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POSSIBILITIES OF REGISTERING NATURAL UNDERGROUND CAVITIES INTO THE NATIONAL INTEGRATED INFORMATION SYSTEM OF CADASTRE AND LAND REGISTRY

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ABSTRACT:

The problem of registering underground cavities and caves is an older one at national level. With the advent of several legislative initiatives regarding this type of entity, the term cadastre of caves also appeared. The case study is represented by the "Șuticoasa" Cave, which is located in the perimeter of the archaeological site, the Șinteu Fortress "Piatra Șoimului", being an integral part of the medieval monument in pestis village, a village belonging to Alesd city in Bihor county. For this purpose, this paper presents the techniques of data acquisition, their processing and a first attempt to refer to this type of entity in an existing land register.

1. INTRODUCTION

The cave is a natural cavity formed in the earth's crust, wide and deep enough to allow man to enter. By extension, the cave can be a system that can have more than one entrance and consists of several galleries, halls, wells and chimneys (Romanian Government, Emergency Ordinance no. 57, 2007).

The first preoccupations on the current territory of Romania regarding the knowledge of caves with an explorative and scientific purpose date back to the beginning of the eighteenth century. Due to the large number of caves discovered, the need for a method of systematizing the discoveries has become increasingly clear. Thus, in 1969 appeared the first catalog of caves in Romania called Map of karst regions in Romania. It contained a list of 984 cavities. Then, in 1976 with the adoption of the decimal system of cave inventory appeared another catalog published by M. Bleahu and I. Povară – Catalog of caves in Romania that included about 2000 cavities. The last catalogue of caves in Romania was published in 1982 by C. Goran under the name: The Systematic Catalogue of Caves in Romania (Institute of Speleology Emil Racoviță, 2023).

To date, amateur cavers have made it possible to discover, explore and often scientifically research nearly 13,000 caves. The caves are inventoried in a database that is hosted by the Institute of Speleology "Emil Racoviţă" within the Carstonomie Cadastre and Karst Protection department (Romanian School of Speleology, 2023), but which does not have spatial information.

In the national integrated information system of cadastre and land registry in Romania there is a limited set of information regarding the natural heritage. The geospatial location and the textual information referring to the geological monuments are also absent from the integrated information system. The problem of the absence of cadastral data on natural caves is also raised at the international level (Samoilenko et al., 2020).

The creation of a database with the spatial and textual data of all the caves in Romania plays an important role in the development and management of natural caves. Thus, it will be possible to access precise positioning information of the existing natural caves (Yoon et al., 2010). In order to achieve such an informatic system, it is necessary to involve the specialists in the geodetic and speleological field.

Caves belong to the category of protected natural areas. In Romania, the legislative regulation on the regime of protected natural areas, the conservation of natural habitats, of wild flora and fauna is established by Emergency Ordinance 57 of June 20, 2007. The purpose of this emergency ordinance is to guarantee the conservation and sustainable use of the natural heritage, an objective of major public interest and a fundamental component of the national strategy for sustainable development (Romanian Government, Emergency Ordinance no. 57, 2007).

Caves being assets of the natural heritage are protected by the establishment of appropriate protection zones as the extent of the purpose of conservation of natural goods (Romanian Government, Emergency Ordinance no. 57, 2007). For caves, the protection zone is established according to the characteristics and class of the cave, with the approval of the Romanian Academy (Romanian Government, Emergency Ordinance no. 57, 2007). Owners or managers of land comprising cave entrances are required to allow access to these entrances (Romanian Government, Emergency Ordinance no.

57, 2007). The beneficiary of an investment work has the obligation to announce the discovery of any cave in the front of a mining work or a quarry of the nearest competent institution, respectively to the administrator of the protected natural area, to the National Agency for Protected Natural Areas, to the county agency for environmental protection or to the representatives of the local public administration authorities (Romanian Government, Emergency Ordinance no. 57, 2007).

Article 42 from Emergency Ordinance 57 of June 20, 2007 establishes a right of way provided for in paragraph (3) the obligation for the owners or managers of land comprising cave entrances to allow access to these entrances. And yet although constituted by law, this right or easement is not currently noted in any land register. Moreover, the law incriminates as a contravention sanctioned with a contravention fine the act of restricting the access of authorized persons to the cave entrances.

Measuring a cave is a difficult process because of the limited and hard to reach space (Giordan et al., 2021), low brightness and the presence of increased humidity (Dabove et al., 2019). All these specific environmental conditions lead to the need to use special measuring instruments. In order to determine the shape and surface of a cave, it is necessary to represent it three-dimensionally, with the help of modern instruments and techniques. Nowadays, through the rapid progress of technology, new tools and techniques for measuring and 3D representation of measured constructions and objects have appeared, offering a high precision and a good interpretation of data, which through classical instruments we could not achieve the same degree of accuracy of results.

The object of the present study is represented by the cave "Șuticoasa", which is an integral part of the archaeological site Fortress Șinteu "Piatra Șoimului" (figure 1) and is on the list of historical monuments under the code LMI BH-I-s-00988.





Figure 1. The archaeological site of the Șinteu Fortress "Piatra Șoimului" (a) and the cave "Șuticoasa" (b) (Tourism Alesd, 2023)

2. RESEARCH METHODOLOGY

Laser scanning technology is an active remote sensing technique that uses the properties of scattered light to determine certain characteristics of distant objects. Laser scanning provides high-accuracy data about land topography, vegetation, buildings, natural resources, etc. (Loghin, 2018).

This technique offers millions of precise 3D points with high density. Laser scanning can be terrestrial, mobile or aerial. Terrestrial laser scanning techniques are used in topographic studies due to the high accuracy, speed in the process of collecting field data (Tarsoly, 2006) and because the laser beam can penetrate vegetation. Although photogrammetric methods are considered as non-invasive, having reduced execution costs, with results often comparable with those obtained through the much more costly 3D scanning (Herman et. al., 2020), in the case of underground cavities with poor illumination, the aforementioned method cannot be used.

After processing the point cloud generated using laser scanning technology, a 3D model of the studied area is created. In the case study to determine the position and surface of the cave, the 3D laser scanning technology was used with the help of the Trimble X7 terrestrial scanning instrument.

Within the studied area we obtained a point cloud with the existing elements in the area (figure 2), being necessary to process these points in order to obtain the surface of the studied cave. This point cloud was processed using specialized software, the Trimble Business Center.

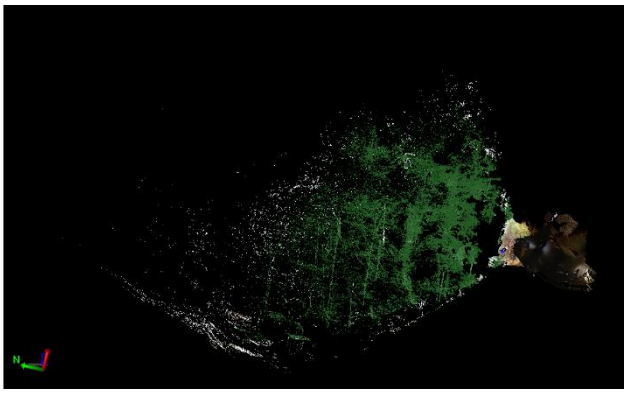


Figure 2. The point cloud in the studied area resulting from the Trimble X7 terrestrial laser scanner

Determining the caves' maximum occupied area in 2D, as well as determining the cave's volume was a key process in obtaining all the required data in order to make the correct registration of the studied objective in the land registry system (Germani et al., 2015).

3. DATA PROCESSING AND RESULTS

In the stage of processing the point cloud we wanted to classify the points by layers in order to be able to process the points in the area of interest, namely the points that determine the surface of the cave.

Using Trimble Business Center software, a certain self-classification was achieved through the "Classify Regions" function. The point cloud we want to classify was selected and the classification groups were established (Zeybek, 2021). The classification was made in the following groups: vegetation and trees, cave and others (figure 3).

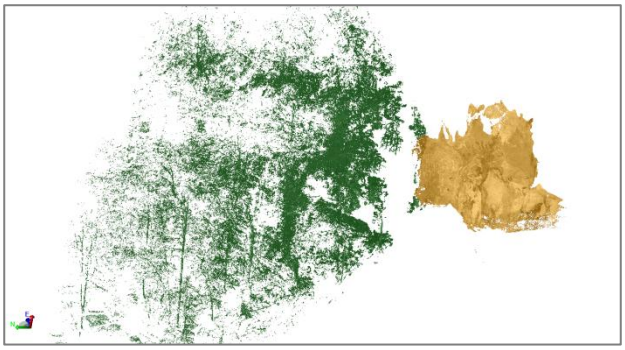


Figure 3. Automatic and manual classification by class groups of the point cloud in the studied area

Following the automatic classification, it was also necessary to manually classify for a small number of points that could not be automatically established the classification group.

After classifying the points, we made a cross-section through the point cloud formed only from the points that target the cave (figure 4) for the 2D determination of the surface of the cave.
This process was necessary for the registration in the integrated system of cadastre and land register of the area of the cave (Van Oosterom, et al., 2019) and to determine its corresponding area to the precision of square meters.

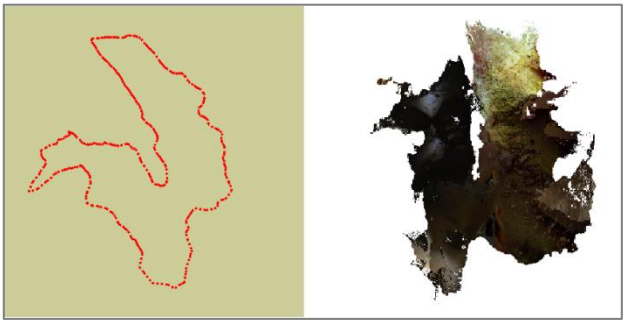


Figure 4. The 2D surface of the cave resulting from the section through the point cloud

Also, another important element to be able to achieve the registration of the cave in the cadastral evidence system was the determination of its volume. In order to determine the volume of the cave, a 3D model of it was made (Figure 5).

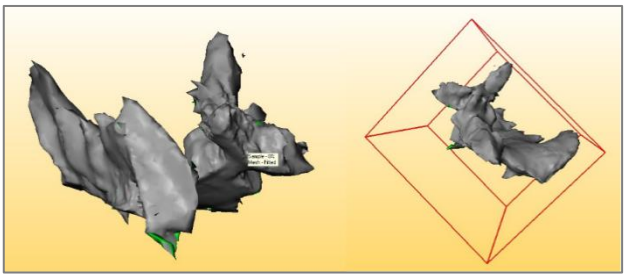


Figure 5. 3D model of the cave based on the point cloud

Following the determination of the area and volume of the cave, the cadastral plan (figure 6) and all the documents necessary for the registration in the Land Registry could be drawn up.

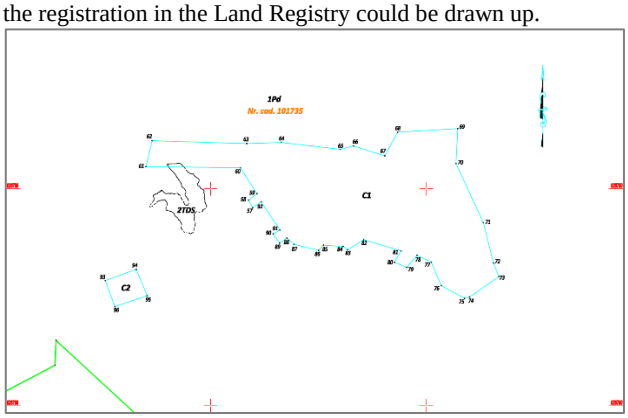


Figure 6. The cadastral plan made for the registration in the integrated information system of cadastre and land registry of the cave "Șuticoasa"

The registration in the integrated information system of cadastre and land registry was achieved by entering only non-spatial data.

The possibility of graphical representation of 3D natural cavities in the information system is currently impossible, because the regulations exist are only for parcels/buildings that can be represented in the 2D plan. The underground cavity was successfully integrated into the land registry, as shown in the figures below (figures 7 and 8).

Nr.	Category of use	Urban area	Area (sq. m.)	Field	Lot	Topogr. Nr.	Observations / References
1	Forest	NO	707.416	-	-	-	
2	Degraded and unproductive terrains	YES	85	-	-	-	Terrain with special destination (TDS), "Șuticoasa" cave with an area of 85 sq.m., volume 1030 cu. m., integral part of the archeological site Șinteu Fortress "Stone of the Falcon"

Nr Crt	Categorie folosință	Intra vilan	Suprafața (mp)	Tarla	Parcelă	Nr. topo	Observații / Referințe
1	padure	NU	707.416	-	-	-	
2	terenuri degradate și neproductive (N) - stâncării, bolovănișuri, pietrișuri	DA	85	-	-	-	Teren cu destinație specială (TDS), Peștera "Șuticoasa" cu o suprafață de 85mp , în volum de 1030mc, parte integrantă a sitului arheologic Cetatea Șinteu "Piatra Șoimului".

Figure 7. Textual details in the land management register of the Șuticoasa cave
(above: in English, below: in Romanian, for authentication)

Land Registry Book nr. 101735 Commune/Town/Municipality: Aleșd

Annex nr. 1 to Part I

Observations / References
On the land parcel, the ruins of the medieval fortress Șinteu "Piatra Șoimului" can be found, along with the ruins of the charnel house and the "Șuticoasa" cave, LMI code: BH-I-s-B-00988, spelean cadaster code: 3813/3

Carte Funciară Nr. 101735 Comuna/Oraș/Municipiu: Aleșd

Anexa Nr. 1 La Partea I

Observații / Referințe
Pe teren se regăsesc ruinele cetății medievale Șinteu "Piatra Șoimului", ruinele capelei funerare și peștera "Șuticoasa", cod LMI: BH-I-s-B-00988, cod cadastru speologic: 3813/3

Figure 8. Textual details mentioning the successful registration of the historical monument under the code LMI BH-I-s-00988 and the Șuticoasa cave beneath it, barring its speleological code in the Land Registry Book nr. 101735 Aleșd, Bihor County, Romania
(above: in English, below: in Romanian, for authentication)

4. CONCLUSIONS

The lack of orientation of the legislation and regulations towards the realization of an informational system of cadastre of the caves with 3D spatial data leads to the impossibility of identifying, managing and determining the geospatial position of the caves.

Although in Romania there is a database of caves discovered by cavers that is hosted by the Institute of Speleology "Emil Racovita", it does not have spatial information through which you can determine the position, surface and volume of caves.

The realization of an inter-institutional collaboration protocol between the National Agency for Cadastre and Real Estate Advertising and the Institute of Speleology could facilitate the development of the informational system of cadastre and land register existing by determining the technical, economic and legal information regarding the caves and noting in the land book the rights, responsibilities and restrictions in the area of protection of the caves.

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