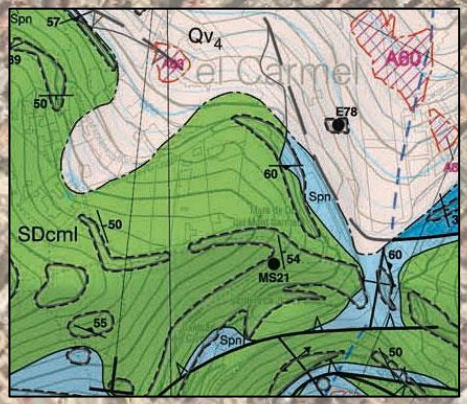

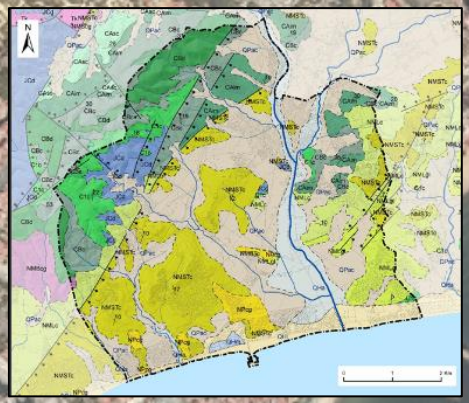

Three different approaches to provide urban geological information from a geological survey perspective: The Catalan case study

Guillem Subiela*, Miquel Vilà, Roser Pi

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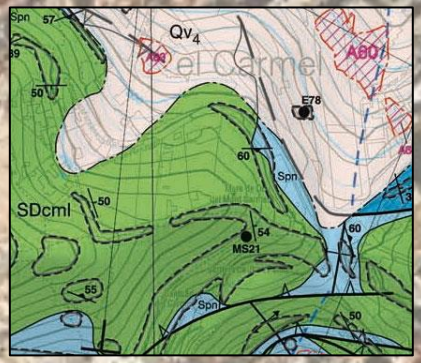
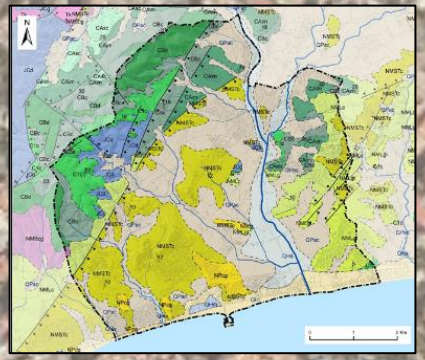
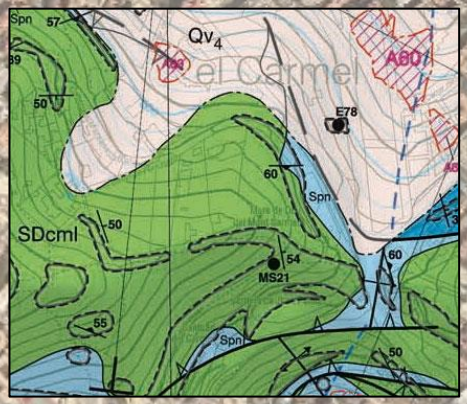
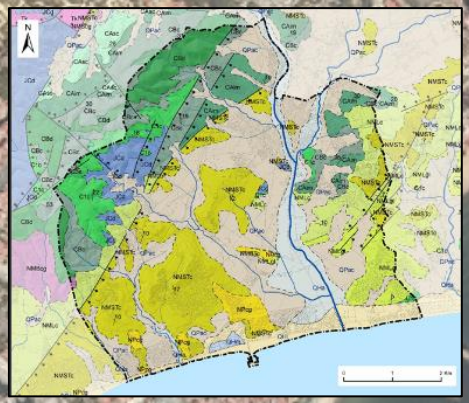


Short version

Long version







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Short version

- At the municipal level, **the development of different activities** related to urban planning, environmental sustainability, construction and so on…

Urban planning

Construction

Environmental sustainability

….may be conditioned by a series of geological factors such as

Anthropic materials

Complex grounds

Mass movements

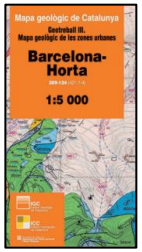
Environmental quality

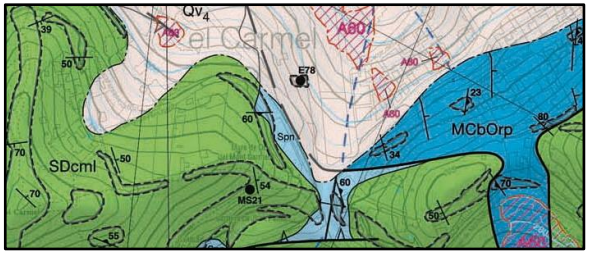
- So, **there is a need for** easy **access to** the **available geological and geotechnical information**. And the **Catalan mapping & geological agency** (*Institut Cartogràfic i Geològic de Catalunya,* ICGC) has the function, by law and to the extent possible, to satisfy this need of geological information.

- In the field of regional urban geology the ICGC has focused on the development of three main projects:

i. **The 1:5,000 scale Urban Geological Map of Catalonia project.**

Urban geological map 1:5,000





ii. **The system of layers of geological information.**

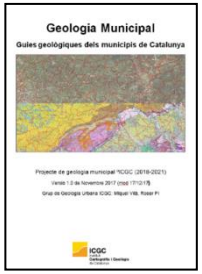
20 Layers of geological information

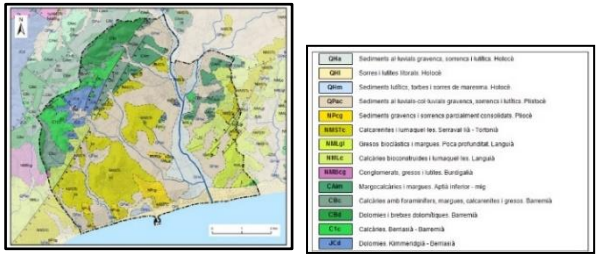
Anthropic grounds

Physical parameters

iii. **The fundamental geological guides of municipalities.**

Fundamental geological guides of municipalities





- The purpose of this communication is showing the utility of these three projects with the aim **of finding effective ways of transferring geological knowledge** and **information of a territory**, from a geological survey perspective.

- (I) The urban geological maps of Catalonia have been a great ambitious project.

Advantages

i. It is focused on **providing detailed, consistent and accurate geological, geotechnical and anthropogenic activity information** of the main urban areas of Catalonia.

ii. All this information of **diverse geothematic** content is integrated into the **map coherently and with explanatory texts**.

iii. In the case of applicability, the map may be useful for urban planning because of the detailed geological and geotechnical information.

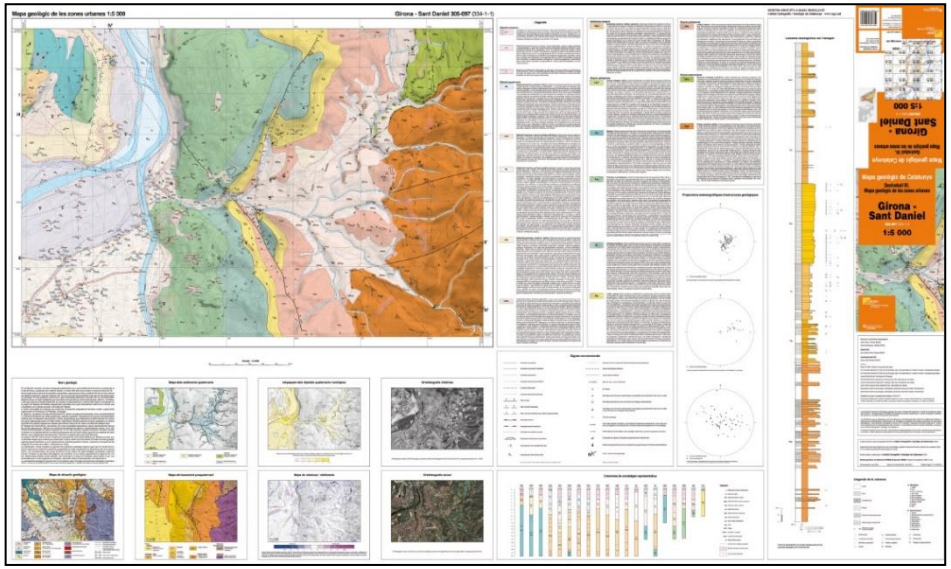
Drawbacks

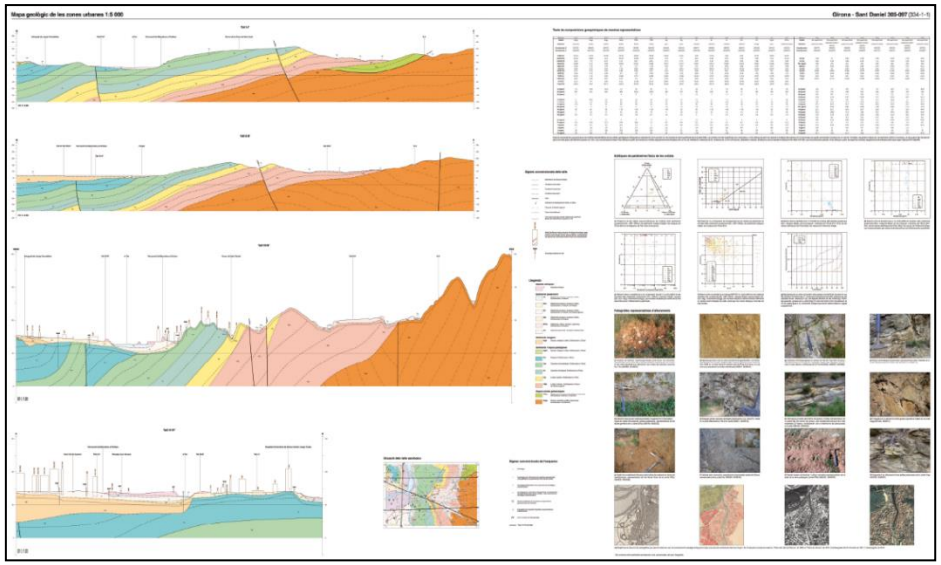
i. By contrast, the compilation and elaboration of a large volume of detailed geological information **require a lot of time for data completeness**.

ii. An homogeneous geological cover of the whole territory of Catalonia is **unviable in term of 5-10 years**.

iii. Moreover, the potential users probably only can be understood by professionals in Geology.

iv. Furthermore, **the data would require updating, reviewing and improving**.





- Nowadays, in order to optimize a greater distribution of information, a pilot project of (ii) a system of layers of geological information covering some urban areas is being developed.

Advantages

i. It integrates 20 layers of diverse geological information and the degree of detail depends on works scale (1:5,000, 1:25,000…).

ii. It requires less time to complete a specific layer of geological information and it does not have to be integrated with other geological information.

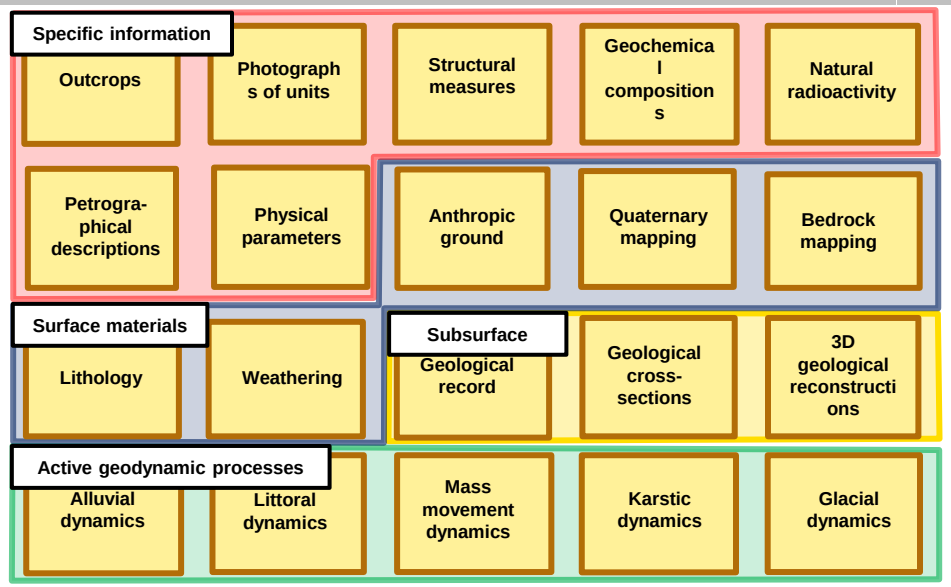
iii. It allows to visualize and analyse in an agile way the characteristics of the land and the processes that take place there.

Drawbacks

i. By contrast, as information layers are treated individually, sometimes it may not be clear the coherence between data from different layers of information and requires some expertise unless a number of parameters are specified.

ii. The data would require updating, reviewing and improving, but probably in lower frequency.

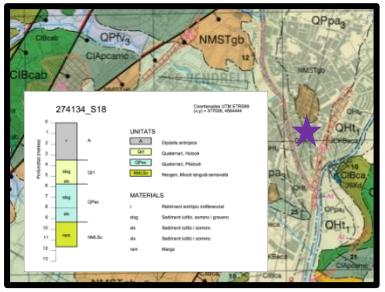
iii. Owing to available resources, this pilot project may not be established in the medium term.



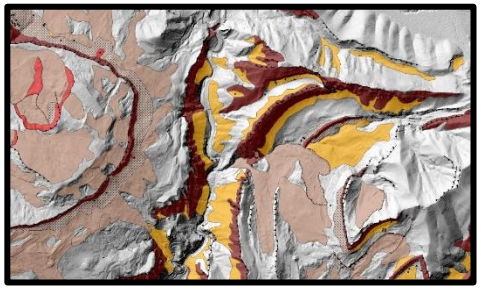
Specific information
Physical parameters

Surface materials
Anthropic grounds

Subsurface
Geological records



Active geodynamic processes
Mass movement dynamic



- As a strategy to reach a wider range of users and also provide a homogeneous and varied geological information, the development of (iii) fundamental geological guides of municipalities is also being carried out.

Advantages

i. This pilot project provides an overview of the main geological aspects to be considered in face of territorial and environmental management.

ii. The information presented is intended to reach a broader range of users, non-geological professionals.

iii. The data would require updating, reviewing and improving, but probably in lower frequency because the data is in 50.000 work's scale.

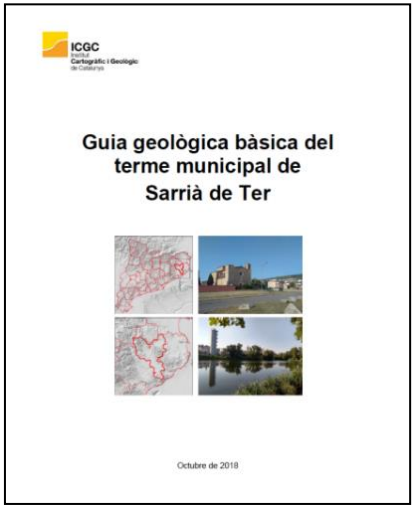
Drawbacks

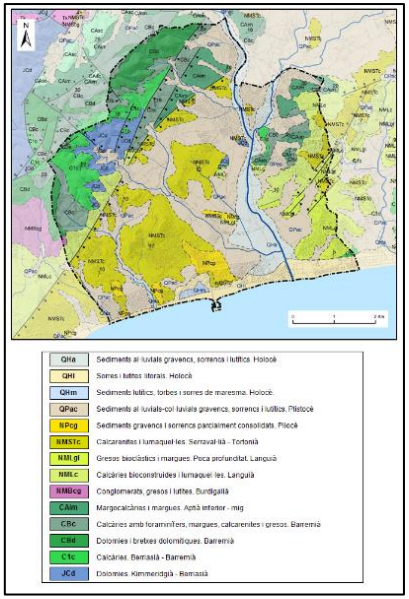
i. It involves a document that is based on a 1: 50,000 work's scale.

ii. It requires time to integrate several geological and geotechnical aspects, but it can be considered lower than urban geological maps.

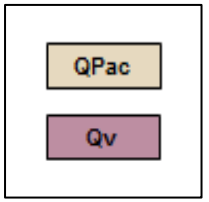
iii. It is recommended to consult a professional of the Earth Sciences about geological interpretations.

iv. Owing to available resources, this pilot project may not be established in the medium term.

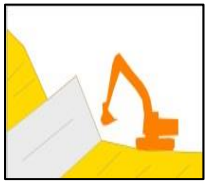




1. **Geological framework**

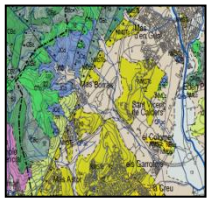


2. **Geological units**



3. **Geological determining factors**

4. **Information sources**



5. **Appendant: 1:50,000 geological map**

	Degree of detail	Coherence with data	Time for data completeness	Purpose of use		Difficulty of Maintenance	Resources needs
				Applicability	Range of users		
1:5.000 UGMC	↑	↑	↑	↔	↓	↑	↑
S20LGI	↑	↔	↔	↑	↔	↔	↔ ?
FGGM	↓	↑	↔	↔	↔	↔	↔ ?

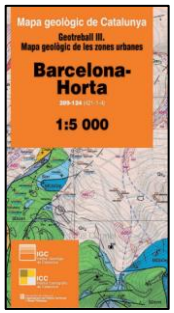
- The (i) 1.5.000 geological urban map, (ii) the system of 20 geological layers and (iii) the fundamental geological municipal guides **facilitate the information of the geological environment of urban areas** in different details, quantities and formats.

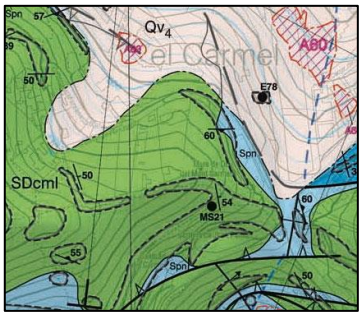
  - Currently, 1:5.000 urban geological maps are not carried out due to its unviability in the medium term. However, whether an urban area needs it, the ICGC has the necessary infrastructure and methodology to generate them. Meanwhile, the two pilot projects are emerging to provide geological knowledge of the territory. In any case, the realization of one of these projects is a matter of **adjusting depending on the government's requirements**, the **society's needs** and the **geological survey's available resources**.

- These documents have an informative and predictive purpose, which are aimed at facilitating the management and sustainability of urban areas. Nevertheless, these documents are not focused on specific geological issues.

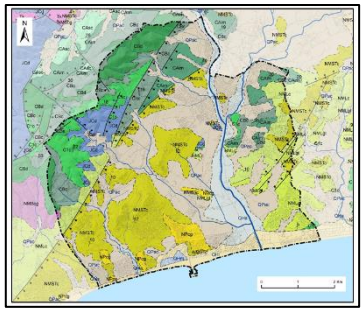
  - Therefore, **these products do not exempt under any circumstances to perform studies and detailed analysis**, which are necessary for execution of building works, for the exploration and mining of soil and geological resources and for the prevention of geological hazards, at municipal or local scale.

Conclusions





20 geological layers system



- **From ICGC perspective, urban geology can be approached** in three different ways:

  The (i) **1.5.000 geological urban map**, (ii) **the system of 20 geological layers** and (iii) **the fundamental geological municipal guides.**

  This set of projects are focused on **providing geological information**, facilitating **access to geological knowledge** and **delving into the geology of an urban area** that requires a different approach.

  The most appropriate project will be **depending on government's requirements**, the **society's needs** and the **geological survey's available resources**.

  Nevertheless, the 3 projects **do not exempt under any circumstances to perform studies and detailed analysis at local scope.**

Thanks for your interest!

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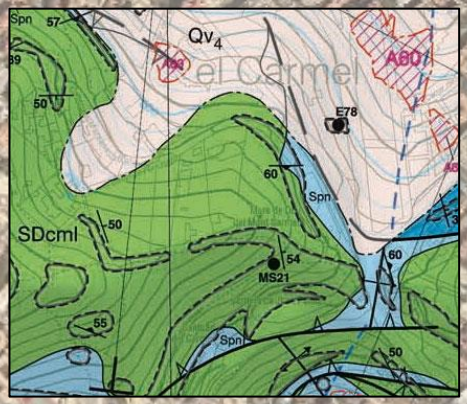

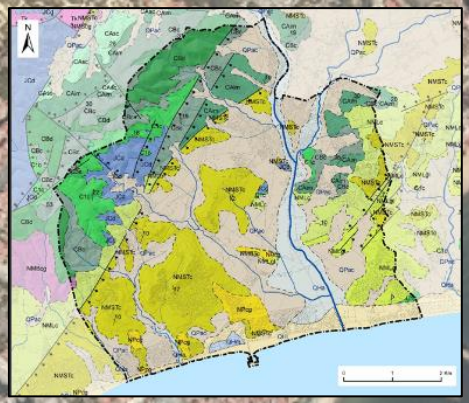

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Long version

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    1. A need for available geological information.
    2. ICGC: Functions and projects
    3. ICGC: Geological information focused on urban geology
2. **The 1:5,000 urban geological map**
    1. Context
    2. Characteristics
    3. Issues
3. **The system of layers of geological information**
    1. Characteristics
    2. Issues
4. **Fundamental geological guides of municipalities**
    1. Context
    2. Characteristics
    3. Issues
5. **Discussion**
    1. How to approach urban geology from ICGC perspective.
    2. Three manners to provide information
6. **Conclusions**

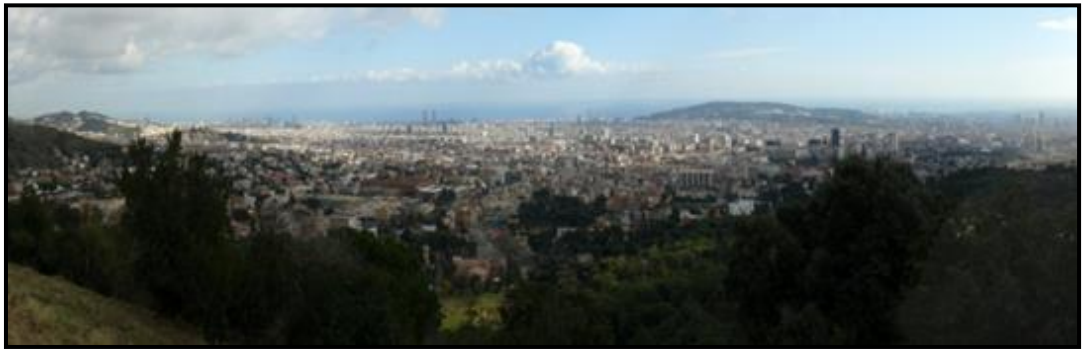
1. Introduction

- Studying urban geology is a key way to identify municipal issues involved with urban development and sustainability, land resources and hazard awareness in highly populated areas.
- At the municipal level, the geological information and knowledge is relevant in the development of different activities related to…

Urban planning

Construction

Resources and waste



Environmental sustainability

Geological heritage

and so on...

- The development of these activities may be conditioned by a series of geological factors

Surface deposits

Bedrock

Anthropic materials

Complex terrains

Underground water

Superficial water

Coastal dynamics

Extractive areas

Mass movements

Soil loss

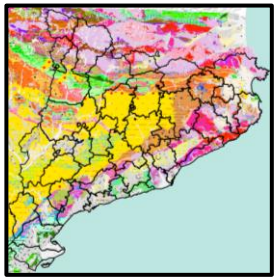
Environmental quality

and so on...

- In order to realise urban planning, management, development **and efficient of the municipalities, there is a need for** easy **access to** the **available geological and geotechnical information**.

- In order to approach urban geology, what **factors** should be taken into account to **provide geological** information as a geological survey?
  - **Available information on the territory**.
  - **Content** of data:
    - **Diverse geotemathic information**.
    - **Degree of detail**
    - **Consistency: Degree of interpretation and Robustness of datasets.**
  - **Time required to complete de data**
  - **Purpose of use**
    - **Applicability** of the geological information in urban planning and risk management**.**
    - Range of **potential user** who will consult the information.
  - **Data distribution.**
  - **Maintenance of data**.
  - **Resources requirements.**
  - **Society's needs**
- Considering the factors mentioned above, the ICGC has the function, by law and to the extent possible, to satisfy this need of knowledge about geological information.

- **The Catalan Geological Survey**



***Institut Cartogràfic and Geològic de Catalunya* (ICGC) is the official Catalan mapping & geological agency, belonging to the Catalan Government and aiming to deliver to users valued geographic and geological information and services.**

- **Functions of ICGC**

The functions of the ICGC are related to the exercise of skills in geodesy and cartography and the spatial data infrastructure of Catalonia, as well as to promote and carry out actions related to knowledge, prospecting and information on soil and subsoil, in the terms established by Laws 16/2005 and 19/2005. Some of them are:

a) Developing and promoting studies, works and evaluations in the field of geology and related disciplines that contribute to improving the knowledge of the soil and subsoil of Catalonia.

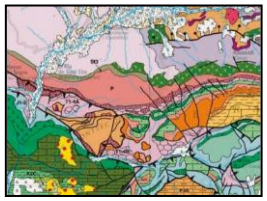
b) Providing the public administrations and the entities and organizations that are attached to the information collected in the databases that are necessary to carry out the works promoting in Catalonia and, in general, to exercise their powers.

c) Elaborating procedures and protocols to be applied in works related to geology and the related disciplines.

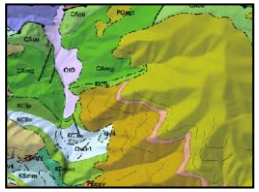
For this reason, the ICGC conducts geological studies throughout the territory

- Sort of ICGC's geological activity:

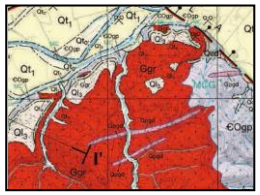
a) Geological mapping



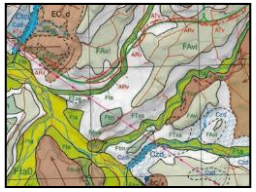
Geological map 1:250,000



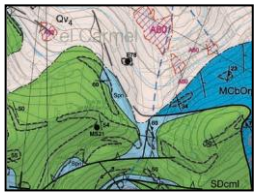
Geological map 1:50,000



Geological map 1:25,000



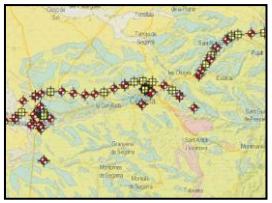
Geoanthropic map 1:5,000



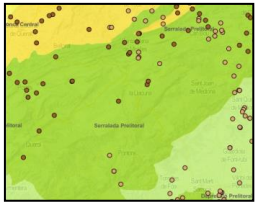
Urban geological map 1:5,000

… and so on

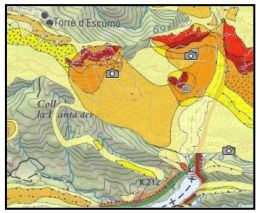
b) Geothematic databases



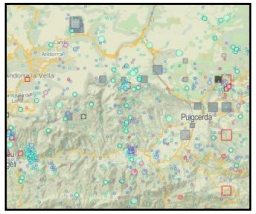
Boreholes



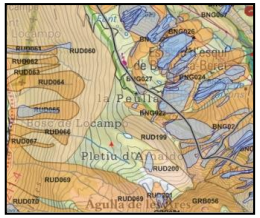
Soils



Geological Risks



Seismology



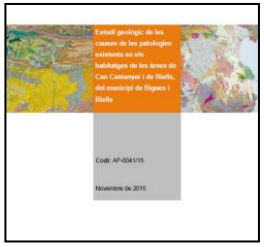
Snow avalanches

… and so on

c) Specific studies

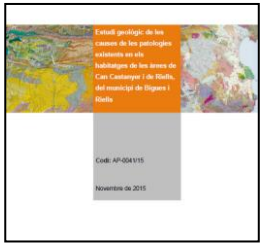
Acid drainage

Axial Pyrenees



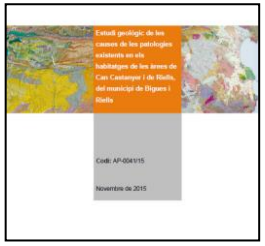
Subsidence:

Ebre Delta



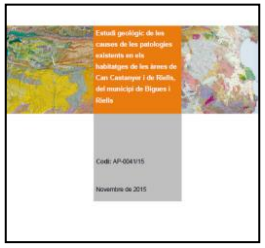
Ground movements:

Metropolitan Area of Barcelona



Subsoil structure:

Nuclear plants



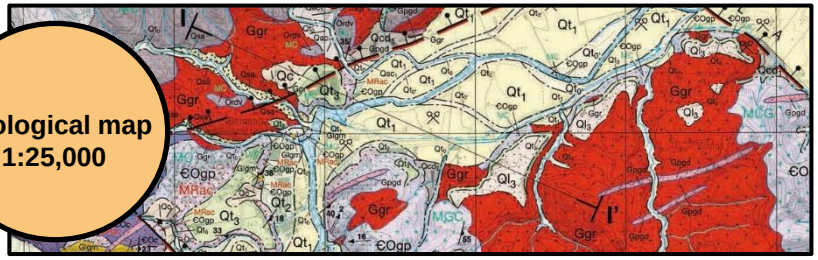
Geological heritage

Geological Park of Central Catalonia

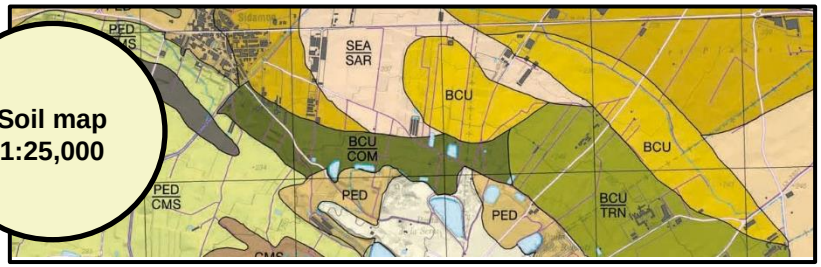
… and so on

- In the framework of an ambitious geological cartography project with the aim of generating geothematic information and elaborating the reference cartography, GeoWorks have been generated. These geographical system are an improved system of the Geological Map of Catalonia.

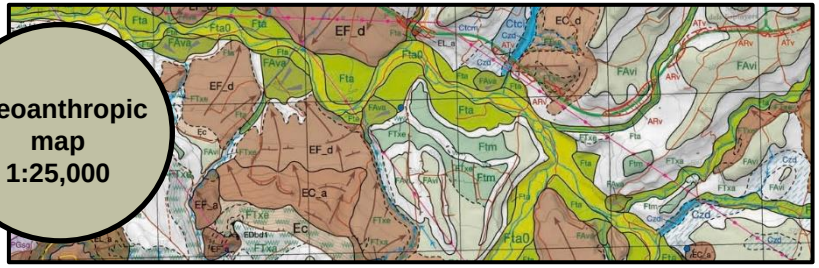
Geological map 1:25,000



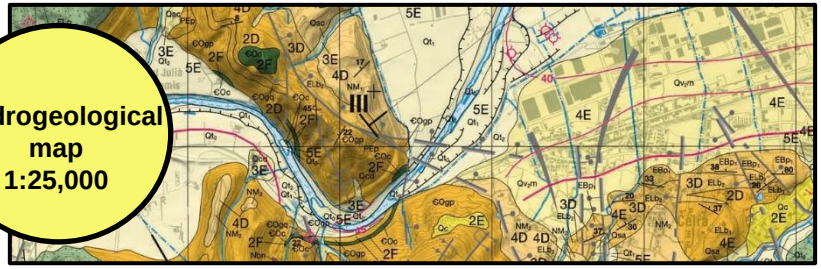
Soil map 1:25,000



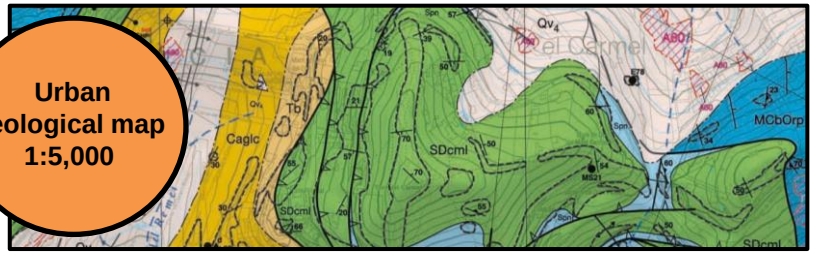
Geoanthropic map 1:25,000



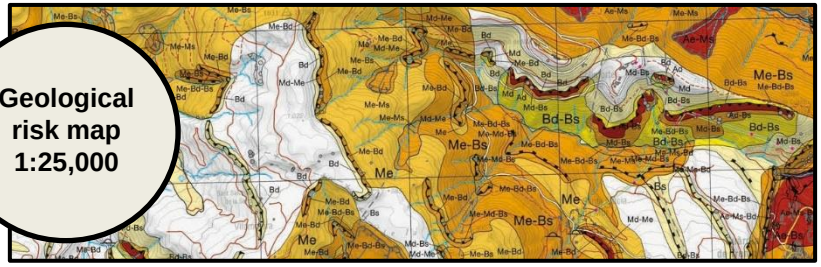
Hydrogeological map 1:25,000



Urban geological map 1:5,000



Geological risk map 1:25,000

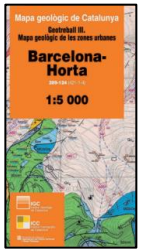


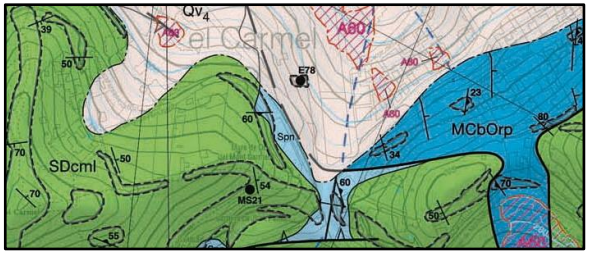
Currently this system of projects is being considered

- Regarding the importance of urban geology, the ICGC's activity in the field of regional urban geology has focused on the development of three main projects:

i. **The 1:5,000 scale Urban Geological Map of Catalonia project.**

Urban geological map 1:5,000





ii. **The system of layers of geological information.**

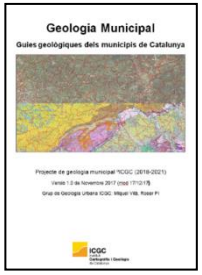
20 Layers of geological information

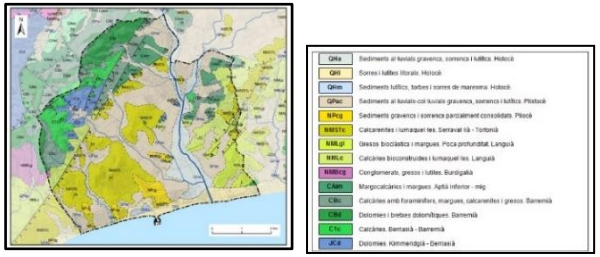
Anthropic grounds

Physical parameters

iii. **The fundamental geological guides of municipalities.**

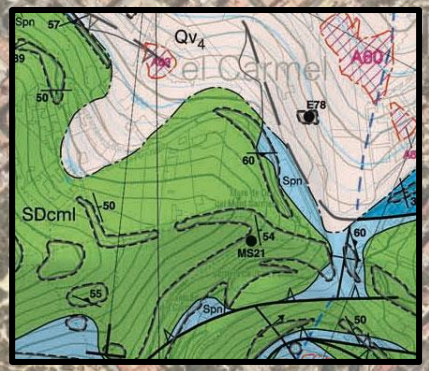
Fundamental geological guides of municipalities

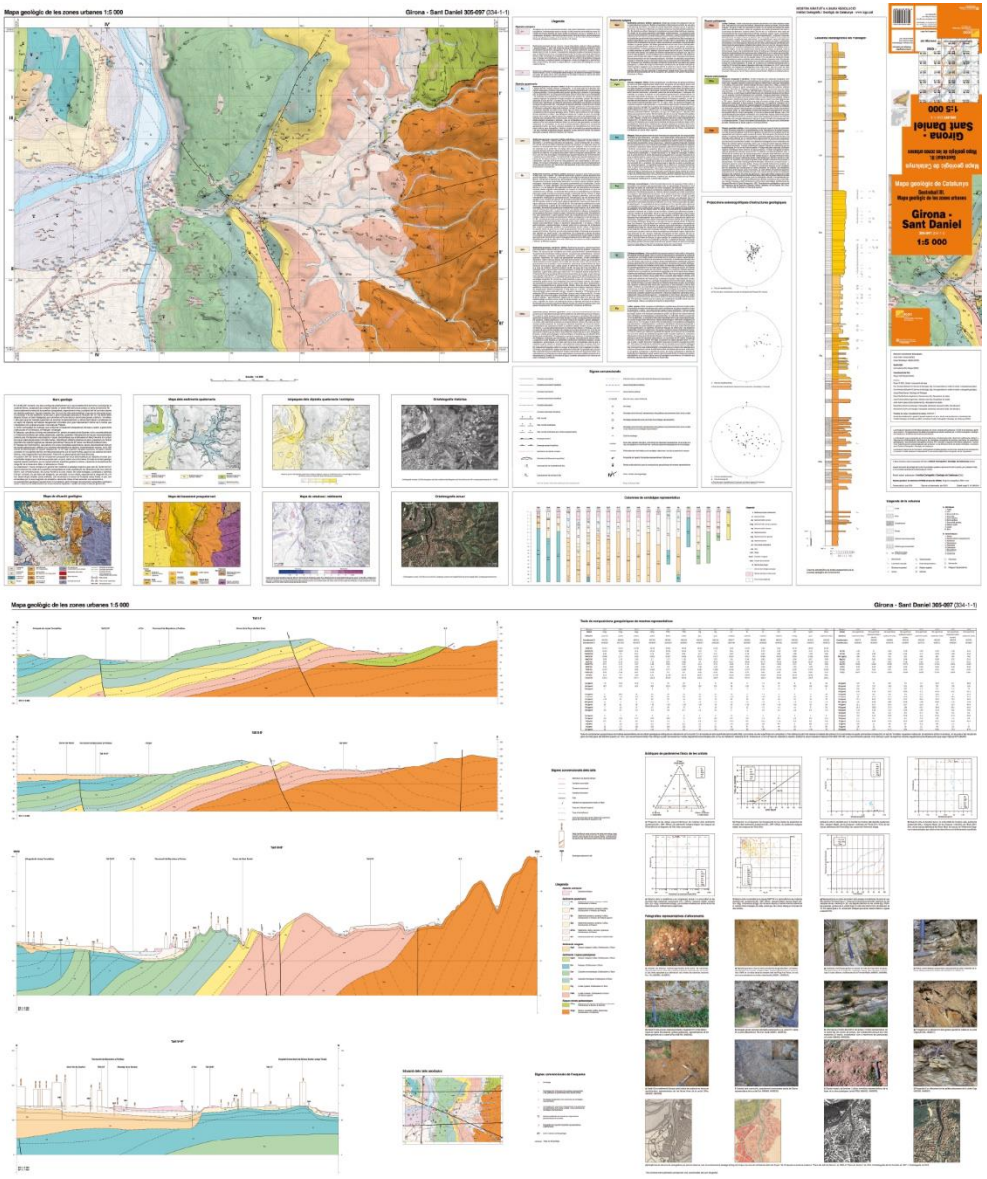




- This communication focuses on the presentation of these three projects and their utility, with the aim **of finding effective ways of transferring geological knowledge** and **information of a territory**, from a geological survey perspective.

2. The 1:5,000 urban geological map



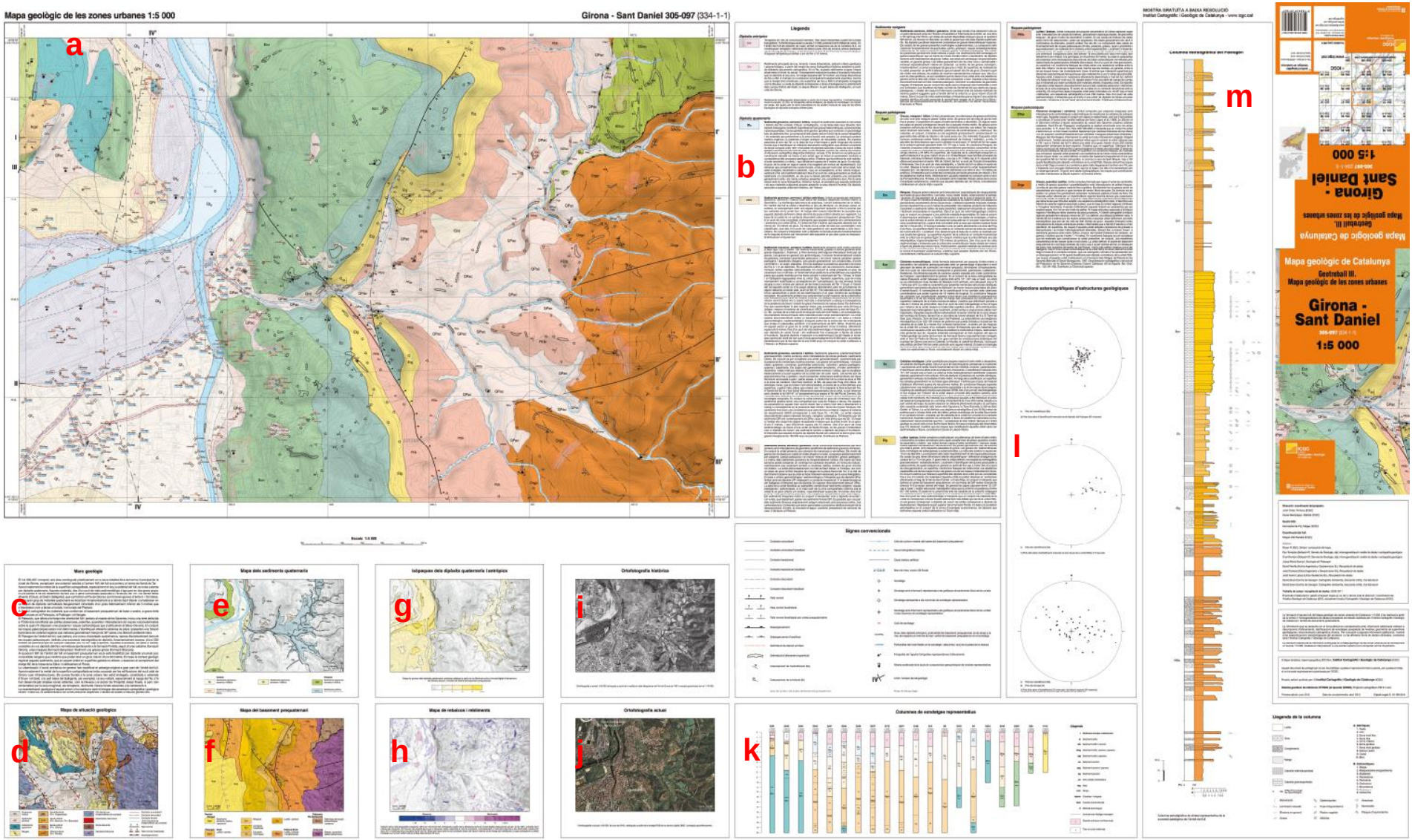


- In the framework of GeoWorks, one of the publications is the Geological Map of urban zones of Catalonia.

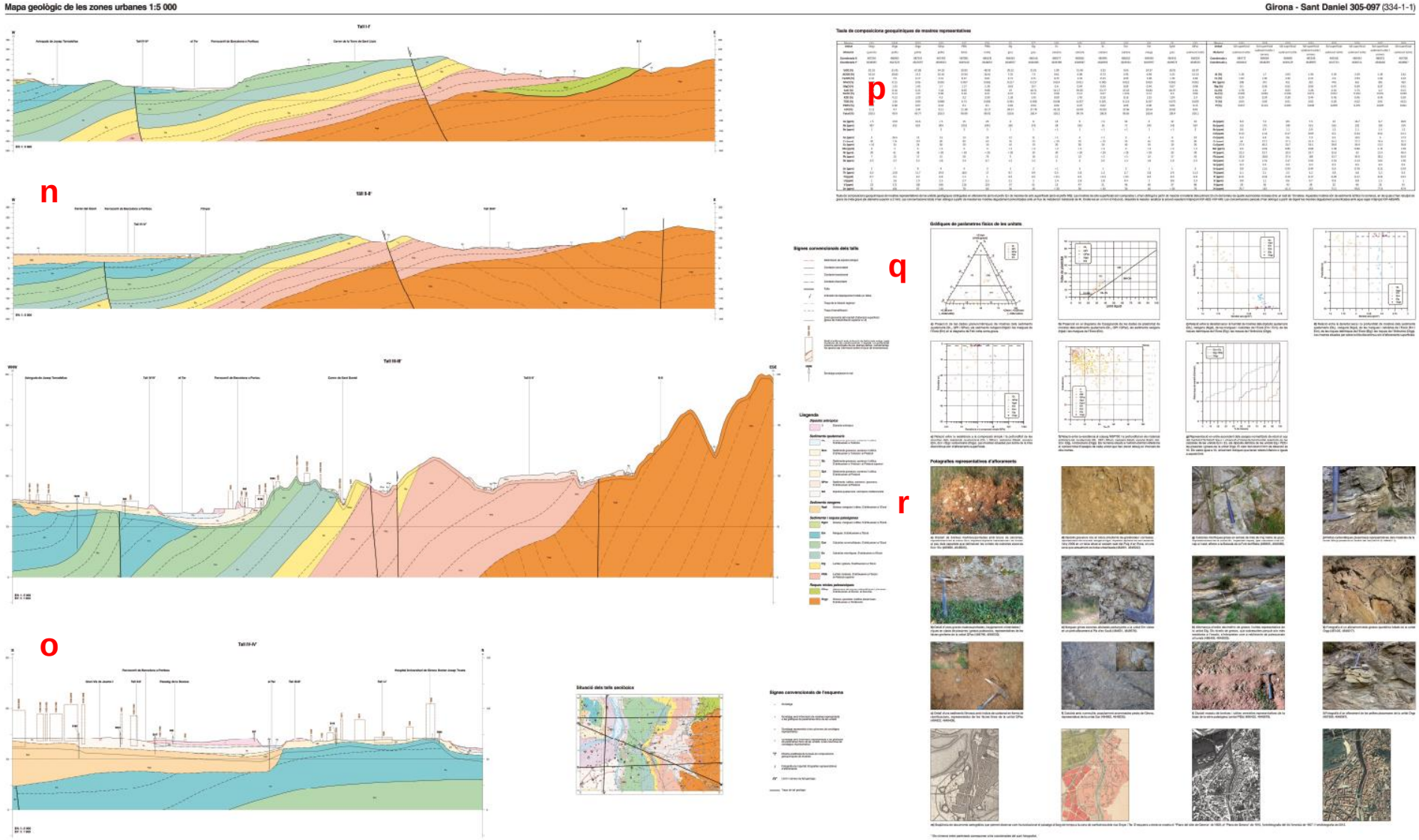
  This project is focused on providing detailed, consistent and accurate geological, geotechnical and anthropogenic activity information of the main urban areas of Catalonia.

  The level of detail that provides the scale 1:5,000 makes it particularly suitable for use in the work of urban planning.

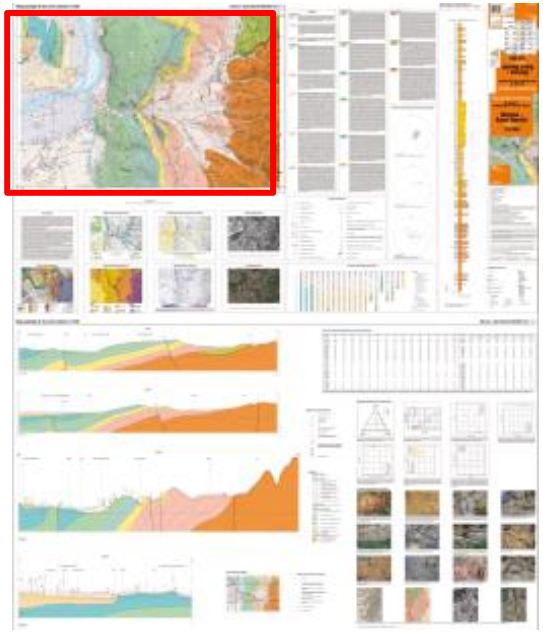
  To carry out this map, it is relevant the collaboration with municipalities because they provide geotechnical information content, such historical information on the evolution of land use and on issues related to geological processes that have occurred in the historical past in the municipality.

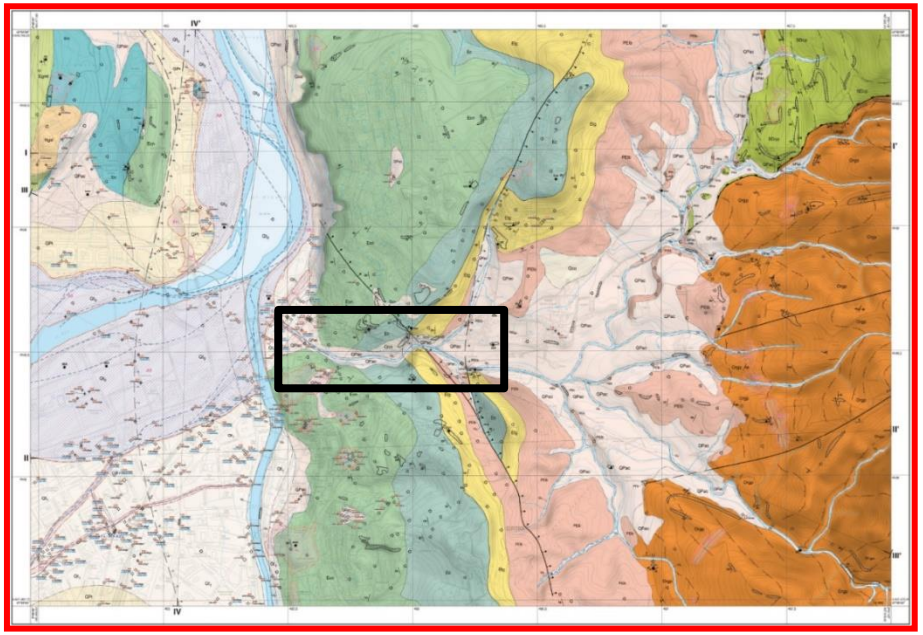


Diverse and detailed information: (a) 1: 5000 scale main geological map; (b) legend; (c) description of the geological frame; (d) regional geological map; (e) Quaternary deposits map; (f) basement map; (g) isopach map of the Quaternary and Anthropocene deposits; (h) ground elevation changes map; (i) historical orthophoto; (j) current orthophoto; (k) representative borehole logs; (l) stereographic projections; (m) stratigraphic column

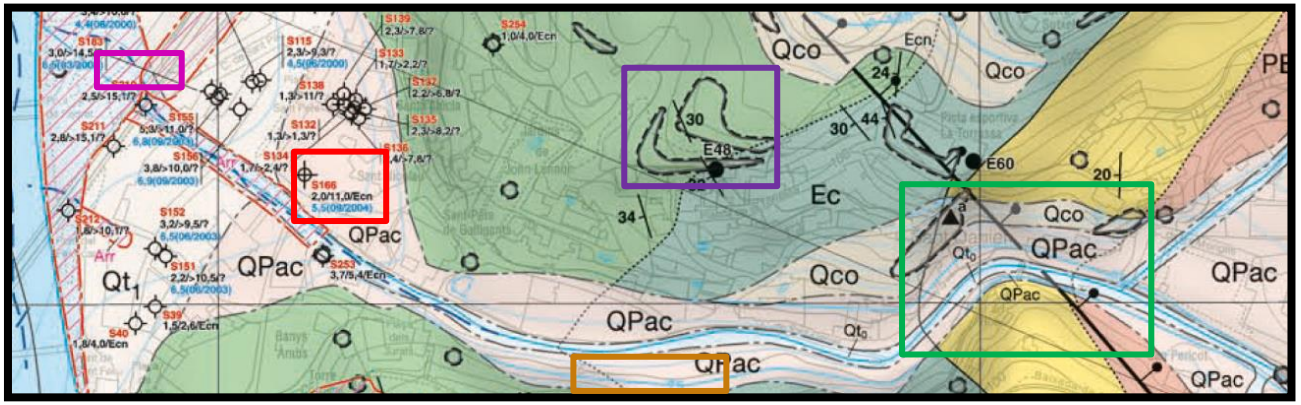


Diverse and detailed information (continuation): (**n**) general cross sections; (**o**) detailed cross sections; (**p**) geochemical compositions of representative samples of the geological units and top soils; (**q**) graphs of some relevant physical and geothecnical parameters of the geological units; (**r**) photo gallery of outcrops, samples and ancient landscapes.





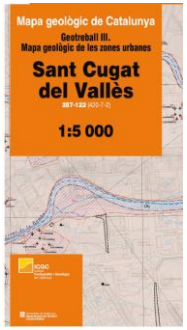
Remarkable details in the map

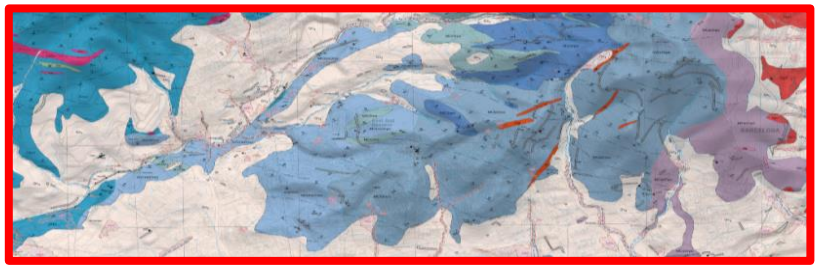


- Main anthropogenic deposits
- Outcropping areas
- Borehole data
- Contour lines of the top of the Pre-Quaternary basement
- Pre-Quaternary concealed boundaries

- Currently this project is being considered. The acquisition of new information is expensive and, in the short and medium term, geothematic information will not be available for the whole territory in sufficient detail.

Geological map 1:5.000 (urban areas)





The available resources over the last years and the results obtained show that in the medium term (5-10 years), it is impossible that there is a homogeneous geological cover of much of the whole of the territory of Catalonia.

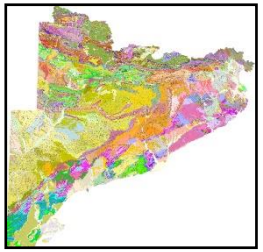
From the 1:5,000 urban geological map there are currently 41 of the 300 sheets around that make up the whole territory. The GT3's average production is around 4 maps per year.

It is clear that this rhythm is not sustainable and that the workflow needs to be significantly modified in order to ensure that, at least in the medium term, quality and uniform information is available throughout the territory.

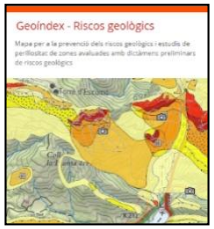
3. The system of layers of geological information

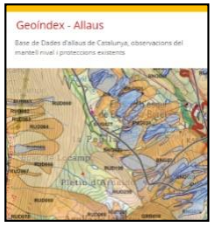
- **Then, how can optimize a greater distribution of information?**

  - The ICGC has a lot of information about the entire region of the Catalan territory



1:50,000 Catalonia's Geological Map

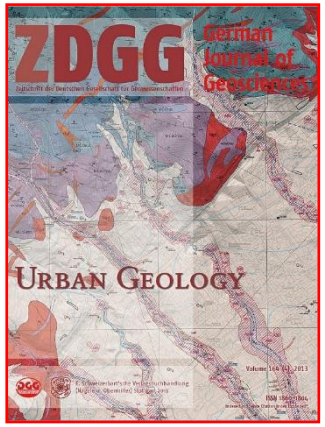




And more other information

  - However there are some issues:

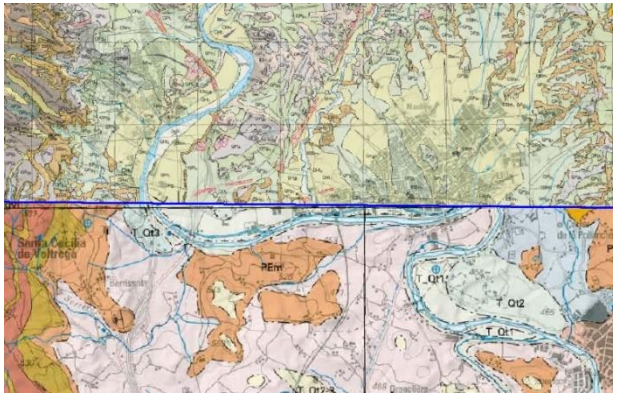
    a) The existing documentation is unknown: the transfer needs to be improved



The 1 : 5000 Urban Geological Map of Catalonia
Die Geologische Stadtkarte von Katalonien 1 : 5000

    b) The existing documentation has heterogeneous contents and formats

25M

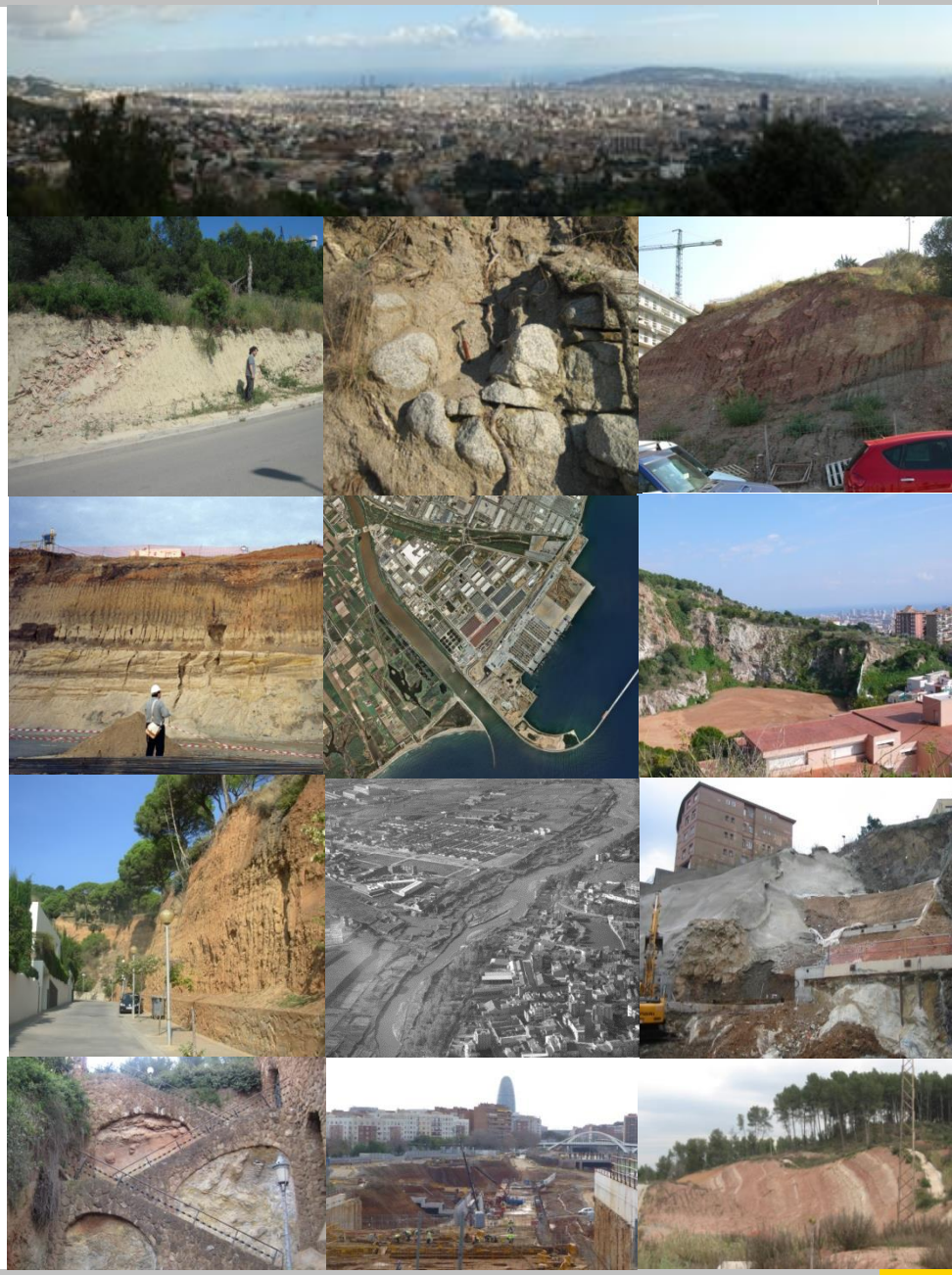


50M

- Nowadays, the development of a system of information layers for the whole of the territory is being considered, which will serve as reference information for the development and regeneration and sustainability of urban areas.

- **This pilot project would be the whole of the territory and would cover urban geology areas.** This system integrates 20 layers of diverse geological information that will be gradually implemented and completed in the coming years in the short and medium term.

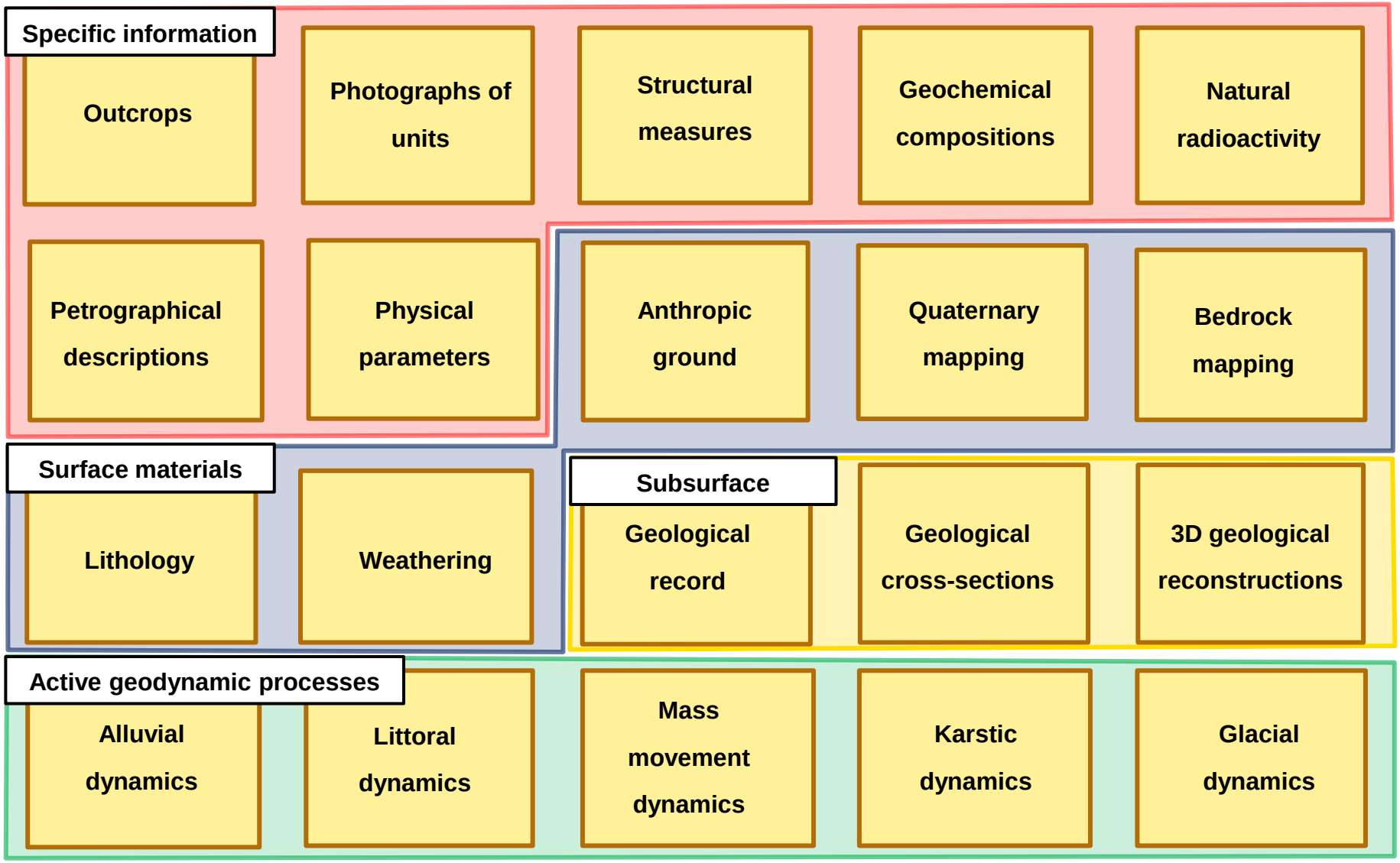
- The layering system geological information that **allows to visualize and analyse in an agile way the characteristics of the land and the processes that take place there**. This information, which has heterogeneous contents and formats, can help facilitate the development of specific projects.



Catalog of geological information layers

Outcrops	Photographs of units	Structural measures	Geochemical compositions	Natural radioactivity
Petrographical descriptions	Physical parameters	Anthropic ground	Quaternary mapping	Bedrock mapping
Lithology	Weathering	Geological record	Geological cross-sections	3D geological reconstructions
Alluvial dynamics	Littoral dynamics	Mass movement dynamics	Karstic dynamics	Glacial dynamics

Catalog of geological information layers



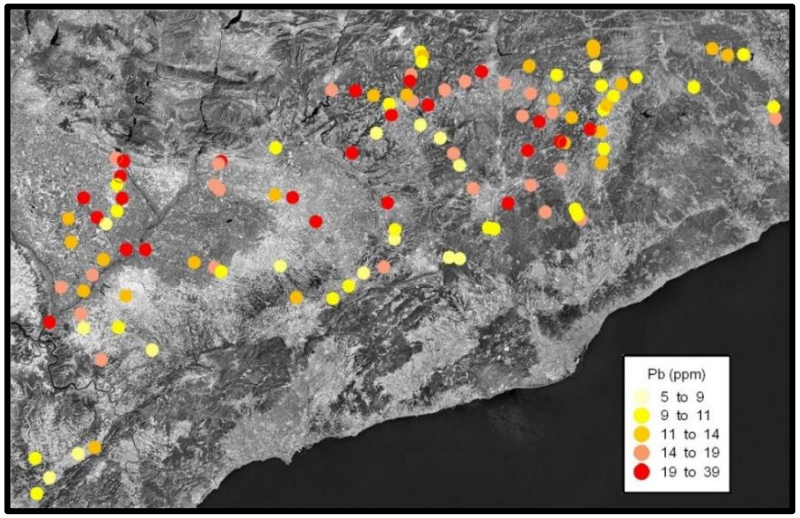
Long version

Specific information

Examples

Outcrops

Geochemical compositions

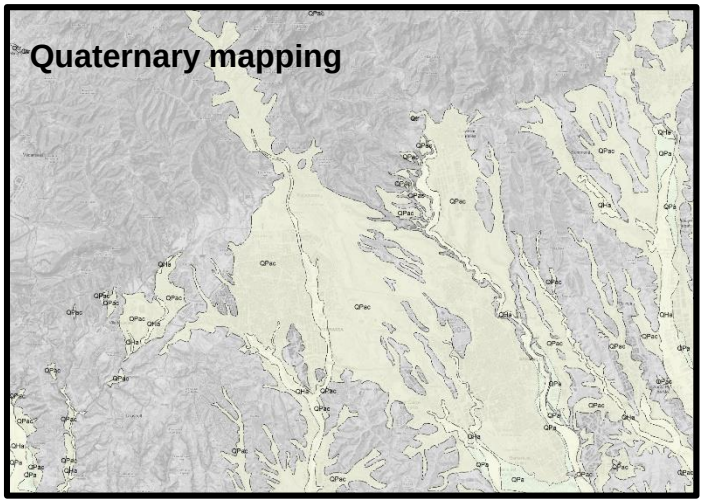


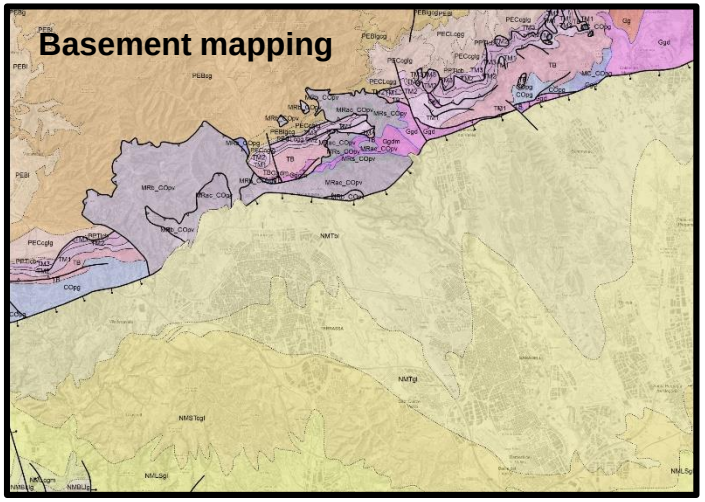
Physical parameters

Prof	SPT	DS	DA	H	LALL	LALP	LAIP	G2	G0,08	RCS	Unitat
3,0	4										A
6,0	14										A
8,00								70,9	15,5		A
9,0	8										Qfd1
11,00								94,1	7,1		Qfd1
12,0	24										Qfd1
14,00					NP	NP	NP	100,0	49,5		Qprd1
15,0	28										Qprd1
18,0	26										Qprd1
21,0	25										Qprd1
24,0	15										Qprd1
27,00		1,60	2,03	27,2	NP	NP	NP	100,0	81,9		Qprd1
30,00		1,55	1,99	28,0	27,8	23,0	4,8	99,9	81,2	0,65	Qprd1
33,0	15				31,8	23,1	8,7	100,0	90,8		Qprd1
36,00		1,55	1,97	27,0	NP	NP	NP	97,7	26,1	0,64	Qtb1+Qpd
39,0	34							98,0	22,5		Qtb1+Qpd
42,0	28							21,8	4,4		Qtb1+Qpd
45,0	50										Qtb1+Qpd
48,0	R										Qtb1+Qpd

Surface materials
Examples

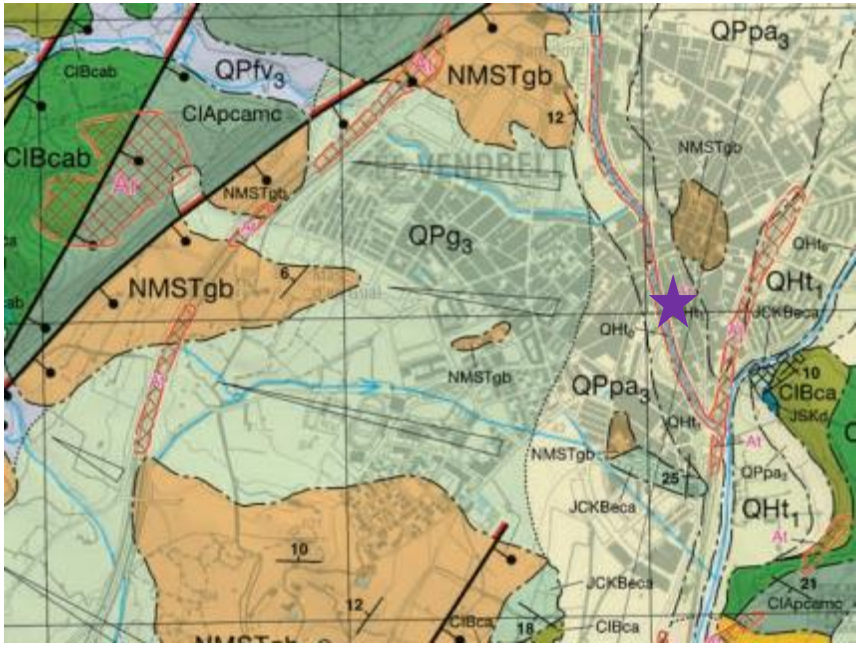
Anthropic grounds

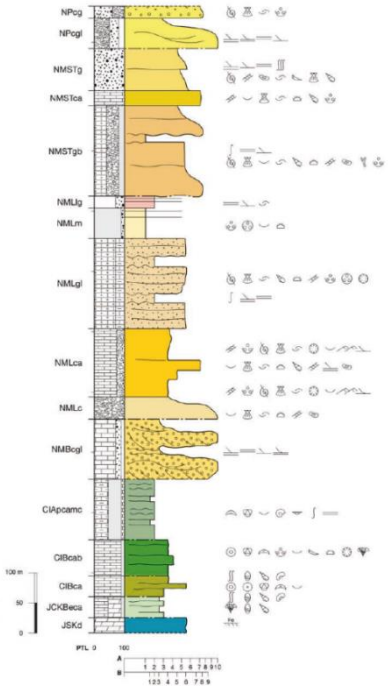


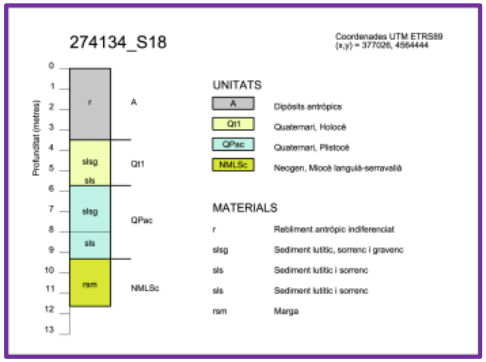


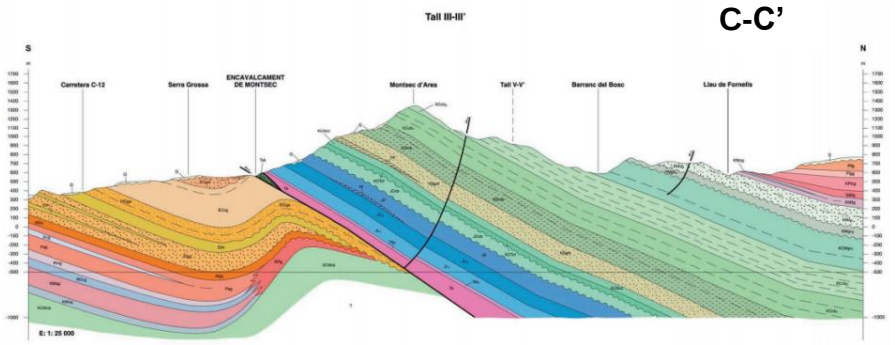
Subsurface
Examples

Geological records



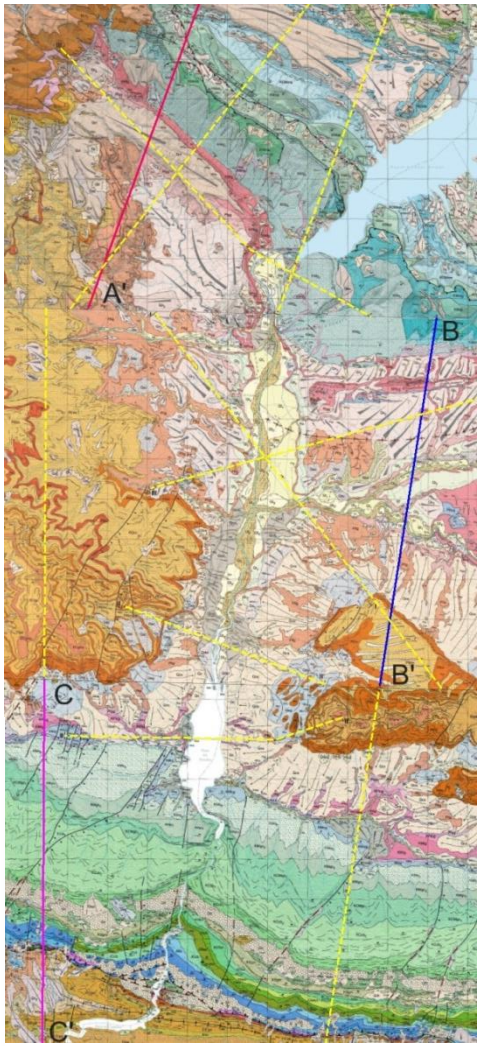






C-C'

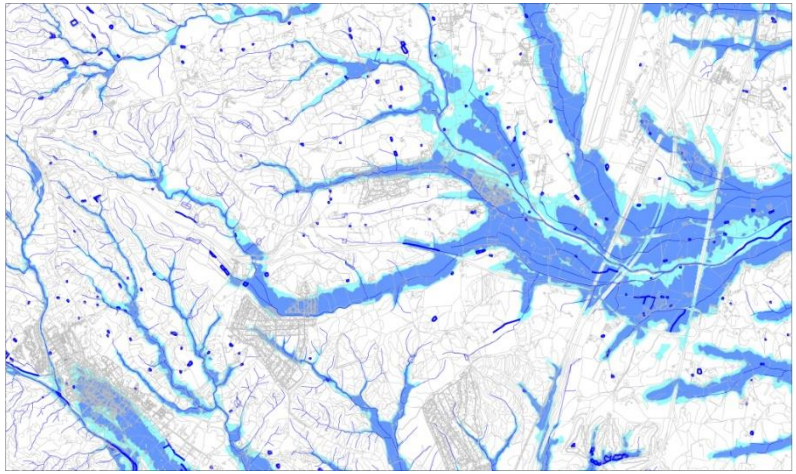
Geological cross-sections



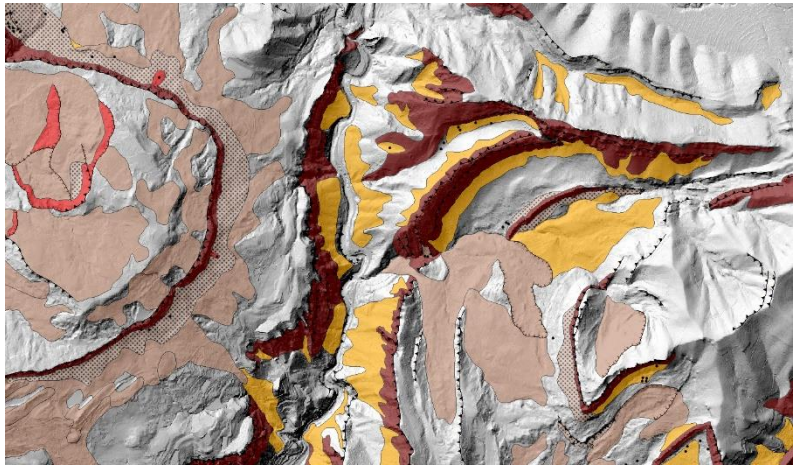
Active geodynamic processes

Examples

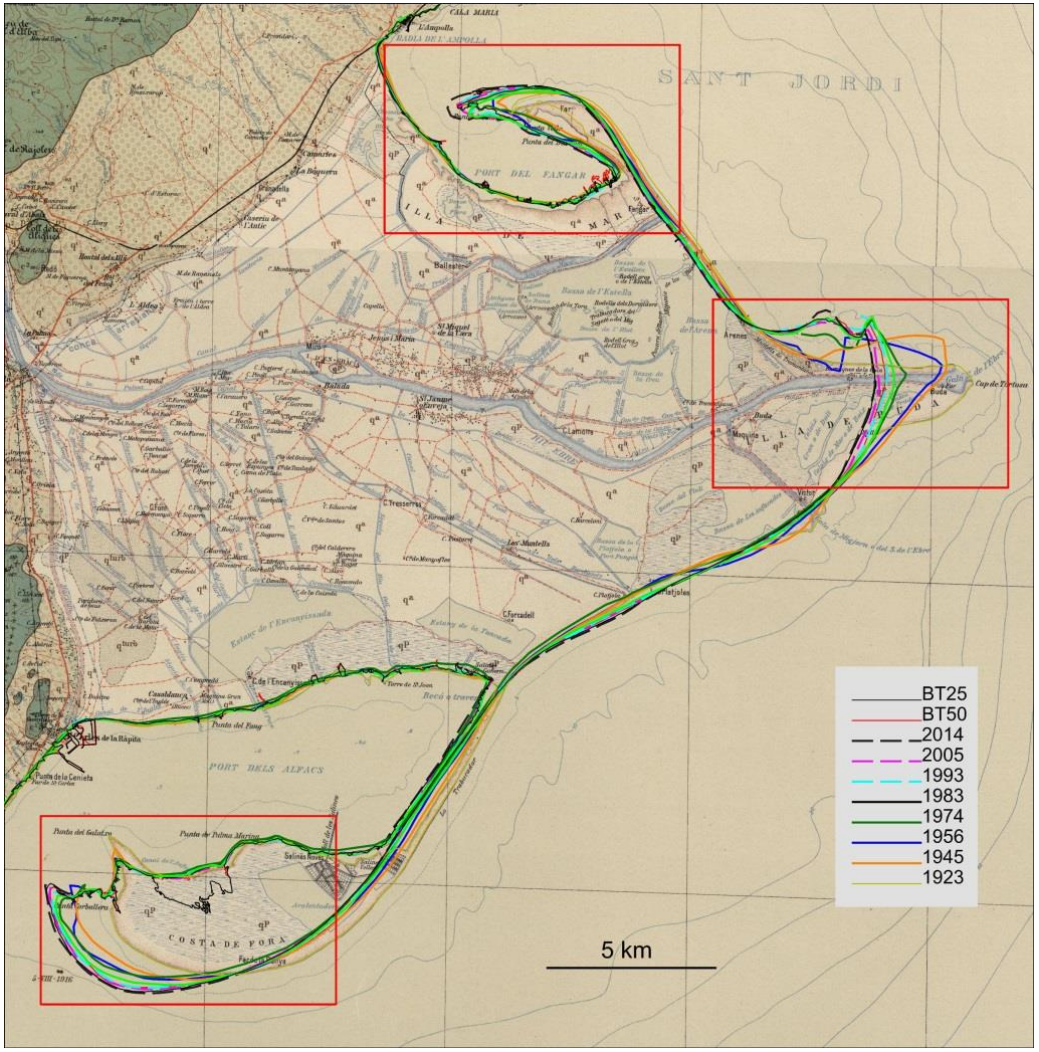
Alluvial dynamic



Mass movement dynamic

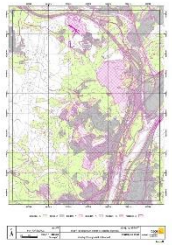


Littoral dynamic

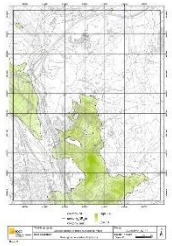


- Apart from these 20 layers of geological information, previously pilot studies have been carried out to develop layers of geological information in high detail in urban areas such as Papiol.This **geological information system** implemented in ArcGIS has been carried out encompassing 20 cartographic information group-layers related to the **geological materials and structure, geological hazards, georesources and environmental concerns, and geotechnical constrains.**

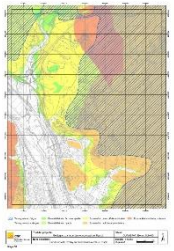
- **Fundamental information layers:**



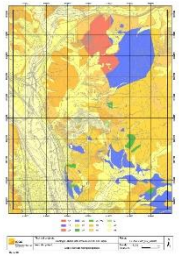
Artificial ground map



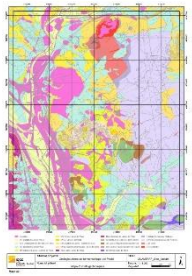
3D model



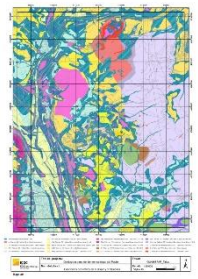
Excavatability (eg at 50 m)



Hidrogeological units



Geotechnical units

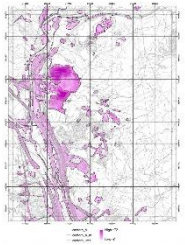


Conditions for slope design

… and so on

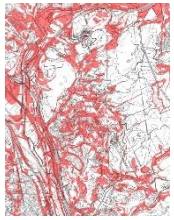
- **Application of the Geological Information System in urban planning and risk management.**

1. Intrinsic factors of the geological units



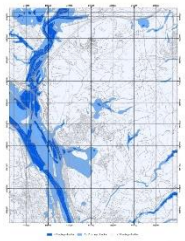
Low resistivity (artificial deposits)

2. Contrast between adjacent units



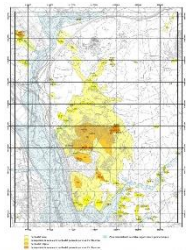
Near surface variable geology

3. Water in the environment



Proximity to the groundwater level

4. Geological hazards

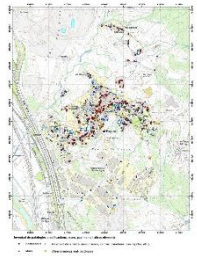


Multihazard map

5. Anthropogenic factors

Urban compacity (height of edifications)

6. Constructive deficiencies



Analysis of the pathologies

- As **information layers are treated individually**, it may **not be clear the coherence between data from different layers** of information and **without explanatory texts.**

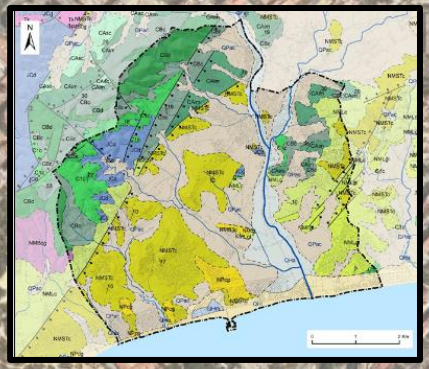
  Its **use is currently limited to geologists** or Earth-science professionals **in order to understand and realise a valid interpretation of geological system of urban areas.** Unless some parameters are given to understand the information.

- Furthermore, as in the case of the **Papiol project**, complete geological information system has been elaborated with specific objectives for urban planning. However, **the acquisition and analysis of information and its updating require financial resources and an organizational structure** that, in the short term, **will be difficult to obtain**.

- In addition, in the municipal context **there is no document that centralizes this information**, which in any case is in heterogeneous formats and its existence is often unknown. Therefore, as a public entity, the ICGC must provide generic information on the territory for all types of users.

  In order to optimizing the transfer of knowledge, **reaching a wider range of users** and also providing a **homogeneous and varied geological information**, the development of **fundamental geological guides for municipalities** is also being carried out.

4. The fundamental geological guides of municipalities

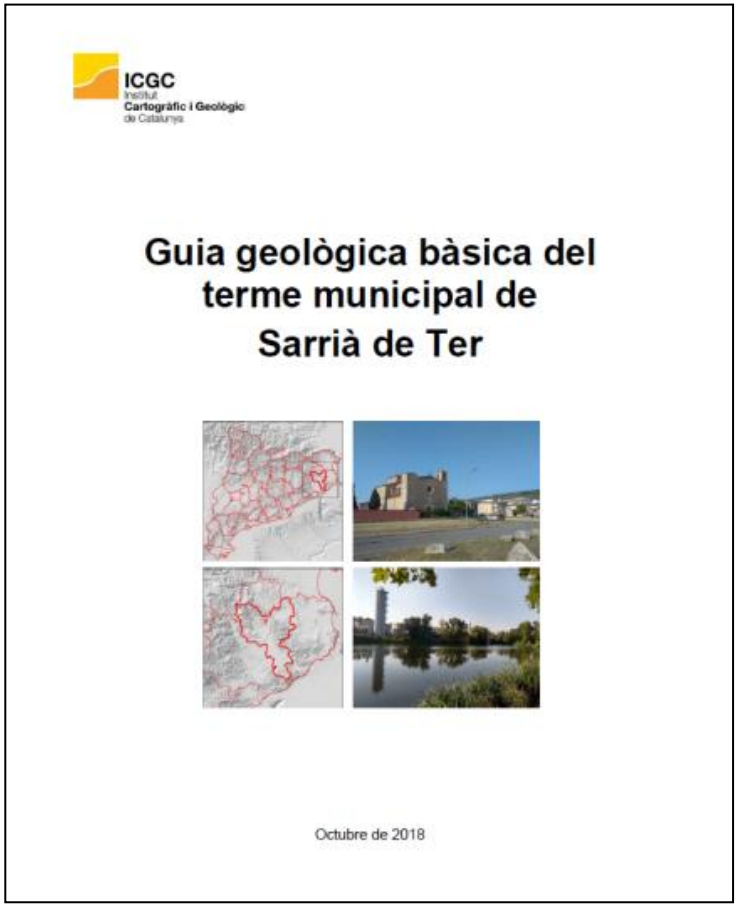


- The fundamental geological municipal guides **allow a synthesis of the geological environment of the different Catalan municipalities.**

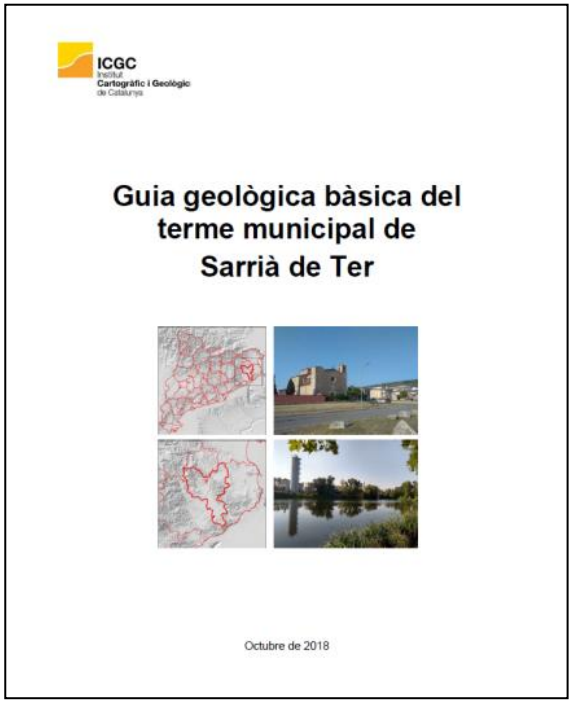
  Besides they provide basic guidelines for the characterization of the geological environment of the municipality and for the assessment of geological conditions in the studies of the terrain and of the physical environment in general.

  The guides are intended to be used as a **reference tool** in the development of field studies, and the actions that, to a greater or lesser extent, are conditioned by geological factors.

  These are **informative documents, not mandatory**, but which in any case should **help the planning, development and control of land studies** that are developed in the municipality.

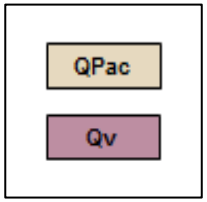


Structure of the geological guides of municipalities

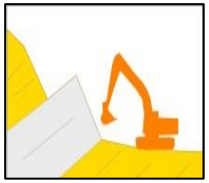


1. **Geological framework**

2. **Geological units**

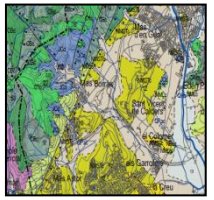


3. **Geological determining factors**



4. **Information sources**

5. **Appendant: 1:50,000 geological map**



- **1) Geological framework**

A short approximate description, of about 500 words, of the geological context in which the whole of the municipal term is located. Includes:

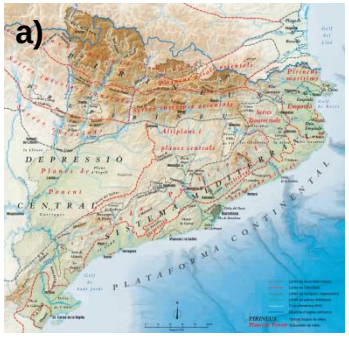
a) Physiographic scope

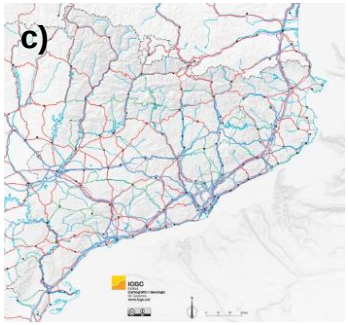
b) Hydrogeological scope

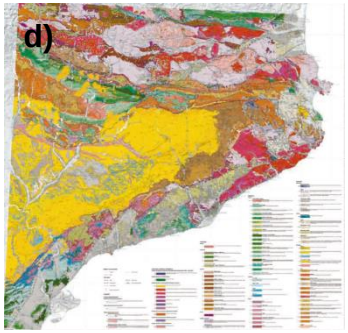
c) The distribution of urban and other relevant anthropized areas

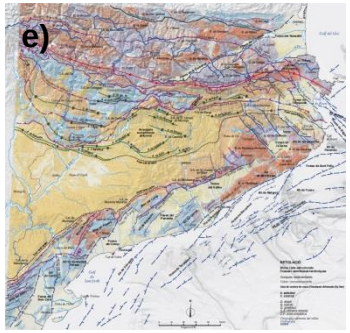
d) The main cartographic units that make up the geological substrate

e) Regional structural geology





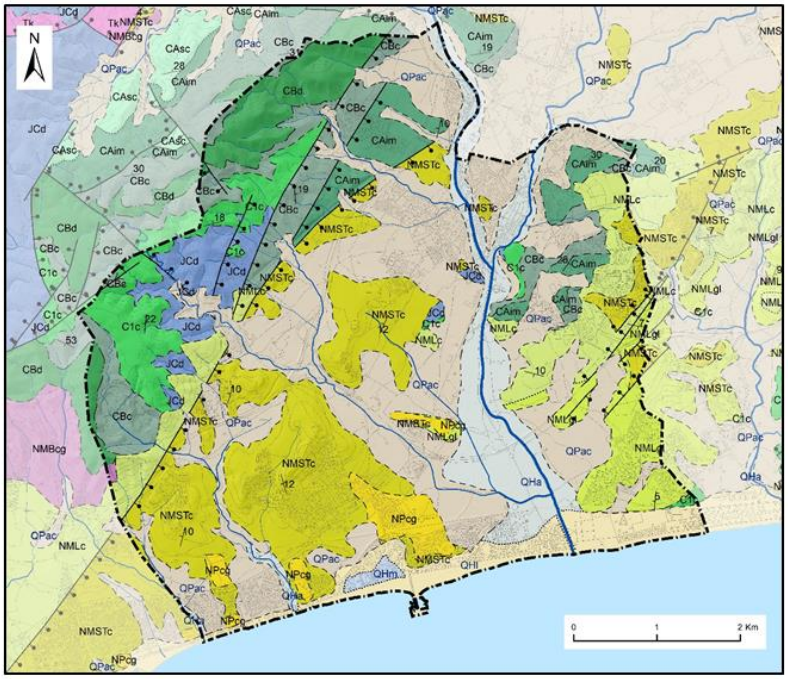




- **2) Geological units**

Brief description of the geological features of the main cartographic units that make up the substrate of the municipality. The section includes a geological map of synthesis at a scale of 1: 50.000, consistent with the system of units described. For each unit:

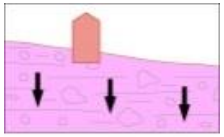
- Synthetic definition
- Lithological description
- Common Name
- Thickness
- Genesis
- Weathering
- Resistance or Resistivity
- Discontinuities
- Massif type
- Hydrogeology



QHa	Sediments al·luvials gravencs, sorrencs i lutítics. Holocè
QHl	Sorres i lutites litorals. Holocè
QHm	Sediments lutítics, torbes i sorres de maresma. Holocè.
QPac	Sediments al·luvials-col·luvials gravencs, sorrencs i lutítics. Plistocè
NPcg	Sediments gravencs i sorrencs parcialment consolidats. Pliocè
NMSTc	Calcarenites i lumaquel·les. Serraval·lià - Tortonià
NMLgl	Gresos bioclàstics i margues. Poca profunditat. Languià
NMLc	Calcàries bioconstruides i lumaquel·les. Languià
NMBcg	Conglomerats, gresos i lutites. Burdigalià
CAim	Margocalcàries i margues. Aptià inferior - mig
CBc	Calcàries amb foraminífers, margues, calcarenites i gresos. Barremià
CBd	Dolomies i bretxes dolomítiques. Barremià
C1c	Calcàries. Berriasià - Barremià
JCd	Dolomies. Kimmeridgià - Berriasià

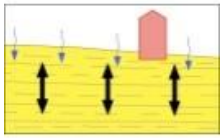
- **3) Geological determining factors**

Geological factors that condition the development and sustainability of the municipality and that must be taken into account when conducting the land studies and the associated actions.

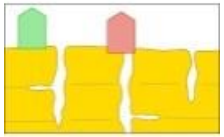


Compressible terrains

Superficial alteration and Weathering

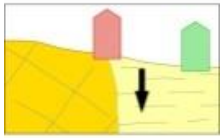


Expansivity

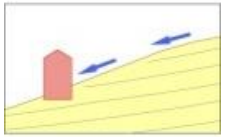


Soluble materials

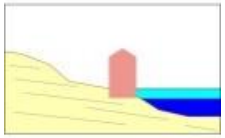
Heterogeneous materials



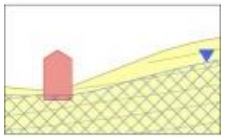
Contrast between geological units



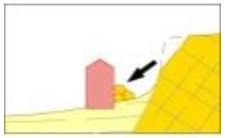
Surface water



Coastal dynamics



Groundwater level



Landslides

Seismic hazard

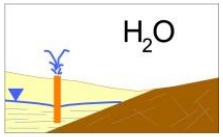
Other passive geological constraints (erodibility, avalanches)

- **3) Geological determining factors**

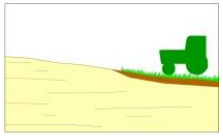
Geological factors that condition the development and sustainability of the municipality and that must be taken into account when conducting the land studies and the associated actions.

Geological active factors

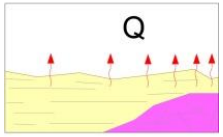
Mineral resources: Throughout history, the municipality has been subjected to extractive activities of different mining products ...



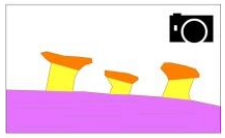
Groundwater: Groundwater is essential for the development of many activities that are carried out in the municipality ...



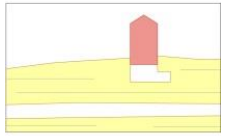
Agricultural soils: Agriculture has a significant importance in the activity of the municipality, for this reason, and in general for the sustainability of the environment ...



Geothermal energy: Geothermal energy is renewable, non-polluting and available throughout the municipality, which is stored in the basement ...



Geological heritage: During the execution of works ... it is advisable to consider their impact on geological heritage in accordance with the technical criteria proposed ...



Underground subsoil: The subsoil of the municipality is a fertile space for developing different urban functions ...

Green areas: it is recommended that the maintenance of the green areas found in the most urbanized areas of the municipality be taken into account.

- **3) Geological determining factors**

Geological factors that condition the development and sustainability of the municipality and that must be taken into account when conducting the land studies and the associated actions.

Human interaction with the geological environment

- **Anthropic deposits,** which are geotechnically disadvantageous land
- **Fillers**, which may contain high concentrations of pollutants
- **Sealing** the ground that modifies the natural flows of the sun
- **Underground infrastructure** that can cause collapses
- **Damage to buildings and infrastructure** during the execution of works
- **The exploitation of aquifers** that can generate subsidence and deteriorate the quality of the water
- **Alteration of soil and water composition** by sources of diffuse pollution
- The risk associated with inhalation of **radon gas** in underground spaces

- **4) Information sources**

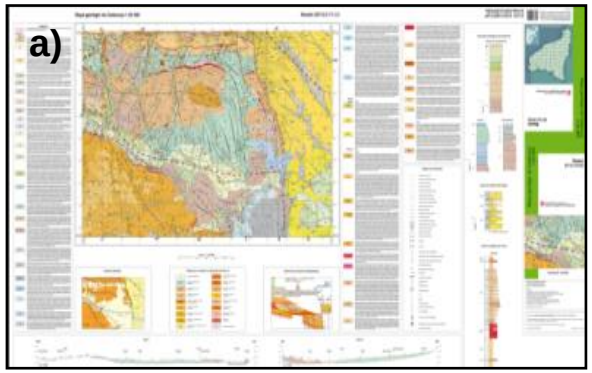
List of basic geological and cartographic documentation aimed at facilitating access to information sources and establishing a knowledge base that must be taken into account when planning and managing the municipality.

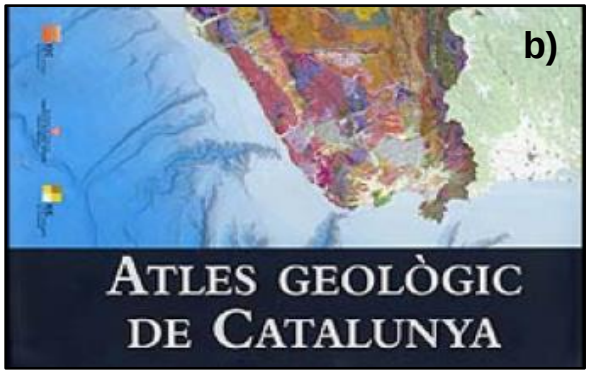
a) **Geological mapping**

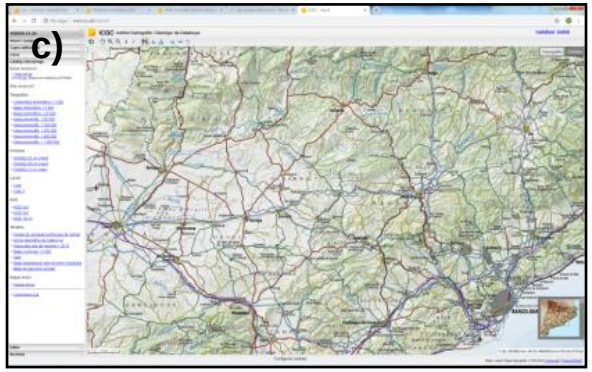
b) **Geological references**

c) **Cartographic bases**

d) **Other sources of geoinformation**







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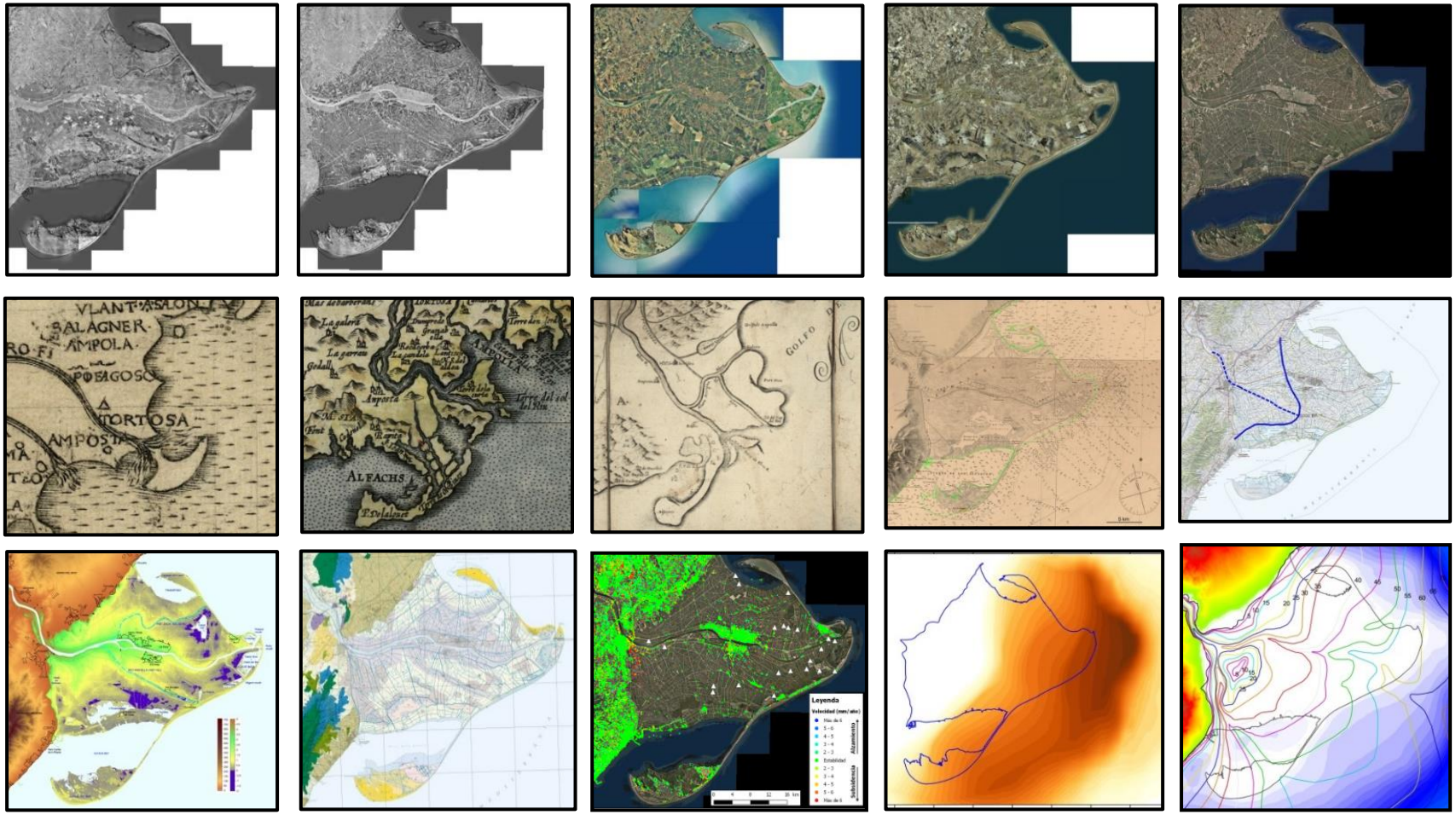
List of basic geological and cartographic documentation aimed at facilitating access to information sources and establishing a knowledge base that must be taken into account when planning and managing the municipality.



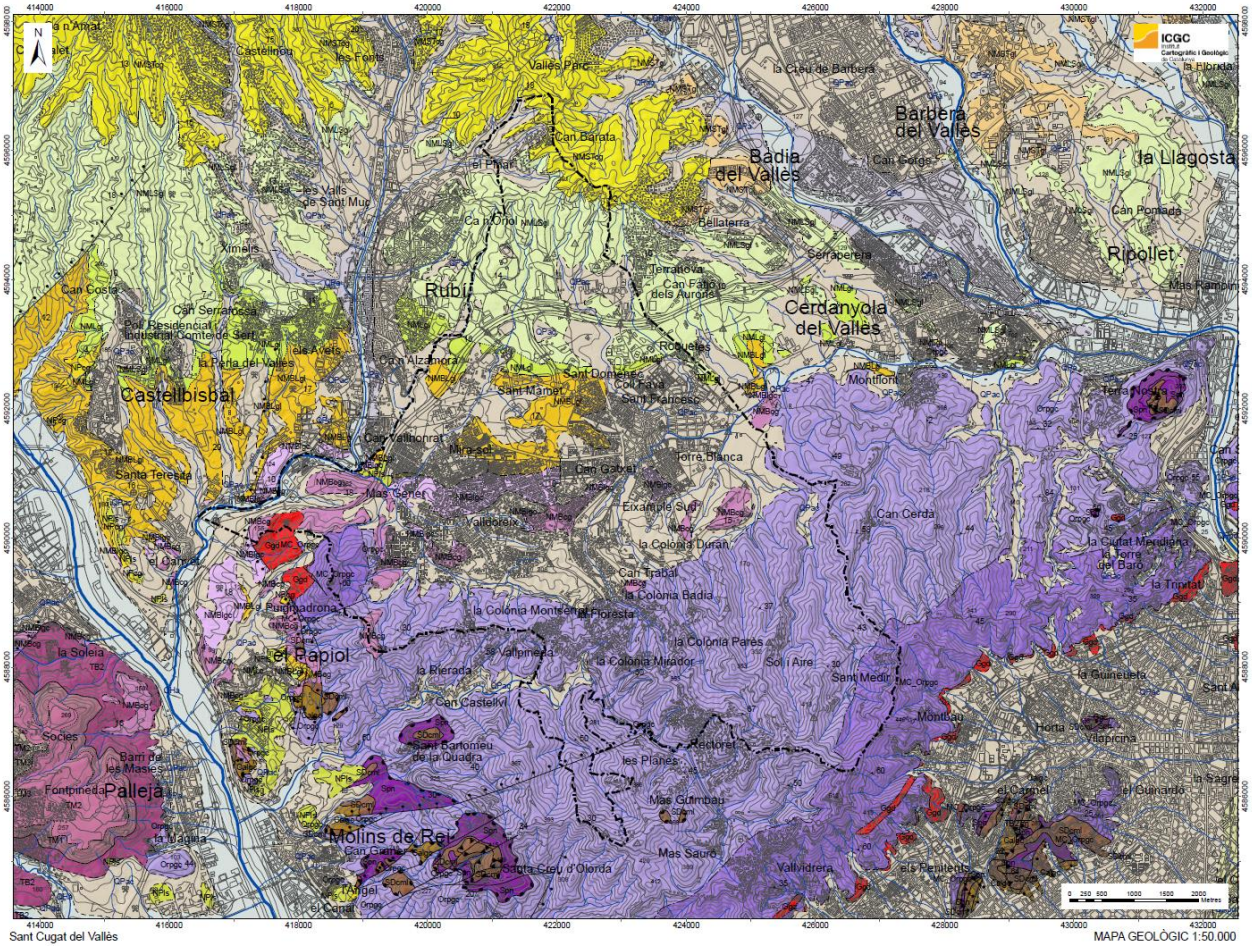
- **5) Append: 1:50,000 urban geological map**

A 1:50,000 Geological map of synthesis of the municipal term and its surroundings:

a) Geological information is a reinterpretation and homogenization of existing cartographic information.

b) Soils, anthropic deposits and other shallow surface deposits are not represented.

c) The guide includes a description of the characteristics of the geological units that are located within the term.



1:50,000 Geological map of synthesis of the municipal term and its surroundings

- The first guides are being developed in the counties of *Vallès Occidental* and *Gironès*. In the short term, the goal is to obtain a significant number of this service and to have a systematic set of guidelines for the development of guides for any municipality.

- Despite the fact that all the fundamental geological information contained, the guide is not conceived as a detailed study of the geological characteristics of the municipality.

  Firstly, the geological guides of municipalities project has a **lower degree of detail** owing to it is based on a working scale of 1:50,000. Whereas, geological urban map and geological system projects are in greater detail.

  The purpose of the guides is to take into consideration all sort of geological factors for urban management and sustainability. And the information presented is intended to reach a **broader range of users, non-geological professionals** (civil and structural engineers, builders, planners, politicians and so on).

  However, the content of the guides is fundamentally qualitative. Therefore, this is descriptive and indicative information, which cannot replace specialist interpretations, professional recommendations and / or detailed specific research and searches. So, **it is recommended to consult a professional of the Earth Sciences for the technical interpretation** of the document

  It is a document directory and compiler of basic information that **serves as a guideline for the identification**, **mapping and characterization of the geological factors** that condition the development and sustainability of the municipality and which is recommended to consider in studies of the physical environment.

5. Discussion

Remember

- What **factors** should be taken into account to **provide geological** information as a geological survey?
  - **Available information on the territory**.
  - **Content** of data:
    - **Diverse geotemathic information**.
    - **Degree of detail**
    - **Consistency: Degree of interpretation and Robustness of datasets.**
  - **Time required to complete de data**
  - **Purpose of use**
    - **Applicability** of the geological information in urban planning and risk management**.**
    - Range of **potential user** who will consult the information.
  - **Data distribution.**
  - **Maintenance of data**.
  - **Resources requirements.**
  - **Society's needs**

Which of these factors must be taken into account in order to elaborate the 3 products systematically?

- The ICGC has a lot of **available information** about the territory and the three projects are 3 different methods to provide geological information related to urban geology. However, nowadays **the three projects do not cover** the information of the whole territory. The 1:5,000 geological map almost cover 15% of the whole territory and the two pilot projects have been starting recently. Besides, **only the urban geological map is available** on the ICGC's website in pdf and shapefile format, while the data of pilot projects are not yet published.

- The three projects **coincide with containing diverse geothematic information** to grasp the geological environment of urban areas. Whereas, these 3 products differ with the **content** of data, the **consistency** of the geological information, time required for **data completeness,** their **purpose of use and the maintenance of data distribution**.

    - **Content** of data:
        - **Degree of detail**
    - **Consistency,** the degree of interpretation and robustness of datasets.
    - **Time required to complete de data**
    - **Purpose of use**
        - **Applicability** of the geological information in urban planning and risk management**.**
        - Range of **potential user** who will consult the information.
    - **Maintenance of data**
    - **Resources requirements.**

These factors must be taken into account in order to elaborate the 3 products systematically

a) The 1:5.000 scale Urban Geological Map of Catalonia project (UGMC).

Degree of detail

It has been a project focused on **providing detailed**, consistent and accurate geological, geotechnical and anthropogenic activity information of the main urban areas of Catalonia in 1:5,000.

Consistency

All this information of **diverse geothematic content** is integrated into the map **coherently and with explanatory texts**.

Time for data completeness

The compilation and elaboration of a large volume of geological information and also the high level of detail require a lot of time for data completeness.

Purpose of use

The map may be **useful for urban planning** because of the detailed geological and geotechnical information and it can be **consulted by professionals in Geology**.

Maintenance of data

The data would require updating, reviewing and improving.

Resources requirement

An homogeneous geological cover of the whole territory of Catalonia is impossible in term of 5-10 years.

	Degree of detail	Coherence with data	Time for data completeness	Purpose of use		Difficulty of Maintenance	Resources needs
				Applicability	Range of users		
1:5.000 UGMC	↑	↑	↓	↔	↓	↑	↑

b) The system of 20 layers of geological information (S20LGI)

Degree of detail

Information layers may have some degree of detail depending on the scale of work (1:5:000, 1:25,000…)

Consistency

As information layers are treated individually, it may not be clear the coherence between data from different layers of information and without explanatory texts.

Time for data completeness

It requires less time to complete the data of the same type of information as it does not have to be integrated with other data of other information.

Purpose of use

This information can help facilitate the development of specific projects. However, sometimes the information is complex and requires some expertise but it can be understood if a number of parameters are specified.

Maintenance of data

The data would require updating, reviewing and improving, but probably in lower frequency because the data consist of individual layers.

Resources requirement

Owing to available resources, this pilot project may not be established in the medium term.

	Degree of detail	Coherence with data	Time for data completeness	Purpose of use		Difficulty of Maintenance	Resources needs
				Applicability	Range of users		
S20LGI	↑	↔	↔	↑	↔	↔	↔ ?

c) The fundamental geological guides of municipalities (FGGM)

Degree of detail
It involves a document that is based on a 1: 50,000 work's scale.

Consistency
They provide a homogeneous and varied geological information.

Time for data completeness
It requires time to integrate several geological and geotechnical aspects, but it can be considered lower than urban geological maps

Purpose of use
The guide provides an overview of the main geological aspects to be considered in face of territorial and environmental management. The information presented is intended to reach a broader range of users, non-geological professionals. However, it is recommended to consult a professional of the Earth Sciences.

Maintenance of data
The data would require updating, reviewing and improving, but probably in lower frequency because the data is in 50.000 work's scale.

Resources requirement
Owing to available resources, this pilot project may not be established in the medium term.

	Degree of detail	Coherence with data	Time for data completeness	Purpose of use		Difficulty of Maintenance	Resources needs
				Applicability	Range of users		
FGGM	↓	↑	↔	↔	↔	↔	↔ ?

	Degree of detail	Coherence with data	Time for data completeness	Purpose of use		Difficulty of Maintenance	Resources needs
				Applicability	Range of users		
1:5.000 UGMC	↑	↑	↑	↔	↓	↑	↑
S20LGI	↑	↔	↔	↑	↔	↔	↔ ?
FGGM	↓	↑	↔	↔	↔	↔	↔ ?

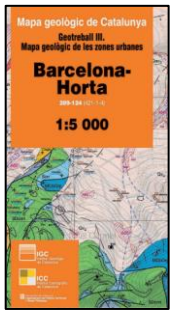
- The (i) 1:5,000 geological urban map, (ii) the system of 20 layers of geological information and (iii) the fundamental geological municipal guides **facilitate the information of the geological environment of urban areas** in different details, quantities and formats.

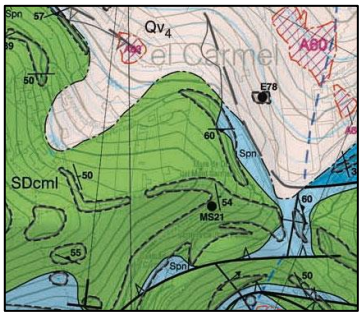
  - Currently, 1:5,000 urban geological maps are not carried out due to its unviability in the medium term. However, whether an urban area needs it, the ICGC has the necessary infrastructure and methodology to generate them. Meanwhile, the two pilot projects are emerging to provide geological knowledge of the territory. In any case, the realization of one of these projects is a matter of **adjusting depending on the government's requirements**, the **society's needs** and the **geological survey's available resources**.

- These documents have an informative and predictive purpose, which are aimed at facilitating the management and sustainability of urban areas. Nevertheless, these documents are not focused on specific geological issues.

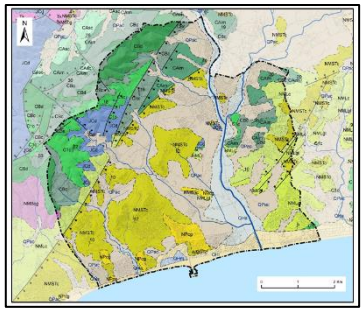
  - Therefore, **these products do not exempt under any circumstances to perform studies and detailed analysis**, which are necessary for execution of building works, for the exploration and mining of soil and geological resources and for the prevention of geological hazards, at municipal or local scale.

6. Conclusions





20 geological layers system



- **From ICGC perspective, urban geology can be approached** in three different ways:

  The (i) **1.5.000 geological urban map**, (ii) **the system of 20 geological layers** and (iii) **the fundamental geological municipal guides.**

  This set of projects are focused on **providing geological information**, facilitating **access to geological knowledge** and **delving into the geology of an urban area** that requires a different approach.

  The most appropriate project will be **depending on government's requirements**, the **society's needs** and the **geological survey's available resources**.

  Nevertheless, the 3 projects **do not exempt under any circumstances to perform studies and detailed analysis at local scope.**

Thanks for your interest!

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