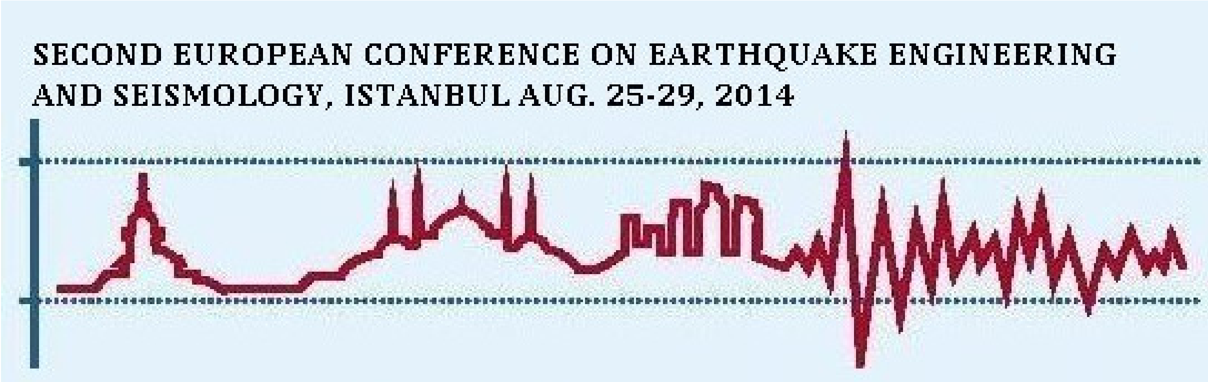

ON THE USE OF GEOLOGIC BASED PROXIES TO ESTIMATE V_{S30}, VIA AN HELLENIC V_S PROFILE DATABASE

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The V_{S30} parameter is by far the most widely used parameter that accounts for site conditions and site amplification in ground motion prediction equations (GMPEs). Albeit, V_{S30}, has been severely criticized for obvious pitfalls that might be misleading in site characterization, it still remains one of the most required parameters in seismic codes and major GMPEs.

Direct measurements of seismic velocities to a depth of 30m consist the best way of obtaining the above parameter; however, it is rather often that no geophysical data are available, and thereof, V_{S30} should be estimated from proxies geology-based (Wills and Clahan, 2006) and ground slope-based (Wald and Allen, 2007). For this reason, a local *profile database* (PBD) has been elaborated, in order to establish local empirical correlations between surface geology and V_{S30}. In the present work, small scale (1:50,000) geologic and topographic maps have been used for Greece.

The *profile database* (PBD) contains 314 sites, 238 of which have profile depths equal or deeper to 30m (fig.1). The rest 76 sites correspond to sites where velocity profiles are established to depths (z_p) less than 30m, but under no circumstances, less than 5m; therefore, V_{S30} cannot be directly calculated. Estimation of V_{S30} for these 76 sites presupposes establishment of an extrapolation V_{SZ} to V_{S30}. These kinds of extrapolated correlation are proposed by Boore (2004) and Boore et al. (2011), and they have been accordingly modified based on local (Hellenic) data. Once, these extrapolated correlations established, the inferred V_{S30} values have been added to the PDB sites. In addition to basic site information (name and location coordinates), information on geophysical test type, profile depth, time-averaged shear wave velocity to the profile depth (V_{SZ} and V_{S30}), are also included in PBD. Almost all kind of test types have been accepted in PBD, to the exception of Remi-type measurements due to probable bias of V_S to depth; indirect V_S measurements, resulting from penetration resistance tests (i.e. SPT, CPT) are also excluded. The best fit local (Hellenic) correlations are depth-dependent linear and exhibit flatter gradients between V_{SZ} and V_{S30}, compared to Californian and Japanese data. The discrepancy is obviously greater for the 5m data, compared to 10m or 20m data. The linear relationship relating V_{S30} to V_{SZ} values in Greece is given by the following equation, deemed to be the most appropriate:

$$\log\left(V_{S30}\right) = c_0 + c_1 \log\left(V_{SZ}\right) \tag{1}$$

In table 1, coefficients c_0 and c_1 are shown for profile depths ranging from 5 to 24m in the PDB. The error term σ_e represents the standard deviation of the fit residuals.

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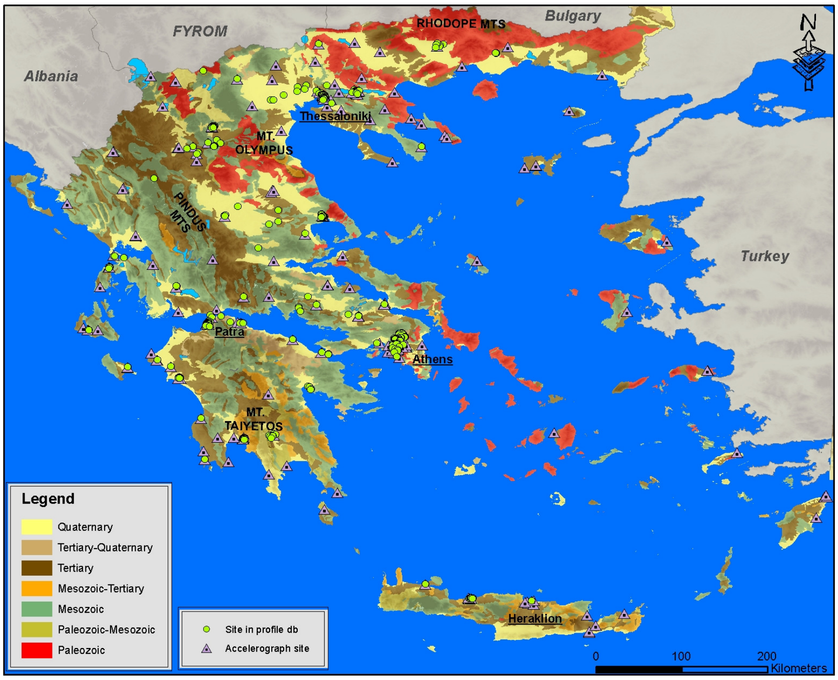

Figure 1. Geologic map of Greece showing locations of sites in profile database (PBD) and locations of strong motion stations in site database (SDB). The geologic map used here is from digital sources (for ease of plotting) with a scale of 1:500,000.

Table 1. Model coefficients for V_{SZ} to V_{S30} extrapolation

z_p (m)	c_0	c_1	σ_e
5	0.522	0.842	0.233
10	0.331	0.907	0.156
14	0.261	0.925	0.121
20	0.144	0.960	0.076
24	0.064	0.984	0.045

The main goal of the present work is to establish a geology-related proxy to estimate V_{S30}. In California, Wills and Clahan (2006) concluded in 19 geologic categories and computed V_{S30} mean values and standard deviations for profiles within those categories. When surface geology serves as a V_{S30} proxy, map resolution and consistency of mapping across the examined region is important. In our case, we used geologic maps of scale 1:50,000 prepared by the Institute of Geological and Mineral Exploration (IGME, www.igme.gr), available for the entire territory, despite inconsistencies regarding a standardized use of lithostratigraphic and structural terms between different geologic sheets. Based on the opinion of an experienced panel of geologists and an appropriate statistical elaboration, it has been feasible to propose a classification of the geologic units met in IGME geologic maps, based on their geologic age, grain gradation and depositional environment. The major geologic age groups are as follows: Holocene (94 sites), Pleistocene (61 sites), mapped Quaternary (67 sites, where geologic age is unspecified), Tertiary: Neogene (63 sites) and Mesozoic-Paleozoic (29 sites).

Classifying data from the Hellenic PDB, according to their geologic age, the histogram seem to be better represented by a log normal shape distribution. By direct comparison of Hellenic results with Californian, it results that: mean V_{S30} values for Hellenic Quaternary and Mesozoic are higher than Californian Quaternary and Mesozoic. As for Tertiary, Hellenic and Californian mean V_{S30} values, are quite similar.

As per material gradation, the examined sites have been classified as follows: 85 coarse, 46 fine and 172 mixed. By segregating Quaternary (Q) and Tertiary (T) data according to coarse, fine and mixed gradations, it turned out that results were not less dispersed regarding V_{S30} estimation based solely upon geologic age, unless this was combined with gradient (fig.2).

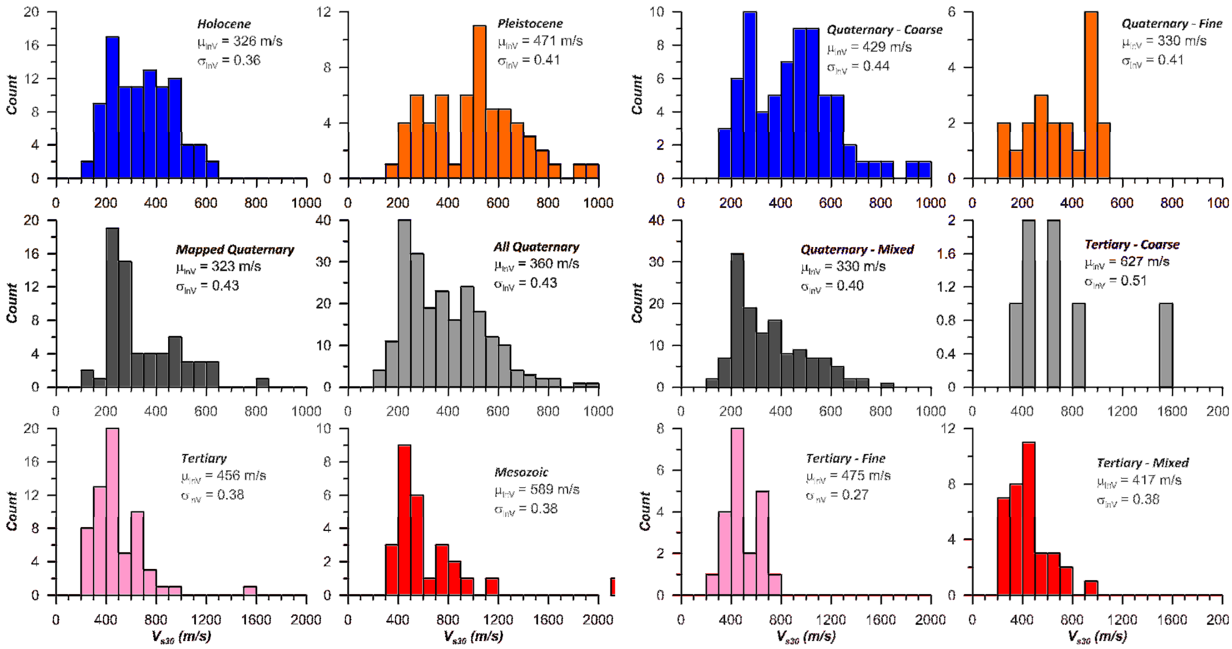

Figure 2. Histograms of V_{S30} coming from data of the Hellenic PDB, sorted solely by geologic age (left) and sorted by geologic age and subdivided by gradation (right). Symbols μ_{lnV} and σ_{lnV} are respectively the exponents of the mean and the standard deviation of logs V_{S30}.

The coarse category has significantly faster mean velocities and higher dispersion for both Q and T, but in the case of T, the data set is so sparse, this difference might not be statistically significant.

Among 22 depositional environment classes stated (Stewart et al., 2014), fluvial and lacustrine prevail (210 and 55 sites respectively); therefore, Q data could not be classified by depositional environment due to dominance of a single category, whereas, T data were too sparse to be considered.

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