

LLADÓS, Agnès, ADELL, Jordi, RIVAS, Gonzalo and BERÁSTEGUI, Xavier

Institut Cartogràfic i Geològic de Catalunya (ICGC). Barcelona, Spain

## Introduction

With the vision to be a reference center for the information and dissemination of mountain soils, the Territorial Support Center of the Pyrenees (CSTP) of the ICGC (Institut Cartogràfic i Geològic de Catalunya), leads several projects related to geology and to pedology. The project "Soil monoliths of the Pyrenees" which began in 2014, has been strengthened with the opening of the embryo of the Center of Interpretation of Soils of the Pyrenees (CISP) in December 2016, as a permanent preservation and exhibition of soil monoliths and related information.

Soil monoliths are used as an element for dissemination and education about soil, its use and the interaction of the environment, climate and humans. After a laboratory process, which includes in some way the artistic skills of the experts, field collected samples of soil profiles are preserved in almost their natural undisturbed conditions. Each monolith also tells a story through its morphological features (e.g., texture, structure, color, horizon thickness) and many of the soil-related limitations to land use are often apparent (Haddad et al., 2009; Krzic et al., 2013; Torres and Madero, 2007). On display, they attract considerable attention. Moreover, well-constructed soil monoliths are beautiful and most of them look like real works of art (Giencke 2014).

The advantages that offers a collection of monoliths of soil in comparison with other elements or activities has been discussed, among others by Lawrie and Enman (2010): they are transportable elements, can be used many times, allow easily compare different soil profiles or group them, can be observed indoor, are very suitable for groups, can be exposed for long periods (monoliths have been made for over 100 years; i.e. Vanderford, 1897). In addition, the use of monoliths is complementary to the field work, and to expand and compare information obtained from direct observation. Conversely, they have also some disadvantages compared to open pits, as for instance that properties as moisture, hardpans or active biological activity among other, cannot be displayed when the monolith has been separated from its natural setting (Lawrie and Enman, 2010).

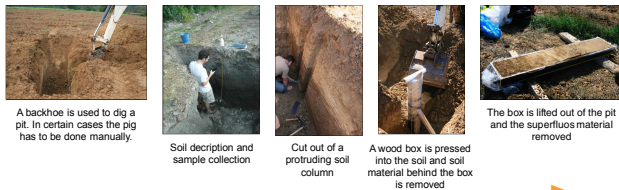
## Summary of methods

The project began in 2014 by searching and comparing related bibliography (Van Baren and Bomer, 1979; Haddad et al., 2009; Más-Martínez et al., 2010 and Torres et al., 2013, among others) and visiting the ISRIC World Soil Information in Wageningen in order to share and discuss the methodology for the elaboration of soil monoliths, and the requirements for their preservation and display. All this actions permitted to define the methodology to be followed, which in several aspects is in close relation to that used for the extraction, transportation and preparation of big to mid-sized fossil bones for paleontological studies.

In 2015 the implementation of the defined methodology resulted in the first 4 monoliths. Those monoliths were extracted from different locations of Pallars Jussà (Southern Pyrenees, Lleida, Spain). In our experience, the methodology for making accurate soil monoliths requires multiple processes for each type of soil, but they are contained in the two known main phases: the sample extraction and its preservation. Figure 1 is a summary of them.

Just to mention one of the innovations of the preservation methodology used in respect to that defined by Torres (2003) and Van Baren (1979), is the successful use of polyvinyl acetate replacing the cellulose lacquer and the organic solvent as consolidation agent.

### EXTRACTION PHASE



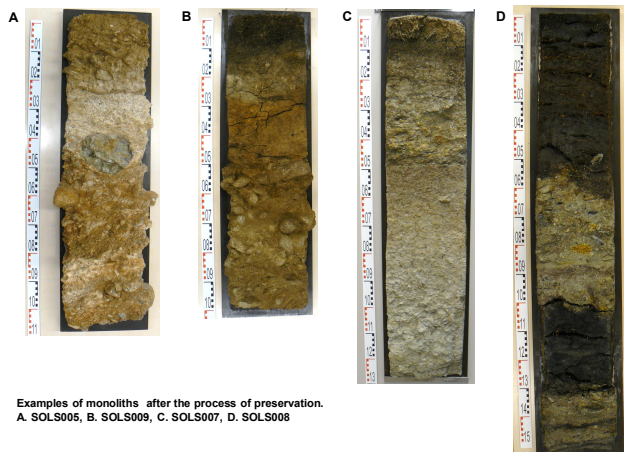
### PRESERVATION PHASE



#### Overview of the two main phases for preparing a soil monolith

After the consolidation there are two other phases: the exhibition and display and the monolith preservation. The chosen display system for exhibition is a 180cm large, 80cm width wooden structure with a support system which provides a slightly tilted position of 80 degrees, so that the monolith weighs down on the wood mount more equitably. The monolith is positioned to one side of the board. This leaves space at the other side to include additional information as soil profile description, maps, images of the landscape, etc. This information can be modified depending on the intended audience (researchers, students, farmers, families, etc.).

The preservation procedure has been defined taking into account the requirements for the long-term preservation of the monoliths. Since the chemical products used on the impregnation usually decompose under the influence of ultraviolet light (Van Baren, 1981) the monoliths should not be exposed to full daylight, using artificial illumination. Although it seems that environmental conditions requirements are not very restrictive, a data logger has been installed in the exhibition room to have a constant record of humidity and temperature.



## Results

During 2015 and 2016 nine soil monoliths 25 cm width, approximately 5 cm thick and 150 cm wide as maximum have been elaborated in the project. Table 1 summarizes their main characteristics.

Soil Monolith	WRB Classification	SSS Classification	Land Use
SOLS001	Haplic Calcisol	Typic Calcixercept	Vineyard
SOLS002	Calcic Luvisol	Calcic Haploxeralf	Quarry
SOLS003	Haplic Vertisol	Cromic Calcixerert	Cereal crop
SOLS004	Haplic Calcisol	Typic Calcixercept	Vineyard
SOLS005	Petric Calcisol	Petrocalcic Calcixercept	Almond crop
SOLS006	Haplic Fluvisol	Typic Ustifluent	Walnut crop
SOLS007	Oxyaquic Fluvisol	Oxyaquic Cryofluent	Grassland
SOLS008	Fibric Histosol	Haplofibrist Fluvaquentic	Grassland
SOLS009	Albic Podzol	Typic Haplocryod	Fir forest

List of the to date monoliths made by ICGC

The methodology for soil monoliths elaboration and conservation has been defined, including extraction, consolidation or preservation, display and exhibition and conservation. It solves some difficulties that can occur during the process of extraction (i.e. the use of a wooden box has been proved as useful in most of the cases, and the use of a polyurethane foam casing has proven to be a very successful solution for stony soils).

The analysis of the consistency and hardness of the resulting monoliths demonstrate that polyvinyl acetate is a very suitable product for the impregnation and consolidation of soil profiles, but this has to be tested after 10 years, and to minimize the cracks frequency, a strict control of the drying period is advisable.

An individual display system has been designed in order to assure the stability of the samples and their conservation. This system allows the exhibition of the profiles regardless of the structure of the soil. As Figure 2 shows, monoliths can be grouped around a particular theme as soil formation factors, physical characteristics (e.g. texture, color), agricultural behavior, etc.



Partial view of the current exhibition of the CISP at the CSTP

Finally, the conservation conditions have been established. The use of Tyvek fabric has proven to be very useful in order to avoid UV light exposure and to prevent fungal growth due to the limitation of transpiration.

## Further work

With the aim to represent the large variety of soils of the Pyrenees and pre-Pyrenees, and to have a collection which permits the explanation the main soil processes, limitations and risks, the collection of soil monoliths will be increased yearly. Currently five new soil monoliths are being extracted and preserved and it is planned to have a collection of 52 samples in 2021.

## Conclusions

An improved methodology for the elaboration of soil monoliths has been defined, comprising the extraction of the sample, the preservation, display in individual support systems and conservation. However, it is not possible to confirm at this moment the adequacy of the conservation methodology as the monoliths are only 1 and 2 years old and a minimum of 10 years is needed.

Today, the CISP holds nine soil monoliths and during 2017 5 new monoliths will be elaborated. It is planned to annually increase their number up to 52 samples in 2021, in order to be able to represent the maximum variety of soils of the Pyrenees and pre-Pyrenees.

As an exhibition of the most representative soil types in the Pyrenees, the CISP will be a very useful tool to raise awareness of the soil importance, both for agricultural and forest production and for environment protection. They also have proven to be a powerful tool for teaching and demonstration purposes. Furthermore, their beauty and visual impact catch people's attention either their age or knowledge.

Soil monoliths are a very reliable testimony of the composition and structure of soil profiles in the moment when have been extracted. In the case that a soil monolith can be extracted on the same place 50 years later it will be possible to determine differences between both monoliths and some climate change consequences will be observed. In this sense, CISP will be a reference for the Pyrenees and Pre-Pyrenees soils in order to determine their condition in the moment of their extraction.

## Acknowledgements

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