

EPFL

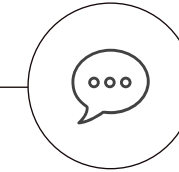


The Laloui Group

2023



— **LYESSE LALOU**
DIRECTOR



DEAR READERS,

I am delighted to present The Laloui Group in brief for 2023 as we continue to grow and adapt our skills and services to the needs of our funders, partners, and the broader community.

Our geotechnical expertise is well recognized across industry and academia and this recognition has allowed us to continue to expand our portfolio of projects with new and well-established partners alike.

I am grateful to these partners, our team members, and other stakeholders for their support and hard work to ensure we remain at the pinnacle of geotechnical research, education, and technical expertise. I thank you for your ongoing interest and continued support of our endeavours, and I look forward to exploring how we can work with you and your team in the near future.

LYESSE LALOU

about us

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WHO WE ARE

The Laloui Group is a world-leading geotechnical research center based at EPFL in Lausanne, Switzerland. Led by Professor Lyesse Laloui, one of the world's top-ranked scientists in engineering and technology, the group develops and utilizes the latest research, education, and technology transfer approaches to provide us and our partners with the tools and technology needed to help our global society and environment adapt and thrive in the 21st century.



OUR MISSION

We strive to develop and provide innovative geotechnical solutions for a sustainable future.



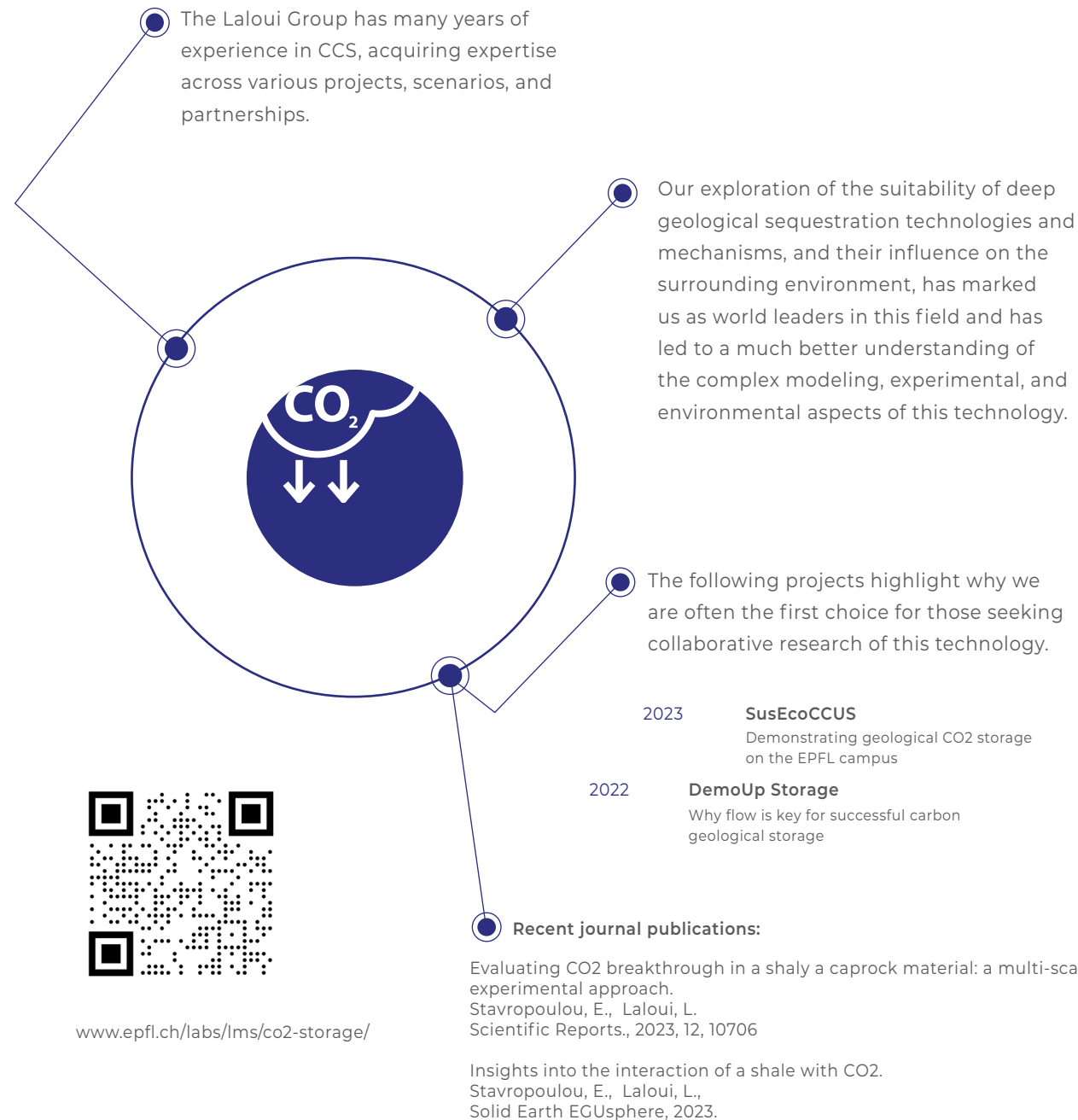
WHAT WE DO?

The Laloui Group is a globally renowned center for geotechnical research, education, technology transfer, and industry services providing a range of services to academic, corporate, and government clients, with a focus on research, education, technology transfer, and industry support.

I RESEARCH LINES

CO₂ storage

CO₂ CAPTURE AND STORAGE (CCS) HAS THE POTENTIAL TO BE A GAME CHANGER IN REDUCING THE IMPACT OF CO₂ ON CLIMATE CHANGE



project

SusEcoCCUS

DEMONSTRATING GEOLOGICAL CO₂ STORAGE ON THE EPFL CAMPUS

At the heart of much of what the Laloui Group does lies our desire to provide technical solutions for our world's growing environmental and sustainability challenges. One of our latest projects is Energy-efficient Carbon Capture, Usage, and Storage for a Sustainable and Circular Economy (SusEcoCCUS).

Working with the EPFL Valais campus, this CHF 9 million project funded by EPFL's 'Solutions4Sustainability' fund, aims to develop a closed (CCUS) loop on campus, including demonstrators and solutions ready for scale-up.

EPFL
SOLUTIONS 4
SUSTAINABILITY



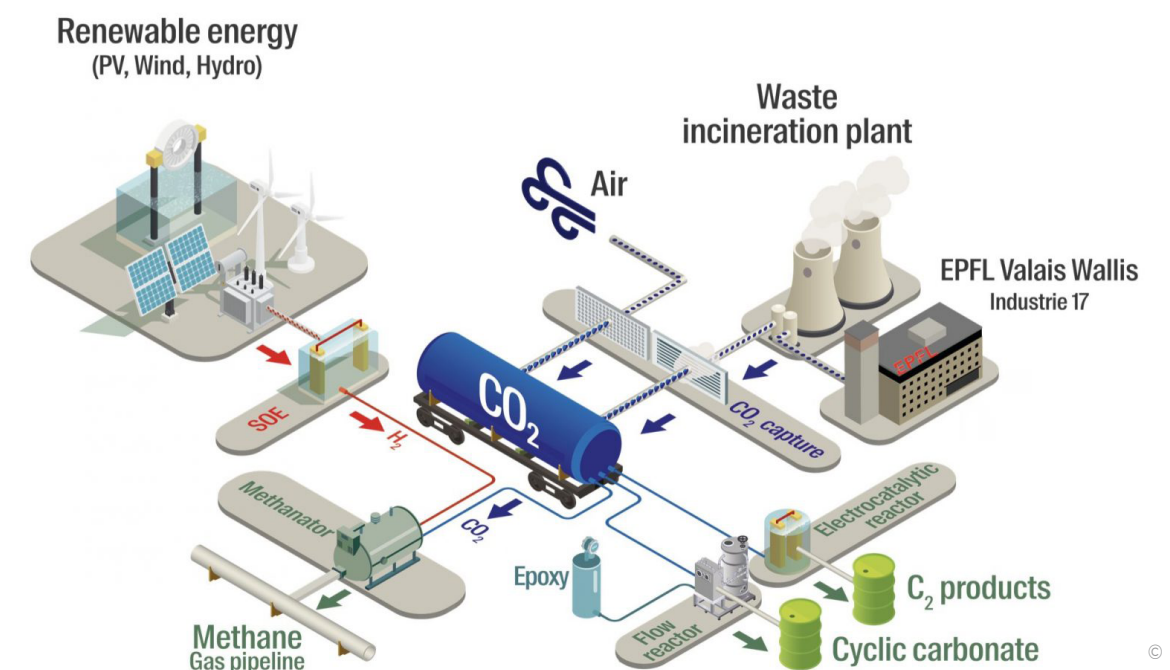
Eleni Stavropoulou
Scientist



Lyesse Laloui
Full Professor

Under the direction of Dr. Eleni Stavropoulou, the Laloui Group is leading the CO₂ storage activities of this ambitious project by developing a unique, meter-scale geological CO₂ storage experiment which will enable, for the first time, a tangible link between lab, often at millimetric scales, and field at kilometric scales.

The objective is to improve our understanding of the multi-physical processes that take place between the different geomaterials (reservoir, cap rock) and the injected CO₂ which in turn will significantly strengthen the numerical models being developed, for future GCS selection sites including in Switzerland.



www.epfl.ch/labs/lms/co2-storage/

project

DemoUp Storage

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Federal Office of Energy SFOE
Federal Office for the Environment FOEN



Eleni Stavropoulou
Scientist



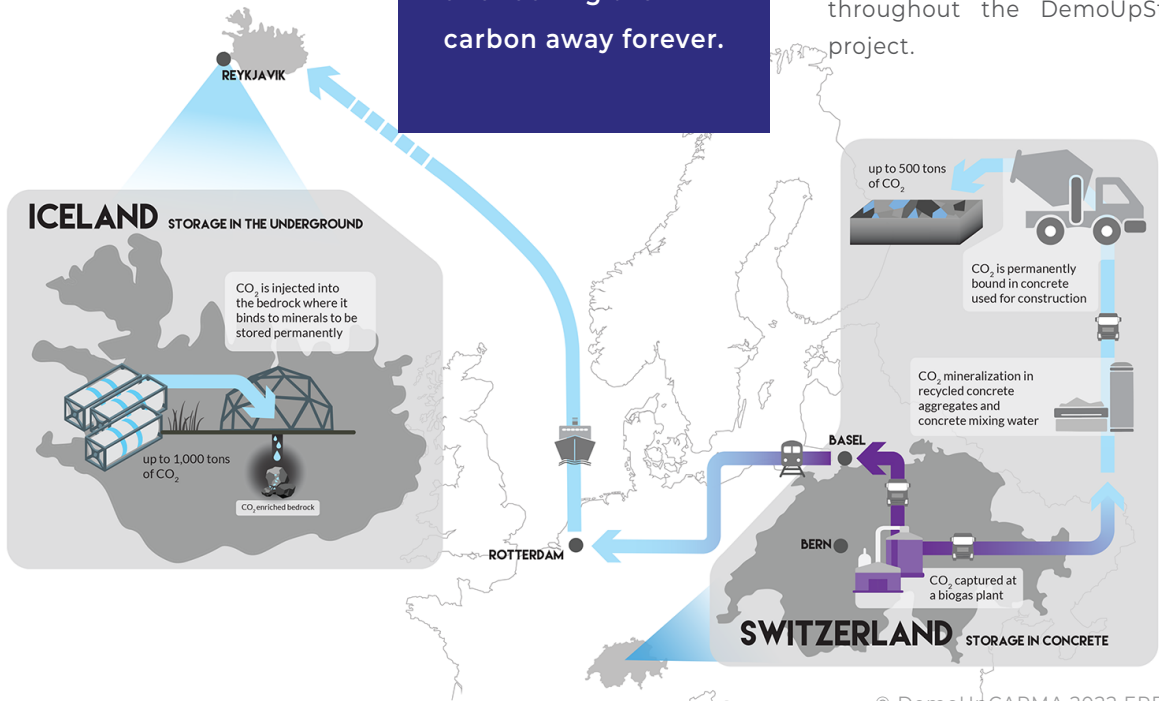
Lyesse Laloui
Full Professor

WHY FLOW IS KEY FOR SUCCESSFUL CARBON GEOLOGICAL STORAGE

The Laloui Group's expertise in the hydromechanical characterization of geomaterials and microstructural analysis was again highlighted when the Swiss Government asked the Group to provide a mineralogical, petrophysical, and hydromechanical characterization of field cores from their carbon storage project in Iceland.

Known as
DemoUpStorage,
the project aims to
demonstrate that
over time, CO₂ will
be permanently
stored within
the basaltic
repositories through
mineralization,
turning it into stone
and locking the
carbon away forever.

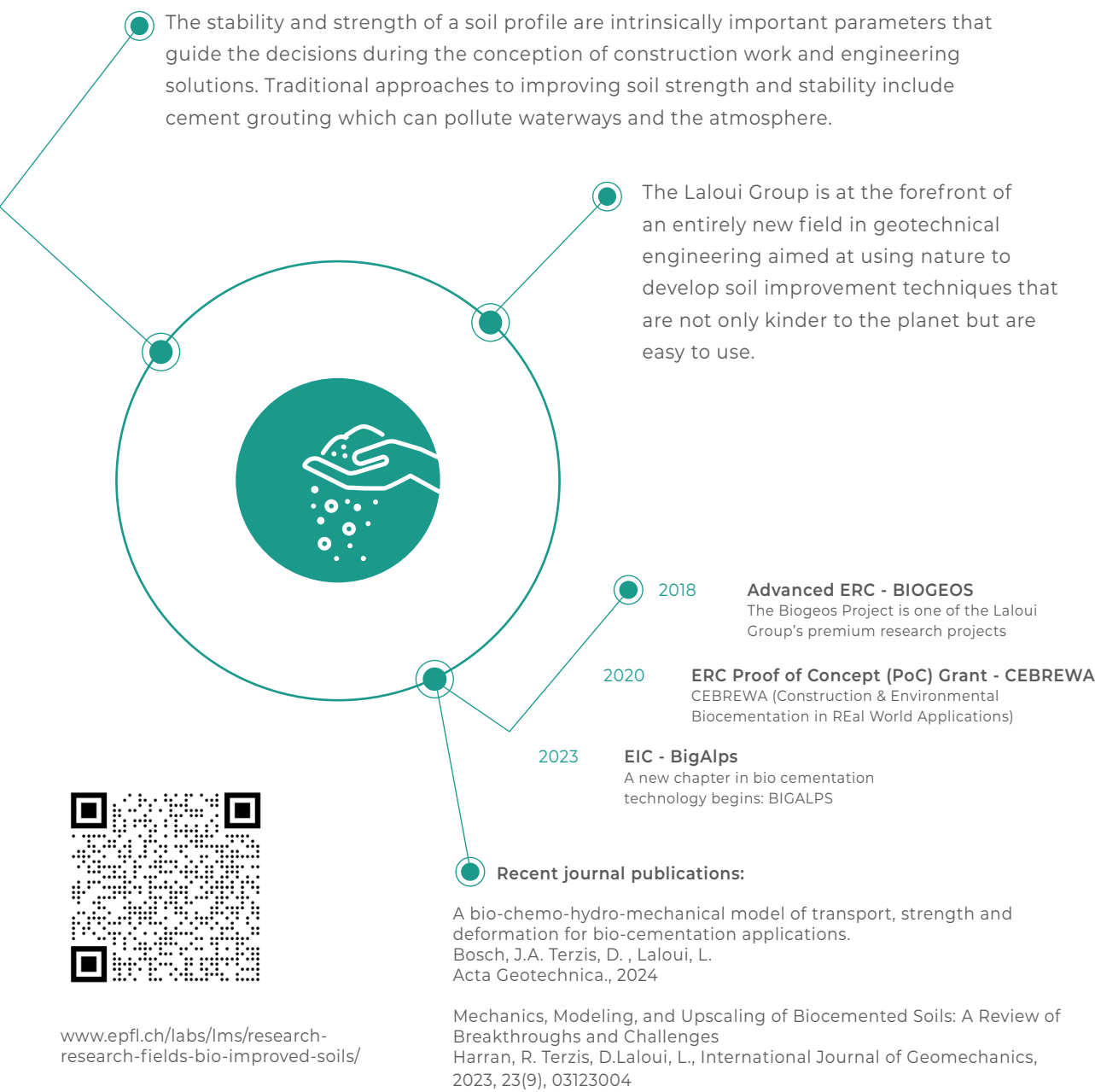
Under the direction of Dr. Eleni Stavropoulou, the team has been exploring the interplay between flow and carbon mineralization using testing procedures that mimicked the pressures found within the repository, and compared hydrologic gradients before and after the injection of CO₂. The results allowed the team to bring their modeling prowess to the fore by deploying a pore network model which will now be used to further enhance the calibration and resolution of the field-scale models developed throughout the DemoUpStorage project.



research lines

bio-improved soils

BIO-INSPIRED SOIL STRENGTHENING



project

BIOGEOS



THE BIOGEOS PROJECT IS ONE OF THE LALOUİ GROUP'S PREMIUM RESEARCH PROJECTS

Funded by the European Research Council (ERC), the project aims to design, test, and ultimately standardize innovative and environmentally responsible solutions through bio-mediated, nature-inspired ground reinforcement.

After five years of groundbreaking research and innovation, the team reached a new milestone in 2023, completing its first extensive large-scale trials involving the preparation and injection of a bacterial solution into a reinforced concrete basin filled with sand.

The results were impressive with a soil resistance level of up to 20 MPa, demonstrating the technology's potential to address real-world challenges.



Dimitrios Terzis
Group leader



Lyesse Laloui
Full Professor



Ariadni Elmaloglou
Doctoral assistant



Jose Bosch
Scientist



Sofie ten Bosch
Doctoral assistant



Ziad Sahlab
Doctoral assistant



Merih Büyüklü
Research Associate

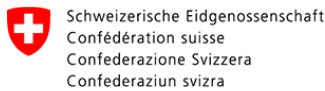


Patrick Dubey
Technical Manager



Julien Birbaum
Trainee

project BigAlps



A NEW CHAPTER IN BIO CEMENTATION TECHNOLOGY BEGINS: BIGALPS

After being awarded two prestigious European Research Council grants and developing three patents for our work in bio-cementation, the Laloui Group will now begin field-scale pilot studies and the testing of market readiness with a European Innovation Council (EIC) Transition Grant for our new project, Bio-Inspired Geotechnical Applications To Launch Pan-European Solutions (BIGALPS).

Partnering with the Technical University of Cluj-Napoca (UTCN) and the French National Research Institute For Agriculture, Food, And Environment (INRAE), our team aims to revolutionize the field of soil stabilization across the engineering and construction industry within Europe and globally.



Dimitrios Terzis
Scientist



Lyesse Laloui
Full Professor



Merih Büyüklü
Research Associate

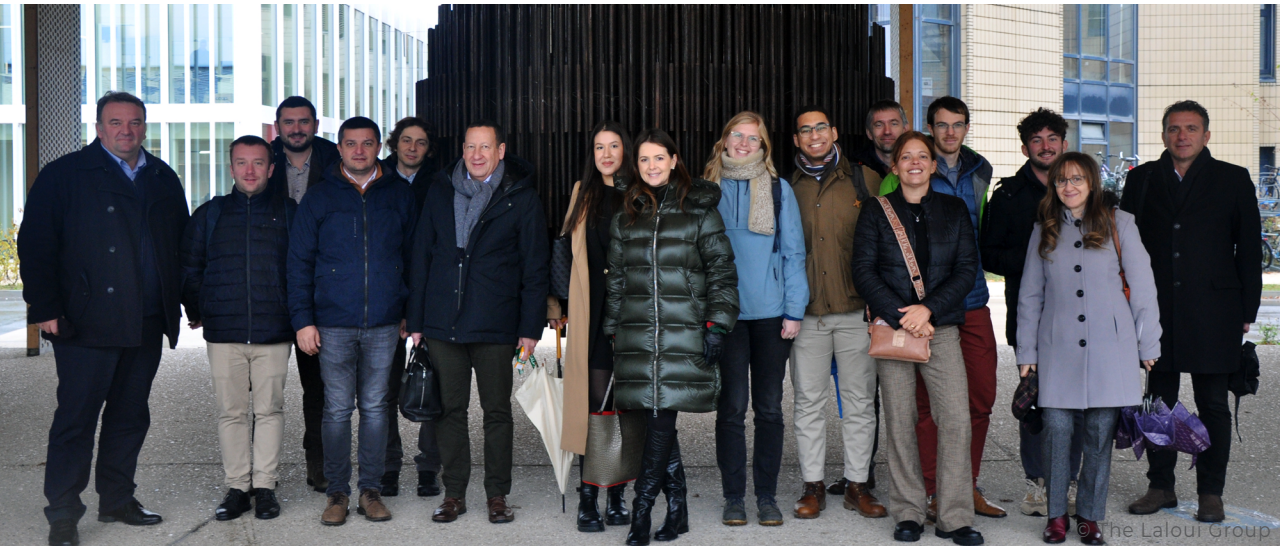


Sofie ten Bosch
Doctoral assistant



Ziad Sahlab
Doctoral assistant

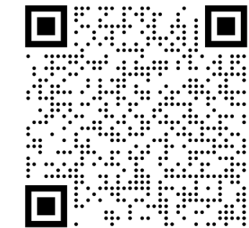
Having developed the technology in the first place, the role of the Laloui Group in providing the engineering design of the soil treatment and production units for each of the three pilots, is vital to ensure the success of this ambitious €1.7 million project.



research lines

energy geostructures

RENEWABLE ENERGY FOR FUTURE CITIES



www.epfl.ch/labs/lms/research-research-fields-energy-ressources/

2023 **Swiss Innovation Agency project in collaboration with Amberg Engineering**
Improving energy efficiency by harnessing underground ventilation systems

Performance of complex energy geostructures
Ravera, E., Rotta Loria, A.F., Laloui, L., Geomechanics for Energy and the Environment, 2024, 38, 100536

Assessing and exploiting the interaction between ventilation and geothermal systems in an underground data centre
ten Bosch, S., Ravera, E., Tobler, M., Bettelini, M., Laloui, L., Tunnelling and Underground Space Technology, 2024, 144, 105563

project

Improving energy efficiency by harnessing underground ventilation systems

AMBERG ENGINEERING  Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Innosuisse – Swiss Innovation Agency



Sofie ten Bosch
Doctoral assistant



Elena Ravera
Scientist



Lyesse Laloui
Full Professor

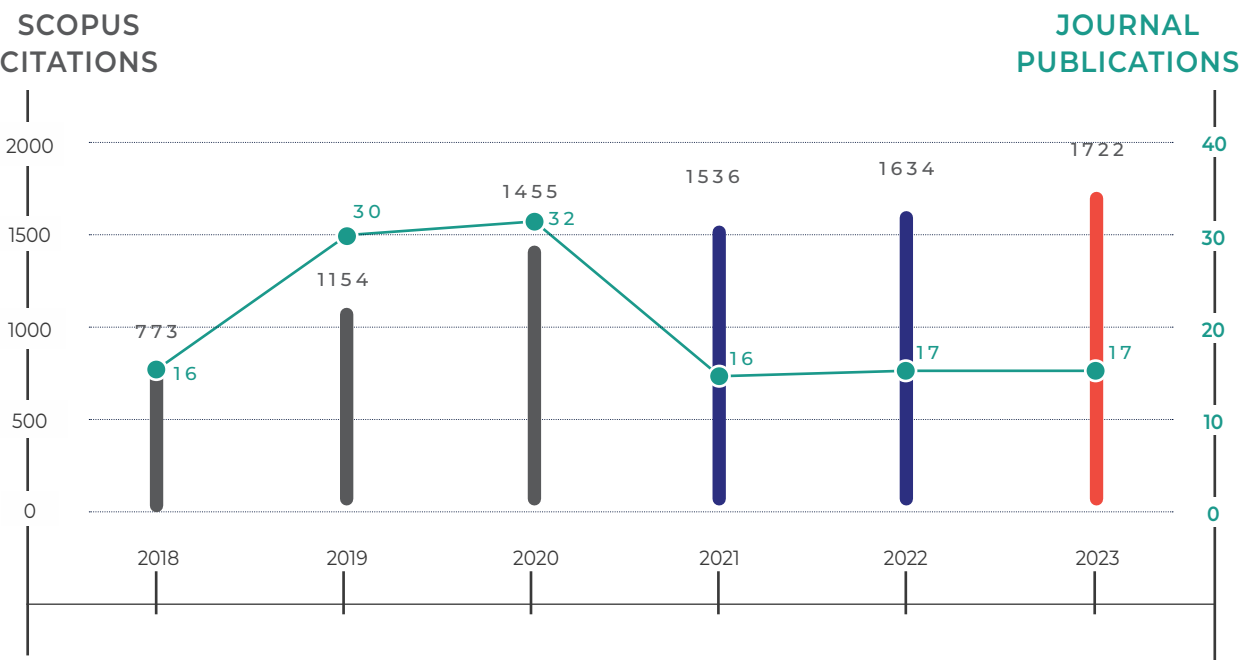
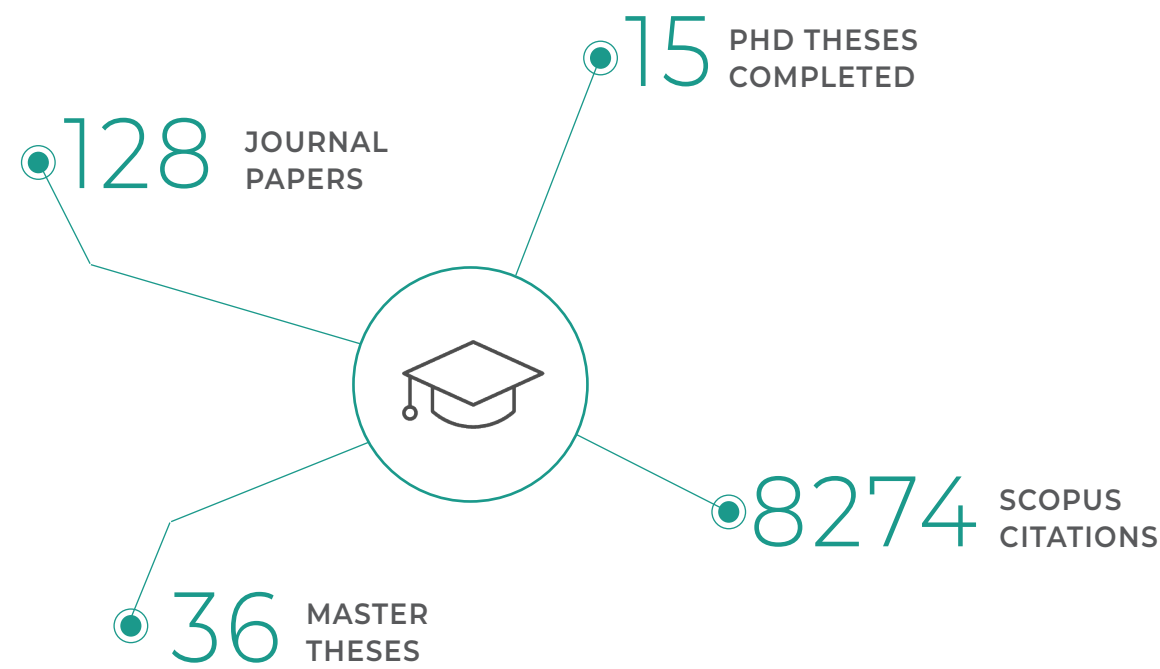
The Laloui Group continues to explore new sustainable infrastructure design and energy efficiency opportunities by completing a first-of-its-kind investigation of the potential for energy savings and optimization from underground data centers. Underground data centers are growing in size and number due to a lack of available land, growth in remote work, and high-speed streaming. In partnership with Amberg Engineering, we explored the potential influence of ventilation systems on passive geothermal energy production through numerical modeling.

The analysis first explored the sensitivity of geothermal potential to varying ventilation conditions (airflow velocities), heat release conditions in the data center, and fluid velocities in the pipes of the geothermal activation. The impact of geothermal activation on air temperature in the underground data center cavern was also assessed, revealing geothermal activation of a section of the cavern leads to a regional decrease in air temperature.

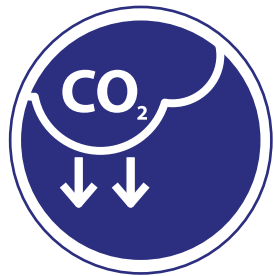
The implications suggest that by optimizing the whole system, we can improve environmental and economic benefits and ensure that data centers operate more sustainably globally.



education + scientific outcomes since 2018



our research lines



CO2 STORAGE

CO2 sequestration in deep geological formations remains the only viable Carbon Capture and Storage (CCS) solution to avoid the worst impacts of climate change. The Laloui Group is exploring a variety of host reservoir types and materials and their interactions with CO2. At the same time we are developing novel approaches to monitoring and predicting CO2 behaviour at full scale and in real-world situations.



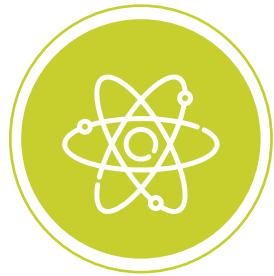
BIO-IMPROVED SOILS

The Laloui Group remains at the cutting-edge development of technologies and solutions aimed at delivering environmentally friendly, low emissions soil stabilisation tools inspired by the natural process of biologically driven crystal mineralization. We aim to revolutionise the construction industry as we begin scaling up to real-world trials.



ENERGY GEOSTRUCTURES

Energy geostructures are an innovative technology that couples the structural role of foundations and the heating/cooling role of geothermal heat exchangers. These passive, renewable energy sources can significantly reduce energy consumption and CO2 emissions. Recognised as world leaders in their research, innovation, design and implementation, The Laloui Group skills and services are utilised across the world.



NUCLEAR WASTE STORAGE

Nuclear energy remains an vital global energy source and disposal in deep clay geological formations is the most promising way of disposing of high-level radioactive wastes. The Laloui Group's skills and dependability in understanding the long-term behaviour of the reservoirs and barrier material is in high demand to provide safe, and long-term disposal solutions.



SHALES MECHANICS

Shales are among the most complex geomaterials in the Earth. They are characterized by a very low permeability and good self-sealing potential; these properties make shales a suitable host material for many engineering applications. For many years, the Laloui Group has worked with industry, governments, the private sector and academic institutions to develop solutions and expand our understanding of this remarkable geomaterial.

factsheet

WHO WE ARE



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WHAT WE DO

The Laloui Group is a globally renowned center for geotechnical research, education, technology transfer, and industry services. We provide a range of services to academic, corporate, and government clients, with a focus on research, education, technology transfer, and industry support.

TECHNOLOGY TRANSFER



InSituStreTech 2022 •
In-Situ Stress estimation Technology for Geo-energy applications



enerdrape 2021 •
Enerdrape turns underground infrastructures into renewable energy sources.



NESOL 2020 •
Providing design and analysis of complex systems employing state of the art numerical tools and dedicated experimental procedures developed in decades of applied research in the field of geomechanics and material science.



medusoil 2018 •
We produce and apply innovative and sustainable binder products based on biomineralization to support development projects get closer to net-zero emissions.

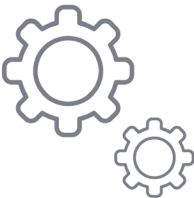


GEOEG 2018 •
A global engineering design and innovation company bringing the experience of a collective of engineers, scientists, inventors, and designers to provide local solutions to make buildings, districts, and cities more sustainable both above and below the ground.

THE LALOU GROUP

FACILITIES AND EXPERTISE

- Energy Geostructures
- GCCS
- Nuclear Waste Storage
- Bio-improved soils
- Shale behavior
- Advanced Numerical Modelling
- Experimental design and testing
- Geotechnical equipment design
- Research and Development
- Laboratory testing
- Consulting services to industry and academia

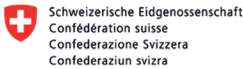


PROJECTS

Biogeos
Biomediated Geomaterial Strengthening



DemoUpStorage
Capturing CO2 from the atmosphere and storing it in geological reservoirs in Iceland



NAGRA site selection
Safely disposing of Swiss radioactive waste

BEACON
Bentonite Mechanical Evolution



New Insights for Chemo-Hydromechanical Modeling of Engineered Geotechnical Barriers



2018

ERC ADVANCED GRANT



SEG 2018

INTERNATIONAL
SYMPOSIUM ON ENERGY
GEOTECHNICS



European
Research
Council

SEG 2018

2018

International Symposium on Energy Geotechnics: The Laloui Group hosts SEG 2018, bringing together keynote lectures, technical sessions, and discussions from the most prominent researchers and practitioners in the field. The proceedings were developed into a book, **Energy Geotechnics**, which has been downloaded **110 thousand** times.



ERC ADVANCED GRANT

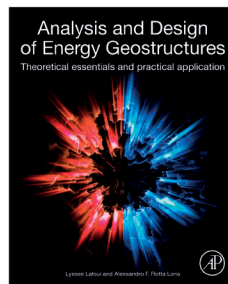
2018

The Laloui Group is awarded **EUR 2.5 million** in funding from the European Research Council to explore bio-mediated soil improvement through the Biogeos project with the objective of improving infrastructure stability while ensuring sustainable construction and land use.



2019

NEW BOOK



NEW BOOK

2019

Book: **Analysis and Design of Energy Geostructures: Theoretical Essentials and Practical Application.** The group, led by Prof. Laloui, develops a book that becomes the fundamental source of information on Energy Geostructures.

2020

ERC POC GRANT

ERC PROOF OF
CONCEPT GRANT
(POC) GRANT



ERC POC GRANT

2020

ERC Proof of Concept Grant (PoC) Grant: Following the success of first 18 months of the BIOGEOS project, The European Research Council (ERC) further validating the technology-transfer vision of the BIOGEOS project and accelerating its progress towards a more sustainable construction industry.

2021

ISSMGE VICE PRESIDENT

INTERNATIONAL SOCIETY FOR
SOIL MECHANICS AND
GEOTECHNICAL ENGINEERING

DEMO UP STORAGE + RADIOACTIVE WASTE SITE DISPOSAL

2022

The Group joins Swiss consortium Demo Up Storage to develop a first-of-its-kind exploration of Carbon Capture and Storage technology. In the same year, the group make significant contributions towards the final site selection for the disposal of Switzerland's radioactive waste.

ISSMGE EUROPE PRESIDENT

2021

Prof. Lyesse Laloui is elected vice president, Europe of ISSMGE (International Society for Soil Mechanics and Geotechnical Engineering), the pre-eminent professional body representing the interests and activities of 21 000 Engineers, Academics and Contractors all over the world that actively participate in geotechnical engineering.



2022

DEMO UP STORAGE AND WASTE DISPOSAL

DEVELOPING CARBON CAPTURE
AND STORAGE TECHNOLOGY

DOCTORATE HONORIS CAUSAE

HERIOT-WATT UNIVERSITY, UK
TECHNICAL UNIVERSITY OF
CLUJ-NAPOCA, ROMANIA.

DOCTORATE HONORIS CAUSAE

2022

The Director of our Group, Prof. Laloui is recognized for his outstanding contribution to the field of geomechanics and solutions for a sustainable world with two honoris causae from Heriot-Watt University in Edinburgh, UK and the Technical University of Cluj-Napoca, Romania.

2023

BIGALPS



A NEW CHAPTER IN BIO
CEMENTATION TECHNOLOGY

SUSECOCCUS

DEMONSTRATING
GEOLOGICAL CO2 STORAGE
ON THE EPFL CAMPUS

SUSECOCCUS

2023

The Group joins an EPFL consortium, **SusEcoC-CUS**, which includes developing a first-of-its-kind geological CO2 storage simulator to ensure safe and reliable carbon capture and storage.

BIGALPS

2023

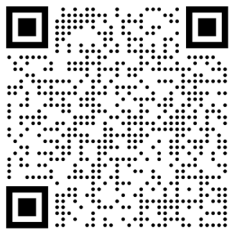
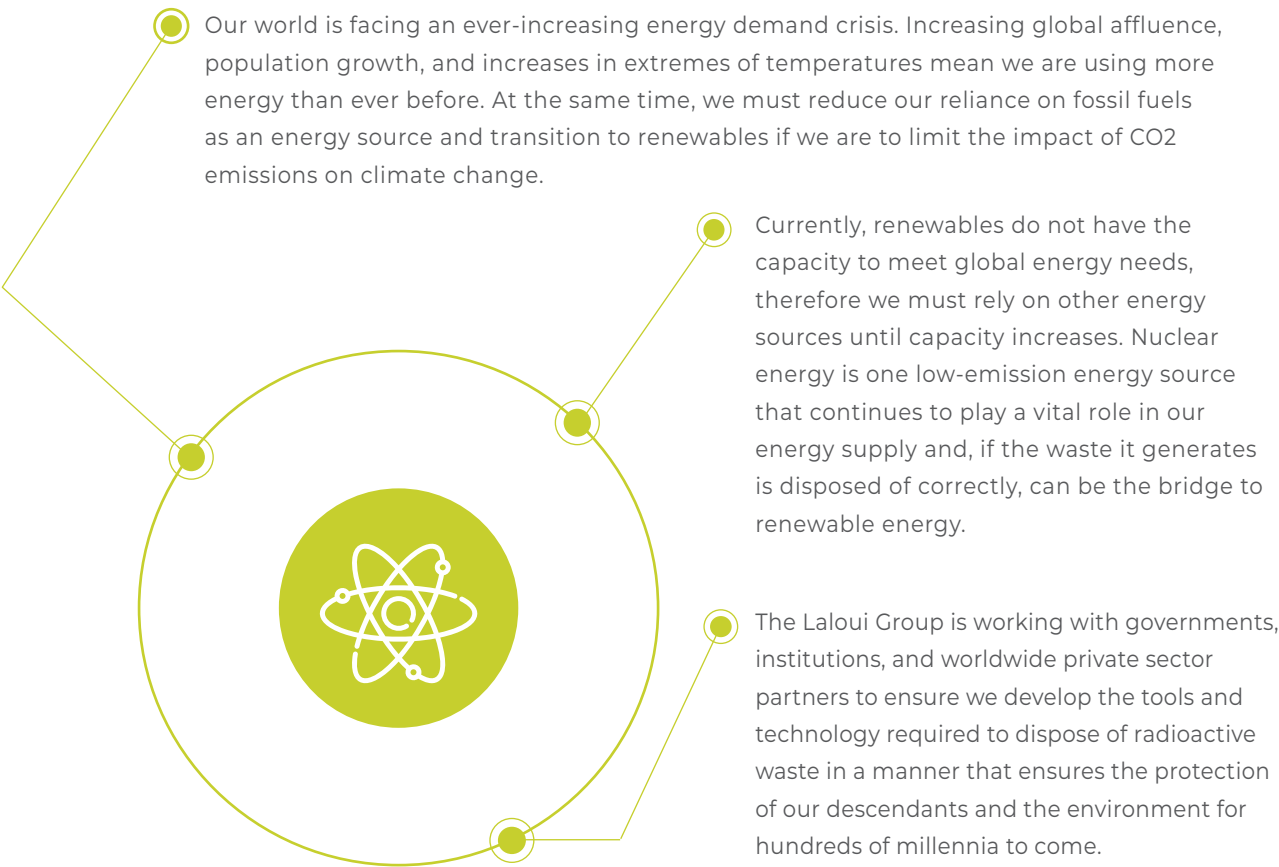
The Laloui Group expands its bio-cementation technology into real-world situations with a European Innovation Council (EIC) grant.



research lines

nuclear waste storage

MEETING GLOBAL ENERGY DEMAND WHILE PROTECTING THE PLANET



www.epfl.ch/labs/lms/research-research-fields-nuclear-waste-storage/

- 2019 FE-M Taks Force**
Highly hazardous nuclear waste treatment is a major environmental issue for nuclear-power-generating countries around the world.
- 2019 CIGEO**
Long-term deep disposal of radioactive waste
- 2019 Gas Transport in Clay Materials**
Impacts on barrier integrity
- 2021 New Insights for Chemo-Hydrmechanical Modeling Of Engineered Geotechnical Barriers**
Clays (particularly active clays) are an important and valuable material due to their high-swelling and hydro-isolating properties making them particularly useful in various geotechnical applications, including deep repositories for nuclear waste and landfills.

project


New Insights for Chemo-Hydro-mechanical Modeling Of Engineered Geotechnical Barriers




CLAYS (PARTICULARLY ACTIVE CLAYS) ARE AN IMPORTANT AND VALUABLE MATERIAL DUE TO THEIR HIGH-SWELLING AND HYDRO-ISOLATING PROPERTIES MAKING THEM PARTICULARLY USEFUL IN VARIOUS GEOTECHNICAL APPLICATIONS, INCLUDING DEEP REPOSITORIES FOR NUCLEAR WASTE AND LANDFILLS.

The mechanical response of the material, like swelling upon hydration, can be predicted by advanced modelling approach accounting for the physical-chemical interactions between water and clay particles.


Such complex multi-physical predictions require precise microstructural investigations, which are critical for understanding the active clays behavior allowing new insights into the types and amounts of water retained at various saturation levels for materials such as MX-80 bentonite.




Lyesse Laloui
Full Professor



Angelica Tuttolomondo
Scientist

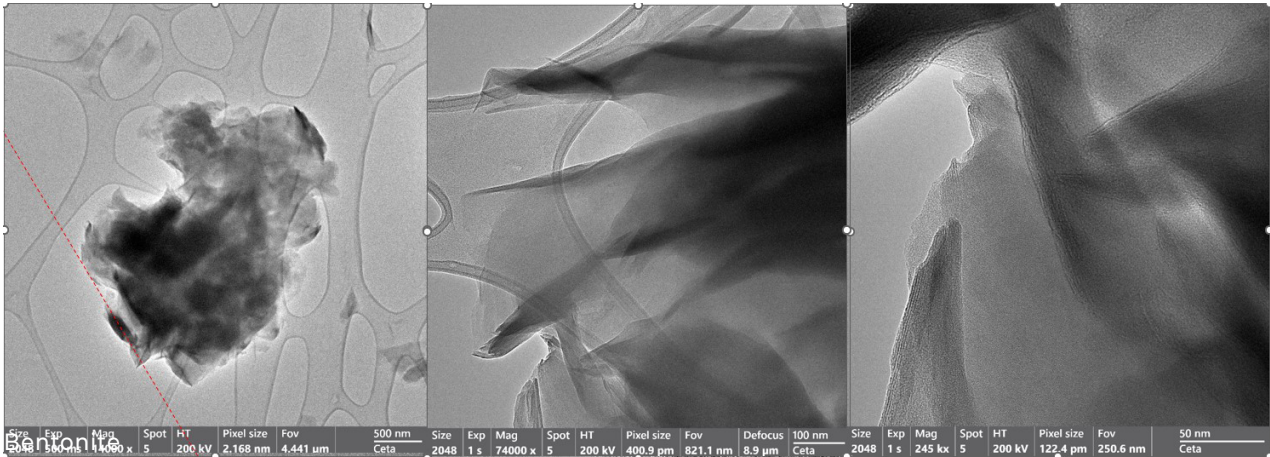


Svetlana Babiy
Doctoral assistant



Alessandro Parziale
Doctoral assistant

The Laloui Group will use these insights which can be integrated into mechanical prediction models to enhance their accuracy.



FE-M Taks Force

HIGHLY HAZARDOUS NUCLEAR WASTE TREATMENT IS A MAJOR ENVIRONMENTAL ISSUE FOR NUCLEAR-POWER-GENERATING COUNTRIES AROUND THE WORLD.

Leveraging its expertise and long-term partnerships, and in line with its environmental values, The Laloui Group is developing numerical tools for the Swiss National Cooperative for the Disposal of Radioactive Waste (NAGRA) in its proposed deep geological repository near Stadel, Canton Zurich.

To ensure the long-term viability of the disposal of radioactive material, the development of reliable numerical tools to simulate long-term repository responses is of paramount importance.



Matthias Wojnarowicz
Doctoral assistant

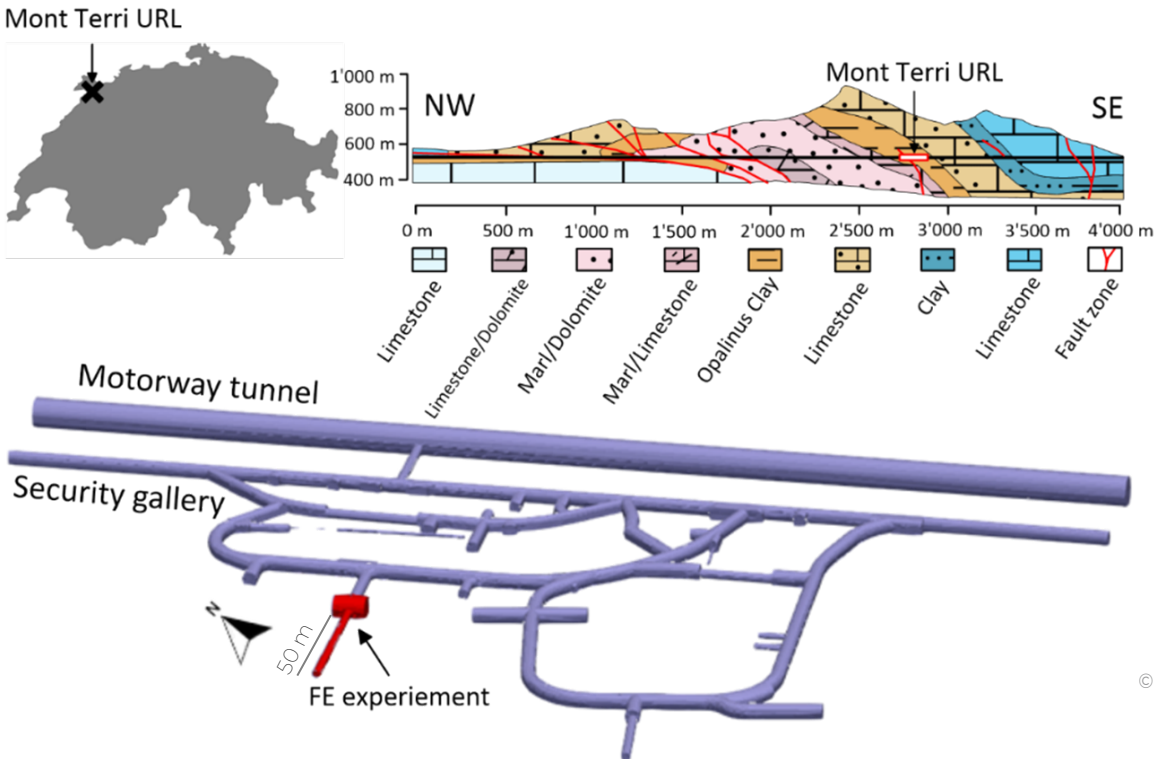


Aldo Madaschi
Scientist



Lyesse Laloui
Full Professor

The Laloui Group was asked to join the FE Modelling Task Force (TF), an international initiative developed by the National Cooperative for the Storage of Radioactive Waste (NAGRA), that aims to build a fully coupled THM model of the repository concept, including the construction history, and compare the results of the different teams in a benchmarking exercise. These results will be compared to an in-situ experiment at Mont Terri underground rock laboratory. Once the models align with the experiment they will be used to forecast long-term interactions and used as predictive tools.



Gas transport in clay materials

IMPACTS ON BARRIER INTEGRITY

Our specialist knowledge of the characterization of the host rock for radioactive waste storage and disposal extends to all phases of the process. In 2020, the Laloui Group was asked to join the European Joint Programme on Radioactive Waste Management (EURAD) to improve the mechanistic understanding of gas transport in clay materials.

Switzerland, like many other European countries, foresees the need for a deep geological repository that relies on a multi-barrier system to isolate the waste from the biosphere for tens of thousands of years.



Qazim Llabjani
Doctoral assistant



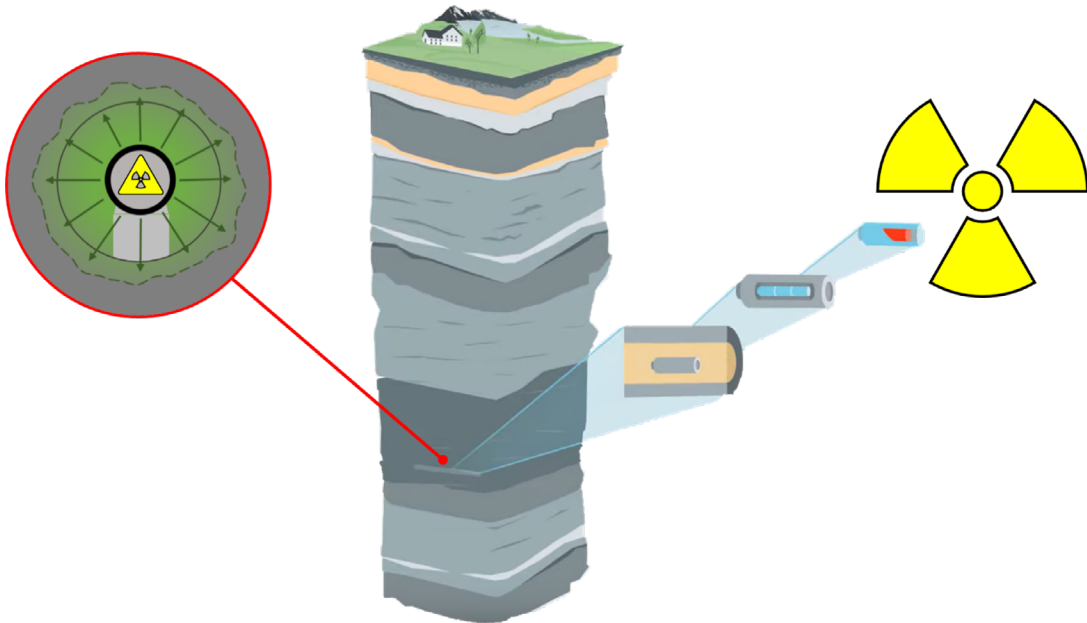
Alessio Ferrari
Researcher and lecturer



Lyesse Laloui
Full Professor

Uncertainties still exist about the late stage of the repository. The Laloui Group aims to change this through advanced experimental design and model-supported data analyses requiring advanced and rigorous experimental set-ups and testing protocols. This has required the specialist skills of our lab team to design and manufacture these special devices in-house.

Using gas injection tests combined with a unique distributed fiber optics monitoring system the objective is to capture, visualize, and understand those complex phenomena.



project CIGEO

LONG-TERM DEEP DISPOSAL OF RADIOACTIVE WASTE

Another of our many collaborations in the development of safe radioactive waste disposal is with ANDRA (The French National Agency For Radioactive Waste Management) on the very long-term deep disposal of radioactive waste where our advanced experimental and modeling procedures bring new insights to the behavior of the local Callovo-Oxfordian claystone.

The CIGEO project is the French concept for radioactive waste storage of high-level, long-life, and medium-level waste produced by the French nuclear industry which aims to build a 500-meter-deep repository in Eastern France in the Callovo-Oxfordian (COx) geological formation.

Leading this important work is Héloïse Fuselier, who has spent several years exploring the behavior of the host Callovo-Oxfordian Claystone geological formation and has designed and performed complex thermo-mechanical experiments on COx claystone specimens to assess the geomaterial behavior dependency on stress and temperature



Héloïse Fuselier
Doctoral assistant



Alessio Ferrari
Researcher and lecturer



Lyesse Laloui
Full Professor

history. Using this knowledge, she and the team have now turned their attention to developing a new constitutive model for the Callovo-Oxfordian claystone in a hardening thermo-elasto-plastic framework. This model aims to predict the claystone volumetric response and the evolution of its strength when subjected to temperature changes.



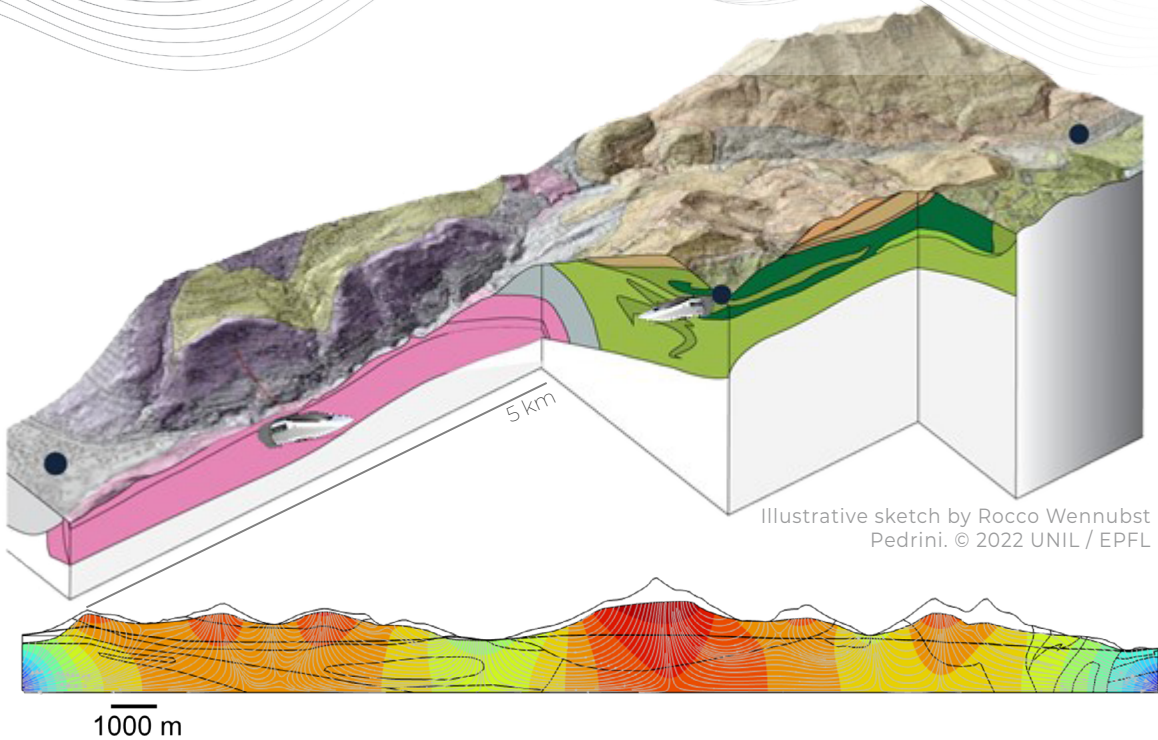
© The Laloui Group

project VAIp

FEASIBILITY STUDY OF A HIGH-SPEED METRO IN THE VAUD ALPS

Creating a high-speed metro with innovative technology in the Vaud Alps in Switzerland. That is the ambition of this unique green rapid transport project.

The concept known as VAlp hopes to make daily commutes feasible and more attractive for those living in the Alps and working in the larger cities such as Friburg or Lausanne by tunneling through the Alps with a metro-style train system.



clim↔act



Sofie ten Bosch
Doctoral assistant



Elena Ravera
Scientist



Lyesse Laloui
Full Professor

In response to Switzerland's mission of green electrical self-sufficiency by 2050, the Laloui Group, in conjunction with Prof. Jaboyedoff's Risk Group at the University of Lausanne, undertook a feasibility study of the project, including investigating the local geology in 3D, refining geotechnical considerations, recommending

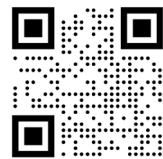
tunnel design and predicting energy consumption and long-term CO2 emissions.

The study will be used as part of a broader assessment to determine future socioeconomic and infrastructure development within Switzerland.

II TECH TRANSFER start ups launched

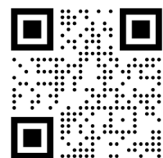


We produce and apply innovative and sustainable binder products based on biomineralization to support development projects get closer to net-zero emissions.



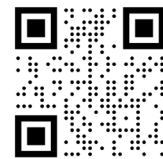
NESOL

Providing design and analysis of complex systems employing state of the art numerical tools and dedicated experimental procedures developed in decades of applied research in the field of geomechanics and material science.



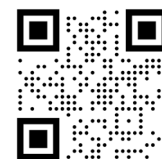
enerdrape

Enerdrape turns underground infrastructures into renewable energy sources.



GECEG

A global engineering design and innovation company bringing the experience of a collective of engineers, scientists, inventors, and designers to provide local solutions to make buildings, districts, and cities more sustainable both above and below the ground.



InSituStreTech



In-Situ Stress estimation Technology for Geo-energy applications

new start-up InSituStreTech

THE INSITUSTRETECH PROJECT IS DEVELOPING A TOOL TO REDUCE THE COST OF GEOLOGICAL EXPLORATION. THIS INNOVATIVE TECHNOLOGY SUITABLE FOR IN-SITU STRESS ESTIMATION FOR CO2 GEOLOGICAL STORAGE.

It exemplifies our multi-faceted approach when working within the group and our international collaborations. The InSituStreTech team is developing a new technology designed to test if a target reservoir is suitable for CO2 storage by assessing its horizontal in-situ stress state, which, until now, has been particularly challenging given the reservoirs are often several kilometers deep and under very high stresses and temperatures.

The team has continued to go from strength to strength achieving several important milestones,

The InSituStreTech Project is a great example of the Laloui Group's research and innovation in one of its specialty areas of geological carbon storage (CCS).

Innosuisse - Swiss Innovation Agency
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra



ENAC Innovation Seed Grant

BRIDGE



Angelica Tuttolomondo
Scientist



Alex Miska Horvath
Scientific assistant



Lyesse Laloui
Full Professor

including the successful development and validation of a proof of concept in laboratory conditions. This will be scaled up at the Mont-Terri underground laboratory (St-Ursanne Switzerland) to measure stress in real underground conditions. More recently, they have continued to attract funding with a grant from Venture Kick foundation, as well as the Bridge program of the Swiss National Science Foundation and Swiss Innovation Agency.



III ACADEMIC ACTIVITIES

new journal papers

THE GROUP AGAIN HAS HAD A FANTASTIC YEAR PUBLISHING 17 JOURNAL PAPERS AND CONTRIBUTING TO SEVERAL CONFERENCE PROCEEDINGS. HIGHLIGHTS INCLUDE

Pore-pressure coefficients for unsaturated soils: generalized effective stress approach.

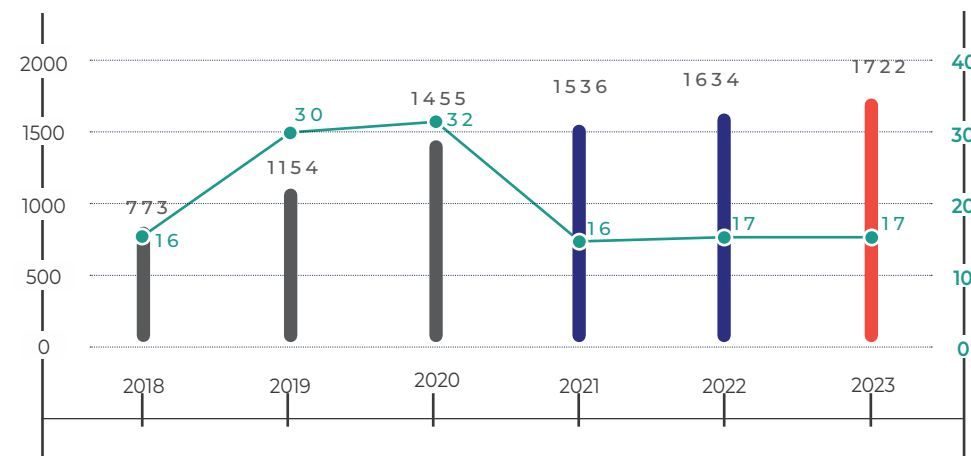
Tuttolomondo, A., Ferrari, A., Laloui, L. Canadian Geotechnical Journal, 2023, 60(11), pp. 1726–1742

Thermo-hydro-mechanical behavior of energy barrettes: Field experiments and numerical simulations

Rotta Loria, A.F., Ravera, E., Laloui, L. Geomechanics for Energy and the Environment, 2023, 34, 100451

SCOPUS CITATIONS

JOURNAL PUBLICATIONS



keynote lectures

THE GROUP WAS WELL REPRESENTED AT SEVERAL MAJOR CONFERENCES IN 2023. SOME KEY HIGHLIGHTS INCLUDE:

Keynote lectures: Prof. Lyesse Laloui



17th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering 2023. **“Energy geotechnology: a new era for geotechnical engineering practice”**



International Conference on Advances in Structural and Geotechnical Engineering (ICASGE'23). **“Smart exploitation of the renewable energy situated under our cities”**

European Conference on Geotechnical Engineering (17DECGE). **“Exploiting the renewable energy resources of our cities' underground”**



9th International Congress on Environmental Geotechnics (9ICEG). **“Carbon Dioxide Injection into Deep Aquifers: A Geomechanical Perspective”**

9ICEG
25-28 June 2023

academic activities

PhD thesis

INFLUENCE OF PORE-SCALE HETEROGENEITY ON THE PRECIPITATION PATTERNS IN MICROBially INDUCED CALCITE PRECIPITATION (MICP) - ARIADNI ELMALOGLOU

As part of the Biogeos project, the group looked to expand our understanding of Microbially Induced Calcite Precipitation (MICP) or biocementation, particularly the effect of the available pore network of various base materials on the MICP process. Already a world leader in our understanding of biocementation, the project aimed to expand on this through a research project by PhD candidate Ariadni Elmaloglou under the supervision of Prof. Laloui and Dr. Terzis.

Biocementation is an environmentally friendly and sustainable alternative to traditional soil stabilization techniques based on harnesses microbial activity that facilitates the formation of calcium carbonate precipitates that fill the pores and can improve the mechanical properties of the soil.

image processing algorithm specially developed for the experiment. These novel techniques and technologies revealed the spatiotemporal evolution of MICP over distance and the change in permeability that occurred between heterogeneous porous media of the same porosity.

The results revealed that despite a similar bacterial distribution across the whole chip, the chemical reaction efficiency was higher in the heterogeneous than the homogeneous porous medium due to a combination of higher numbers and sizes of crystals, as well as a higher precipitation rate in the heterogeneous than the homogeneous porous medium. Exploring further through a second experiment, Elmaloglou showed the effect of pore network heterogeneity on calcite deposition during MICP, resulting in distinctive precipitation patterns in porous media subjected to the same MICP treatment due to their intrinsic structure.



While significant steps toward the characterization and application of MICP have already taken place, we know less about the effect of the available pore network of various base materials on the MICP process, which is fundamental to understanding and addressing precipitation inhomogeneities. Using a multi-scale approach, Elmaloglou conducted meter-long microfluidics and time-lapse microscopy experiments incorporating an

RELATED JOURNAL PAPERS :

Microfluidic study in a meter-long reactive path reveals how the medium's structural heterogeneity shapes MICP-induced biocementation. Elmaloglou, A., Terzis, D., De Anna, P., Laloui, L., Scientific Reports, 2022, 12(1), 19553

Microfluidic-Based Study on the Activation and Evolution of Calcite Bio-Mineralization for Geotechnical Applications. Elmaloglou, A., Terzis, D., De Anna, P., Laloui, L., Mahé, S., Miele, F., Geotechnical Special Publication, 2020, 2020-February(GSP 320), pp. 74–82

academic activities

new PhD projects

SOFIE TEN BOSCH

2023 saw Sofie commence her PhD with the group after spending the previous two years with us as a Scientific Assistant, contributing to several key projects, including VALps, BIGALPS, and ventilation systems interactions with energy geostructures. Supervised by Prof. Lyesse Laloui and co supervised by Dr. Dimitros Terzis, she will exploit her expertise in multiphysical modeling to examine the potential to use modeling to explore the innovative and sustainability focussed topics of energy geostructures and microbially induced calcite precipitation.



Multiphysical modelling of sustainable geotechnics with a focus on energy geostructures and biocementation

ZIAD SAHLAB

Ziad completed his Master's in Civil Engineering at EPFL before joining our group in 2023. Ziad will use geomechanical modeling to explore biocemented soils and their potential applications for geohazard mitigation and exploring ways to upscale this sustainable, low-emissions technology for the BIGALPS project. He will be joining our Bio-improved Soil team under Prof. Lyesse Laloui and Dr Dimitrios Terzis's supervision.



Geomechanical modeling of biocemented soils: applications for geohazard mitigation

PhD guest



New insights in the analysis and prediction of the mechanical behavior of compacted expansive clays as engineered barriers

ALESSANDRO PARZIALE

Alessandro joins us from the Politecnico di Torino where he obtained his Master's Degree in Civil Engineering, Geotechnical Engineering. Alessandro is contributing to our Swiss National Science Foundation work on "New insights in the analysis and prediction of the mechanical behavior of compacted expansive clays as engineered barriers." Under the supervision of Prof. Laloui and Dr. Tuttolomondo, Alessandro is hoping to build on our existing knowledge of materials such as clays and how they can be used as barriers against fluids and gases in geotechnical engineering.



A constitutive model of under-consolidated soft clay and hydromechanical analysis of deep excavation in under-consolidated clayey deposit

XINGBANG LU

Lu Xing-bang from Tongji University in Shanghai, China, joined the Laloui Group as a visiting PhD student in 2023. He explored under-consolidated soft clay formed by sedimentation or filling which widely distributed in eastern coastal China, leading to challenging civil engineering construction and maintenance issues. As a result, Xing-bang explored the hydromechanical behaviors and constitutive modeling of under-consolidated soft clay to benefit foundation pit construction and underground space development in coastal areas. Having spent 2023 with us and using our facilities and skills to further his research, Xing-bang returned to China in early 2024 to finish his PhD dissertation. We wish him all the best in his future endeavors.

IV MEDIA & EVENTS

symposium: Perspectives in Geotechnical Engineering

The Group hosted a very successful symposium this year featuring some of the world's leading experts in geotechnical engineering to discuss the role of sustainable urban planning, current trends and technologies, current projects, and the future trajectory of the sector.

The symposium was also an opportunity to celebrate the honorary lecture of Professor Laurent Vulliet later that evening, who, after many years

with the Laloui Group, including being the former director of the Laboratory of Soil Mechanics (LMS), is retiring. We thank him for all his contributions and wish him the very best in his future endeavors.

Lectures:

Geo-Sustainability and Geo-energy development at EPFL, Prof. Lyesse Laloui (EPFL)
Underground Strategy Switzerland, Dr. Anne Eckhardt (Federal Geological Commission, Risicare GmbH)

Project Cargo Sous Terrain – Geotechnical explorations and models, Florian Fischer (Cargo Souterrain)

Underground Architecture, Prof. Dominique Perrault (Perrault Architecture)

Energy Geotechnics: Fluids, Prof. J. Carlos Santamarina (Georgia Institute of Technology)
Artificial Intelligence in Geotechnical Engineering, Prof. Alexandre Alahi (EPFL)



Dr. Anne Eckhardt Prof. Lyesse Laloui



Prof. Laurent Vulliet

Prof. Lyesse Laloui and Prof. Dominique Perrault

V MEET OUR TEAM

The Laloui Group welcomed Dr. Yuhei Kurimoto as our new academic guest at the end of 2023. Upon his arrival, we asked him about his first impressions of the Laloui Group.

What's your field of expertise?

Geotechnical Engineering, especially now architecture engineering in Japan.

Why did you choose to come to the Laloui Group?

I've been researching environmentally friendly soil and ways to reduce CO2 emissions not only in Japan but abroad, so when I told my former supervisor that I wanted to expand my research in this area, he immediately recommended Prof. Laloui and introduced me straight away and here I am.

Congratulations to our apprentice **Natacha Romanens**, who successfully completed her federal certificate of competence (CFC) as a physics laboratory assistant.

For four years, Natacha Romanens has worked with the Laloui Group in our state-of-the-art laboratory where she learned to test soil samples and cores for our researchers as well as clients such as engineering firms who are often interested in learning about the ground on which their future building, railroad, or bridge will stand. We are all proud of her achievements and wish



Dr. Yuhei Kurimoto

Institute of Technology, Shimizu Corporation, Japan.

So, you've been here almost a month, what are your early impressions of the Laloui Group and Switzerland?

Public transport and food are expensive compared to back home in Japan, and I miss the food, but everyone so far has been very kind and welcoming and making me feel comfortable here, and I can't wait to meet the rest of the team.



her the very best in her future career path. When we asked her what would be her advice for anyone interested in becoming a physics laboratory assistant? She responded, "It's a job that suits curious people. It's diverse, you gain a lot of skills, particularly perseverance. When a test doesn't work as it should, you can't give up, you have to keep trying because customers expect results!"

meet our team

MANAGEMENT



Lyesse Laloui
Director

SENIOR SCIENTISTS



Alessio Ferrari
Researcher and lecturer



Dimitrios Terzis
Group leader and lecturer



Jose Bosch
Scientist



Elena Ravera
Scientist



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PROJECT
The Laloui Group

GRAPHIC DESIGN & CONTENT
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PRINTING
Repro – Print Center EPFL, 2024

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