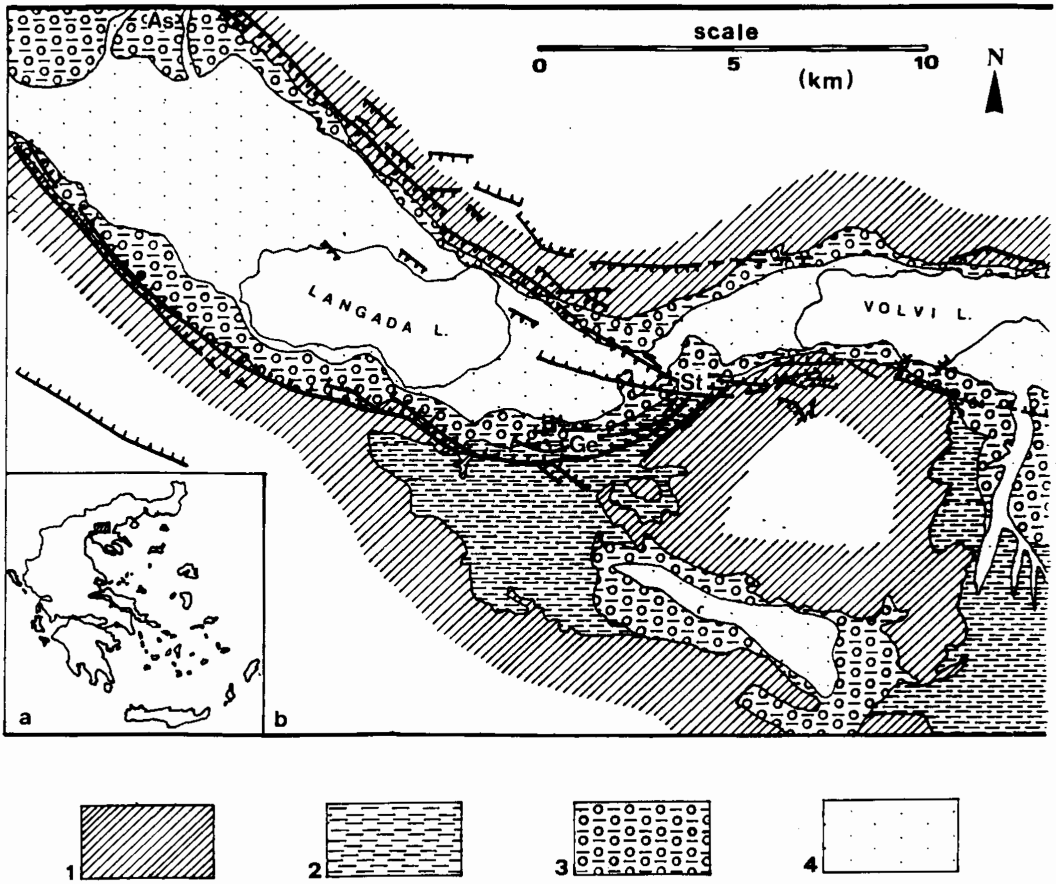

Fig. 1: a. Location map of Mygdonia basin. b. Geological formations of the basin (**1.** Pre-Neogene basement, **2.** Pre-Mygdonian sequence, **3.** Mygdonian sequence, **4.** Holocene sediments), and sites referred in the text (**Ge:** Gerakarou, **St:** Stivos, **As:** Assiros). The active faults of the basin are also represented as thick lines with teeth indicating the downthrow block.

Pre-Mygdonian basin was formed (Psilovikos, 1977, and new data from Koufos et al., in press). The corresponding Pre-Mygdonian stratigraphic sequence, which reaches up to early Pleistocene (Villafran-chian), underlies the Mygdo-nian sequence which was deposited after the middle Pleistocene extensional phase; during this phase the main Mygdonia basin was formed. Deformation continues until the present days, due to the active tectonic stress field that dominates the broader northern Aegean region. Because of this, many moderate to strong earthquakes have been recorded in instrumental and historical records. The purpose of this study, which is the first of its kind in Greece, is to find and date prehistorical shocks by using paleoseismological techniques (e.g. McCalpin, 1989, Yeats & schwartz, 1990, Vittori et al., 1991), and to start the establishment of a paleoseismological record of the area.

SEISMOTECTONICS OF THE AREA

The main faults of the basin are normal ones, and are of NW-SE (sinistral

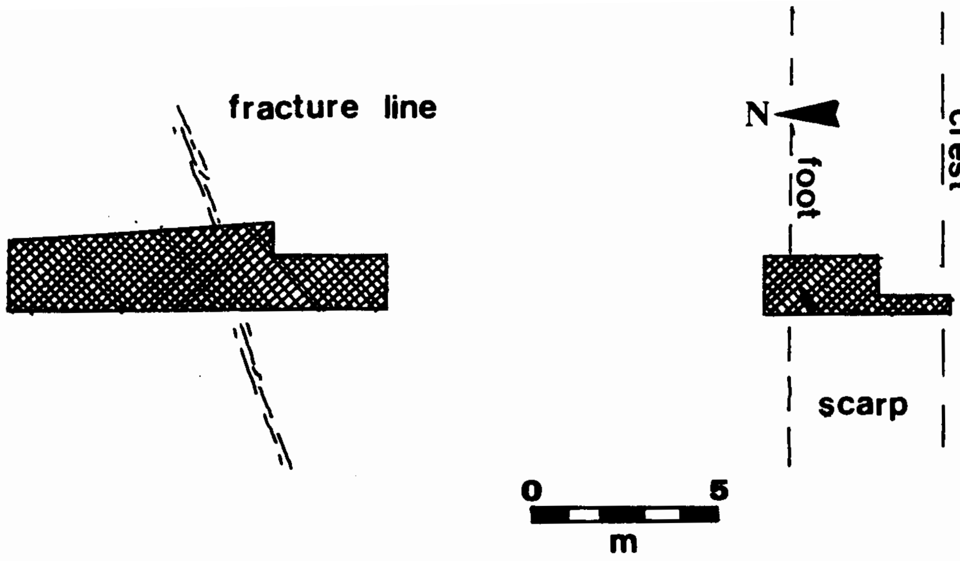

Fig. 2: a. Map view of the trench location in respect to the scarp and the surface fissures. b. Topographical profile of the scarp with the corresponding dip angles of the ground surface.

component), ENVE-WSW (dextral component) and E-W strike. The complexity of the fault strikes, the cross-fault pattern (Pavlides, 1993) and geodetic surveys of the basin (Vlachos, 1980, Stiros, 1986) indicate a very complex tectonic structure. They affect both the basement rocks and the sedimentary filling of the basin, forming well-defined morphological features (Pavlides and Soulakellis, 1991, Chatzipetros and Pavlides, 1993). The faults have produced a number of earthquakes with MM = VII-IX (corresponding to Ms = 6.5 - 6.6) during the historical period (620 to 1759 A.C., Papazachos and Papazachou, 1989). The instrumental seismicity during the present century has to show two major shocks; the 1902 Ms = 6.6 Assiros earthquake and the 1978 Ms = 6.5 Stivos earthquake. The latter shock sequence has been studied by many researches coming from different disciplines of the earth sciences. The cracks that opened during this earthquake helped in the mapping of unknown faults that had no surface expression (e.g. Papazachos et al., 1979, Mercier et al. 1979, 1983, Mountrakis et al., 1992). At one of these cracks (Gerakarou site) a paleoseismological trench has been excavated; the data and the preliminary results are given at the next paragraph.

PALEOSEISMOLOGICAL DATA

During the summer of 1993 some open fissures has been observed in a field east of Gerakarou village. As can been seen at fig. 2 the crack was close to a scarp which, up to then, was considered to be a fault scarp. This fissure had a visible length of about 100 m. The fact that the 1978 seismic crack passed through the same field as well as the presently observed deformation of the continuation of this crack at the Thessaloniki - Kavala national road, led to the assumption that this crack should be the surface expression of the same 1978 seismic fault itself that has been moving with aseismic creep. For those reasons the excavation of a paleoseismological trench has been decided.

The first of two trenches has been excavated across the scarp in a N-S

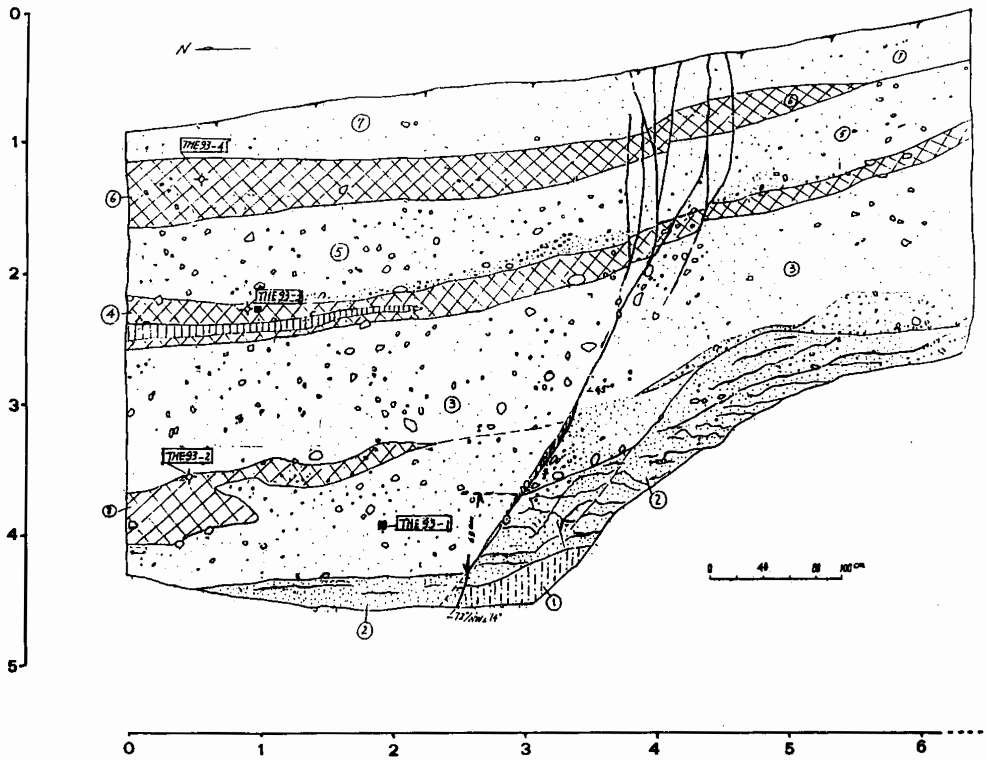

Fig. 3: Log of the east wall of the trench. Solid squares mark the points from where material was sampled for thermoluminescence and 14C dating.

direction. This was a pilot trench (5 x 1.5 m) to test the hypothesis of fault scarp. The strata at this trench were found to be totally undisturbed by faulting or any other cause, indicating that this particular scarp was not in fact the fault scarp itself, but rather a backwards-degradation morphological expression of it, produced by natural erosion and/or farming activity.

The second trench was excavated in such a way that it would contain the surface cracks. The dimensions of this trench were 10 x 1.7 m, and the depth 4-5 m. This trench was successful in revealing the actual fault which coincided with the surface fissure. The log of the east wall of the trench is shown in fig. 3. The main fault is a normal one with a strike of 72o and dip 65o-74o NW, A possible oblique component, that would be expected at faults of this direction, might be indicated by the steepness of the fault surface. Towards the upper part of the trench the fault is separated into a number, at least eight, of separate strands. Some minor synthetic faults could be inferred for the hangingwall block. The stratigraphy of the deposits is shown in fig. 4. The most important features are the two upper layers of paleosoils (4, 6, the lower one bifurcating towards the end of the trench) situated in a late Quaternary colluvium, and the underlying liquefacted sands [2] which suggest an intense earthquake activity. The fault has, as expected, smaller displacement at the upper part than at the lower. The total displacement of the lower sands [2] is 63 ± 2 cm. By assuming that the

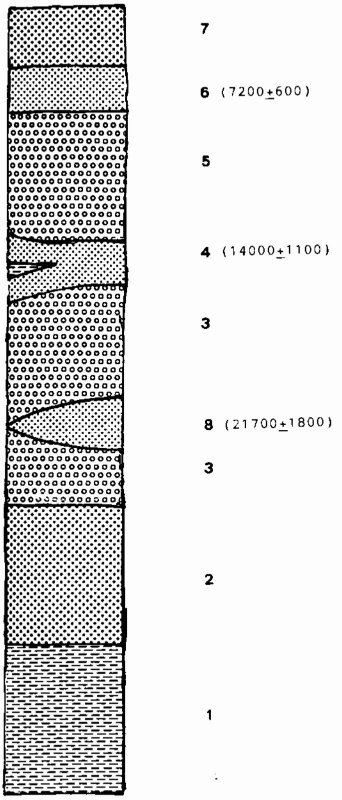

Fig. 4: Stratigraphical column of the trench sediments and corresponding ages: [1] fine-grained sand. [2] yellow liquefacted sand. [3] coarse-grained colluvium. [4] second paleosoil. [5] coarse-grained colluvium. [6] first paleosoil. [7] surface deposits and modern soil. [8] probable third paleosoil.

upper paleosoil [6] has been displaced by the 1978 shock, then at least three other distinct paleoearthquakes can be traced, with an average displacement per event of 6.5 to 16 cm. At the other wall of the trench the fault is defined not as a clear surface, bur rather as a crush zone. A very interesting point is two "fossilised" cracks filled with fine-grained grey material (fig. 5) situated in the layer [2], but not extended into the colluvium [3]. This is an indicator for an ancient earthquake that left its mark in the geological record.

Material for dating by thermoluminescene and 14C have been taken from the paleosoils. The thermoluminescence datings from paleosoils [4] and [6] indicate that two paleoseismic events could have occurred in 7,200 ± 600 yrs B.P. and 14,000 ± 1.100 yrs B.P. with an average recurrence interval of about 7,000 years for the specific fault. A dating for the possible paleosoil [8] gives an age of 21,700 ± 1,800 yrs B.P., which comes in agreement with this recurrence interval. 14C radiocarbon dating process is currently in progress.

CONCLUSIONS

Paleoseismology has been boosted during the last decade due to its highly appraised research and practical applications (e.g. Crone & Omdahl, 1987, Brunamonte et al., 1992). By using paleoseismological techniques for the first time in Greece (dating of fault deposits by 14C for paleoseismological purposes has been done by Boccaletti et al, in press) an addition to the earthquake record of a particularly active area has been made. Based on the fact that soils are formed in relatively long periods of tectonic quietness, one could correspond the found paleosoils to such a period, while the colluviums could correspond to the episodic period of the fault, which is short. The coarse-grained unsorted material of the alluvium indicate that it was formed during an episodic period, which, in this case, is an ancient

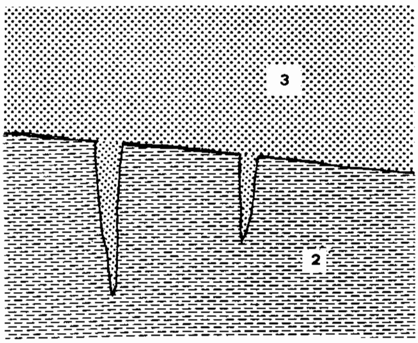

Fig. 5: Sketch of the two "fossilised" cracks indicating a paleoseismic event after the formation of layer [2] and before the deposition of alluvium [3].

earthquake. The recurrence intervals between those earthquakes are regularly distributed as has been found by the thermoluminescence datings. A point that needs further explanation is the fact that those intervals seem to be too long, taking into consideration the seismological data for the area.

The maximum expected magnitude of the shocks (Ms) can be calculated by using seismological and geological data, and for Mygdonia basin has been determined at about 6.5 to 6.6. This comes in agreement with the paleoseismological data, that is the fault displacement, considering the surface displacement of the 1978 earthquake. This fact is an extra plus to the reliability of the paleoseismological research.

ACKNOWLEDGEMENTS

The last author would like to thank the State Scholarship Foundation of Greece for financial assistance during this research.

REFERENCES

BOCCALETTI, M., CAPUTO, R., MOUNTRAKIS D., PAVLIDES S. and ZOUROS, N. (1996). Palaeoseismicity of the Souli fault, Epirus, western Greece. J. Geod.(Hancock & Michetti Eds) V. 24.

BRUNAMONTE, F., MICHETTI A. M., RICCI LUCCHI, F. and SERVA, L. *eds.* (1992). Second Workshop on Paleoseismology, *Gruppo Nazionale per la Difesa dal Terremoti, ENEA-DISP, Roma, Italy, June 9-12, 1992.*

CHATZIPETROS, A. A. and PAVLIDES, S. B. (1993). Fault scarp height-angle relationship from the active basin of Mygdonia, Northern Greece, *EUG VII, Strasbourg, 4-8 April 1993, Terra abstracts, suppl. No.1 to Terra nova, 5, 325-326.*

CRONE, A. J. and OMDAHL, E. M., *eds.* (1987). Directions in Paleoseismology, *U. S. Geological Survey Open-File Report 87-673, 456 pp.*

KOUFOS, G. D., SYRIDES, G. E., KOSTOPOULOS, D. S. and KOLIADIMOU, K. K. Stratigraphical and palaeonvironmental data from Mygdonia basin, Macedonia, Greece, *Geobios.*(in press)

McCALPIN, J. (1989). Current investigative techniques and interpretive models for trenching active dip-slip faults, *in* Watters, R, J., *ed.*, Engineering Geology and Geotechnical Engineering, *Balkema, Rotterdam, 249-258.*

MERCIER, J. L., MOUYARIS, N., SIMEAKIS, C., ROUNDOYANNIS, T. and ANGELIDHIS, C. (1979). Intra-plate deformation: a quantitative study of the faults activated by the 1978 Thessaloniki earthquakes, *Nature, 278, 45-48.*

MERCIER, J. L., CAREY-GAILHARDIS, E., MOUYARIS, N., SIMEAKIS, K., ROUNDOYANNIS, T. and ANGELIDHIS, C. (1983). Structural analysis of recent and active faults and regional stress state of stress in the epicentral area of the 1978 Thessaloniki earthquakes (northern Greece), *Tectonics, 2 577-600.*

MOUNTRAKI,S D., KILIAS, A., PAVLIDES, S., KOUFOS, G., VAVLIAKIS, E., PSILOVIKOS, A., SOTIRIADIS, L., ASTARAS, T., TRANOS, M. and SPYROPOULOS, N. (1992). Neotectonic mapping of the northern Greece: problems and results, *in* Morner, N.-A, L. A. Owen, I. Stewart and C. Vita-Finzi, *ends.*, Neotectonics - Recent advances: Abstract vol., *Quaternary Research Association, Cambridge, 42.*

PAPAZACHOS, B., MOUNTRAKIS, D., PSILOVIKOS, A. and LEVENTAKIS, G. (1979). Surface fault traces and fault plane solutions of the May-June 1978 major shocks in the Thessaloniki area, Greece, *Tectonophysics, 53, 171-183.*

PAPAZACHOS, B. and PAPAZACHOU, C. (1989). The earthquakes of Greece, *Ziti editions, Thessaloniki, 356 pp.*

PAVLIDES, S. B. (1993). Active faulting in multi-fractured seismogenic areas;

examples from Greece, *z. Geomorph. N. F., 94, 57-72.*
PAVLIDES, S. and SOULAKELLIS, N. (1991). Multifractured seismogenic area of the Thessaloniki 1978 earthquake (northern Greece), *in* Savascin, M. Y. and A. H. Eronat, *eds., Proc. International Earth Sciences Congress on Aegean regions, Izmir, Turkey, 1-6 October 1990, 2, 64-75.*
PSILOVIKOS, A. (1977). Paleogeographic development of the basin and lake of Mygdonia (Langada-Volvi area, Greece), *Ph. D. thesis, University of Thessaloniki, 156 pp.*
STIROS, S. C. (1986). Geodetically controlled taphrogenesis in back-arc environments: three examples from central and northern Greece, *Tectonophysics, 130, 281-288.*
VITTORI, E., SYLOS, LABINI, S. and SERVA, L. (1991). Palaeoseismology: review of the state-of-the-art, *Tectonophysics, 193, 9-32.*
VLACHOS, D. (1980). The control network for monitoring crustal movements in the epicentric zone of Volvi, 1978, *Quaterniones Geodaesiae, 1, 1-31.*
YEATS, R. S. SCHWARTZ, D. P. (1990). Paleoseismicity: extending the record of earthquakes into prehistoric time, *Episodes, 13, 9-12.*