Active Faults and Seismic Hazard Assessment at the Mygdonia, Strymon and Drama Basins, Northern Greece, based on Paleoseismic Trenching and Radiometric Dating

I. Papanikolaou[1], G. Deligiannakis[1], P. Dafnis[2], J. Hengesh[3], A. Panagopoulos[2], E. Lymperis[4]

(1) Mineralogy-Geology Laboratory, Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens, 75 Iera Odos Str., 118-55 Athens, Greece. Email: i.pap@aua.gr
(2) Geoskopio SA – EDAFOMICHANIKI GROUP, 19 Emmanouil Papadaki Str., 141 21 N. Iraklio, Greece
(3) Interface Geohazard Consulting LLC, 20 Plumeria Pl., Lahaina, HI 96761 USA
(4) Edafos Engineering Consultants SA, 9 Iperidou Str, 10558 Athens, Greece

Introduction

The NW–SE trending fault-bounded Axios, Mygdonia, Strymon and Drama basins dominate the Central and Eastern Macedonia landscape and geological structure (Mercier et al. 1989, Mountrakis *et al.*, 2006, Tranos 2011). They were formed during the Late Miocene to Pliocene NE–SW directed extensional stresses, which primarily activated NW–SE striking normal faults. Since the Quaternary the stress field has changed and is now dominated by N-S extension, resulting to the formation of E-W trending normal faults, reshaping the pre-existing basins (e.g. Lyberis 1984, Pavlides & Kilias 1987). Isoseismal data from past earthquakes indicate that both the NW-SE faults (e.g. 1902 M=6.6 Assiros and 1932 M=7.0 Ierrisos earthquakes) and the E-W trending faults (e.g. 1932 M=6.2 Sochos and 1978 M=6.5 Volvi earthquakes) are active (Papazachos *et al.*, 1979, Voidomatis *et al.*, 1990). Limited paleoseismic investigations have been carried out along some of the E-W oriented fault zones in northern Greece (e.g. Chatzipetros *et al.*, 2005), yet none have previously applied on the NW-SE oriented fault zones in this region.

4 paleoseismic studies were carried out to assess the location, geometry, kinematics, and past surface displacements of the NW-SE trending Symvoli-Fotolivos (SFFZ – Drama Basin), Tholos-Nea Zichni fault zone (TNFZ – Strymon Basin), Assiros Krithia fault (ASFZ – Mygdonia Basin) and Drymos fault zone (DRFZ – Mygdonia Basin) (Figure 1).

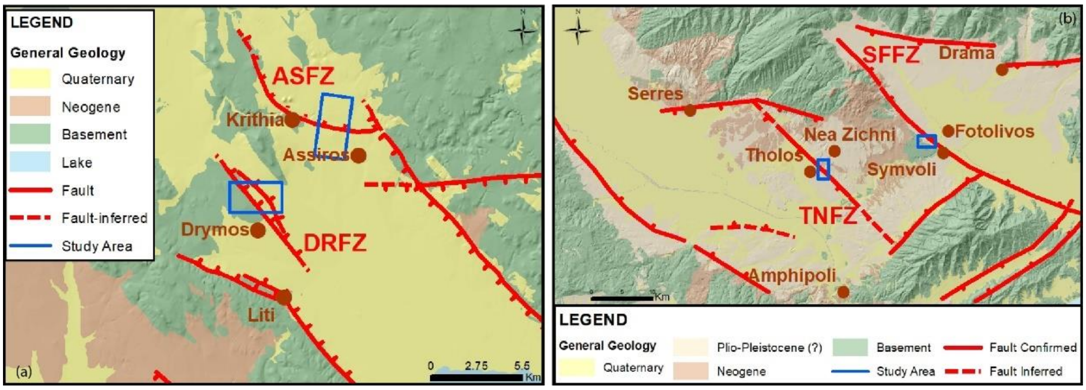

Figure 1. Simplified geological map showing the main faults of the Mygdonia basin (a) and Drama and Strymon Basins (b).

Methodology

The largest paleoseismic study has been performed in Northern Greece in order to assess whether NW-SE trending basin bounding faults are Holocene active with important implications in seismic hazard assessment. Kinematics and past surface displacements associated with these fault traces were assessed by detailed geomorphological, geological and paleoseismic trench investigations. For the SFFZ a 221 m long and 3 m deep trench was excavated, while for the TNFZ the trench was 153 m long and 1.5 - 3 m deep. Paleoseismic observations for ASFZ and DRFZ were performed along targeted sections of an existing 3 m deep, two-side sloped construction trench. All trenches were cleaned, gridded, photographed, georeferenced and logged. Samples also were collected for radiocarbon dating where evidence for active faulting was found.

Results & Discussion

The SFFZ has a segment length of 32 km and yields an average magnitude value of Mw=6.61. 2 events are inferred with vertical displacements of 66 cm (penultimate event ~11350±40 BP) and 75 cm (most recent event ~5620 ± 30 BP) implying an approximate 0.12 mm/yr throw-rate and 0.14 mm/yr slip-rate, respectively (Figure 2). Geological and geomorphological data for TNFZ strongly support a 15 km long fault segment, which represents the preferred rupture scenario. Radiometric dating provides limiting ages of surface displacements along a synthetic fault plane about 4950 ± 30 years ago, and along an antithetic fault plane about 2840 ± 30 to 6300 ± 30 years ago. As a result, 1 or 2 events appear to have occurred along this fault in the past 6300 years, implying slip-rate of 0.20 ± 0.1 mm/yr, with recurrence intervals of ~3000 yrs (Figure 3).

Holocene deformation occurred along both the ASFZ and DRFZ. 2 events have occurred in ASFZ, around 4540 and 7900 years BP. The total displacement over the last 7900 years is 121 cm, implying a 0.15 mm/yr slip-rate, with a recurrence interval of 3360 yrs. The DRFZ is an 8 to 10 km long structure with a slip-rate on the order of 0.1-0.3 mm/yr. The fault could produce average displacements of 13 to 28 cm and maximum displacements of 24 cm to 40 cm. We interpreted 3 possible paleo-events with vertical displacements exceeding 40 cm, implying a possible multi-segment rupture scenario involvinh the Gerakarou-Liti fault zone, which is parallel to DRFZ with a step over of only 2 km. The DRFZ is characterized by distributed deformation with 8 major and secondary fault planes observed at four different sites (T1-T4) across the trench. Dating results confirm that 4 of these fault planes have produced displacements between approximately 4000 and 9000 ybp (Figure 4).

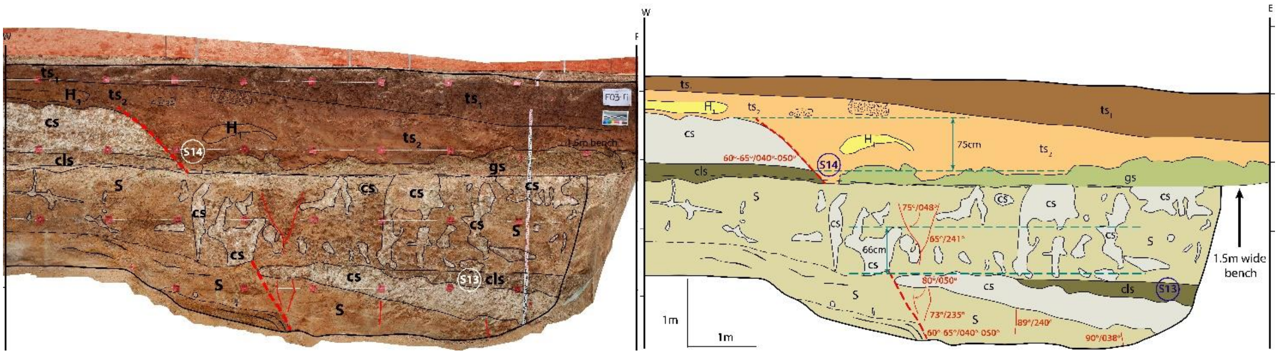

Figure 2. Left: Orthomosaic of the 9m long active fault area (from 212 up to 221m) of the SFFZ trench. Right: Two events are inferred with 75 cm (most recent) and 66 cm (penultimate) of vertical displacement. Sampling locations shown inside circles.

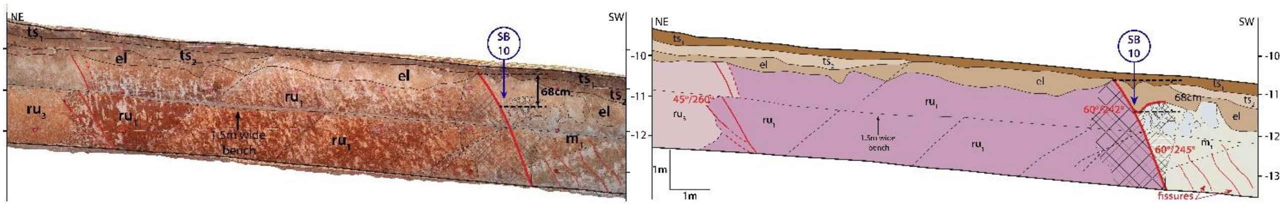

Figure 3. Left: Orthomosaic of the TNFZ trench from 109 to 123 m, showing the main fault plane. Right: Final logging, depicting all major boundaries, trench stratigraphy, displacement scenario and sampling locations for radiocarbon dating.

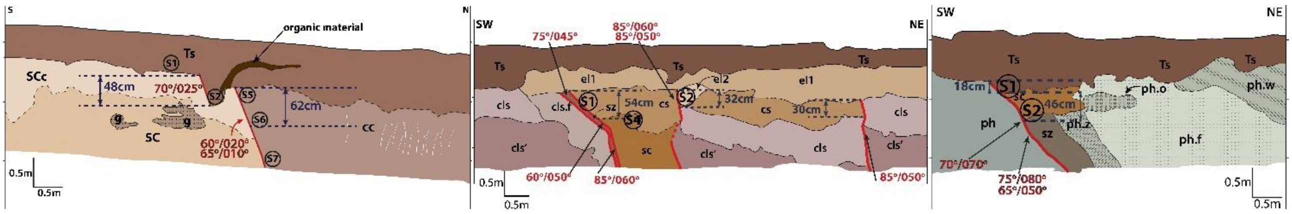

Figure 4. Left: Interpretation of the ASFZ trench with 2 inferred events. Middle: Interpretation of section T1 of DRFZ with 3 inferred events. Right: Interpretation of section T4 of DRFZ with 2 inferred events.

Acknowledgements

We would like to thank all personnel involved to excavating and cleaning these trenches.

References

Chatzipetros, A., Kokkalas, S., Pavlides, S., Koukouvelas, I., 2005. Palaeoseismic data and their implication for active deformation in Greece. Journal of Geodynamics 40, 170-188.

Lyberis, N., 1984. Tectonic evolution of the North Aegean trough. Geological Society of London, Special Publications 17, 709-725.

Mercier, J.-L., Simeakis, K., Sorel, D., Vergély, P., 1989. Extensional tectonic regimes in the Aegean basins during the Cenozoic. Basin Research 2, 49–71.

Mountrakis, D., Tranos, M., Papazachos, C., Thomaidou, E., Karagianni, E., Vamvakaris, D., 2006. New neotectonic and seismological data about the main active faults and stress regime of Northern Greece. Geological Society of London, Sp. Publications 260, 649–670.

Papazachos, B., Mountrakis, D., Psilovikos, A., 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.

Pavlidis, S.B., Kilias, A.A.,1987. Neotectonic and active faults along the Servomacedonian zone (SE Chalkidiki, northern Greece). Ann. Tecton. I 2, 9–104.

Tranos, M.D., 2011. Strymon and Strymonikos Gulf basins (Northern Greece): Implications on their formation and evolution from faulting. Journal of Geodynamics 51, 285–305.

Voidomatis Ph.S, Pavlides S.B., G.A. Papadopoulos 1990. Active deformation and seismic potential in the Serbomacedonian zone, northern Greece. Tectonophysics 179, 1-9.