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Definition of subsoil structure and preliminary ground response in Aigion city (Greece) using microtremor and earthquakes

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Abstract

An extensive campaign—including detailed geologic and geotechnical surveys both existing and news as well as noise measurements—was conducted along a cross-section in order to define both geometry and soil properties (mainly the shear wave velocity) of the main formations in Aigion city. Aigion city is located in the Gulf of Corinth, Greece, a highly seismic region of the Aegean Sea. The main objective of the accurate 2D soil model is its use in site response modeling and in the interpretation of observations from a vertical down-hole accelerograph array. This model revealed a complex geologic structure with a multi-faulted shear zone related to the Aigion fault. The defined subsurface structure offered the possibility for its correlation with estimated site effects, in terms of spectral ratios. Two different data sets, earthquakes recorded at down-hole accelerograph network and noise measurements at 17 sites, were used. To translate the empirical transfer functions with the geologic structure, the 1D estimates were also computed. All these results are consistent, indicating a satisfactory correlation between the soil model and preliminary site response.

Keywords: Shear wave velocity; 2D soil model; Microtremors; Spatial autocorrelation coefficient, SPAC; Transfer function; Site effects; H/V technique; Down-hole array; Aigion shear zone

1. Introduction

The intensity of strong ground motion is a function of many parameters such as the earthquake magnitude, epicentral distance, seismic source characteristics, as well as local soil conditions. However, local geology is the most important parameter, which governs the large variation of site response at any particular site [1]. To translate the distribution of damages and macroseismic intensities into site response qualitative and quantitative attributes, the geometry and the mechanical properties of the recent sedimentary deposits and bedrock are essential prerequisites. The usefulness of the subsurface soil model knowledge is two-folded: for an accurate theoretically prediction of the strong ground motion and for the reliable interpretation of earthquake observations. Taking advantages from a high-quality data set of earthquakes and information regarding the soil conditions at the city of Aigion, a detailed 2D cross-section is proposed together with a first evaluation of its seismic response.

The city of Aigion is located in the Gulf of Corinth, Greece, which is one of the most active seismotectonic areas in Europe. At the surrounding area of the city, eight strong earthquakes have occurred in the past with magnitude, Ms, ranging from 6.1 to 7.0 (Fig. 1a). The latest strong earthquake with magnitude, Ms, 6.2, was occurred on June 15, 1995, and caused human casualties (25 deaths) and severe collapses. All strong earthquakes were caused through five major north-facing WNW, trending normal faults that are segmented along their strikes at the surface on the southern flank of the Gulf of Corinth in the Aigion city area (Fig. 1b). The closest of these faults to the city is the 12 km total length Aigion normal fault, which reactivated during the 1995 earthquake [5]. A geomorphological escarpment (40–100 m) as well as monoclinal warps marks the position of this fault, forming a hill-front along the coast of the gulf, suggesting that the fault controls the uplift of the built up area of Aigion city.

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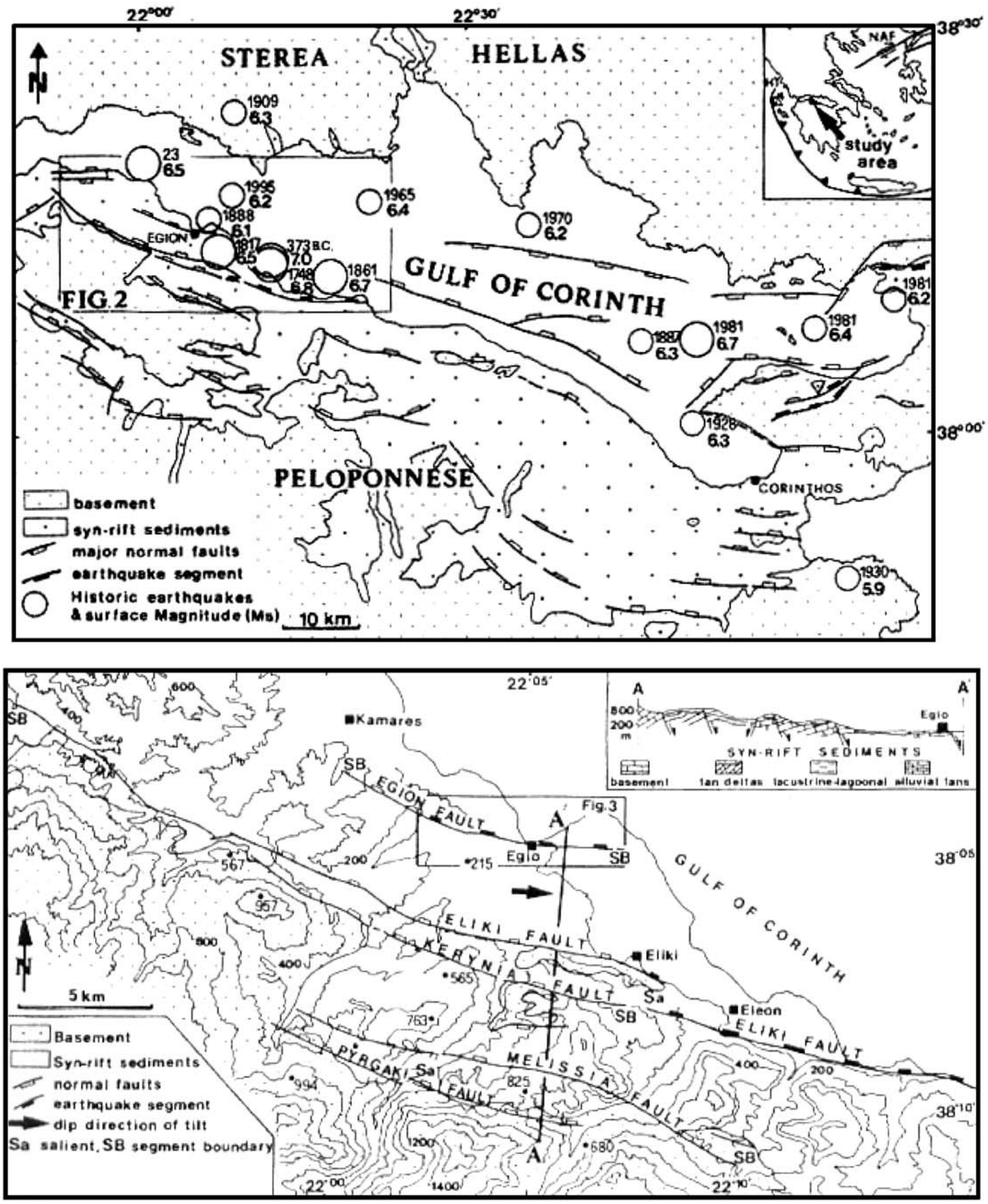

(a)
(b)

Fig. 1. (a) Tectonic map (after [2]) of Corinth Gulf and Aigion city active faults, syn-rift sediments and historical earthquakes (after [3,4]) and (b) Simplified geologic, tectonic and topographic map with the major active faults at the Aigion city ([5]).

The strong 1995 earthquake and its consequences on the broader region of Aigion city excited the interest of many researchers to study the geologic [5–7], seismotectonic [8–11], and the geophysical environment [11–13]. Recently, results of many studies—during a European research project called Corinth Rift Laboratory (CRL) with four associated sub-projects—were published in Comptes Rendus Geoscience (vol. 336, 2004). Meanwhile, the interest of the engineering community [14–20] has been focused on damaged structures and simulations of strong ground motion. Among all these studies only the last papers [17–20] are based on a few soil data in a few specific sites, in order to finally evaluate for specific aspects of the site response such as topographic effects. Because of their objectives both papers proposed roughly estimated 2D soil models at completely different regions, accounting mainly for soil properties, but not for their geometry, such as thickness of layering and shape of the geologic structure.

For these reasons, in this paper, we report a detailed 2D cross-section of the complex geologic structure regarding the shear zone of the Aigion fault beneath the Aigion city and a first evaluation of its seismic response correlating soil conditions and soil resonant frequencies. This cross-section, of about 1 km long, includes the urban area of