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The H+V+H/V Single Station Tremor Analysis as a Passive Stratigraphic Tool.

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According to the diffuse elastic wavefield definition, the coherent signal present in seismic tremor is due solely to features of the continuum in the vicinity of the measurement site, so that single station spectra of tremor contain information about local structure near the station. This stands for the possibility to use single station tremor measurements as a passive stratigraphic tool, a possibility which has been so far exploited through H/V measurements inverted on the basis of the ellipticity of the fundamental mode of Rayleigh waves, relying on the tacit assumption that the latter are the main components of tremor. This approach has produced some remarkably positive results in spite of the fact that it often requires to assume unrealistically large values of the seismic impedance contrast. By using new portable high resolution tremor instruments - the Trominos, the performance of which was checked against that of full size broadband Guralp CMG-3Ts/DM24 seismographs - we attempted single station passive imaging at a variety of sites in North Italy for which accurate stratigraphies were available from previous cross-hole and down-hole seismic surveys together with well logs. The sites explored ranged from the 1-dimensional sedimentary basins of the Po Valley, up to several 100 m thick, with large gradients and modest impedance contrast with the bedrock, to steep sloping 3-D landslides with multiple reworked layers of clayey material, thickness of the order of 1 - 10 m and low impedance contrasts, to small scale complex superficial foundation environments typical of engineering geology, with layer thickness of the order of 0.1 – 1 m and a wide range of impedance contrasts.

In all cases, clear spectral patterns stable in time to be significant beyond 2 sigma were obtained in 20 minutes measurements without any data pre-treatment or selection. A

simultaneous modal analysis of the Horizontal and Vertical spectral components of tremor together with their H/V ratio according to a simple 1-D perturbative model including the first 3 modes of Rayleigh waves as well as Love and body P and S waves allowed the positive identification of most layers below a station. It also allowed to characterize the constituents of tremor, which appeared mostly composite, with a major role played by body waves.

In most cases several strata could be resolved, with the best results on the clay/gravel alternated fluvial layers of the Livenza river, along the coast North of Venice. In the case of landslides the identification of the main sliding surface proved always straightforward and in many cases it was possible to identify also the secondary and tertiary surfaces. While many stratigraphic features could also be extracted from a careful H/V analysis, the H+V+HV analysis achieved always superior resolution. However, single station tremor analysis can only provide a relative stratigraphy, which can be translated into absolute stratigraphy only a) if the velocity profile is known or b) if it can be "calibrated" at a site where the well log is available. In the latter case, which is likely to be the most frequent, single station tremor analysis provides an extensive stratigraphic capability at extremely low cost and can also be inverted to estimate the average seismic velocity profiles.