Lithium and other CRM related projects in the University of Miskolc

Norbert Németh

University of Miskolc

Institute of Mineralogy and Geology

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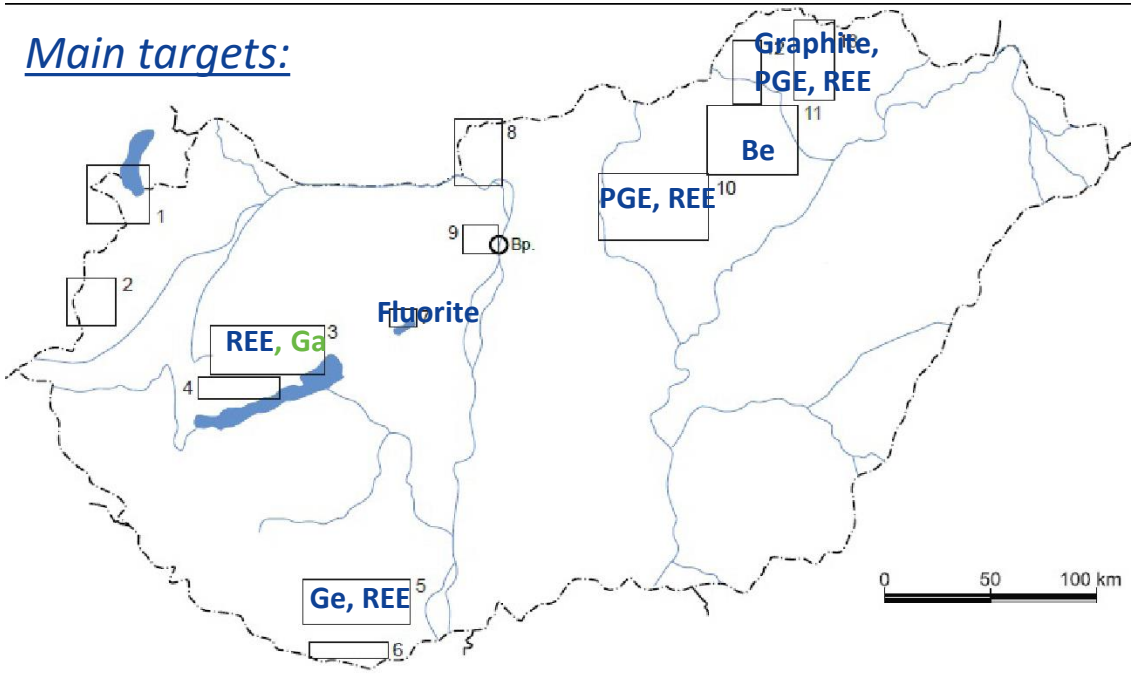
CriticEl – assessment of the critical raw material potential of Hungary

- **Homepage:** http://kritikuselemek.uni-miskolc.hu
- **EU 2010:** 14 CRM: Antimony, Beryllium, Cobalt, Fluorite, Gallium, Germanium, Graphite, Indium, Magnesium, Niobium, Tantalum, Platinum group elements (PGE: Pt, Pd, Ir, Rh, Os, Ru), Rare Earth Elements (REE: Lanthanides, Y, Sc), Tungsten

Main targets:



- **UM 2012-2014:** gathering and processing of archive data, sampling and analysis of known resources (incl. secondary resources)
- **Results:** CriticEl Monography Series (9+1 volumes)

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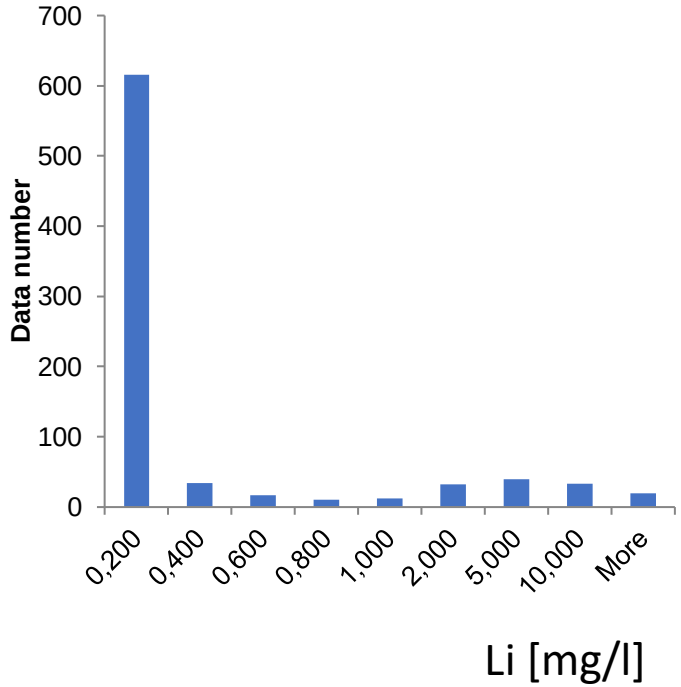
Water chemistry related additional work

- **1991, Department of Mineralogy and Petrology**
- **R&D assignment from the Hungarian Geological Institute**
- **Accessible wells, springs of Hungary; thermal water, brines**
- **Atomic absorption analysis**
- **812 samples with Li analysis**



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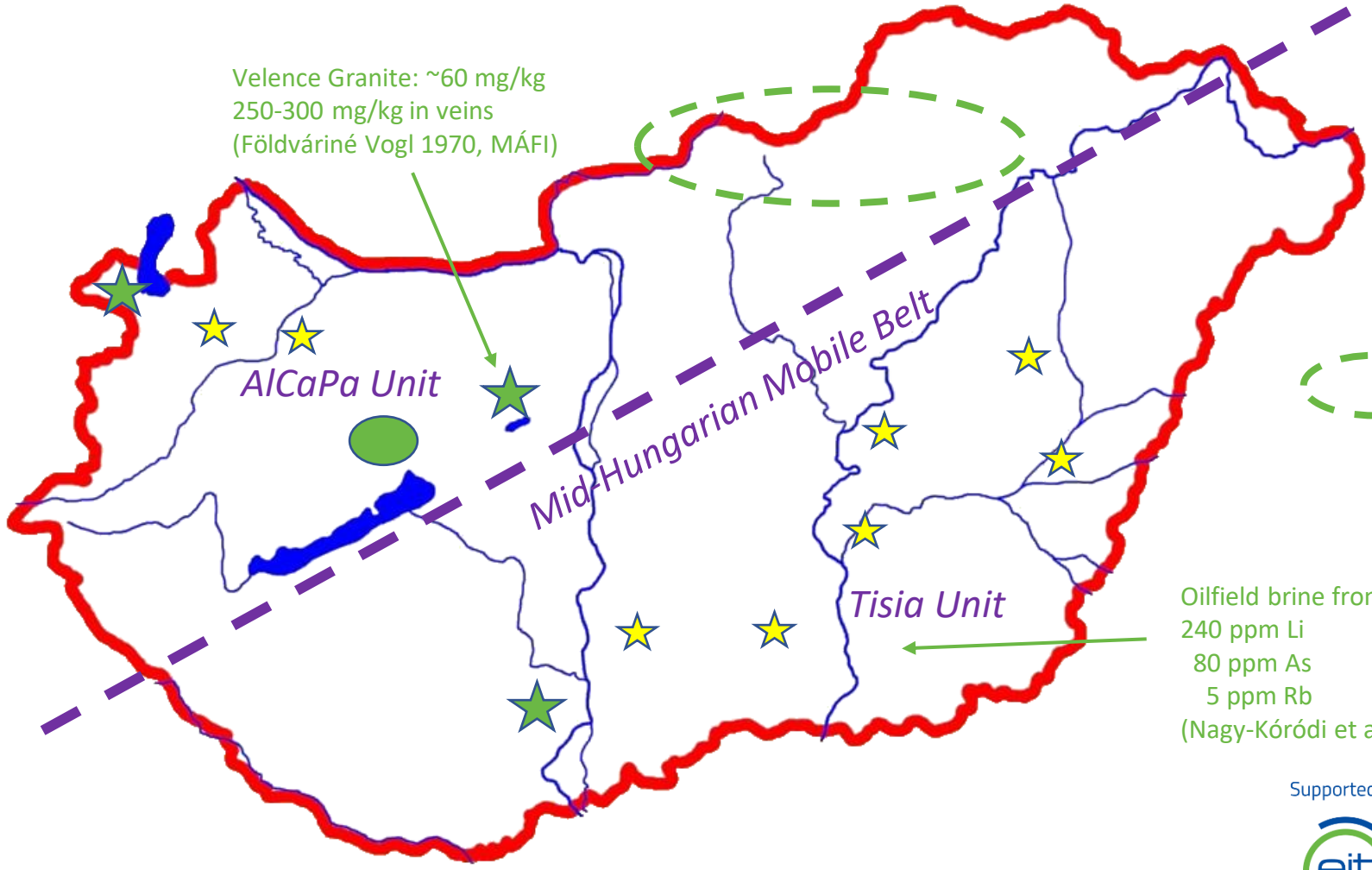
Potential lithium resources in Hungary



Granitic and gneissic rocks

Bauxite and manganese deposits

Early Miocene intramontane basin + rhyolitic tuffs

Li-rich brines (10-50 mg/l)

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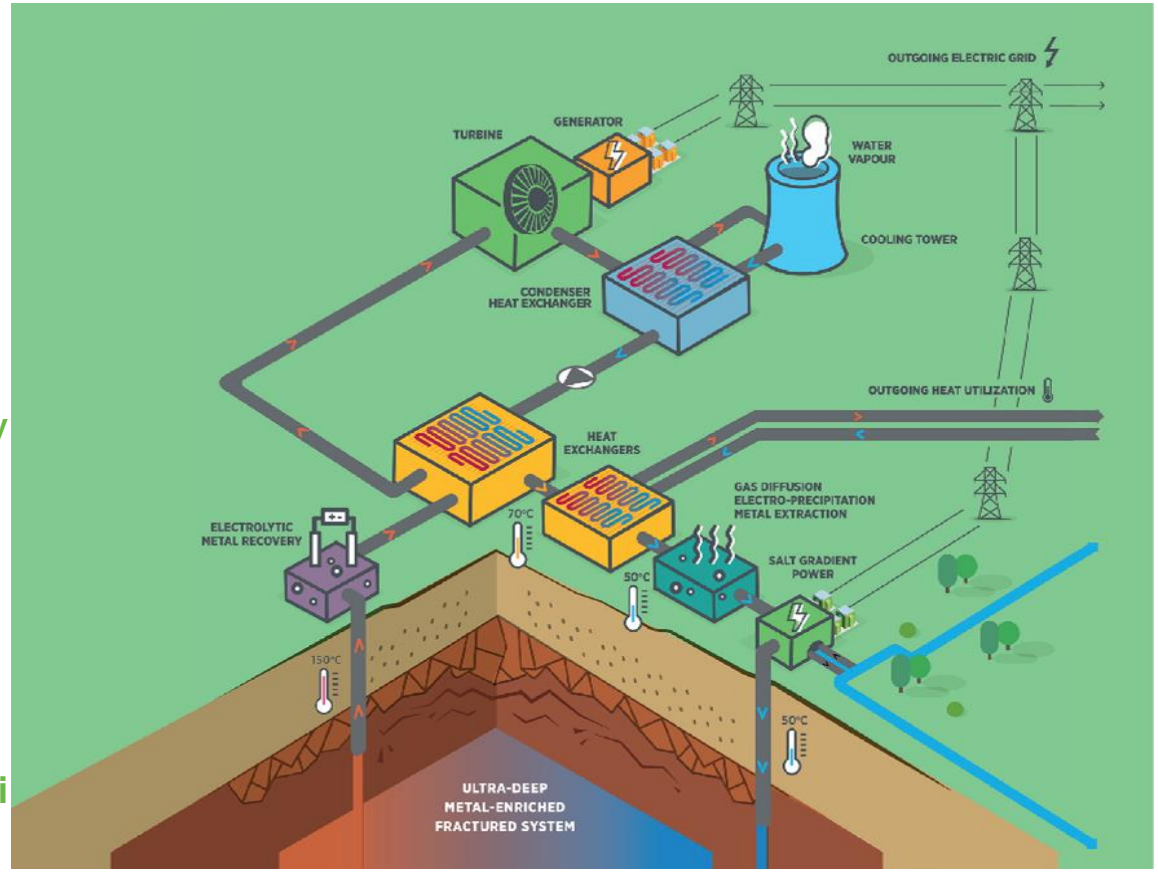
CHPM – Combined Heat, Power and Metal extraction from ultra-deep bodies

- **Homepage:** https://www.chpm2030.eu
- **Horizon2020, 2016-2019**
- **Partners:**
  - University of Miskolc, Faculty of of Earth Science & Engineering, *Hungary*
  - University of Szeged, *Hungary*
  - European Federation of Geologists / EFG
  - Iceland GeoSurvey / ISOR
  - Natural Environment Research Council / NERC, British Geological Survey / BGS
  - Laboratório Nacional de Energia e Geologia / LNEG, *Portugal*
  - Vlaamse Instelling voor Technologisch Onderzoek / VITO, *Belgium*
  - La Palma Research Centre S.L. / LPRC, *Spain*
  - Agency for international mineral policy / MinPol
  - Geological Institute of Romania / IGR
  - KU Leuven, Dept. Materials Engineering, *Belgium*
  - Geological Survey of Sweden / SGU
- **Working example:** EuGeLi project, Soultz-sous-Forêts, ~140 ppm Li



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CHPM – 2016-2018

- Europe's mineralised regions were screened in terms of their EGS potential.
  D1.1 EGS-relevant review of metallogenesis
- The mineralisation and the geothermal potential of the four study sites in Portugal, Romania, Sweden and the UK were studied.
  D1.2 Report on data availability – compiled from 5 reports
- The EGS-relevant geochemical and rock mechanical properties of the ore bodies were defined.
  D1.3 EGS-relevant review of orebody structures
- A conceptual framework for the orebody-EGS was formulated.
  D1.4 Conceptual framework for orebody-EGS
- **A 3D stochastic fracture model was built and the extractable amount of heat and metallic minerals in different scenarios were defined. Recommendations were provided for the integrated reservoir management.**
  D2.1 Recommendations for integrated reservoir management
- **It was proved that relatively 'mild' leaching agents were capable of liberating metals into the recirculating fluid within an EGS.**
  D2.2 Report on metal content mobilisation using mild leaching
- **It was proved that surface modification of nanocarbon particles allowed metals to be adsorbed, both in acid and alkaline pH regions.**
  D2.3 Report on metal content mobilisation with nanoparticles
- **The overall system dynamics were defined and data for environmental assessment were provided.**
  D2.4 Report on overall systems dynamics

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CHPM – 2018-2019

- It was proved that metals can be successfully electrodeposited at elevated pressure and temperature (up to 300 °C and 238 bar); higher pressures and temperatures lead to higher recovery rates.
  D3.1 Report on performance and design criteria for high-temperature, high- pressure electrolysis
- It was proved that gas-diffusion electroprecipitation and electrocrystallization (GDEx) is a novel way to recover metals from dilute solutions. The patent of this process has been granted in Europe. It was proved that GDEx allows nearly full recovery of the relevant metals present, and selectivity can be achieved. The GDEx experiments are up-scalable and work for most of the critical raw materials. Preliminary economic feasibility calculations show positive results.
  D3.2 Report on performance, mass and energy balances and design criteria for gas-diffusion electroprecipitation and electrocrystallization
- It was proved that the presence of multivalent ions in the geothermal brine does not eliminate the potential for salinity gradient power generation by reverse electrodialysis (SGP-RE), though a reduction in power was noted. However, the extraction of electrical energy was enhanced significantly by increasing the brine temperature.
  D3.3 Report on performance, energy balances and design criteria for salt gradient power reverse electrodialysis
- A mathematical model framework was created based on the technology component-level models, which enables linking downstream and upstream geothermal engineering subsystems.
  D4.1 Conceptual framework for CHPM power plant
- The overall model can be used to study different scenarios, perform simulations, and develop optimisation and other kinds of system analysis.
  D4.2 Report on CHPM process optimisation

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CHPM – 2018-2019 continued

- A decision support tool has been developed for the economic feasibility assessment allowing users to simulate revenue streams from both energy and metal extraction levels. The tool will remain accessible after the project lifetime through the MinPol website.
  D5.3 Self-Assessment Tool
- Best practices have been suggested to companies planning to run CHPM plants for minimising the social and environmental impacts of the technology.
  D5.5 Environmental impact assessment framework
- A wide array of convergent technologies and relevant issues were defined (linked to CHPM exploration, development, operation and market) that can support the implementation of the technologically challenging CHPM scheme by 2030/2050.
  D6.1 Report on Emerging and Converging Technologies
- Detailed studies on the potential pilot sites and European-level databases provide the foundations for the implementation of pilot CHPM projects by 2030.
  D6.2 Report on pilots – compiled from 5 reports
- Roadmaps for the implementation of future CHPM projects have been provided for 2030 and 2050 time horizons, including actions, targets and milestones.
  D6.3 Roadmap for 2030 and 2050

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REFLECT – Redefining geothermal fluid properties at extreme conditions

- **Homepage:** www.reflect-h2020.eu
- **Horizon2020, 2020-2022 – continued as CRM Geothermal from 2022**
- **Partners:**
  Helmholtz Centre Potsdam – German Research Centre for Geosciences / GFZ, Germany
  United Kingdom Research and Innovation / UKRI, UK
  Bureau de recherches géologiques et minières / BRGM, France
  European Federation of Geologists / EFG
  Institutt for energiteknikk / IFE, Norway
  Pfalzwerke Geofuture GmbH / PGF, Germany
  Université de Neuchatel / UNINE, Switzerland
  Islenskar Orkurannsoknir / ISOR, Iceland
  University of Miskolc, Hungary
  Izmir Institute of Technology / IZTech, Turkey
  Technische Universiteit Delft, Netherlands
  Landsvirkjun Sameignarfelag / LVK, Iceland
  Hydroisotop GmbH Laboratorium zur Bestimmung von Isotopen in Umwelt und Hydrologie, Germany
  Nederlandse organisatie voor toegepast natuurwetenschappelijk onderzoek, Netherland
- **Fluids used for generation of electricity (> 100 °C) + heating (> 50 °C)**
- **European Fluid Atlas: Data of reservoirs, wells, fluid and rock samples**
- **Sampling sites:** Austria, France, Germany, Iceland, the Netherlands, Turkey, England
- **Final conference:** 19th October 2022 as a side-event of the European Geothermal Congress 2022 in Berlin, Germany

- **Sources:** REFLECT webinar, 17th March 2022; REFLECT DELIVERABLE D3.1: Report on the collection of data on geothermal fluids at a European level

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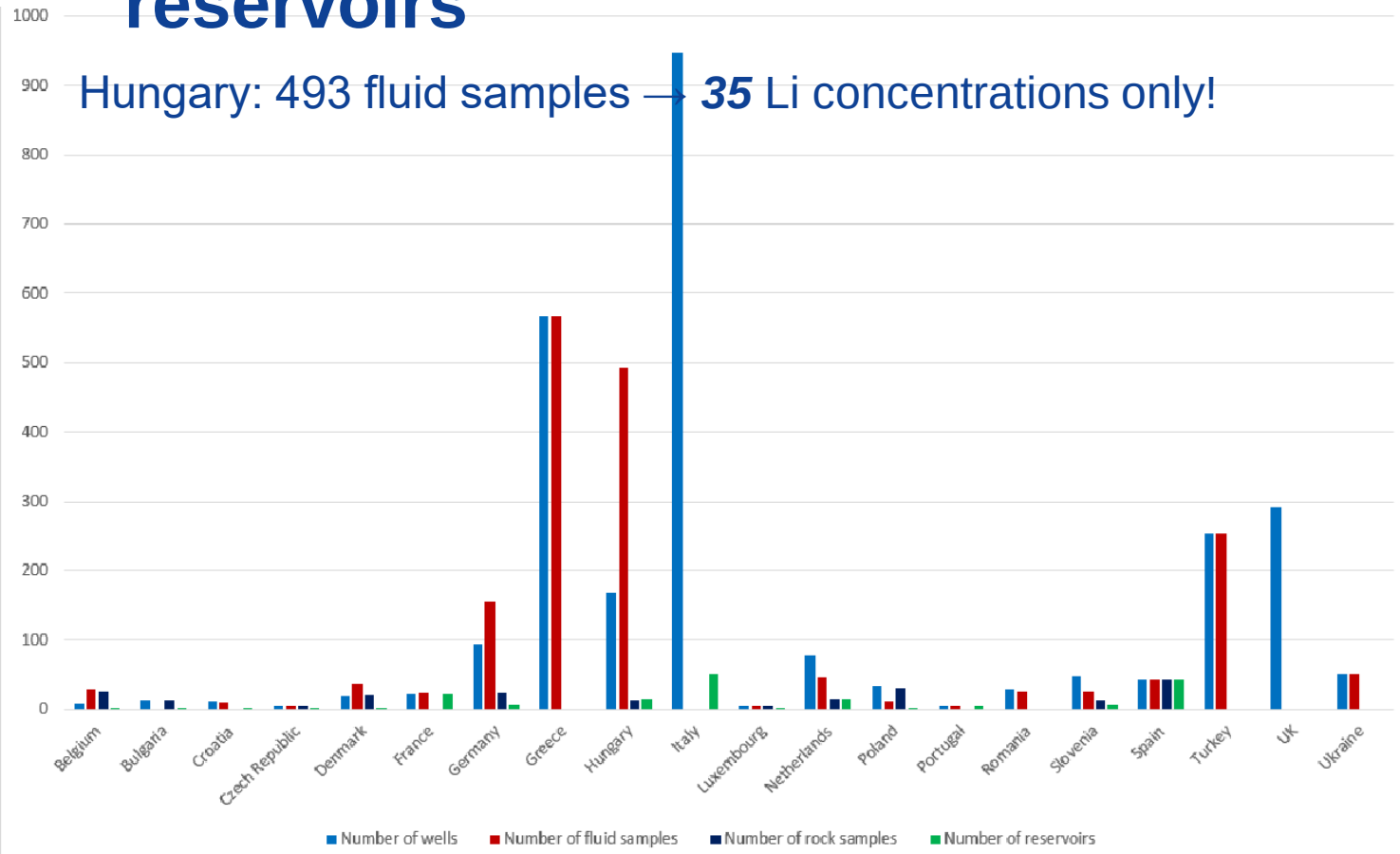
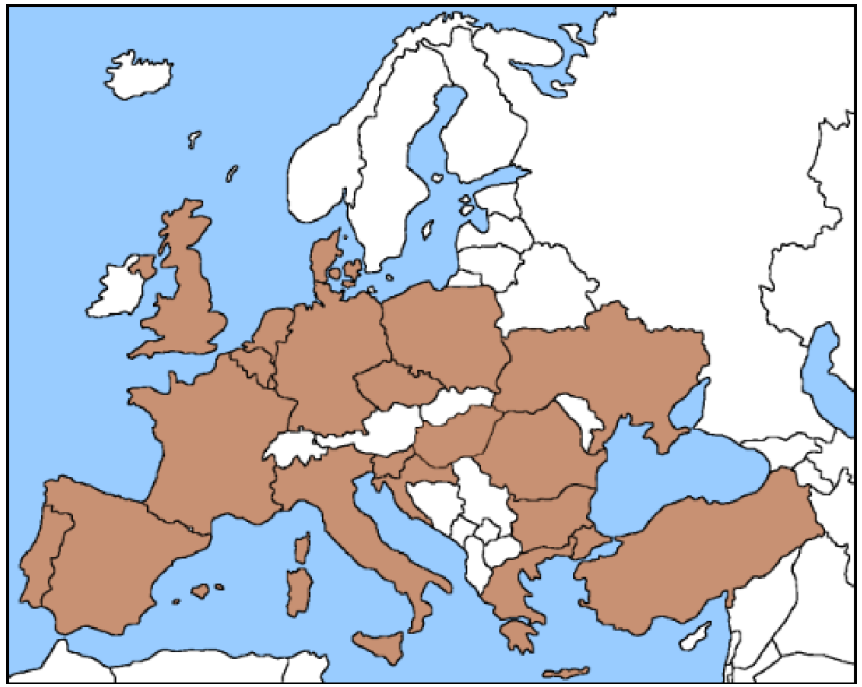
REFLECT – European Fluid Atlas

- **2691 wells, 1784 fluid samples, 210 rock samples and 175 reservoirs**

Hungary: 493 fluid samples → ***35*** Li concentrations only!





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