Titolo: Development of a 3D geological model of the urban area of Bologna

Durata: 12 mesi

Sede di lavoro: Dipartimento BIGEA Università di Bologna, Via Zamboni 67 Bologna

Problem statement

Many urban areas reflect past or recent unplanned development shaped by social and economic trends. Cities are growing at an unprecedented rate and high levels of complexity. Then, the demand for a risk-informed planning and management of cities is increasing, in order to foster resilient societies and sustainable urban settlements. Hazards that may be unimportant in undeveloped areas become major problems in vulnerable urban areas increasing enormously the level of risk. Every growing city depends on adequate supplies of suitable development land, construction, resources and raw materials, water and energy, and produces wastes and pollution of soils, water and air.

Engineering geology can provide meaningful scientific information for the present management and future development of urban areas in order to establish sustainable and resilient cities and communities within the framework of the United Nations international policies for sustainable development. Increased demand for space on the surface and the increased use of the underground space, both for structures and infrastructures, have generated new requirements and approaches for geodata type and quality.

Within this framework, a key step is the the generation and management of geodatabases for the reconstruction of the geological settings over large areas. This implies the improvement in the definition of uncertainty, the interpretation of the occurring processes and geohazards, the monitoring data and the advanced modelling tools, as well as the assessment of the impacts of climatic and socio-economic changes. Geo-energy storage and exploitation, complex ground structures and underground infrastructure designing, water demand and groundwater rebound management, all require an advanced engineering geological characterization.

The development of urban areas require large volumes of construction materials and adequate and safe water supplies even where rising groundwater levels are observed because of reduced abstraction and artificial recharge. By far one the most costly issues in urbanized areas is flooding which can become more effective because of the groundwater rising. Subsidence is widespread resulting from the presence of natural and artificial underground cavities, groundwater abstraction, soil shrinkage and compressibility, suffusion.

There is an urgent need to provide the required capabilities to understand the possible evolution and impact of geohazards on the urban fabric, by harmonizing geological knowledge, technical characterization of geomaterials, conceptualization, monitoring and modelling. This requires an integrated holistic approach to deal with the different natural hazards and risks, affecting an urban settlement and its historical-cultural heritage, and to manage risk mitigation and sustainable development strategies.

Research activities

The research grant is funded by the Research Project URGENT (Urban Geology and Geohazards: Engineering geology for safer, resilieNt and smart ciTies; PRIN: PROGETTI DI RICERCA DI RILEVANTE INTERESSE NAZIONALE – Bando 2017 - Prot. 2017HPJLPW). The research activities of the grant are part of WP1 (Database Design and Implementation) and WP2 (3D Geological models of urban areas). The description of these two work packages is given below.

WP1 - DATABASE DESIGN AND IMPLEMENTATION

Aim:

1) To design Data Model of a relational database for UG applications

2) To create a database of geological information for the five pilot cities (Milano, Bologna, Firenze, Roma, Napoli)

Description:

An efficient database supports analyses of complex data. Source data can contain information in the third dimension (geotechnical and geophysical investigations), as well as temporal (e.g. groundwater level and quality, monitoring data) or spatial data (e.g. maps, DTM/DSM, satellite images). Most municipalities maintain databases of geological data, which are often incomplete and rarely comparable.

Activities:

A1.1) Data Model design. The aim is to design the Data Model of a relational database suitable for a set of UG applications. The structure will be inspired to the Open Geoscience data model (British Geological Survey). The BGS data structure provides pre-populated entities, relationships, and dictionaries for geoscientific information. The model, designed as a Database Management System, will use Open Source Modeling Tools (DBDesigner, ArgoUML) and the open source-database engine MySQL.

A1.2) Geological database of pilot cities. A relational database that collects relevant geological information for the five pilot cities will be created. This will include both proprietary data (owned by municipal administrations) and open source datasets from other public authorities or freely available online. Efforts will be made to establish standard formats for information from different sources.

WP2 - 3D GEOLOGICAL MODELS OF URBAN AREAS

Aims:

1) To develop an operational procedure for 3D geological modelling in urban areas

2) To demonstrate how models for specific use can be obtained from a general-purpose geological model

Description:

Lacking outcrops and visible geological structures, 3D geological modelling in urban areas is different from traditional geological mapping, and requires specific methods to analyze and visualize subsurface data. Best practices for the reconstruction of urban subsurface will be reviewed, considering: i) harmonization of input data; ii) man-made grounds; iii) criteria to establish engineering-geological and hydrogeological units by geologic, geotechnical, hydraulic characterizations; iv) spatial modeling methodology; v) evaluation of model uncertainty; vi) visualization techniques.

Activities:

A2.1) General-purpose geological models. This aims to create geological models which can be used for different applications at different scales. The models will be based on standardized lithological descriptions and will retain the resolution of the original data. The analysis will be conducted on sample subsurface volumes, selected in the pilot cities to be representative of the geological complexity. Geological units will be defined by both the traditional layer-based approach and stochastic modeling with geostatistical techniques (voxel-based) allowing to evaluate uncertainty.

A2.2) 3D models for specific use. Subsurface models for specific applications (e.g. ground instability, land subsidence, groundwater management, seismic response) will be obtained from the general-purpose geological models by exploiting geotechnical, hydrogeological, and geochemical data. Multivariate statistics and geostatistical modelling will be used.

The research activities of the grant will focus on the urban area of Bologna and will be conducted in collaboration with the Geological Survey of the Emilia-Romagna Region.