THE NEW DIGITAL GEOTHERMAL ATLAS OF CATALONIA FOR VERY LOW TEMPERATURE (GACvLT)

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1. INTRODUCTION AND OBJECTIVES

Catalonia is located in the NE of the Iberian peninsula (*Figure 1*). With 7.5 million people and 32.100 Km^2, its territory has a great geographic variability with an altitude range that covers from sea level in the Mediterranean up to 3.100 m in the Pyrenees. The climate is predominantly Mediterranean although with Atlantic's nuances inward.

The possibilities of implementing the very low temperature geothermal energy in Catalonia are real. Despite its potential, there is an evident contrast between the use of geothermal energy of very low temperature in Europe and Catalonia, where its implementation has been delayed.

Therefore, the ICGC is developing the new ***digital Geothermal Atlas of Catalonia for very Low Temperature*** **(GACvLT)** with the following aims:

Figure 1: Map situation of Catalonia.

ALTITUDE (masl)	ANNUAL MEAN AIR TEMPERATURE (ºC)	AREA CATALONIA		URBAN SOIL	
		%	(Km^2)	%	(Km^2)
0 – 500	12 – 17	44	13.879	88	1963
500 – 1000	8 - 15	40	12.913	5	107
1000 – 1500	5 – 13	8	2.685	2	56
1500 – 2000	3 – 9	5	1.481	5	109
2000 - 3150	0 -7	3	1.150	0	0

Table 1: Mean air temperature (ºC) in Catalonia depending on altitude (*Niyerola, M., 2000*), area covering these altitudes, and urban soil surface where most of the population is concentrated.

a) To spread geothermal energy of very low temperature knowledge, its implementation and promote the use of this type of renewable energy in Catalonia

b) To make data available to potential users compiling and generating new information about thermal parameters and subsoil temperatures

d) To provide useful data to preliminary feasibility assessment of very low geothermal energy installations and give a fair indication about the associated costs

The contents of the GACvLT are mainly oriented to vertical closed-loop systems, but also includes hydrogeological information related to vertical open-loop systems and soil data related to horizontal ground loop heat exchangers.

2. BACKGROUND AND ORIGIN

In 2012, the ICGC published the **Geothermic Atlas of Catalonia (GAC)** at a scale 1:500 000 (*Puig, C et al, 2010*). This project was planned as a product for the dissemination of geothermal energy knowledge in Catalonia *(Figure 2*) specially with regard to high and medium temperature geothermal energy.

Due to the need for deeper understanding shallow geothermal energy in Catalonia, in December 2014 the Executive Board of the Government of Catalonia established the creation of the new GACvLT as one of the ICGC main lines of work for the period 2014-2017.

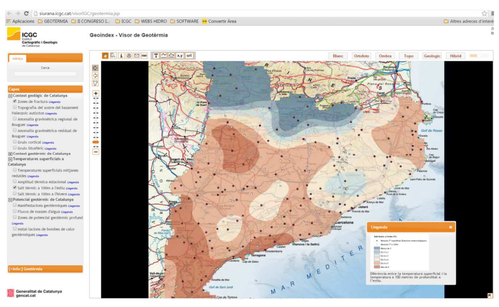

Figure 2. Geothermal Atlas of Catalonia at a scale of 1:500 000 mainly for high and medium temperature resources. See it at www.icgc.cat.

3. GENERAL STRUCTURE

The GACvLT is divided into three main parts (*Figure 3*):

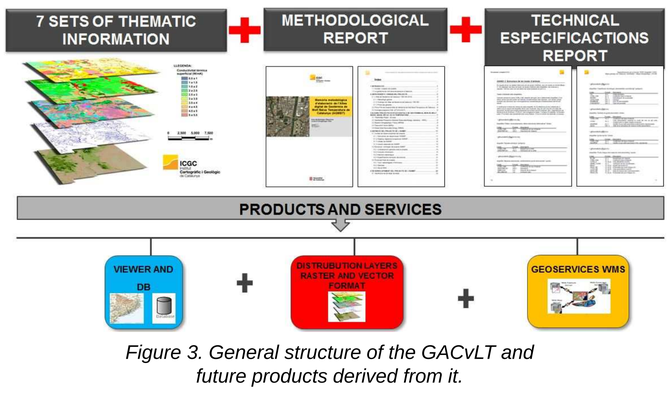

Figure 3. General structure of the GACvLT and future products derived from it.

27 layers (both raster and vector formats) divided in 7 thematic geoinformation sets.

Methodological report; methodology, original data and the significance results obtained will be pointed out.

Technical specifications report explaining the structure and organization of data and how to symbolize them.

SETS OF THEMATIC INFORMATION	NUMBER OF LAYERS	DESCRIPTION
Geological information	1	Drilling complexity prognosis map
Soil information	3	Depth, texture and thermal conductivity of soil map
Hydrogeological information	5	Depth to groundwater surface level, Langelier Saturation Index, confined aquifers with potential artesian phenomena and hydrothermal sources location
Subsoil thermal properties	4	Thermal conductivity, volumetric heat capacity, thermal diffusivity, heat flow, geothermal gradient and thermometry location maps
Climatology	4	Temperatures and surface thermal oscillations maps
Subsoil temperatures	8	Temperature distribution at 2, 50, 100, 150 and 200 meters deep maps
Geothermal potential	2	Geothermal potential for both open loop and closed loop heat exchange systems

Table 2: Information of the 7 sets contained in the (GACvLT) and general description.

4. DETAILED CONTENTS

4.1. Geotechnical information

- Drilling complexity prognosis map (*Figure 4*).

Considering the subsoil mechanic characteristics, three difficulty levels have been assigned indicating the likelihood of instability during drilling.

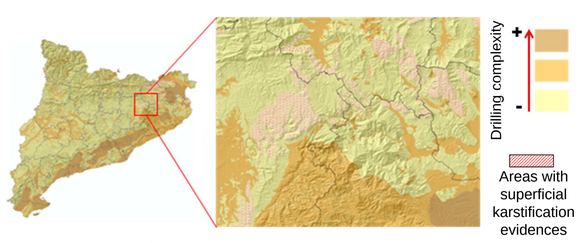

Figure 4. Drilling complexity prognosis map.

4.2. Soil information data set

- Soil depth and texture, soil thermal conductivity and soil profiles localization maps.

The information comes from manual interpolation of over 14.000 soil pits. Thermal conductivity has been estimated from *Dehner* (2007) method which have been applied also in the Thermomap Project (*Bertermann, D, 2013*). *(Figure 5)*.

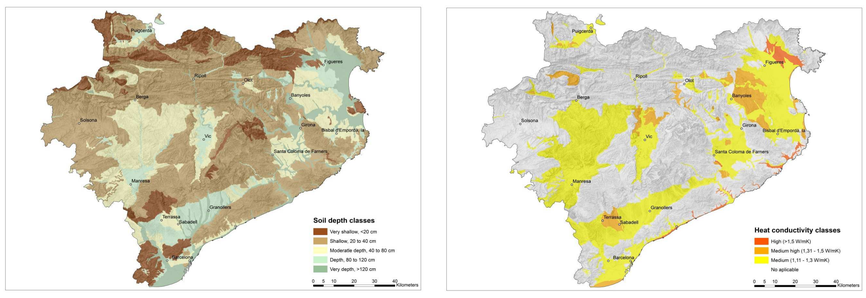

Figure 5. Soil depth classes and soil heat conductivity classes maps. The GACvLT also includes the location and point information of the soil pits gathered.

4.3. Hydrogeological information data set

- Water points with groundwater level information map
- Depth to water range map
- Langelier Saturation Index map
- Aquifer distribution 1:50 000 scale map
- Hydrothermal springs and wells location map

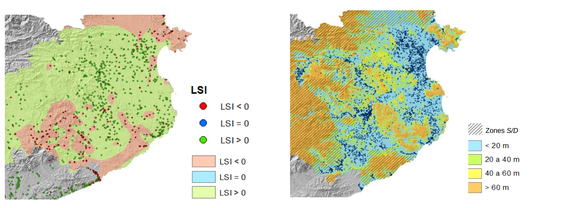

Figure 6. Langelier saturation index map and depth to water classes map where areas without data available are pointed out.

Over 8.500 groundwater level data and over 5.000 groundwater chemical analyses have been investigated. Continuous layers have been made using interpolation methods.

4.4. Subsoil thermal properties data set

- Surface thermal conductivity map
- Surface thermal diffusivity map
- Surface volumetric thermal capacity map
- Stratigraphic columns with thermal parameters assignment

Thermal parameters values have been assigned to geological units from 1:50.000 ICGC geological maps depending on lithology and porosity (AENOR, 2014).

430 lithological columns deeper than 50 m have been incorporated allowing users to see the geothermal parameters vertical distribution.

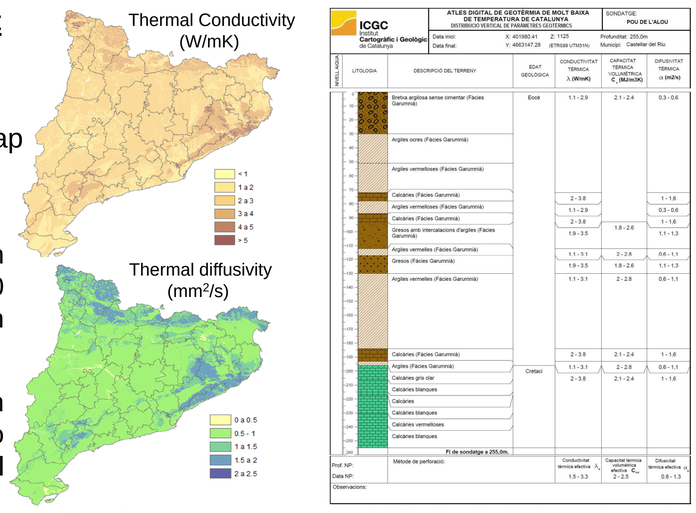

Figure 7. Superficial thermal conductivity and diffusivity distribution and example of lithological column with assigned thermal parameters.

4.5. Climatology layer set

- Annual average air temperature map
- Average minimum temperature of the coldest month map
- Average maximum temperature of the hottest month map
- Annual semi-amplitude

Using multiple regression techniques these maps take into account regional geomorphology parameters (*Ninyerola, M., 2000*).

4.6. Subsoil temperatures data set

- Average minimum and maximum temperature of soil at 2 m depth maps
- Annual semi-amplitude at 2 m depth map
- Average temperature of subsoil up to 50, 100, 150 and 200 m depth maps
- Temperature profile points location map

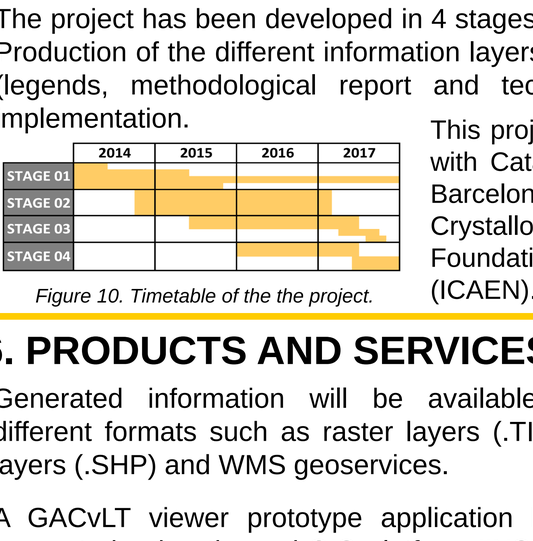

Figure 8. Conceptual model applied for subsoil temperatures estimation.

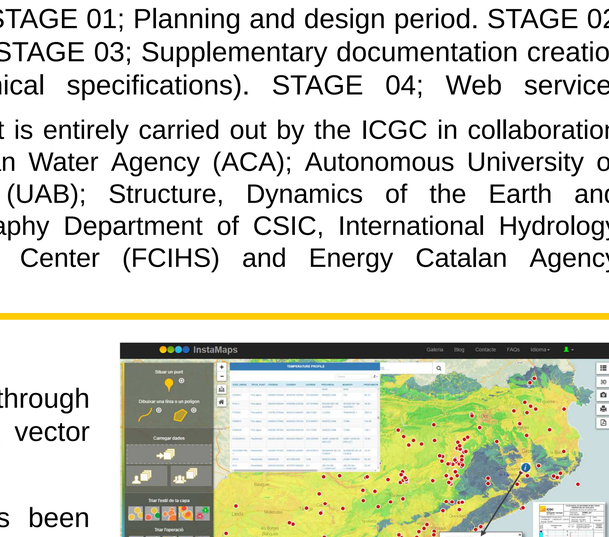

Figure 9. Theoretical subsoil temperature at 50, 100, 150 and 200 m depth, and example of real temperature profile

454 temperature profiles have been compiled to show the differences between theoretical temperature estimated and these real point data (*Figure 9*).

4.7. Geothermal potential layer set

In the case of closed systems, the estimated geothermal potential is directly related to rock lithology and the heat extraction capacity. In the case of open loop systems, geothermal potential depends on groundwater temperature and water extraction capacity of the subsoil.

5. PROJECT TIMETABLE AND COLLABORATORS

The project has been developed in 4 stages: STAGE 01; Planning and design period. STAGE 02; Production of the different information layers. STAGE 03; Supplementary documentation creation (legends, methodological report and technical specifications). STAGE 04; Web services implementation.

	2014	2015	2016	2017
STAGE 01				
STAGE 02				
STAGE 03				
STAGE 04				

Figure 10. Timetable of the the project.

This project is entirely carried out by the ICGC in collaboration with Catalan Water Agency (ACA); Autonomous University of Barcelona (UAB); Structure, Dynamics of the Earth and Crystallography Department of CSIC, International Hydrology Foundation Center (FCIHS) and Energy Catalan Agency (ICAEN).

6. PRODUCTS AND SERVICES

Generated information will be available through different formats such as raster layers (.TIF), vector layers (.SHP) and WMS geoservices.

A GACvLT viewer prototype application has been generated using the webGIS platform 'INSTAMAPS'. It is a public tool and open webgis platform, entirely developed by the ICGC, for the creation, dissemination and sharing of maps on the Internet. (http://www.instamaps.cat/)

Figure 11. The GACvLT viewer prototype application using the webGIS platform 'INSTAMAPS'.

7. REFERENCES

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