GROUNDWATER FOR THE FUTURE. THE HYDROGEOLOGICAL MAP OF CATALONIA 1:25.000.

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INTRODUCTION

The Geological Institute of Catalonia (IGC) is a public entity of the Catalonian government created for the study, research and compilation of information of the ground and underground characteristics and conditions of the Catalonian territory.
One of the main IGC competences is the generation of geothematic maps at 1:25 000 scale. The hydrogeological map is part of the geological database. The main IGC's objective is to generate a clear map displaying of hydrogeological data. Nevertheless, IGC is not the main water management agency). The institution in charge of the water policies in an integral way to manage and plan the whole water cycle in order to maintain ecosystems equilibrium is the Catalan Water Agency (ACA). The IGC hydrogeological database and maps are based in information from different institutions, and the main source of the information is ACA database on the complete cycle of water complemented with other sources and own specific fieldwork. Consequently, both institutions, IGC and ACA are implicated in the generation of the hydrogeological map of Catalonia.

THE HYDROGEOLOGICAL MAP OF CATALONIA

The hydrogeological map of Catalonia is GIS-based. It represents all those characteristics and phenomena related with the groundwater and surface water relative to the rock-water relationship as a system in which the variables change.
The influence of atmospheric and anthropic aspects is also represented adding a degree of complexity to the maps. Considered phenomena are exploitation volumes, water quality, geodynamic processes and environmental protection.
Other sources of point type of information that are included in the map are water quality and measurements data from Catalonian Water Agency, Hydrographical Confederation of Ebre River (CHE), Geological Institute of Spain(IGME), Spanish Mines Bureau, and others from the municipalities.
The main reason to generate a map at 1:25000 scale is the existence of a geological and topographic maps of quality at the same scale. Cartographic elements and map legend is based in Struckmeier and Margat(1995), and Vrba and Zaporozec (1994) guidelines.
The map is divided in three levels of information that combined among them allow to generate graphically the different hydrogeological aspects:

1 Hydrogeological structure (aquifer thicknes, depth, extent, etc)
2 Ground water dynamics Data (water table depth, extraction points, etc.)
3 Water quality data

MAIN MAP

The main map will be a 1:25 000 scale where some intrinsic and variable characteristics related with the cycle of the water will be represented.
Firstly, a relation is established between lithology and permeability (Figure 1). The criterion is deduced from geological data base, pumping tests and bibliography information.

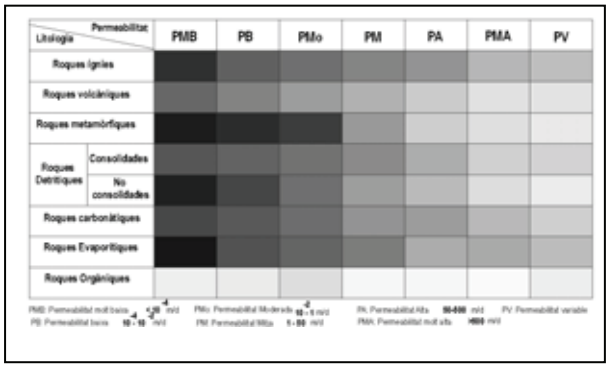

Figure 1: Table of rank of permeability versus lithology

The hydrogeological formations and their extent (aquifers and impermeable units) are taken from ACA definition. Modifications to their extent are

made on the basis of geological units from the geological map.
Hydrological surface elements are extracted from topographic maps to establish aquifer relationships: flow data (maximums and minimums), calculation of river basin area, presence and quantities of irrigation, and presence of dams and lakes.
The piezometric surface morphology and evolution is characterized on the ACA information and represented in the map. The ACA provides all the information on aspects such extractions, artificial reload, regenerated waters, hydraulic barriers, etc., to characterize water levels, Figure 2.

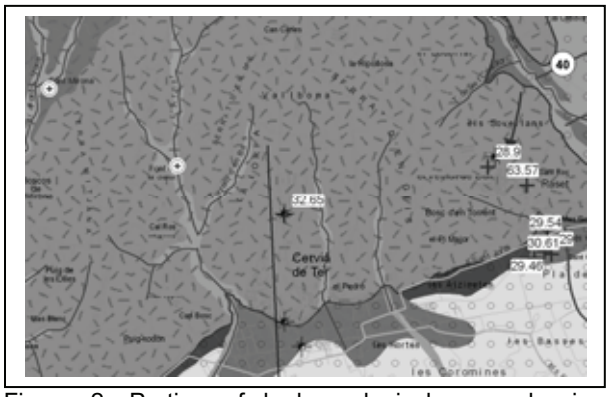

Figure 2: Portion of hydrogeological map showing piezometry, permeability, surface water information, aquifers, etc.

The Catalan Water A*g*ency's monitoring network for groundwater consists of 405 groundwater points that are taken on a monthly basis. Series dating back over 30 years are available for more than 300 of these points. In order to complete the network and adapt it to the criteria of the European Water Framework Directive (WFD), a total of 160 new water level points with a total forecast perforation length of approximately 13,000 m are under construction.

COMPLEMENTARY MAPS

Hidrogeochemical map

The base of the map will be a conversion of geological units to geochemical units. Data from four monitoring quality control and piezometric networks will be incorporate in this map and database.
Two maps will be developed:
Maps that show the intrusion of saline water and its time evolution.
Maps showing the different types of water according to the ionic content (Evolution graphics will be presented associated to this maps, see Figure 3).

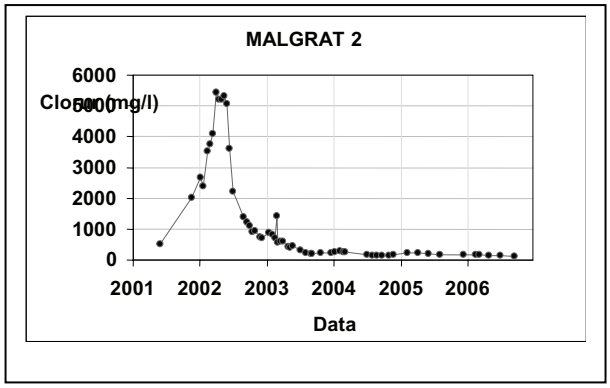

Figure 3: Chlorides at the Tordera deep aquifer (Niñerola and Ortuño, 2008)

Porosity type map

The porosity map is based on the conversion of geological to porosity units. The criterion for conversion is based on the geological data base and bibliography information (see Figure 4).

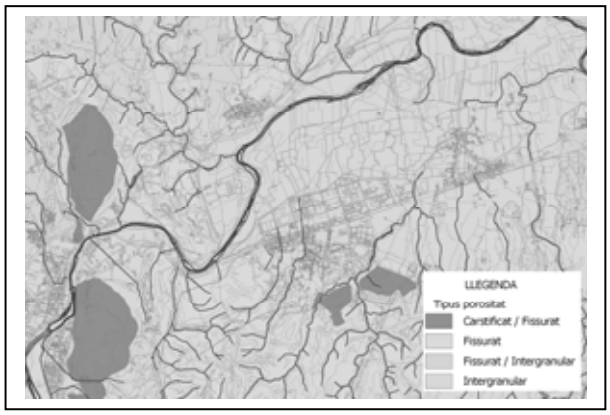

Figure 4: Map of porosity type of Sarrià de Ter.

Vulnerability map

The WFD states that prevention and protection criteria must be coherent with all legislation concerning nutrients, and in particular with European Directive 91/676/EEC concerning on the protection of waters against pollution caused by nitrates from agricultural sources (definition of vulnerable zones).
Nitrates and pesticides are the only substances with concentrations that are subject to quality regulations.
The Catalan Water Agency's pesticides operational control network has 88 control points with a six-monthly testing frequency. The Pesticide monitoring and control plan came into operation in 2007, in compliance with Article 8 of the Water Framework Directive.

The Catalan Water Agency's nitrates operational control network has 765 control points with a six-month testing frequency and has 694 control points with an annual testing frequency.
Once the bodies of water were defined, the stressing aspects affecting them were analysed. Stress is understood as the potential of those human activities that may affect the flow or the chemical composition of groundwater. The main stressing aspects affecting the groundwater bodies in Catalonia are those listed in Table 1.

Affection to the state	Kind of stressing aspects	Pressure
Chemical	Local	Industrial spills
		Waste disposal
		Construction and demolition waste
		Contaminated soils
		Waste Water Treatment Plant
		Tip mining
		Buried tanks
	Diffuse	Application of livestock manure
		Fertilisation practices
		Returns of irrigation
		Sewage system
		Pipe lines

Table 1: Main pressures affecting the groundwater in Catalonia (Niñerola and Ortuño, 2008)

Aquifers intrinsic vulnerability to pollution by nitrates and/or pesticides is evaluated. The map is generated by the parameter weithging method DRASTIC (Aller et al., 1987) (see figure 5).

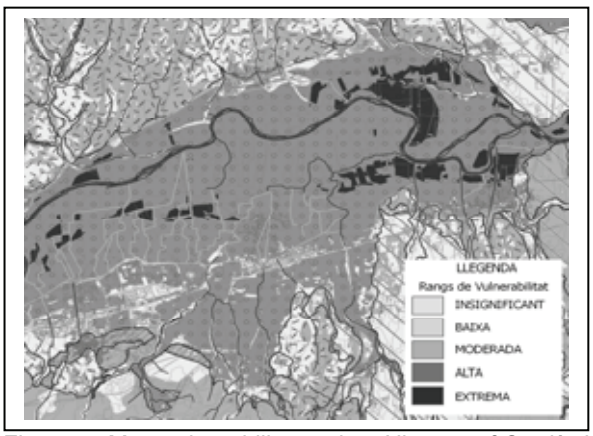

Figure 5: Map vulnerability against Nitrates of Sarrià de Ter.

OTHER COMPLEMENTARY ELEMENTS

The map also represents the groundwater particularities in chemical composition or temperature, or the conceptual hydrogeologic functioning model. It is represented showing geometry and relationships between aquifers (see figure 6).

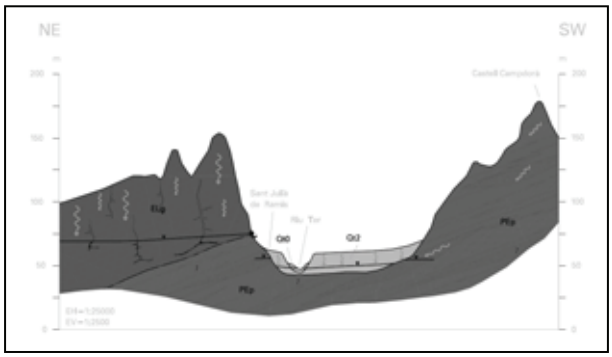

Figure 6: Hydrogeology system functioning sketch.

Climatology aspects will be represented in the map as rainfall distribution, thermal regime, and its influence in evaporation.

CONCLUSIONS

The hydrogeologic data of Catalonia will be incorporated and systematized within a GIS and associated data base, in a way that new data and information will be updated and changed easily for the map not to lose validity through time.
The hydrogeological map of Catalonia is generated to become the management tool of groundwater and surface water in Catalonia.

ACKNOWLEDGEMENT

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BIBLIOGRAPHY

ALLER L., BENNETT T., LEHR J. H., PETTY R.J., HACKET G, (1987). DRASTIC A. Standardized system for evaluating ground water pollution potential using hydrogeologic settings. EPA600/2-87/036. 641 pp

NIÑEROLA, J.M., ORTUÑO, F., 2008. The quantitative and chemical status of groundwater bodies in Catalonia. State of the art on the implementation of the water framework directiveand grounwater directive., 13-15 November 2008.

STRUCKMEIER, W.F. MARGAT, J. (1995). Hydrogeological Maps: A Guide and a Standard Legend. Vol 17. IAH. Verlag Heinz Heise. Hannover. 177 p.

VRBA, J. Y ZAPOROZEC, A. (Ed.). (1994). Guidebook on Mapping Groundwater Vulnerability. Vol 16. IAH. Verlag Heinz Heise. Hannover. 131 p.