3D RECONSTRUCTION OF THE MULTI-LAYER AQUIFER IN A PO PLAIN AREA

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REFERENCE PROJECT

“Hydrogeological model of Po Plain groundwaters”
(in cooperation with AdBPO, CNR-IDPA, DISAT-Milano Bicocca)

• Address water resource management problem through a regional scale modellistic approach

• Make the procedure more automated thanks to a stratigraphic database (TANGRAM©, www.tangram.samit.unimib.it)
OBJECTIVES

• Define the geometry of geological and sedimentary bodies in plain areas

• Reconstruct underground textural distribution in order to assign appropriate hydrogeological parameters to aquifers (for further applications)
HYDROGEOLOGICAL DATA MANAGEMENT

SPATIAL DATA: TOPOGRAPHY AND AQUIFER BASES

GEOLOGICAL ELEMENTS GEOMETRY

WELL DATA: ADMINISTRATIVE DATA, STRATIGRAPHY

TANGRAM© DATABASE

LITHOLOGICAL INFORMATIONS

3D STRATIGRAPHIC GRID

3D PHYSICAL MODEL: TEXTURES, PERMEABILITY, POROSITY

ESTIMATION OF WATER AVAILABILITY

FLUX AND CHEMICAL TRANSPORT MODELS
3D PHYSICAL MODEL

- Storage of hydrogeological informations related to water wells, collected from existing archives or from territorial surveys data, into TANGRAM© database: in this database, wells stratigraphic data are codified and georeferenced.

- Extraction (thanks to TANGRAM©) of textural terms percentage and hydrogeological characteristics.

- Elaboration of textural data according to normalized intervals, identified on the basis of the detail scale.

- Definition of 3D reference geometries.

- Creation of a 3D stratigraphic grid (S-GRID) thanks to GOCAD.

- Conversion of archived data into XYZ points in GOCAD.

- 3D interpolation through the use of geostatistical techniques (Kriging).
STUDY AREA

Approximately 2900 Km$^2$
GIT – Geology and Information Technology
8ª Riunione del Gruppo di Geologia informatica
Sezione della Società Geologica Italiana
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GEOLOGICAL FRAMEWORK

Sections from Francani et al. 1988

LEGEND
- GRAVEL AND PEBBLES
- SANDS
- LIMESTONES AND CLAYS
- MORAINAL DEPOSITS
- CONGLOMERATES AND SANDSTONES
- PEAT AND FOSSIL
- ROCKS
DATA COLLECTION: SPATIAL DATA

AQUIFER A BASE

Lombardian plain perimeter

AQUIFER B BASE

Lombardian plain perimeter

AQUIFER C BASE

Lombardian plain perimeter

AQUIFER D BASE

Lombardian plain perimeter

Input data from Regione Lombardia & ENI Divisione Agip, 2002
DATA COLLECTION: WATER WELL DATA (TANGRAM©)

5704 WATER WELLS INSIDE STUDY AREA

http://www.tangram.samit.unimib.it
DATA COLLECTION:
OIL WELLS DATA (VIDEPI)

151 OIL WELLS INSIDE STUDY AREA

http://unmig.sviluppoeconomico.gov.it/videpi/
CREATION OF GEOLOGICAL SURFACES: FOOTHILL CRETACEOUS FORMATION

Points of DTM 20m related to Albian & Cenomanian formations (Sass de la Luna & Bergamo flysch)

+ 167 points representing layers containing rock:
  - 143 from TANGRAM
  - 24 from Francani et al.1988
CREATION OF GEOLOGICAL SURFACES:
TOP OF PLIOCENE DEPOSITS (from 147 VIDEPI well logs)
CREATION OF GEOLOGICAL SURFACES: OVERALL MODEL

- DTM
- AQUIFER A BASE
- AQUIFER B BASE
- AQUIFER C BASE
- TOP OF PLIOCENE DEPOSITS

2300 m
RELATIONS BETWEEN WELL DATA & GEOLOGICAL SURFACES

4000 active wells, 3225 with stratigraphy

DATA LIMIT

DISTRIBUTION OF 5704 WATER WELLS OF THE STUDY AREA WITHIN AQUIFER GROUPS

- DTM
- AQUIFER B BASE
- TOP OF PLIOCENE DEPOSITS
CREATION OF COMPUTING GRID

Two grids with different vertical resolution were created:

- **Upper grid**: represents A and B aquifer groups
- **Lower grid**: represents the deeper aquifers, located between the bottom of base B and the newly created top of Pliocene deposits

**Upper grid**:  
- 50 layers;  
- 400 columns and 380 rows;  
- grid spacing of 250 m  
- average cell thickness of 10m;  
- total average thickness of 500 m

**Lower grid**:  
- 40 layers;  
- 400 columns and 380 rows;  
- grid spacing of 250 m  
- average cell thickness of 26m;  
- total average thickness of 1000 m
DATA ENCODING & ELABORATION OF WATER WELLS DATA

3225 water well logs elaborated:
- average depth of 50m;
- maximum depth of 300m;

Quantification of different textural terms is possible thanks to the encoding of well logs data and thanks to TANGRAM® extraction tool.
RECONSTRUCTION OF TEXTURAL TERMS: WATER WELLS

COARSE TERMS (%)

MEDIUM TERMS (%)

FINE TERMS (%)

- DTM
- AQUIFER B BASE
- TOP OF PLIOCENE DEPOSITS
RECONSTRUCTION OF TEXTURAL TERMS: VIDEPI WELLS

COARSE TERMS (%)

FINE TERMS (%)

MEDIUM TERMS (%)

-0 20 40 60 80 100
RECONSTRUCTION OF TEXTURAL TERMS

COARSE TERMS (%)  MEDIUM TERMS (%)  FINE TERMS (%)
RECONSTRUCTION OF TEXTURAL TERMS (video)

FINE TERMS (%)

![Map showing fine terms percentage distribution]
**VALIDATION**

**COARSE TERMS (%)**

- Fluvio-glacial coarse deposits in the upper layers, interspersed with medium textural terms
- Gravel and pebbles found in the Brembo riverbed (as shown in Section 5), and recognizable in GOCAD section (red circle)
Coarse deposits in the upper layers, while lower layers are mainly made of medium and fine terms.

Sands are found near Cremona region (as shown in Section 10), interspersed with gravelly and clayey lenses recognizable in GOCAD section [light blue colours with green-yellow (finer terms) and blue lenses (gravel)].
DISCUSSION

• Decrease of grain size from North to South, according to the decrease of depositional energy of the main rivers located within and near the study area;

• In the Bergamo region there is a large amount of coarse textures near foothill conoids, while Cremona province is characterized by finer deposits;

• The upper aquifers are composed of coarse deposits, while the lower aquifers are composed of finer deposits, according to the different depositional environments (continental and marine);

• Clayey lenses are small and thin in the upper part of the study area, large and thick in the lower part of the area, leading to the separation of different aquifers
CONCLUSIONS

• Reconstruction of the textural distribution is fundamental to estimate the main hydrogeological properties of deposits for further implementation in flow models

• Use of an automated procedure able to couple the large amount of available data, a continuous updating of well characteristics and a good detail level
THANK YOU FOR YOUR ATTENTION!
CREATION OF GEOLOGICAL SURFACES: AQUIFER BASES

4000 active wells, 3225 with stratigraphy