Introduction. The Mw 6.1 earthquake struck on April 6, 2009 a wide area of the Abruzzi region in central Italy, causing strong damages in L’Aquila town and surroundings. L’Aquila historical downtown, encircled inside the medieval walls, was strongly affected and some important site effects were recognized (Martelli et al., 2012). Previous works have suggested that different amplification effects, recorded into the historical downtown, may be related to the complex subsurface geologic architecture, given by the variability of the thickness and the lithology of the Quaternary deposits, on which the city was built (Martelli et al., 2012).

Thus, after April 6, 2009 earthquake, to improve the subsoil model for the seismic site response estimation and the Seismic Hazard evaluation of L’Aquila historical downtown, a multitask project has been carried out. It consists of the integration of subsurface dataset, including geological and geophysical surveys. The data have been interpreted with the aim to reconstruct a detailed 3D geological model of the Quaternary filling part of the continental basin on which L’Aquila historical downtown is located and the geometries of the Meso-Cenozoic bedrock located below the Quaternary cover. More precisely, we report the preliminary results concerning the interpretation of three high-resolution seismic reflection profiles provided in SEG-Y format by the IAMC-CNR research group.

Geological setting. L’Aquila historical downtown is founded on terrace that gently slopes down toward SW direction and strongly dissected by the Aterno River. The terrace is formed by slope-derived Middle Pleistocene calcareous breccia (the so-called L’Aquila breccia pertaining to Colle Macchione-L’Aquila Synthem by Nocentini et al., 2016), with a variable thickness in the range of 20 to 100 m. In the southern sector of L’Aquila downtown, a thin unit of shallow red soils dated back to the Eemian (Nocentini et al., 2016) causes a further shallow seismic impedance contrast that may have influenced the damage distribution during the 2009 earthquake (Del Monaco et al., 2013; Tallini et al., 2016a). The L’Aquila breccia and the red soils overlie a thick alluvial sequence consisting of Calabrian silty and sandy layers (Madonna della Strada Synthem, Nocentini et al., 2016), with a thickness of 200 m as reported by recent drilling data (Nocentini et al., 2016b). The Meso-Cenozoic limestone bedrock was intercepted in one single borehole (Amoroso et al., 2010), whereas its geometry, which is poorly known, was studied in detail through microtremor array measurements (Di Giulio et al., 2014).

The high-resolution seismic reflection profiles: results and discussion. This work shows preliminary results obtained by the integration of subsurface dataset, including geological (above all several hundreds of borehole logs) and geophysical surveys, such as high-resolution seismic reflection profiles, microtremor data, down-hole and deep cross-hole investigations, seismic tomography and electrical tomography. The data have been interpreted with the aim to reconstruct a detailed 3D geological model of the filling part of the continental basin on which L’Aquila historical downtown is located.

More precisely, we present the preliminary results of three high-resolution seismic reflection profiles provided in SEG-Y format. Such three lines were collected in order to shed light on a restricted subsurface area of L’Aquila historical downtown.

The equipment used encompassed by 24 channels seismographs (GEODE, Geometrics), 10 Hz geophones (Geospace), and a “MINIVIB” source, able to generate sweep (P-wave in this case) in a frequency range between 5-150 Hz. We analyzed the seismic lines in Fig. 1, named as “Corso” (NNE-SSW direction), “Duomo” and “Sallustio” (both in WNW-ESE direction). The
first is about 1 km long and was recorded using 8 seismic units, 192 geophones (5 m spacing, 10 m between the shots along the array). The receiver array of the second line is 96 m (with an eastward end-spread configuration of the sources), and it was collected using 2 seismic units and 48 receivers (distance 2 m). The latter profile is 360 m long and a number of three seismic recorders plus 72 geophones were used for its acquisition. The SEG-Y files have been treated by editing coordinates and elevations and defining a common datum. Then, such lines and a DEM (Tarquini et al., 2007, 2012) were imported in the MOVE software (www.mve.com) to provide a pseudo-3D interpretation of the local geological structures (Fig. 2). A time-to-depth conversion of the seismic lines have been successively performed, using a constant velocity value of 2500 m/s.

The seismic facies description was based on reflector parameters as geometry, amplitude strength (high or low), continuity, and qualitative reflection frequency, all of which can be described in qualitative terms. This led to recognize 3 main seismo-stratigraphic units (A, B, C): one shallow and poorly resolved unit (from 0 to 50-70 ms) (A), an intermediated well resolved unit (B) with sub-horizontal reflectors interrupted between the CDP 98 and 178 (from 70 to 250 ms) and a lower well resolved unit (C) with a general south dipping of a few degrees.

In addition, we have also integrated stratigraphic information collected from 11 borehole data which have been drilled in the study area between June 2010 and August 2013 (see Amoroso et al., 2010 for further details about the boreholes) (Fig. 1). These boreholes have been drilled to final depths ranging between 53 (S8) and 300 m (S2) with the maximum depth investigated lying at 407 meters a.s.l. Almost all these boreholes (all excluding S3 and S4 sites), drilled the L’Aquila breccia which, considering local silty levels, showed thicknesses ranging between 7 and 70 meters. Only the S7 borehole did not intercept the Calabrian alluvial silty and sandy sequence, while only the S3 borehole encountered the
bedrock consisting of Lower Miocene calcarenite. After drilling, several holes have been used for Vs estimates through SDMT test (S1-S2), cross-hole seismic (S3-S4) or downhole seismic (S6-S8) methods.

Conclusions. The results of the interpretation of the seismic lines, integrated by borehole stratigraphic and geotechnical data, may be summarized in the identification of two main horizons corresponding to the main lithological discontinuities. More precisely, the shallowest horizon, located to the top of the intermediate seismo-stratigraphic unit, likely corresponds to the lithostratigraphic boundary between the coarse deposits of the Middle Plesistocene L’Aquila breccia and the fine grained deposits of the Calabrian fluvial cycle (Madonna della Strada Synthem). The position and geometry of this horizon is well constrained by the borehole data. The other important horizon is located at the top of the lower seismo-stratigraphic unit (C). This could correspond to the top of the Meso-Cenozoic carbonate bedrock, which has been intercepted at the borehole S3. Data from the boreholes have allowed to constrain the depths of these two main horizons and their geometry.

The in-progress combined approach to data collection and analysis may give useful information to improve the subsoil model for the seismic site response estimation and the Seismic Hazard evaluation of L’Aquila historical downtown.

References


