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# Nonlinear seismology, the seismology of this Century

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Motto: ”The nonlinear seismology is the rule,
The linear seismology is the exception.”
Paraphrasing Tullio Levi- Civita (1873-1941)

The seismologist performing the seismic hazard analysis is really carrying out one part of an engineering process. National Science Foundation (USA) highlights grand challenges for seismology in next time inclusively nonlinear behavior of soils. The location and severity of many natural hazards are strongly influenced by near-surface nonlinear material properties. Nonlinear responses of soils to shaking and knowledge of soil properties an understanding that straddles the interface between seismology and earthquake engineering. Most cities and villages are located on alluvial deposits / sediments, on Quaternary geological structures or in river valleys. A soil is of basic type sand or gravel (termed coarse soils), silt or clay (termed fine soils) etc. and soils exhibit a strong nonlinear behaviour under cyclic loading conditions. Strong ground accelerations from large earthquakes can produce a non-linear response in shallow soils. All extra-Carpathian area from Romania and Rep. of Moldova are situated in a Miocene alluvial basins with thick sedimentary formations between hundred of meters and kilometers. Sands typically have low rheological properties and can be modeled with an acceptable linear elastic model and clays which frequently presents significant changes over time can be modeled by a nonlinear viscoelastic model. Aki: Nonlinear amplification at sediments sites appears to be more “pervasive” than seismologists used to think... Any attempt at seismic zonation must take into account the local site condition and this nonlinear amplification” Tectonophysics,218, 93-111;1993).Prof. Shearer(2009) wrote: When a non-linear site response is present, then the shaking from large earthquakes cannot be predicted by simple scaling of records from small earthquakes. Our work is placed on the local site effects and soil behavior during of strong and deep Vrancea earthquake in the extra-Carpathian area. Soils exhibit a strong nonlinear behaviour under cyclic loading conditions. So great are the effects of local site conditions that the propensity for earthquake damage at some locations may be much more dependent upon these conditions than on the proximity of nearby earthquake sources. As a seismic wave passes through a region of increasing impedance, the resistance to motion increase and, to preserve energy, the particle velocity and therefore the amplitude of seismic wave decreases. Currently, there are no constitutive laws to describe all real mechanical behaviors of deformable materials like soils. The amplification factors are decreasing with increasing the magnitudes of deep and strong Vrancea earthquakes and values are far of that given by Regulatory Guide 1.60 of the U. S. Atomic Energy Commission and IAEA Vienna. All analyses are conducting by using records on last strong Vrancea earthquakes (August 30, 1986; MW=7.1; h=131.4 km; May 30,1990; MW=6.9 ; h=90.9 km & May 31,1990; MW=6.4;h=86.9 km).The amplification factors decrease with increasing the magnitudes of deep and strong Vrancea earthquakes and are far of that given by Regulatory Guide 1.60 of the U. S. Atomic Energy Commission and accepted also by IAEA Vienna. All data were used by us, as alternative, to last STRESS Test asked by IAEA Vienna after strong Fukushima earthquake to NPP Cernavoada.

Key Words: nonlinear seismology, response spectra, spectral amplification factors, site effects.