INSIGHTS ON THE DEEP STRUCTURE OF THE NORCIA BASIN (CENTRAL ITALY) BY COMBINATION OF GEOLOGICAL DATA AND SEISMIC NOISE MEASUREMENTS

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Introduction. The area located between Norcia and Castelluccio di Norcia has been affected by a strong shaking and damaging due to the complex seismic sequence occurred during the 2016-2017 (Chiaraluce *et al*., 2017). Four regions (Umbria, Marche, Abruzzi and Lazio) have been interested by the events and were affected by important damaging. The city of Norcia has been historically stuck by several strong events, and the Mw 6.5 mainshock occurred the 30th October 2016 has again produced strong damages of the city. It is evident how different areas of the basin have had different response to the shaking, so that parts of the city of Norcia and some little villages result severely damaged in comparison to others characterized by poor or absent damage (Galli *et al*., 2017). The architecture of the basin surely has played an important role in regulating seismic response (Luzi *et al*., 2018). Despite of numerous studies (e.g. microzonation 3th level) carried out during the last 40 years, the subsurface geology and structure of the region (Porreca *et al*., 2018), as well as that of the Norcia basin is still debated. For this reason, we used an integrated approach combining geological and geophysical data, to investigate the deep structure of the Norcia basin aiming to better figure out possible relationships with its seismic response.

Data and Method. In this work we applied an integrated approach including detailed geological mapping and geophysical surveys. The combination of new geological field data with stratigraphic data provided by wells and literature maps, provided indications on the main Quaternary lithostratigraphic units filling the basin; also, the location of the main faults has been drawn updating a geological map using this approach. In the same way, the geophysical data include information provided again by literature (e.g. Bindi *et al*. 2009; Bohm *et al*., 2011; Luzi *et al*., 2018), but the latter were also integrated by new data provided using passive noise measurements (Di Giulio *et al*., 2003; Di Giulio *et al*., 2016). An extensive campaign of the Norcia basin results in 54 new measurements of seismic noises, placed along two main transects in NW-SE and E-W directions (Fig.1). Four bidimensional arrays, made by eleven stations and located in the Northern sector of the basin, have been collected; two of them in the

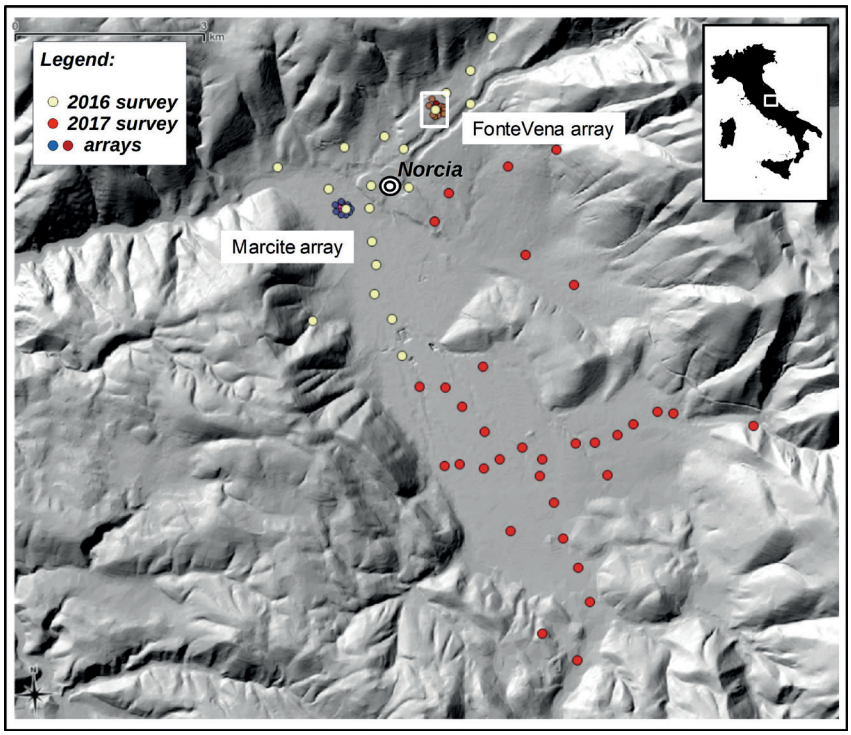

Fig. 1 - Location Map of the study area; dots represent the location of the noise measurements.

"Fontevena site" and the two others in the "Marcite" area. The noise data have a duration of at least one hour and were recorded through Reftek130 digitizer with Lennartz-5 sec equipment, and in few sites though a SARA Geobox 4.5 Hz. The data were processed and analyzed using Geopsy (http://geopsy.org/), by first removing the transients, then obtaining the HVSR ratios and fundamental resonance (F0) peaks for each station.

Results and conclusions. The results of the HVSR analysis display a really heterogeneous pattern of "fundamental frequency" (F0) in the different parts of the basin, even if a clear difference is visible between the North and South sector. The first sector is characterized by F0 values ranging between 0.6-0.8 Hz, whilst in the second sector between 0.9-1.3 Hz for the majority of the stations. A preliminary integration of all the datasets available, provide a first image of the deep structure of the basin, in particular about a variable interface between the infilling Quaternary units and the rigid bedrock, that was dissected by the normal faults activity. Clear changes in the thickness of the deposits, and therefore in the depth of the top bedrock interface, are visible mainly in the SW-NE direction in the Northern part of the basin (high amplitude and narrow HVSR peaks), but also a clear variability in visible in the NW-SE direction along the basin, with a progressive reduction southward. Integrating the velocity information from the literature and the microzonation 3th lev. (http://www.regione.umbria.it/paesaggio-urbanistica/area-terremoto-2016/2017), and the new ones coming from the arrays analyses, we have defined the velocity models in order to obtain the depth values from the HVRS peaks. Therefore, we extrapolated the average thickness of the deposits, that look considerably higher in the Northern sectors in the "Marcite" area (250-300 m), whilst the thickness appears lower in the southern sector. We currently provide as results: 1) a new digital geological map (scale 1:10.000) created in a GIS environment (QGIS, https://www.qgis.org/en/site/); 2) a new "Frequency-Amplitude" map obtained after the HVSR analysis for the entire basin (Fig. 2); 3) four new deep velocity models, particularly in areas like the "Marcite" previously uncovered by

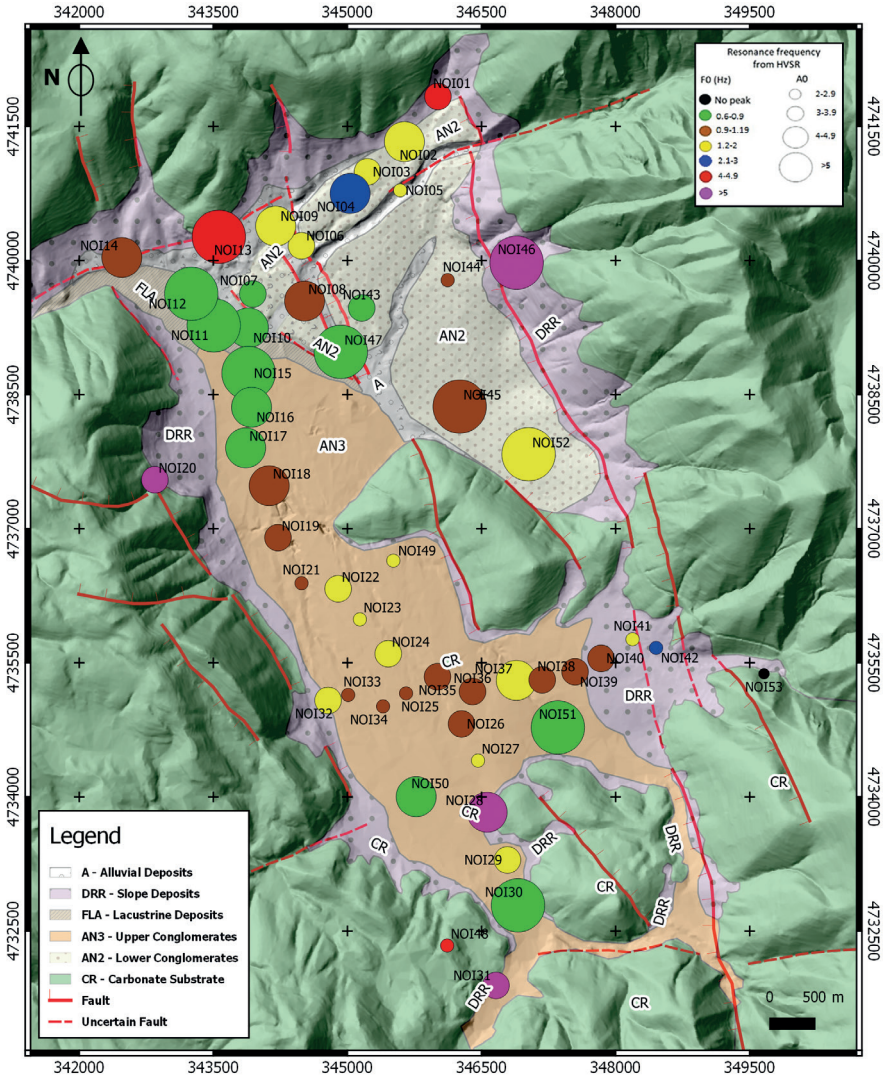

Fig. 2 - "Frequency-Amplitude" map obtained after the HVSR analysis for the entire Norcia basin.

any literature data; 4) two seismo-stratigraphic cross sections, that show a great match with the 2D HVSR contours obtained after the interpolation of the HVSR results. Further acquisition of 2D arrays will be necessary to better constrain the shear-wave velocity profile in the Southern sector of the basin, as well an accurate and reasoned integration of all the geological, structural and geophysical data gathers. Such a process would be useful in order to create a geological model of the entire basin aiming to clearly display the depth variations of the deposits/bedrock interface, that may bring onto a better the understanding of a possible link with the seismic response of the basin.

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