



# The Newsletter

Issue No.3 April 2019

## 🚺 E N O S

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## ENOS International Master Course on CO<sub>2</sub> Geological Storage

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-ENDS project is recognised by Carbon Sequestration Leadership Forum -ENDS 2nd Spring School on CO<sub>2</sub> Geological Storage -ENDS e-learning courses -ENDS webinars -Come and talk to us at upcoming events -ENDS publications University of Rome and University of Zagreb with participation of Tallinn University of Technology, Heriot-Watt University, University of Nottingham, GEUS and NORCE (Figure 1) are jointly hosting a one year postgraduate specialist university Master Course for 60 credits (ECTS).

All participating universities research and teach topics related to Carbon Capture and Storage (CCS) and the participating research institutes undertake relevant research at pilot  $CO_2$  storage sites onshore Europe which will help inform the Master course. The partners have a long history of joint cooperation through EU FP6, FP7 and H2020 projects and the  $CO_2$ GeoNet and ENeRG networks.

Main agreement (signed by Rectors to include the Master into the educational offer)	Teachers from other ENOS partner universities	Other research institutes will host student for thesis work	
SAPIENZA UNIVERSITÀ DI ROMA	SOTACARBO	Invoition for life	
These two universities will pro- vide the sites for lessons and other facilities for up to 10 stu- dents. Each of them will host one student for the thesis work.	These universities will allow professors to teach in the Master Course and each of them will host one student for the thesis work.	These research institutions will host students for the final thesis work.	

Figure 1. Main structure of the ENOS International Master Course and partners involved.

 $CO_2$  capture and storage (CCS) is a rapidly advancing field with many technical and global challenges already addressed. The course aims to prepare a new generation of young professionals to work and research on CCS. The course will present the state-of-the-art of CCS operations and research, including  $CO_2$  injection and safety monitoring, exploration of critical processes using laboratory experiments and numerical modelling,  $CO_2$  storage capacity estimation,  $CO_2$  use options, economics and planning of mitigation measures in case regulatory requirements are not fully met. Post-graduates that complete this course will be equipped to work in  $CO_2$  geological storage projects. In addition, knowledge acquired on integrated exploration and use of the deep subsurface will enable them to apply these skills in other uses of the subsurface for sustainable resources such as geothermal energy, energy storage etc.

Lectures in the first semester, consisting of two blocks in Rome and one in Zagreb, are organised in 14 modules with exams after every second module. After passing all the exams and participation in a joint project (5 ECTS), each student will spend a mobility period (15 ECTS) at one of the partner institutes or universities to undertake individual research and to write their final thesis (to be defended at the joint final event of the study, Figure 2).



Figure 2. Educational plan of the ENOS International Master Course on  $CO_2$  Geological Storage.

Candidates with a Master degree in Earth Sciences at a level in accordance with the European Qualification Framework are eligible for this Master course. Students with a degree issued by non-EU universities can be admitted for the course with the permission of the Scientific Educational Council. The course will be financed by tuition fees (EUR 2000), contributions from ENOS project and possibly other funds. Extra expenses for student mobility will be covered by each student. Up to 10 students with the possibility of having reduced tuition fee will be accepted onto the course. The Call for Application for the Academic Year 2019-2020 will be published in November 2019 and lessons will start in February 2020.

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Other information are available on the <u>Sapienza University</u> <u>Website</u> (https://www.uniroma1.it/en/offerta-formativa/ master/2019/co2-geological-storage-internazionale)

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Sabina Bigi, <u>UNIROMA1</u> Bruno Saftic, <u>UNIZG-RGNF</u> Alla Shogenova, <u>TalTechDG</u>

## ENOS FIELD SITES

## LBr-1 HYDROCARBON FIELD, CZECH OS REPUBLIC

The LBr-1 hydrocarbon field, one of the ENOS project field sites. is situated in the Czech part of the Vienna Basin (SE Czech Republic), close to the border of Czechia, Slovakia and Austria. It represents the northern part Brodské of the hydrocarbon complex several small hydrocarbon accumulations located at both sides of the Czech-Slovak border.

The exploration of the Brodské complex started already in 1917. In its northern part, i.e. in the LBr-1 area, the first successful well was drilled in 1957. followed



Figure 4. Static geological model of LBr-1 - depth (structural) maps. MB – top of Middle Badenian caprock, L1, L2, L3, L4 – tops of partial sand layers of Láb Horizon, LB – top of Lower Badenian underlier, F1, F2, F3 – faults. Depth to top Láb horizon is 1055-1095 m. Depth to top of MB is 1005-1045 m.

drilled in 1957, followed by drilling of another 24 exploration and production wells penetrating the reservoir until 1960. All wells are currently abandoned.



Figure 3. Production history of LBr-1.

The cumulative production from LBr-1 amounted to  $61,900 \text{ m}^3$  of oil and  $68.7 \text{ million m}^3$  of gas. The main volumes of oil and gas were produced between 1959 and 1969, but occasional production continued until 2001. Figure 3 provides an overview of field production history. In 2004, the field was declared abandoned and in 2016 the production licence was cancelled. Nevertheless, the whole area is still covered by the oil and gas exploration licence.

The main stratigraphic oil-bearing horizon of the LBr-1 field comprises the Middle-Badenian sands, known as the Láb horizon. This horizon can be divided into four sand layers deposited on top of each other (L1, L2, L3 and L4 – Figure 4) that are separated by less permeable clayey intercalations with occasional interconnections. The sands are medium to fine grained and generally poorly consolidated. They lie at a depth of circa 1,050-1,100 m below surface and have outstanding reservoir properties (porosity up to 25%, permeability up to 500 mD). This fact, in combination with relatively good geological knowledge and presence of a good-quality cap rock (the Middle-Badenian shale), is the main reason why LBr-1 is considered a good candidate for a pilot project for geological storage of  $CO_2$ .

LBr-1 is a combination of lithological and tectonic trap. The Láb horizon pinches out at the East/ North-East edge of the field while minor faults of the Brodské fault system confine the field in the South and partly in the South-East.

LBr-1 is now the subject of a detailed site assessment that will examine the possibility of turning the abandoned oilfield into a research  $CO_2$  storage pilot site. The work started with the previous project REPP-CO<sub>2</sub> funded by Norway Grants and is now continuing within the ENOS project. The current research programme is focusing on two main topics:

- assessment of risk connected with the potential of unwanted migration and/or leakage of fluids from the reservoir through faults and abandoned wells

- investigation of reservoir behaviour in the presence of  $CO_2$  and hydrocarbons, including possible mobilisation of hydrocarbons and use of  $CO_2$  as agent for enhanced oil recovery.

LBr-1 represents a typical small-scale hydrocarbon field of the Vienna Basin and can serve as an example for broader implementation of CCUS activities in the whole area.

V. Hladik, M. Pereszlényi, J. Francu <u>Czech Geological Survey</u>



## **ENOS NEWS**



Work package 1. Ensuring safe storage operations	Work package 2. Ensuring storage capacities and cost-effective site characterisation
An advanced static model of Hontomín site was developed by GEOGREEN with PETREL <sup><math>M</math></sup> and dynamic model with GEM <sup><math>M</math></sup> considering temperature and multiphase flow effects. UNNOT modelled the impacts of heterogeneities on CO <sub>2</sub> plume movement using ECLIPSE and INTERSECT <sup><math>M</math></sup> . TNO completed reliability, sensitivity and accuracy assessment of the Hontomin seismic network. BRGM conducted a new deep sampling at 1155-1170 m depth in the French Aquitaine Basin. A new velocity model is generated by OGS using the first 3D VSP seismic data. CO <sub>2</sub> is monitored by BGR soil stations and UNIROMA1 new probes.	UNOTT is improving geological model of Hontomin reservoir using high resolution INTERSECT Reservoir Software to fit pressure and more recent brine/ $CO_2$ injection data. Long term injection scenarios will provide a range of storage capacity in Hontomin. HWU is developing a surrogate modelling toolbox combining Polynomial Chaos expansion and machine-learning for Uncertainty Quantification of $CO_2$ storage capacity. CIUDEN and SOTACARBO completed the FEED study on light drilling. Specific conditions to determine drilling rig applicability at other sites will be defined.
Work package 3. Managing leakage risks for protection of the environment and groundwater	Work package 4. Integration of CO <sub>2</sub> storage with local economic activities
Significant progress has been made in advancing monitoring tools and techniques. Five innovative groundwater monitoring tools have been improved, most are now ready for deployment at field labs. Design of the geophysical sensor array to monitor $CO_2$ migration at the Sotacarbo Fault Lab will be finalised soon. More rapid & responsive surface monitoring tools have been tested at a number of locations. Valuable learnings have been gained from using real world data to inform and constrain modelling work. A successful workshop with $CO_2$ storage site operators was held in Venice.	$CO_2$ -EOR optimization modelling for maximized $CO_2$ storage and oil production was done for the Lbr-1 field. Slim tube tests performed in the laboratory of METU-PAL, Turkey, resulted in minimum miscibility pressure for $CO_2$ with Lbr-1 oil. The design of the $CO_2$ -EOR pilot will be constructed and techno-economic evaluation performed. The Q16-Maas $CO_2$ geological buffer design for re-use in greenhouses was completed. To be complemented by a monitoring plan for the quality of back-produced $CO_2$ and a techno-economic evaluation of the buffer concept.
Work package 5. Coordination with local communities	Work package 6. International cooperation & seeding pilots and demos in Europe
Meetings with citizens took place in the Netherlands and UK in 2018, collecting numerous questions from the public. Researchers are working now to better understand how awareness of social requirements can grow in the expert community. Putting themselves "in the citizens' shoes" requires a strong commitment and time investment. During the 3rd internal WP5 workshop in Rome researchers have developed a fuller insight of how people can feel, when they consider $CO_2$ storage. This is being elaborated to reflect an integrated expert/non expert view in the final guidelines.	Activities of the ENOS Experience-Sharing Focus Groups continued by their second workshop devoted to "Advanced techniques for site characterisation" and the third online webinar focusing on "CO <sub>2</sub> supply, on-site handling and injection strategies for CO <sub>2</sub> storage pilots". More information is available on <u>ENOS website</u> . A successful <u>workshop on onshore</u> <u>CO<sub>2</sub> storage</u> was organised in Tallinn together with BASRECCS, the network of CCS expertise in the Baltic Sea Region. ENOS researchers gave lectures on CO <sub>2</sub> storage at the <u>Petroleum Engineering</u> <u>Summer School</u> in Dubrovnik.
Work package 7. Spreading innovation	Work package 8. Promoting CCS through education and training
The WP7 continues coordinating dissemination and publication actions of the project, updating the <u>ENOS website</u> and preparing the "Best practices". Two last knowledge integration workshops were dedicated to brainstorming and discussions around structure, layout and content of the Best Practices. When ready, the documents will be a focused summaries of the ENOS outcomes aimed at different stakeholder groups such as industry, public, regulators and scientific community. The documents should be available both as a context- rich web version and a downloadable PDF.	The 1st ENOS spring school took place in spring 2018 in the ECCSEL NatLab Latera (Italy) with 15 young participants. The <u>2nd school</u> will be in Hontomin, Spain in May 2019. An up-to-date education tool an <u>E-learning platform</u> with 10 e-lectures grouped in 3 e-books is available for a broader community. One year <u>ENOS Master course</u> hosted by Sapienza and Zagreb Universities will start in February 2020. The 1st event with journalists took place in May 2018. ENOS participated in COP24 associated with CO2GeoNet. WP5 and 8 will be at <u>11th World</u> <u>Conference of Science Journalists</u> , Lausanne 2019.
	<ul> <li>Work package 1. Ensuring safe storage operations</li> <li>An advanced static model of Hontomin site was developed by GEOGREEN with PETREL™ and dynamic model with GEM™ considering temperature and multiphase flow effects. UNNOT modelled the impacts of heterogeneities on CO<sub>2</sub> plume movement using ECLIPSE and INTERSECT<sup>™</sup>. TNO completed reliability, sensitivity and accuracy assessment of the Hontomin seismic network. BRGM conducted a new deep sampling at 1155-1170 m depth in the French Aquitaine Basin. A new velocity model is generated by OGS using the first 3D VSP seismic data. CO<sub>2</sub> is monitored by BGR soil stations and UNIROMA1 new probes.</li> <li>Work package 3. Managing leakage risks for protection of the environment and groundwater</li> <li>Significant progress has been made in advancing monitoring tools and techniques. Five innovative groundwater monitoring tools have been improved, most are now ready for deployment at field labs. Design of the geophysical sensor array to monitor CO<sub>2</sub> migration at the Sotacarbo Fault Lab will be finalised soon. More rapid &amp; responsive surface monitoring tools have been tested at a number of locations. Valuable learnings have been gained from using real world data to inform and constrain modelling work. A successful workshop with CO<sub>2</sub> storage site operators was held in Venice.</li> <li>Work package 5. Coordination with local communities</li> <li>Meetings with citizens took place in the Netherlands and UK in 2018, collecting numerous questions from the public. Researchers are working now to better understand how awareness of social feel, when they consider CO<sub>2</sub> storage. This is being elaborated to reflect an integrated expert/non expert view in the final guidelines.</li> <li>Work package 7. Spreading innovation and publication actions of the project, updating the ENOS website and preparing the "Best practices". Two last knowledge integration workshops were dedicated to brainstorming and discussions around structure, layout and content</li></ul>

### Work package 9. Project management

The annual ENOS General Assembly, Knowledge Integration Workshop & WP meetings took place on 6-9 November 2018 hosted by GBA in Vienna, Austria. The next project meeting is planned for autumn 2019 in Burgos, Spain.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 653718



#### **ENOS** project is recognised by Carbon Sequestration Leadership Forum

At their meeting in Melbourne on 18 October 2018, the Carbon Sequestration Leadership Forum (CSLF) Policy Group formally recognised the valuable contribution of the ENOS project to advancing CO<sub>2</sub> capture, utilisation, and storage technologies. The ENOS project was recommended for recognition by the Technical Group meeting in Venice (April 2018) following a presentation by Marie Gastine (ENOS Coordinator, BRGM). Formal CSLF recognition was subsequently granted by the Policy Group meeting in Melbourne (Figure 5). This raises the visibility of ENOS and places it alongside other high-impact CCS projects. The full list and description of the projects recognised by the <u>CSLF</u> is available at its website.

### ENOS 2nd Spring School on CO<sub>2</sub> Geological Storage 22-29 May 2019, Hontomin, Spain

The overall objective of the ENOS Spring School in Spain is to communicate knowledge, understanding of CO<sub>2</sub> geological storage and aspects of CO<sub>2</sub> required to respond to global climate change. We have an urgent duty to meet the growing demand for a near zero emission. In this pursue, special emphasis will be on the European context. Target group: young scientists, PhD students and post docs with background in geology, engineering and geotechnologies. Master students are considered on free chairs. Deadline for applications: 31 May 2019. After the deadline, ask for free seats. More information www.enosproject.eu/highlights/

#### Niels Poulsen, GEUS

#### **ENOS** webinars

All webinars carried out by the project are available in the highlights section. The last two webinars were focused on "CO2 supply, onsite handling and injection strategies" and "Smart" drilling for CO2 storage sites - reduction of costs". Both were organised as a part of the ENOS Experience Sharing Focus Groups. A new webinar presenting and discussing the Best Practices is in the planning phase for June 2019.

#### Come and talk to us

Many of ENOS researchers will be present on the 14th CO2GeoNet Open Forum (San Servolo Island, Venice, 6-9 May 2019 together with workshops) entitled "Act now for zero emissions". You will also find us on the upcoming TCCS-10 conference in Trondheim on 17-19 June.

#### **ENOS** publications

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ENOS website offers a large variety of scientific and educational materials created by ENOS project. Materials range from "Participating in CO2 Geological Storage Research" aimed at general public to educational e-books and various publications and conference materials available at http://www.enos-project.eu/highlights/ under E-books, publication and conference filters respectively.



#### **ENOS** e-learning courses

\*\* - Associate Members)

Europe: CO2GeoNet

Belgium: GSB-RBINS\*

Croatia: UNIZG-RGNF\*

Czech Geological Survey\*\*

France: BRGM\* (Coordina-

tor), Flodim, Geogreen, IDIL

Czech Republic:

Denmark: GEUS\*

Germany: BGR\*\*

Estonia: TalTechDG\*

Austria: GBA\*

ENOS has produced an up-to-date education tool as an E-learning platform, available for the broader community. It will help to grow public awareness on climate change mitigation actions using CCS. The E-learning is a flexible and convenient educational method, providing a wider community of users with learning materials. It can be accessed at any time and place allowing users to learn at their own pace. ENOS 10 e-lectures are grouped into 3 e-books covering the following topics:

Climate change and importance of CCS technology for decarbonisation of energy and industry - Geosciences applied to geological storage of CO<sub>2</sub>

- Regulatory and social aspects of CCS technology

List of ENOS partners (\* - Members of CO<sub>2</sub>GeoNet,

Italy: NHAZCA, OGS\*

Sapienza University of Rome\*, Sotacarbo

Romania: GeoEcoMar\*

Norway: NORCE\*

Slovakia: SGUDS

Slovenia: GEOINZ\*

**Spain**: CIEMAT, CIUDEN\*, IGME\*

UK: BGS\*, Heriot Watt University\*, Silixa, University

The Netherlands: TNO\*

Turkey: METU-PAL\*

of Nottingham

Stefan Knopf & Dorothee Rebscher, BGR Niels Poulsen, GEUS

Figure 5. Didier Bonijoly (left), BRGM, France and Sergio Persoglia (right), Secretary General CO2GeoNet, of receiving the Recognition Award from Steven Winberg, Policy Group Chair courtesy P. Deiana, CSLF Policy (photo ËNEA).



ENOS

partners

brqm

BGR































BGN

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Design, layout and computer typesetting: Kazbulat Shogenov