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The contribution of seismic noise and geological data to reconstruct the infilling architecture of the Norcia basin (Central Italy)

Ruggieri E., Di Giulio G., Porreca M., Ercoli M., Vassallo M.

During the 2016-2017, a long and complex seismic sequence struck the Central Italy, involving four regions (Umbria, Marche, Abruzzi and Lazio) and causing important damages and victims in inhabited areas such as Norcia and Amatrice towns. Norcia is an historical town situated in an extensional inter-montane basin, and a MCS intensity level of 7.5 was estimated after the 30 October 2016 Mw 6.5 event. In order to shed light on the subsurface geology and seismic response of the Norcia basin, we have performed an integrated geological and geophysical study, focusing our efforts on its most populated northern sector.

The results of the field geological survey and the collection of available well stratigraphic logs have allowed us to identify the main Quaternary lithostratigraphic units laying on the carbonate substrate. From the bottom to the top we find:

i) clayey deposits typical of lacustrine deposition, intercepted only by deep boreholes;

ii) cemented conglomerates outcropping in the NE sector, related to wide alluvial fans occasionally affected by pervasive fracturing and faulting;

iii) unconsolidated conglomerates units in silt and clay matrix typical of alluvial plain environment, mainly outcropping in the SW sector of the alluvial plane;

iv) unconsolidated carbonate units representing debris-flow deposits filling the valleys that connect the carbonate slopes with the flat morphology of the plain;

v) marshy and clayey deposit related to the actual palustrine deposits;

After identified the main Quaternary geology units, we performed a geophysical survey with the well-known Horizontal-to-Vertical Spectral Ratio (HVSR/Nakamura) method. We deployed 20 single-seismic stations to record some hours of ambient vibrations. We used two different equipments (Reftek130 digitizer with Lennartz-5sec and a SARA Geobox 4.5 Hz) deployed along two main orthogonal transects (ENE-WSW and N-S direction, respectively) covering the whole area of interest.
HVSR analysis shows and heterogeneous pattern of “fundamental frequency” (F_0) according to the different portions of the basin.

F0 is varying in the Norcia basin from 0.55 to 10 Hz. HVSR results can be summarized in four main groups, suggesting a direct link with the different characteristics of the lithostratigraphic units and their variable thickness:

1) a relatively flat spectrum with a single peak at high frequencies (range 4-10 Hz) for stations located above the carbonate bedrock;
2) broad peaks and F0 larger than 1 Hz in the NE area with respect to Norcia town. We observed broad peaks between 1-4 Hz and often a secondary peak at about 10 Hz, that is likely related to the presence of alluvial fan;
3) very narrow sharp peaks at 0.5-1 Hz are characteristic of the stations located in the SW-zone, which is the part where the basin shows higher thicknesses of the infilling continental deposits;
4) a bi-modal behaviour of the spectra, with a first broad peak between 0.5-1 Hz and a second one over 10 Hz is observed in the area of the inhabited city centre.

The integration between the data provided by the geological survey, experimental geophysical H/V data and available information on the velocity allows us to infer the thicknesses of deposits underneath the basin, and the depth of the underlying carbonate bedrock. The integration of geological information and geophysical data, that show sharp lateral changes in the shape of peaks, suggest also a possible control of the main tectonic elements that characterize the area. Such new results, allowed us to carry out an integrated model of the substructure geometry of the Norcia basin. More specifically, the alluvial conoids present in the NE area seems to reach a depth variable from 20 to about 50 m, overlaying thick alluvial and lacustrine deposits throughout the basin. Below the Norcia inhabited area and in the SW part of the basin, which is the areas where the bedrock is suspected to be deeper, these “soft” deposits may reach a depth of 250-300 meters.

The preliminary results of this study, also include some research products: an inedited digital geological map scale 1:10.000 created with QGIS software; a “Frequency-Amplitude” map from the HVSR analysis and two seismo-stratigraphic cross sections, highlighting the contact between infilling Quaternary units and the seismic "bedrock". Further acquisition of ambient vibrations trough 2D array of seismic stations will be carried out to better constrain the shear-wave velocity profile.