3D MODELLING OF THE HOLOCENE SUCCESSION IN THE SOUTHERN PO DELTA (ITALY)

SITUATION

The Po Delta in Italy is a magnificent landscape, full of hundreds of bird species, lush meadows, sprawling rice fields, and winding rivers. It’s the largest wetland area in Italy, and one of the biggest in Europe. As this region is a hub for tourists, naturalists, and bird-watchers, there is a need to understand the geology as the area gets developed. These insights also need to be easily communicated to all stakeholders (planners, civil engineers, and other decision-makers).

Traditionally, 2D maps and cross-sections are used for geological data analysis, however, these are not ideal for fully understanding the complexity of the features, or for communicating the data to other stakeholders. The Geological Service of the Emilia-Romagna Region decided to create the first 3D geological model for the southern margin of the Po Delta using Leapfrog.
The map would be created by integrating all existing data and adding any new insights uncovered from that integrated data. The existing data set included a large amount of Cone Penetration Tests (CPTs) that had rich insights into the physical and geotechnical characteristics of the area’s Holocene coastal and deltaic deposits. The study area extends over approximately an 800 km² region of the southern margin of the Po Delta. The geological model describes the Holocene sequence, which is characterized by unit thicknesses of about 30 metres. It exhibits typical behavior of a transgressive-regressive depositional system with paralic deposits and submerged beaches overlaying Pleistocene alluvial deposits and prodelta, delta front and delta plain deposits following in sequence.

Accurately understanding the geological sequence helps researchers understand other processes like liquefaction due to earthquakes, coastal subsidence (sinking), and saltwater intrusion along the coast into the aquifers. In turn, this affects decisions around land use and resource management.

**RESPONSE**

Leapfrog was used for the study to create the 3D geological model. The data is mostly derived from CPTs, but also includes data from continuous corings, boreholes, and water wells. Several parameters including Soil Behavior Type (SBT), Yield Stress Ratio (YSR), Factor of Safety against Liquefaction (FSL) were calculated for each vertical log, and these parameters were then modelled using Leapfrog.

The researchers manipulated the model by varying the inputs for the interpolating function, to understand how the model would change with different inputs. They noted changing the trend and the compositing of the logs had the greatest influence on the model outputs.

After the 3D model was successfully created, the researchers were able to see the lateral and vertical variations of the lithologies, and the geometry, thickness and distribution of the most yielding levels.

“With a better understanding of the subsoil, we are able to better disseminate information and have more productive discussions with other stakeholders.”

Lorenzo Calabrese, Ph.D., Geologist and Public Official of Emilia-Romagna Region

**Figure A:** 3D model of the Holocene succession (southern margin of Po Delta)
and liquefying strata. The model also highlighted a detailed lithological characterization of the coastal phreatic aquifer, making it possible to visualise the variation of groundwater parameters (such as electrical conductivity and temperature).

**OUTCOME**

The 3D modelling results from Leapfrog Hydro proved to provide richer insights than the traditional 2D methods used. Lorenzo Calabrese, Ph.D., Geologist and public official of Emilia-Romagna Region, noted that using Leapfrog had the following benefits:

1. Previous knowledge of the area was improved through the use of 3D visualisation. Specifically, the 3D models helped geologists correct old stratigraphic correlations and trace new ones, while also uncovering new understandings about the subsoil properties.

2. This was the first time the physical and geotechnical subsoil properties were 3D modelled on a variable scale, from local to regional. As a result, areas with critical subsoil properties were able to be identified and differentiated as volumes for analysis.

3. Leapfrog had features, such as the ability to make videos and take images, that were vital for disseminating the results to technical specialists and the general public. This means that now the previous knowledge of the area is accessible to anyone, regardless of their technical understanding.

**What next?**

The great results have encouraged geologists to extend modelling in other areas of the Emilia-Romagna Region. The 3D maps were made available to the Authority to support the drafting of regional plans and help with better decision making on any engineering or infrastructure works in the region.

For a more detailed review of the project, you can read the paper [here](#).

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Lorenzo Calabrese, Ph.D., Geologist and Public Official of Emilia-Romagna Region

“Before we started this project, we were only ever able to model in 2D. **Leapfrog has given us the powerful 3D visualisation tools, which has helped us improve our previous analysis and interpretation of the subsurface.**”

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