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Single-Station Passive Seismic Stratigraphy for the characterization of subsurface structure of the Valtellina valley (central Alps, northern Italy)

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The reconstruction of the subsurface structure of alpine valleys plays a key-role in the evaluation of their genesis, entrenchment and tectonic evolution. As a matter of fact, their characterization is strictly dependent on borehole data (water wells, shallow geognostic logs) and land based, deep seismic reflection/refraction lines; unfortunately, the availability of these datasets is often limited by economic and logistical limitations.

In this work the subsurface structure of the Valtellina buried valley (central Alps, northern Italy) was investigated by the means of Single-Station Passive Seismic Stratigraphy (S-SPSS), which yields the 1D shear velocity (Vs) profiles, based on the Horizontal to Vertical Spectral Ratios (HVSR) of microtremors produced by Raleigh waves trapped in the ground and provided by measurements of the resonance frequencies produced by a layered seismic stratigraphy.

The study area is the central part of Valtellina, W-E oriented along the Insubric line and drained by the Adda river. The sedimentary succession is known by shallow (<100 m) core data; it is dated to pre- and post- LGM (Last Glacial Maximum) and infills a deep buried valley, resting on a crystalline bedrock. The sedimentary fill is composed by loose coarse-grained and fine-grained sediments and its internal architecture is related to the interplay between the advance/retreat of alluvial fans, the aggradation of the Adda fluvial plane, the progradation of the glacial complex related to Adda Glacier and the develpoment of wide lacustrine environment. The investigated area is 30 km2 wide and lie in the present-day valley floor. Microtremor acquisition was carried out at 71 sites with a 3 component sensor and data recording ranged from 14 up to 100 minutes. Data-processing was performed in order to achieve the HVSR function and the HVSR peaks at frequency ranging from 0.7 Hz to 20 Hz.

S-SPSS was calibrated with the seismic stratigraphy revealed by a reflection seismic profile carried out in 2004 at Teglio (roughly 8 km E, uphill from study area), using the depth of the seismic basement as constrain for the interpretation of the seismic basement's HVSR peak measured at two calibration sites across the reflection profile. Estimated Vs for sedimentary fill varies between 200 m/s and 1500 m/s, whereas it is greater than 2000 m/s for the seismic basement. A deep seismic interface (max depth 600 m below ground surface, corresponding to a 0.7 Hz HVSR peak) was traced; some HVSR peaks at greater frequencies are also evident but the lack of deep direct data did not allowe to calibrate them in order to trace seismic interfaces within the sedimentary fill.

The seismic interface shows that the central part of Valtellina is a wide, asymmetrical palaeo-valley, with a steep side to South and a series of wide, flat terraces underlying the sedimentary fill to North. From E to W the talweg has not a constant slope but some apparent depocentres, splitted from rocky threshold, possibly corresponding to Deep-Seated Gravitational Slope Deformations or to a tectonic build-up, characterize the valley floor.