3D geological model to support the management of urban subsurface environment:

Bucharest City case study

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INTRODUCTION

The knowledge of subsurface environment is of great importance, particularly in urban areas, where the complexity of the geological settings analysis is further increased by the presence of underground engineering works. Hence, under the continuous expansion (horizontal and vertical) of modern cities, an integrated management of urban subsurface is becoming a necessity. This requires developing tools, methodologies and models allowing to accurate map the subsurface variability.

This paper presents the methodology used to elaborate the 3D geological model of the Quaternary sedimentary deposits of Bucharest City and several urban hydrogeological applications. The methodology is based on the GIS tools developed by Gogu et al. (2011) and on the geospatial database concept (Gogu et al, 2001).

Bucharest City is located in the central part of the Moesic Platform which lies on a rigid base of metamorphites, and various igneous intrusions (granodiorit, granite).

Figure 1 – Geological map of Bucharest City

The sedimentary deposits covering this rigid base are made by different phases of erosion and sedimentation processes (marine, lacustrian, or continental) ending with Quaternary sediments (Figure 1). As a result, different alluvial deposits (such as wetland and lacustrine deposits) can be found.

DATA AND METHODS

The 3D geological model of Bucharest City was computed based on a large volume of information comprising of geological, hydrogeological and geotechnical borehole logs (over 1500 boreholes with depth between 5 and 275 m), geological and hydrogeological maps, geophysical logs, digital elevation model (DEM). These data were:

(1) Processed and stored into a geospatial database.

(2) Analysed using a 3D geological modelling instrument elaborated by Gogu et al. (2011). This consists on building 3D geological profiles which were interpreted using litho-stratigraphical criteria.

(3) The resulted processed data (3D geological cross sections) were used to identify the key layers of the Quaternary deposits which were then interpolated to delineate the main sedimentary aquifer strata.

(4) The structural maps were than intersected with the geometry of existing urban infrastructure elements (subway network, sewer system).

RESULTS

The Quaternary sedimentary deposits have been described and organized into 6 structural hydrogeological units, from top to down as follows (Serpescu et al. 2013):

- Superficial deposits represented by loess and anthropogenic materials.
- Colentina Formation made up of poorly sorted, cross-stratified sand and gravel with clay lens.This layer represent the shallow aquifer of Bucharest City.
- Intermediary deposits made of silty-clay with fine sand intercalation.
- Mostistea Formation made of sediments with a variety of grain size, from fine sand to coarse sand with small intercalations of gravels. This layer represent the second Quaternary aquifer of Bucharest City.
- Marly Complex made by a succession of marls and clays with lenticular sandy intercalations indicating a fluvial-lacustrine environment.
- Fratesti Formation made of sand and gravel which includes three aquifer sub-units (A, B and C). This layer represents the deeper Quaternary aquifer of Bucharest City.

The first two aquifer layers have a direct interaction with most of the urban infrastructure: sewer network, subway tunnels and stations, water supply network (Boukhemacha et al., 2015). By intersecting the 3D geological model (Figure 2) with the aforementioned urban infrastructure elements it has been possible:

- To identify sewer conduits located partially or completely in the upper aquifer unit (showing a high potential of water exchange between groundwater and the sewer system). This was the first step towards the quantitative assessment of water exchange between the aquifer and the sewer system using the conceptual approach developed by Boukhemacha et al. (2015).
- To provide the geometrical parameters necessary to assess the barrier effect induced by the presence of underground works (subway infrastructure, underground parking lots, etc.) on groundwater flow (Boukhemacha et al.,2013).

Furthermore, the existing 3D geological model provides the basic input for several urban hydrogeological and geotechnical models elaborated for Bucharest City (e.g. CCIAS 2012, Boukhemacha et al., 2015) used for urban groundwater managing, assessing land surface deformations (as presented in the research project SIRYS www.ccias.ro/sirys) and other civil engineering works.

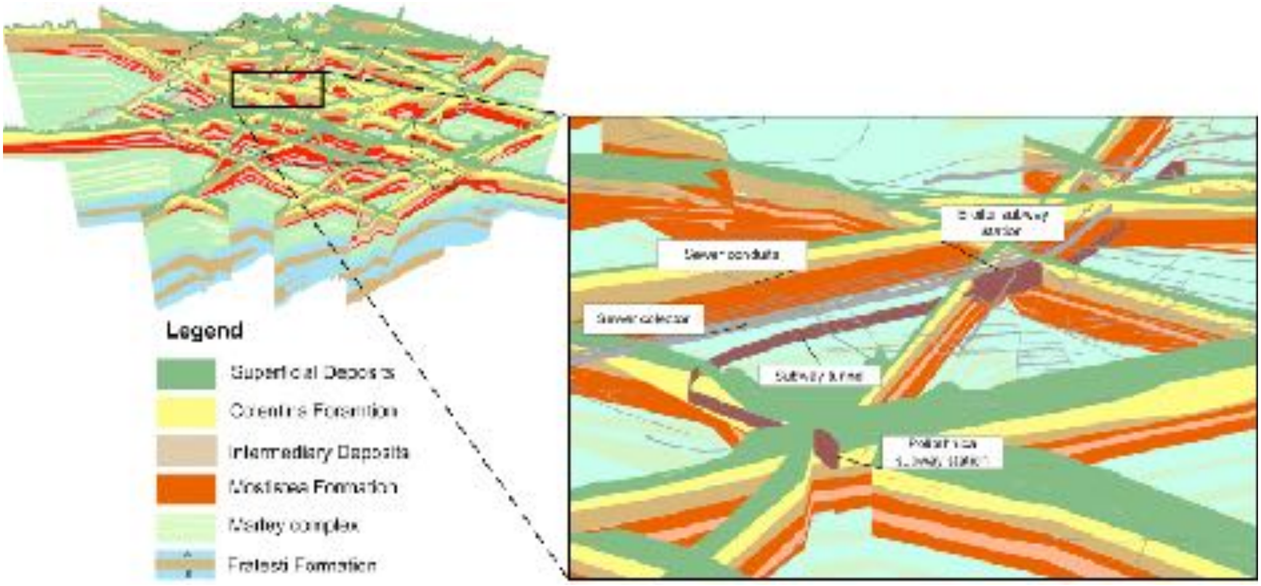

Figure 2 – 3D geological model intersection with the urban infrastructure of Bucharest City.

CONCLUSIONS

This paper presents the methodology used to elaborate the 3D geological model of the Quaternary sedimentary deposits of Bucharest City and several urban hydrogeological applications. The developed 3D geological model is a reliable support for further hydrogeological and geotechnical studies.

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