Report on the results obtained in 2023 in the projects PN 23 30 04 04: Development of an Environmental Monitoring Methodology for Potential CO2 Storage Sites in Romania

The aim of the project is to elaborate and develop an innovative environmental monitoring methodology (namely for CO2 leakage) of for future geological CO2 geological storage sites in from Romania. This methodology, designed for potential onshore CO2 geological storage projects, where the first storage projects in the country are already planned, will be based both on the application of the methods already used in the field of CO2 leakage monitoring (geochemical methods - soil - flux measurements, sol-gas surveys, near-surface seismics), but also on methods less used for this purpose (electrometry, GPR, microgravimetry). We aim thus to demonstrate that these les-used geophysical methods is also feasible in the environmental monitoring of CO2 sites. The newly developed methodology and the methods included will be tested on natural analogues for CO2 geological storage, namely natural emission sites (analogue for CO2 leakage sites) and natural CO2 reservoirs (analogue for safe and permanent storage). We also want to understand the underlying mechanisms of CO2 leakage by making a comparative analysis between the geological and structural models of sites where CO2 comes to the surface and those where CO2 remains inside the reservoir, an essential analysis for the planning of the environmental monitoring and detection of potential leaks.

For 2023, two phases were planned and realized, the first phase having the deadline on 14.06.2023 and the second phase ending on 13.11.2023.

For Phase 1, entitled “The substantiation of an environmental monitoring solution for CO2 geological storage sites”, the objective was to substantiate the environmental monitoring methodology for CO2 geological storage sites based on the best practices in the field, existing standards and legislative requirements. In order to achieve the objective of the phase, the following three activities were carried out:

* The analysis of internationally existing monitoring solutions;
* The analysis of the implementation of the existing environmental monitoring methods in the ongoing programs of the CCS projects all over the world;
* The analysis of the legislative, international and national requirements for the environmental monitoring, detection and quantification of CO2 leaks from anthropogenic reservoirs.

In this phase, following the implementation of the activities in from the project implementation plan, a substantiation of the monitoring solution that will be developed within the project was obtained. Thus, the phase goal was achieved 100%.

Firstly, internationally existing monitoring solutions and methodologies for the geological storage of CO2 have been studied through extensive documentation, using sources from our own database (documentation from the international projects we have participated in, documentation provided by the research networks and associations in which we are members), as well as literature sources that we accessed on this occasion using the databases to which we have access to.

Secondly, a study was carried out on national and European legislative requirements related to the environmental monitoring of CO2 geological storage sites and the existing standards for safe storage.

At European level, monitoring is regulated by CCS Directive, and at national level by the law for CO2 geological storage (Law 114 of 2013) transposing this directive. At national level, we have also inventoried other laws, decisions and orders from competent authorities (e.g. ANRM, ANPM) relevant for environmental monitoring. Regarding the storage and monitoring standards, the only standard identified is ISO 27914:2017 - Carbon dioxide capture, transportation and geological storage. This standard is at present under review. In addition to this standard, there are several good practice guidelines for monitoring, developed under the funding of the United States Department of Energy (US DOE). In addition, the reports produced by the IEAGHG monitoring programme summarising the results of research, the implementation of monitoring programmes on CO2 storage projects in the world and international cooperation in this field, they can also serve as reference documents for monitoring.

The implementation phase of the project is in the beginning. However, in addition to meeting the specific objectives of this stage, the preparation of subsequent stages was initiated, namely, the inventory of test sites for the monitoring methodology to be developed within the project. Therefore, we made an official request to ANRM (NAMR) for access to the site and documentation for two natural CO2 deposits of CO2, Ocolisu Mare and Ciocaia. As the Ciocaia deposit is currently in operation, at the recommendation of the NAMR, the documentation and access will have to be requested to the Petrogas operator, which will be done in the next phase of the project. As regards to Ocolisu Mare CO2 deposit, it has its exploitation stopped, and, following the signing of a confidentiality agreement, the documentation can be obtained from NAMR. With the support of the NAMR and its Territorial Inspection Department Hunedoara, during this phase, we also made a field campaign of recognition that allowed us to have a better image of a possible working perimeter on which we will test the environmental monitoring methodology to be developed in the next phases.

Phase 2 - “The elaboration of the methodology/preliminary environmental monitoring solution for CO2 geological storage”-, aimed at developing the preliminary environmental monitoring methodology for CO2 geological storage. In this phase, a first achievement was the development of the preliminary environmental monitoring methodology, the phase target being met 100%.

At the same time, the preliminary database of the project, which will be updated throughout the entire project, was also developed at this stage.

In order to achieve this phase objective, three activities were carried out:

* The analysis of the implementation of geochemical and geophysical methods, as part of the proposed monitoring methodology;
* Designing and developing the environmental monitoring methodology for identifying CO2 leaks based on the peculiarities of onshore storage sites;
* The Inventory of potential test areas for the proposed monitoring methodology.

A first significant result of the phase was the development of the preliminary environmental monitoring methodology based on documentation of how methods were applied in CO2 monitoring projects and based on previous experience in previous projects research we had participated to. The preliminary methodology shall include methods of ecosystem monitoring, geochemical methods and geophysical methods.

The proposed geochemical methods for environmental monitoring are soil gas - flux measurements, soil-gas surveys, surface and groundwater sampling and analysis, and specific soil analysis. All these are proven methods for highlighting potential CO2 leaks. Groundwater monitoring should be started before the CO2 injection in well-established sampling stations with precise coordinates, set on the basis of existing groundwater sources (springs currents, surface water, water wells of the inhabitants in the area) and additional monitoring wells (specially built for the project).

For ecosystem monitoring, the methodology developed shall include vegetation surveys and microbiological monitoring. Before injection, in different seasons, vegetation surveys will be conducted on the surface of the entire storage site in correlation with land use, especially with agricultural activities. After injection, changes in the spread of the initially identified species and spatial distribution will be tracked. Substitution of species with some more resistant to high CO2 concentrations, the appearance of bio-indicators will be carefully documented. After the start of the CO2 injection, the microbiological analyses will be seasonally repeated, at points where there will be variations/increases in CO2 concentrations (from the soil-gas surveys data), tracking variations in the concentration of bacteria and fungi, as well as substitution of species, bio-indicators of some CO2 leaks.

The environmental monitoring methodology includes as geophysical methods, gravimetric and electrometric measurements, GPR and shallow seismics.

Based on the existing data in the project, a database was built in the Microsoft Access program in English to be consulted by a wider audience. The database will be updated as new information is accumulated in the project. The first two tables created were “Methods” and “MethodDetails” as a structured container of the methods used in this project.

In this phase, we also carried out the inventory of possible test areas, natural CO2 emission areas in Romania and natural CO2 reservoirs, for which we collected all the available documentation (articles, articles, PHD theses, reports, etc.), consulting in the same time with specialists from the Society of the National Mineral Waters with whom we had already collaborated.

To carry out this activity, we conducted a research and mapping campaign and mapping of possible test areas in an area with post-volcanic activity. Thus, we investigated as potential test areas deposits of moffeetic CO2 - mineral waters and the areas with natural CO2 emissions. The mineral water reservoirs investigated in the field and documented were: Talomir-Bodoc, Malnas Baths, Bixad Olt, Siculeni, Rich Hill, Stanceni, Bilbor and Borsec. As a potential test site with natural CO2 emissions, we investigated in the field the Lăzărești site.

As for the dissemination activities, the idea of the project was presented at a prestigious CO2 storage conference, namely the CO2GeoNet Open Forum, which took place between 2-5 October 2023. At this conference, we presented the poster with the title “Development of an Environmental Monitoring Methodology for Potential Geological CO2 Storage Sites in Romania”. The second dissemination activity was in GEOSCIENCE 2023 on the 9 of November 2023 where we presented the paper “Environmental monitoring of onshore CO2 geological storage sites in Romania”. The paper will be published in a volume of works that will appear at the beginning of next year under the aegis of SGAR (Society of Applied Geophysics in Romania).

Another important result of the phase was the organization of the first workshop in a series of stakeholder information and engagement workshops. The idea of the project and the preliminary results were met with interest, giving us also the opportunity to debate some important issues for monitoring future storage sites in Romania and for the success of future projects, including the involvement of the general public. The workshop was attended by regulatory authorities (NAMR, Geological Storage Service), representatives from the cement industry, GeoEcoMar team and 2 international experts in the field of

monitoring and communication science, namely Sabina Bigi and Samuela Verceli of Sapienza University of Rome. Thanks to the participation of international experts, the workshop was in English.

At this stage, seismic equipment (basic configuration) and a graphics station were purchased.