

Introduction on GEOCHEM's activity R&D – Petrophysical laboratory – Sales – Service



Ferenc Fedor, PhD, MBA

Owner, CEO

COSVIG-CAPES meeting, 28-29.06.2022



Ferenc FEDOR, PhD, MBA – geologist engineer

Experience: CEO – GEOCHEM, Sycamore R&D Expert – GINOP-2.2.1 Geothermal Project – Univ. Pécs Formerly lecturer – Univ. Pécs, Szeged, Miskolc

Social activity: President – CAPES Chairman – Hungarian Geol. Soc. – Geomatematical Section Membership in National and International Associations (AAPG, SPWLA, ICCP, HGS, Eng. Chamber, H. Academy of Science' subcommities, H. Chamber of Commerce and Industry P-B, H. Mining and Metallurgical Soc.)

Expert activity: EURGEOL, Eng. Chamber, H. Geol. Service

Practice:

Petrophysics, LLW/ILW and HLW disposal project, geothermal and other R&D, equipment development (Smartlab)





- GEOCHEM was established in 2003 (2006).
- Located in Hungary, Central-Europe.
- Our R&D activity is focused mainly on:



- complex laboratory investigation of different materials, i.e very tight and unconsolidated rocks, concretes
- special instruments, equipment and methodological development, Smartlab
- Our measurement and development services are demanded in the fields of geology, like hydrocarbon and raw material exploration, geothermal energy research, radioactive and hazardous waste disposal.
- MSZ EN ISO 14001 Environmental Management System and the MSZ EN ISO 9001 Quality Management System. Temperature, humidity and ambient pressure are controlled separately in each laboratory room. Safety of continuous power supply is supported by Riello MST-80 UPS and standby DPG 150 diesel generator.
- Member of the Cluster of Applied Earth Sciences







OUR SERVICES

- Reservoir qualification
 - Acoustic velocity measurement SRL-A1000
 - Reservoir state permeability measurement RS-PPD-1
 - Gas permeability measurement Coreval-700
 - Measurement of electrical properties EPS 700
 - Relative permittivity measurement
- Pore structure investigation
 - Porosity and density measurements gas pycnometer Pentapyc 5200e
 - Pore size distribution measurement mercury-porosimeter Poremaster-60 GT
 - Physisorption-, microporosity measurement Autosorb-<u>1-MPV</u>
- Grain size/shape analysis-sedimentology
 - Particle size distribution measurement CILAS 1180 LD
 - OCCHIO Zephyr ESR
 - ISO/ASTM Sieve analysis











OUR SERVICES

- Drilling & Stimulation Properties (joint operation with Mecsekérc)
 - Gravel pack testing system self designed
 - Fracture conductivity measurement system self designed
 - Leak-off measurement system self designed
 - Proppant qualification (ISO 13503-5)
 - HPHT mud/gel viscosity CHANDLER 5550
- Aging
 - Benchtop Temperature Humidity Test Chamber (Xi'an LIB)
- Sample preparation
 - Drilling, end-facing, embedding, drying, 3D scanning, etc.
- Product, method and software development (R&D)
 - Cryodesiccation
 - Smartlab
 - Artificial cores
 - MEIST3D





Smart Reservoir Lab

a new concept of global petrophysical laboratory service



Problems with traditonal laboratory service and future activities

Transportation need

permits

problems during transportation (phyiscal and chemical changes, dustiness, dilapidation) Qualified staff need

Time-consuming (3-6 months)!

New frontiers of exploration and production

- Unconventional resources (H2, CO2, petroleum, outback, seafloor)
- Automation (cobots, machine learning, AI, big data)
- Principles: Industry 4.0, "Design as you go"
- Environmental protection (using renewable energy, less chemicals)

Using only geophysics, remote sensing – lack of real data (calibration, upscaling)!



The SmartLab concept

On-site laboratory service anywhere

Fully automized (first time a technician need for maintenance using expended reality tool, next step robotization and AI)

VR/AR tools for education and service

Sustainability

Energetically independent (solar, wind, accumulator)

Chemicals not need (water, air, nitrogen from surroundings)

Data transportation via secure satellite internet to Geochem Laboratory Interpretation by experts living anywhere in the world (i.e. CAPES members) Payment via internet.

Time-saving service (1-5 days)!

Concentrating on non-conventional exploration Complement geophysical and remote sensing activity (calibration, upscaling)



Smart Reservoir Lab - The Solution, all-in-one

Reservoir state measurements in one automized step – porosity, permeability, acoustic velocity, electric resistance (later induced polarization tomography), thermal conductivity (and later diffusivity) using water or gas. SRL needs only 4 m² area instead of 100 m² reservoir laboratory.

First and second realizations





Smart Reservoir Lab software background

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Artificial cores

Products made only from natural materials

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MEIT3D

Multifrequential electronic impedance tomography

Reservoir state measurement (500 bar, 150 oC) 0.01-89.99 KHz, 240 electrodes, (8x multiplex)

Development (prototype, methodology) is on progress (2021-24)

The goal: Laboratory injection/production tests for EOR, flooding simulation Visualisation of 3D flow of pore fluids



Our Services – *Core description and sample preparation*









Our Services – *Reservoir qualification*

- Acoustic velocity measurement SRL-A1000
- **Permeability measurement** RS-PPD-1
- **Permeability measurement** Coreval-700
- Measurement of electrical properties EPS 700







Our Services – *Reservoir qualification*

• **Reservoir-state permeability measurement** – RS-PPD-1











Our Services – *Reservoir qualification*

• Gas permeability measurement – Coreval-700









Our Services – Reservoir qualification: Electrical measurements

- Acoustic velocity measurement SRL-A1000
- **Permeability measurement** RS-PPD-1
- **Permeability measurement** Coreval-700
- Measurement of electrical properties EPS 700









Our Services – Pore structure investigation

- **Porosity and density measurements** gas pycnometer -Pentapyc 5200e
- Pore size distribution measurement mercury-porosimeter
 Poremaster-60 GT
- Physisorption-, microporosity measurement Autosorb-1-MPV









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Our Services – Grain size and shape analysis-sedimentology













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R&D activity – Product, method and software development

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R&D activity – *Product, method and software development*





Drilling & Stimulation Properties – Rheological characterisation

• Chandler Instruments – Model 5550 HPHT Viscometer

Max. Pressure	2,000 psi / 14 MPa
Max. Temperature	500 °F / 260 °C
RPM / Shear Rate	0,1-1000 rpm with standard R1 rotor and B5 bob
Shear rate accuracy	+/- 0,01 rpm
Tech standards	ISO 13503-1, API RP 39



● 90°C ● 75°C ● 60°C ● 45°C ● 30°C



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Drilling & Stimulation Properties – Formation Damage Evaluation and Simulation

• Formation damage testing (with gravel packed core holder)

Pore pressure:	max. 400 bar
Confining pressure:	max. 1000 bar
Differential pressure on	max 30 bar
rock:	
Temperature:	max. 150 °C
Liquid inflow speed:	1-60 cm³/min
Core sample-1:	\varnothing 1-1,5"x50-200 mm with 3 core holders
Saturation:	water and oil saturation is provided with a pump
	sandstone,
Sample arrangements:	sandstone+proppant+filter
	sand+proppant+filter.
Filter:	wire filter, d ₅₀ ≈5*D ₅₀
Flow:	two way
Turning and rotating of core	
holder	









Drilling & Stimulation Properties – Proppant conductivity evaluation system

• Fracture Conductivity Measurement

Max. Loading	650 kN (~ 1000 bar fracture closure stress)
Max. Temperature	300 °F / 150 °C
Max. Pore Pressure	70 bar
Tech standards	ISO 13503-5:2006, API1 RP-612











Drilling & Stimulation Properties – Proppant qualification

ISO 13503-2: Measurement of properties of proppants used in hydraulic fracturing and gravel-packing

- Sieve analysis
- Proppant sphericity and roundness
- Acid solubility
- Turbidity test
- Bulk density, apparent density and absolute density
- Crush–resistance test









Drilling & Stimulation Properties – Dynamic leak-off measurement system

• Dynamic leakoff test apparatus

Max. Pore Pressure	2,000 psi / 14 MPa
Max. Confining Pressure	7,250 psi / 50 MPa
Max. Temperature	300 °F / 150 °C
Shear rate in the cell	40 / sec
Max. shear rate in the shear history simulator	~ 3000 / sec





Petroleum and natural gas industries. Completion fluides and materials. Part 6: Procedure for measuring leakoff of completion fluids under dynamic conditions (ISO 13503-6:2014)



Sales & Services

GECHEM









MAIN REFERENCES:

Low and intermediate level radioactive waste repository (Bátaapáti, Hungary)

- 2015-2016: Porosity and water conductivity measurements on concrete structures, related to the construction of the Bátaapáti National Radioactive Waste Repository, Mecsekérc Plc, RHK Ltd.
- **2011-2012:** Measurement of porosity and water permeability of the built-in shotcrete in K1 chamber in the Bátaapáti National Waste Repository in the framework of the contract with Bátatom Ltd.

Site investigation for the final disposal of high level radioactive wastes (Boda Claystone)

- **2014-** : Geological investigation of the Boda Claystone Formation (BCF). Surface research phase I, 2. stage: professional documentation and reports, petrophysical measurements, Mecsekérc Plc.
- **2012:** Data supply, complementary petrophysical measurements and their interpretation related to Boda Claystone Formation for the project of Mecsekérc Ltd. (GOP-1.3.1-11/A-2011-0098, "Preparation of a Complex Transport Model and its Application in West Mecsek"
- 2008-2011: Petrophysical investigations, participation in BCF (Boda Claystone Formation) research, preparation of studies, Mecsekérc Plc.

Paks II Nuclear Power Plant Expansion, Hungary

• **2016:** Petrophysical investigation of core samples related to the preparation of future nuclear power plant blocks in Paks, Mecsekérc Plc, MVM Paks II. Nuclear Power Plant Development Ltd.



MAIN REFERENCES:

Petroleum Industry – Upstream

- 2019 2020: Petrophysical investigations on reservoir rocks for MOL
- **2014 2015:** Petrophysical investigations on reservoir rocks for RAG Kiha Ltd.
- 2011: Data supply, laboratory measurements related to the geological assessment of concession areas (Algyő Formation), Geological Institute of Hungary

Petroleum Industry – Downstream

• **2014-2015:** Production of active pellets from petroleum coke for the purpose of binding hydrogen sulfide, MOL Group

Geothermal research:

- **2012-2014:** R&D work related to Mecsekérc Plc's GOP-1.1.1-11-2012-0033 project (petrophysical qualification of Upper Pannonian core samples, investigation of migrating clay content, the determination of best practices of well completion in unconsolidated sandstones, etc.)
- 2017- : R&D work related to Mecsekérc Plc's GINOP-2.2.1 project (petrophysical qualification of Upper Pannonian core samples, investigation of migrating clay content, the determination of best practices of well completion in unconsolidated sandstones, etc.)

Other projects:

- **2013-2014:** Physisorption and BET analysis of soil samples, MTA Research Centre for Astronomy and Earth Sciences
- 2013-2014: Grain size distribution measurement of sea sediment samples by dry and wet sieving and laser diffraction method, Biokör Ltd.
- **2011-2012:** Laboratory analyzes and development connecting to CBM and UCG project, Mecsek Mountains, Hungary, Wildhorse UCG Kft.
- **2010-2012**: Professional consulting service for the construction of a petrophysical laboratory in the framework of a complex laboratory investment, ALT-ENERGO Invest Ltd.
- 2011-2012: Laboratory measurements related to extraction of coal-bed methane and completion of necessary developments
- 2003-2004: Raw material research (precious ore research) in the English-Irish owned EASTMINE Mining Ltd. in the Mátra hill



Main publications:

FEDOR, F., MÁTHÉ, Z., ÁCS, P., KORONCZ, P.: *New results of Boda Claystone research - genesis, mineralogy, geochemistry, petrophysics,* chapter in in: NORRIS, S., NEEFT, E.A.C. & VAN GEET, M. (eds) Multiple Roles of Clays in Radioactive Waste Confinement. Geological Society, London, Special Publications, 482, https://doi.org/10.1144/SP482.13

KORONCZ, P., LEMBERKOVICS, V., ÁCS, P., FEDOR, F.: Pore characterization, acoustic and permeability measurements on core plug triplets, from the Miocene Tótkomlós (Calcareous Marl) Formation of the Pannonian-basin, Hungary, Geologica Croatica, vol.70/2., 2017, pp. 87-92 (ISSN 1330030X)

KORONCZ, P., FEDOR, F.: *Complex petrophysical investigation of pannonian-miocene shales – preliminary results of acoustic anisotropy measurements,* 35th IGC, Instrumental, experimental and laboratorybased developments in the Geosciences, 31.08.2016, Cape Town, SA

KORONCZ, P., FEDOR, F.: *Experimental investigation of stress-dependent petrophysical behaviour of reservoir rocks,*, in Cvetkovic, M., Novak-Zelenika, K., Horváth, J., Hatvani I.G. (eds) Geomathematics – present and future of geological modelling, Croatian Geological Society, 2016, pp. 83-87 (ISBN 978-953-59036-1-1)

HORVÁTH, J., KORONCZ, P., FEDOR, F.: *Petrophysical and hydrodinamical investigation of unconsolidated rocks – measurement vs. empirical estimation*, in: Cvetkovic, M., Novak-Zelenika, K., Geiger, J. Geomathematics – from theory to practice, Croatian Geological Society, 2014, pp. 167-174



Thank you for your kind attention!

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