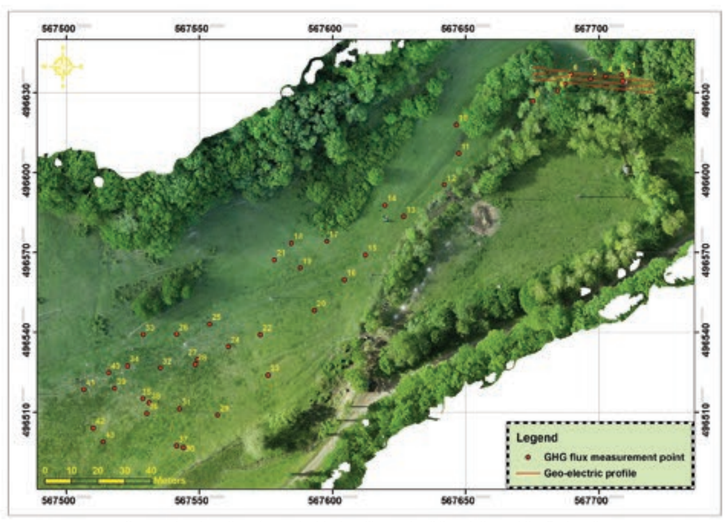
New investigation of a natural analogue site for CO_2 geological storage in Romania

Alexandra Constanța Dudu, Corina Avram, Gabriel Iordache, Andrei Gabriel Dragoș, Sorin Anghel, Constantin Ștefan Sava, Irinel Caraban

The National Institute for Research and Development on Marine Geology and Geo-Ecology – GeoEcoMar

Introduction

The purpose of the project PN 23 30 04 04 is the elaboration and development of an innovative methodology for environmental monitoring (of CO_2 leaks) of potential geological CO_2 storage sites in Romania). This methodology, designed for the onshore, where the first storage projects in the country are planned, will be based on the application of geochemical, biological and shallow geophysical methods. A secondary objective is to demonstrate the feasibility of using shallow geophysical methods in the environmental monitoring of CO_2 sites. The newly created methodology and included methods will be tested on natural CO_2 reservoirs from Romania. This spring we have made a final selection of the testing sites and a field campaign to determine their suitability for the project.



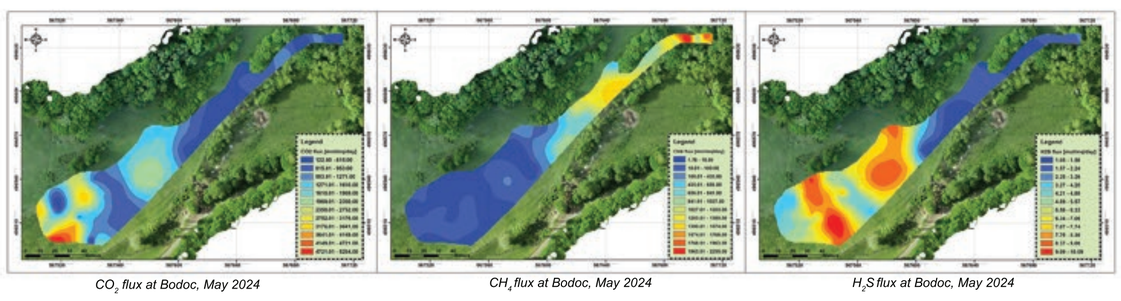
Survey plan. Location of geo-electrical profiles and soil flux stations at the Bodoc site

One of the promissing sites to be used as natural analogue for CO_2 geological storage is Bodoc mineral water deposit, located in Covasna County, central Romania. In order to determine the suitability of the site for the project, a small field

8-11 May 2024. Apart from identification and positioning (using GPS GNSS Trimble R2) of geological features, old exploitation wells, of suitable future testing perimeter, we have also conducted a small soil flux survey, geoelectrical survey and photogrammetry.

Soil flux measurements

Within the Bodoc perimeter, soil gas flux measurements (CO_2, CH_4 and H_2S) were made with a West Systems portable flux meter equipped with CO_2, CH_4 and H_2S sensors. A total of 43 stations were measured, and the measurement points were chosen in areas considered representative of the perimeter and future field campaigns. The objective of the gas flow measurement campaign was to obtain an overview of the variation of gas emissions within the perimeter. As we expected, being a well-exploited mineral water deposit in the past, we did not identify any gas vents.



CO_2 flux at Bodoc, May 2024 *CH_4 flux at Bodoc, May 2024* *H_2S flux at Bodoc, May 2024*

CO_2 flux varied between 122 mol/mq/day and 5264 mol/mq/day. Higher CO_2 fluxes were recorded in the southern part of the perimeter. The CH_4 flux varied from 1.76 mol/mq/day to 2255 mol/mq/day. The highest values, in this case, were measured in the northern part of the perimeter. The flux of H_2S varied very little, from 1.05 mol/mq/day to 10.09 mol/mq/day. The variation of greenhouse gas fluxes will need to be confirmed by measurement campaigns over several seasons. It is important to exclude seasonal variation and implicitly to exclude variation due to biological activity that could have a significant impact on CO_2 and CH_4 flux values.

Flux measurements in the centre of Bodoc perimeter

Flux measurements at Bodoc, near Matilda spring

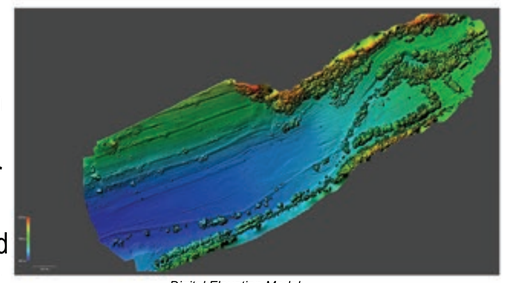
Portable fluxmeter West Systems used in the field campaign at Bodoc, May 2024

Photogrammetry

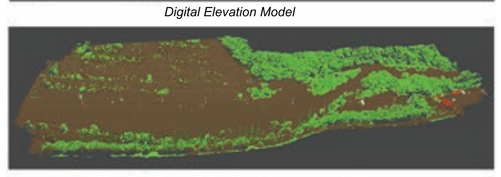
The drone that was used for this study is a DJI Phantom 4 Pro V2.0 quadcopter drone (that is equipped with a 3 axis motorized gimbal and a 1-inch 20MP CMOS sensor with a mechanical shutter), a Trimble R2 GNSS system, and a set of 9 targets (GCP - ground control points) used to improve positioning and elevation accuracy. The flight plan was executed on a Dell rugged laptop, via DJI's Terra software, in which the following flight/camera pa rameters were implied:

- Flight altitude - 65 m;
- Side / forward photograph overlap - 75% / 85%;
- Gimbal pitch - 90° (Nadir) - the camera axis is perpendicular to the ground / object;
- Camera settings - f/5.6, a fast shutter speed of 1/2400s, a fixed ISO of 100, and camera focus set to manual.

The mapping process was completed by analyzing and processing the 2D photographs, captured by the camera, in dedicated software - Agisoft Metashape.



Digital Elevation Model

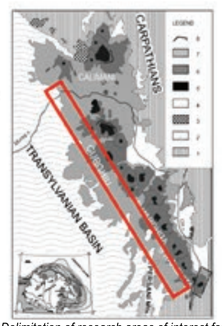


Classified Dense Point Cloud: brown - terrain, green - vegetation, red - buildings, yellow - man made objects

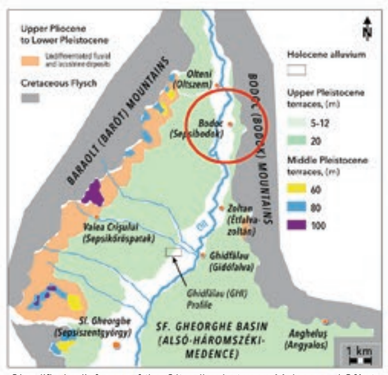
DJI Phantom 4 PRO V.20 UAV System

Geological description of Bodoc site

The geological-structural framework consists of the deposits of the Ceahlău nappe (Bodoc branching) that outcrop on the mountain area and the post-tectonic deposits that form the filling of the Bodoc-Malnaș depression, part of the Brașov basin. The deposits relevant for our study (Sânmartin-Bodoc strata) are located in the lower part of the succession in marl-sandstone flysch facies (lower part of Upper Barremian-Lower Albian series) and in the upper part in sandstone-conglomerate facies (upper part of Middle Albian series).



Delimitation of research areas of interest for environmental monitoring, in the post-volcanic area Călimani-Gurghiu-Harghita.



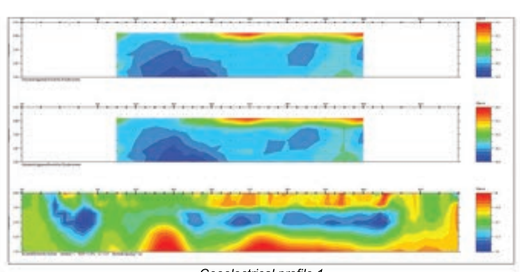
Simplified relief map of the Olt valley between Malnaș and Sfântu Gheorghe area— adapted from Ghenea et al. (1971) showing the distribution of river terraces and location of Ghidfalău (GHI) profile. (in Csaba Jánosi, Dávid Karátson, and Ferenc Wanek, 2022)

The Bodoc area is located in the western extremity of the Cretaceous flysch zone, intensely folded and faulted. The flysch deposits are comprised of an alternation of sandstones, marls, clays and conglomerates.

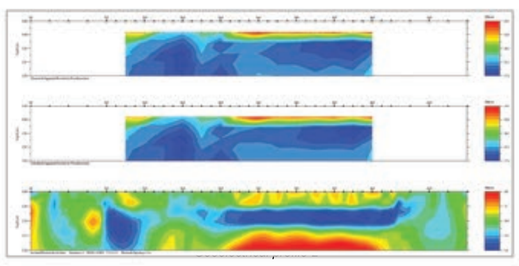
In the basement deposits, aquifer accumulations of medium depth are individualized, and in the upper part there are post-tectonic deposits of the cover, with aquifer accumulations of shallow depth. The conglomerate facies located in a synclinal structure, is strongly affected by tectonic movements (a series of transverse faults), responsible for the migration of mineral waters to the surface.

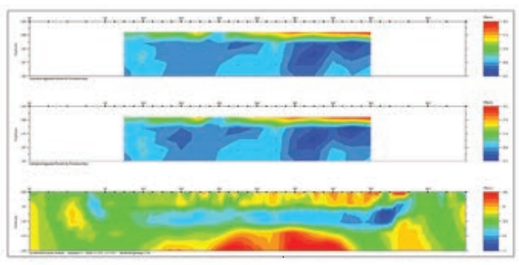
Geoelectrical survey

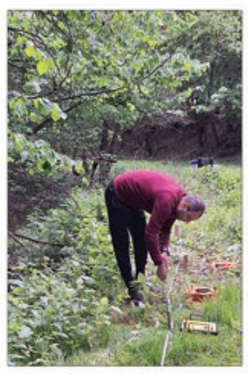
The geoelectrical survey was conducted using an AGI Ministing resistivimeter. 3 geoelectrical profiles were surveyed through Vertical Electrical Sounding (VES), Schlumberger array type. The distance between the profiles was of 2 meters and each of them consisted of 14 VES. With a profile lenght of 46 meters, the maximum investigation depth was calculated at 4.2 meters. Data processing was made with AGI Earth Imager 2D/3D software.



Geoelectrical profile 1



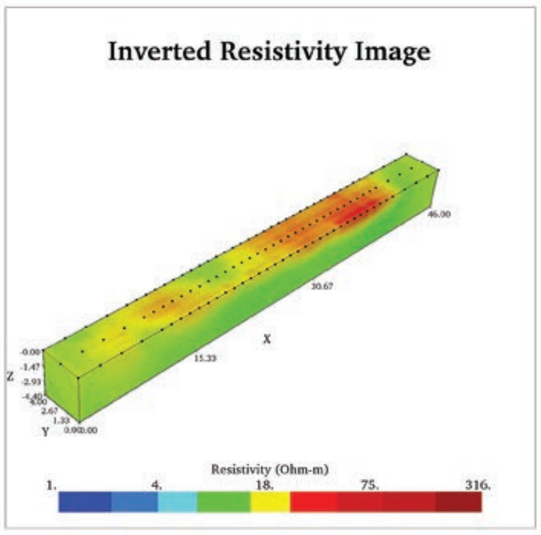




Geoelectrical survey

The geoelectrical investigation highlighted that the presence of clay content tends to reduce the increase of resistivity caused by the displacement of water by less conductive CO_2. As a result, CO_2 saturations estimated from resistivity measurements without any correction for the clay effect are considerably lower than the actual saturations. The

important to realize, however, that the resistivity values is an index tool that must be correlated or calibrated to site-specific soil measurements through water and soil sampling.



Resistivity 3D Model. Depth of penetration - 4.4 meters

Geoelectrical measurements

Conclusions

Following the assessment made, especially in the field campaign, we can conclude that Talomir Bodoc is suitable to be used as testing site for our environmental monitoring methodology. The testing will begin this autumn when we plan to conduct an extensive soil flux survey, soil gas measurements, biological sampling, electrometric survey, GPR survey and seismics.

References

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