THE ROLE OF 3D MODELLING IN THE URBAN GEOLOGICAL MAP OF CATALONIA

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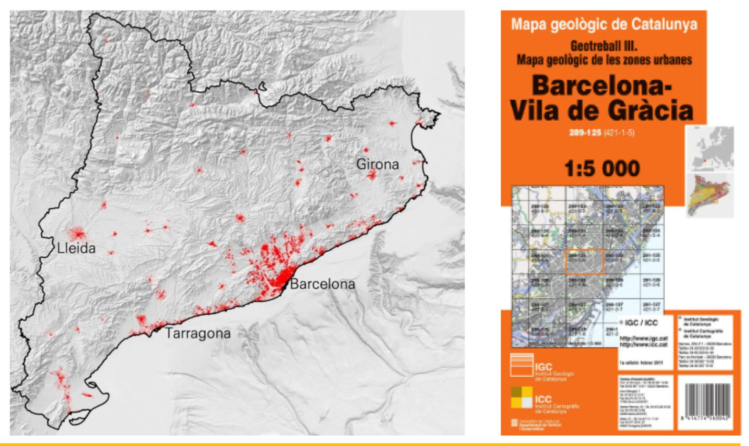
Introduction

The Urban Geological Map of Catalonia project focuses on the geologic characterization of county capitals and towns with a population larger than 10.000. This represents 131 municipalities hosting ~6.2 million inhabitants and a study area of 2.200 km^2.

To address the underground geological structure and properties of the geological units we apply a set of 3D modelling methodologies that pay special attention to the structure of the near surface.

3d geological models are basically built using the MicroStation CAD software (extensive format interoperability, a complete system of general geometric and data management tools, specific terrain modelling applications, flexible file georeferencing, powerful visualization tools and easy programmatic extensibility). We also use other applications such as Saga, Surfer, Geomodeller or GeOrient to solve specific tasks of the 3D modelling workflow.

In this poster we present the most relevant 3D geological modelling methods applied in this particular project of urban geological mapping.



Method 1

Determination of elevation changes, including infilled and excavated areas, basically related to human activity, derived by comparing the digital terrain models of two different times, one from the present and the other from the 1960's. If historical aerial photographs, with adequate resolution, are available, the implementation of the method can be very useful.

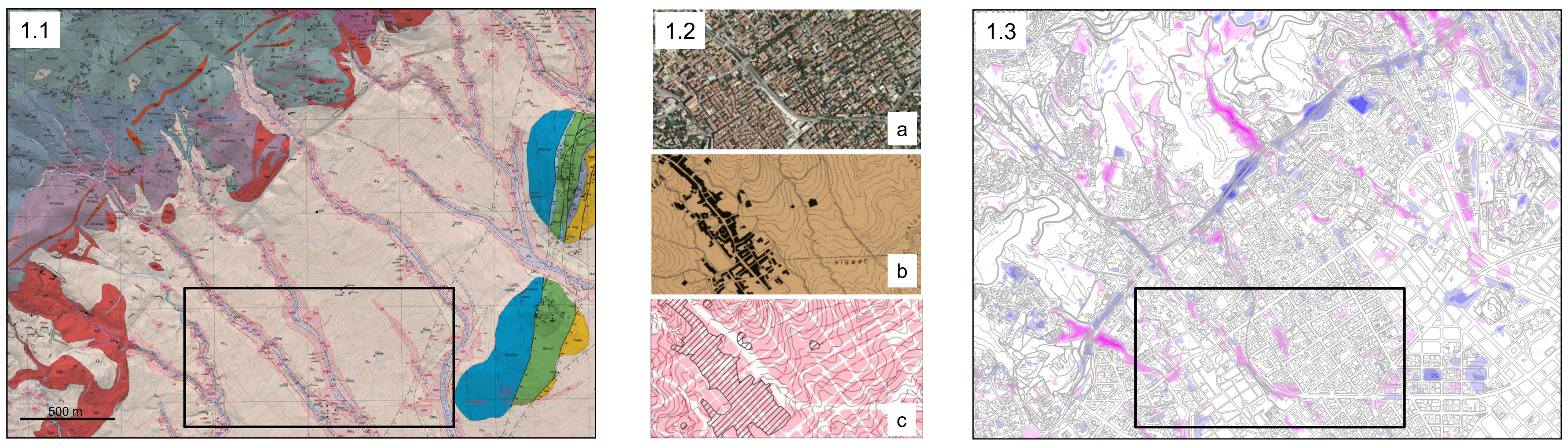
Case study: Determination of the thickness of artificial deposits related to the infilll of the river channel network of the Barcelona-Vallvidrera map sheet.

Figure Captions:

1.1 Geological map 1:5000 scale showing a system of infilled river channels. The black rectangle represents the area of Fig. 1.2a, b and c.

1.2 (a) Current orthophoto. (b) Topographic map from 1850's. (c) Detailed map showing the variation of the urbanization and the relief during the last 160 years. In urban areas the natural relief has been extensively remodeled through time and usually is very difficult to characterize the artificial ground.

1.3 Ground elevations changes map obtained from the difference of digital terrain models (2010 minus 1960). Pink areas represent infilled terrains and blue areas excavated terrains.



Method 2

Determination of the base of the Quaternary (Holocene and Pleistocene) and Neogene deposits obtained from the delineation of contour lines at 5 meter intervals and seriated cross sections taking into account borehole data, geomorphological features, detailed geological mapping and H/V measures.

Case study: Modelling the Quaternary and Pliocene deposits of the lower course (top figures) and delta plain (bottom figures) of the Llobregat river in the southern Barcelona metropolitan area. The method to construct the contour lines varies depending on the geomorphometry of the study area, the existence of outcrops, and the availability of borehole and other subsurface data.

Figure captions:

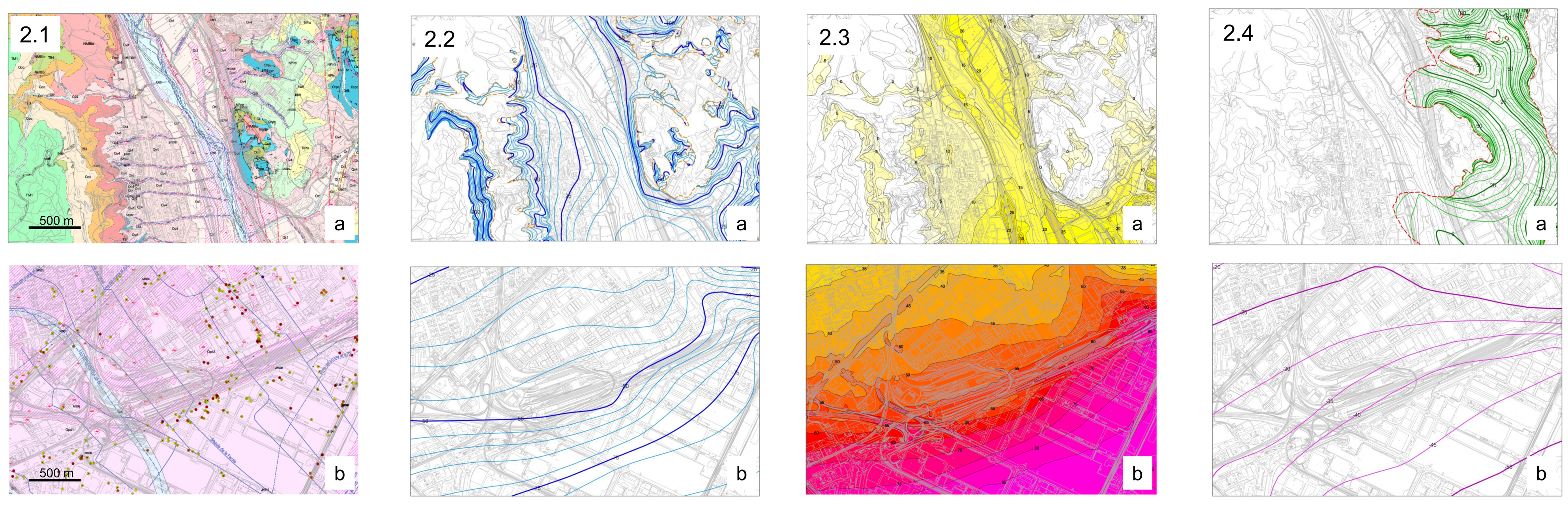
2.1 Geological map 1:5000 scale of Sant Andreu de la Barca (a) and Bellvitge (b).

2.2 Contour lines of the top of the pre-Quaternary basement. In absence of Pliocene deposits, this surface represents the top of the bedrock.

2.3 Isopach maps of the Quaternary and Anthropocene deposits.

2.4.a Contour lines of the base of the Pliocene deposits of the lower course of the Llobregat river.

2.4.b Contour lines of the Upper Pleistocene transgressive deposits of the Llobregat delta.



Method 3

Determination of the structure of multilayer sequences applying the dip-domain method, that consists in the compartmentalization of geological horizons in sectors where bedding orientation is approximately constant separated by lines of locally sharp curvature .

Case study: 3D modelling of the folded and faulted structure of Tarragona city. The 3D surface reconstruction from the integration of local structural measurements, with sparse observations and uncertain considerations is very tedious and requires a thorough geological structural analysis.

Figure captions:

3.1 General geological map and cross section of the urban area of Tarragona.

3.2 Distribution of outcrops (red) and boreholes (blue) studied in Tarragona's city center.

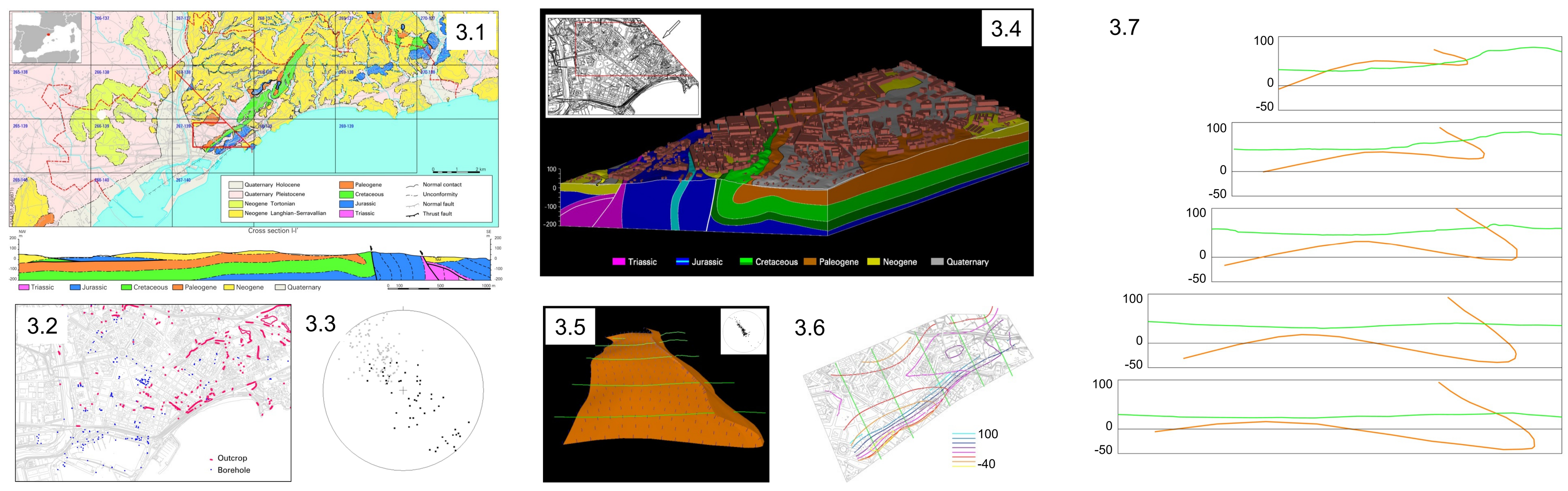
3.3 Stereoplot of the poles of bedding of Mesozoic and Paleogene rocks.

3.4 3D view (from NE to SW) of the geological structure.

3.5 Reconstruction of the base of the Paleogene. The stereoplot represents the poles of the surface.

3.6 Structural contour map of the surface of Fig 3.5 (the interval between contours is 20 m)

3.7 Seriated cross sections derived from the reconstructed surface of the base of the Paleogene.



Method 4

Determination of regular grids of regional planar geological structures derived from the interpolation of field measurements of the dip direction and the dip, through direction cosine interpolation method. This grids can be very useful, for example, for the construction of trace maps and cross sections or, the prediction of modes of rock slope failures.

Case study: Prediction on the orientation in the near surface of the Hercynian regional foliation of the Cambro-Ordovician succession of the Collserola Range (Barcelona Metropolitan area).

Figure captions:

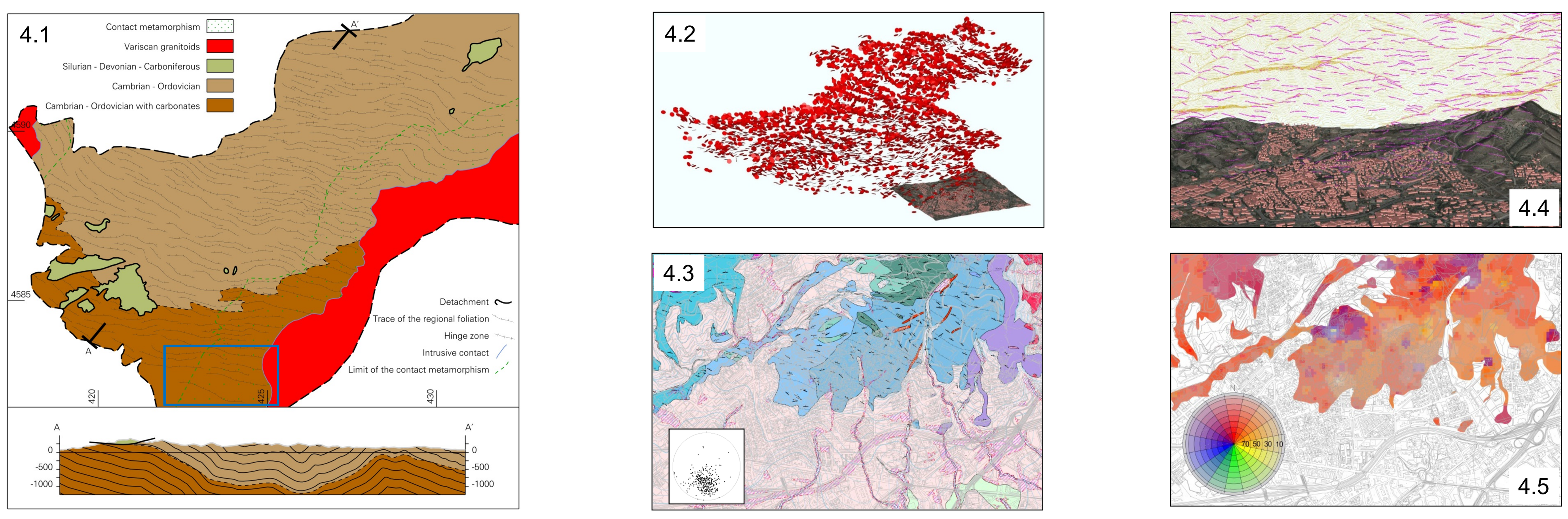
4.1 Structural geological map and synthetic cross-section of the Collserola Range.

4.2 3D view of the Variscan regional foliation measures in the Collserola Range.

4.3 Geological map 1:5000 scale of Sant Just Desvern (dropped ortofotograph of Fig. 4.2) and stereoplot of the poles of the regional foliation measures.

4.4 3D traces derived from the intersection of the regional foliation with the digital terrain model.

4.5 Map showing the orientation of the regional foliation obtained from interpolation of field measurements.



Method 5

Determination of the basement structures from interpolation of data derived from multiple cross sections and contour lines after a detailed structural analysis of the data.

Case study: Reconstruction of the surfaces of the main Tertiary geological units (Paleogene and Neogene) that define the underground of the urban area of Girona.

Figure captions:

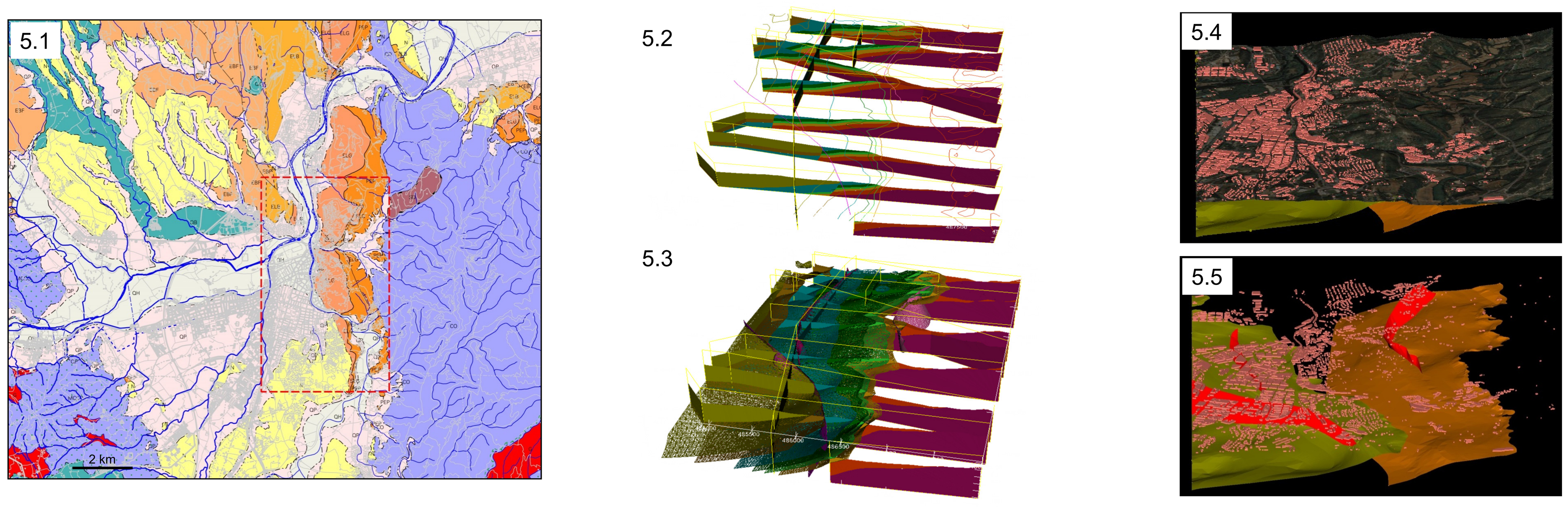
5.1 General geological map of the urban area of Girona. The red rectangle represents the area of the 3D views of Fig. 5.2, 5.3, 5.4 and 5.5.

5.2 Block diagram showing the reference cross sections and 3D cartographic traces used to reconstruct the geological surfaces.

5.3 Contact surfaces and faults that bound the main Tertiary geological units obtained from the interpolation of the cross sections and the cartographic traces using Geomodeller.

5.4 3D view of the ground of the Girona urban area.

5.5 3D view showing the spatial relationship between the urban constructions and the base of the Neogene succession (yellow), the base of the Paleogene succession (orange) and the main faults (red).



Conclusions

The role of 3D modelling in the Catalan urban geological project is oriented to build different components of the 1:5000 scale geological map sheets, such as the pre-Quaternary basement map, the cross sections, and the isopach map of the drift deposits. The resulting 3D surfaces can be distributed by means of meshes, contour maps or 3D visualization files. This requires an additional effort that with few resources can be achieved.

Currently, many urban communities are immersed in the Smart City fever. Urban geology can be considered as a basic layer of this trending topic, for example to assess the vulnerability and resilience of the urban subsurface to future environmental change. In this context, it is feasible that in the near future 3D geological models will be integrated in the virtual 3D city models, following for example the CityGML application schema. This is possible and represents an opportunity for the geoscientific community.

This poster reveals that the methodology to reconstruct the 3D underground structure of urban areas varies depending on geological, geomorphological and anthropogenic features, and the available data. The reconstruction of the 3D underground structure of the different types of urban environments of Catalonia can be obtained using the described methods.

Despite these advances and possibilities, it must be taken into account that the value of urban geology is not fully recognized by the wide range of potential users. Most Catalan city authorities do not have the resources or the enthusiasm to integrate basic urban geology in their environmental information systems for planning. Perhaps 3D geological modelling could be a window to communicate better the potential benefits of urban geology in terms of cost and environmental improvement.