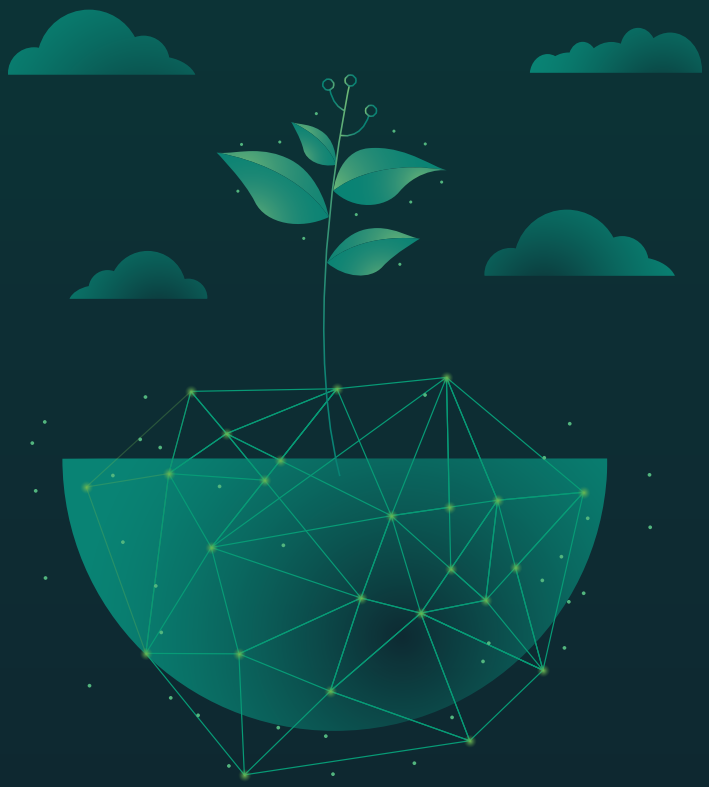
DEEPSURF CONFERENCE

TOWARD SOLUTIONS FOR ENERGY AND ECOLOGICAL TRANSITION



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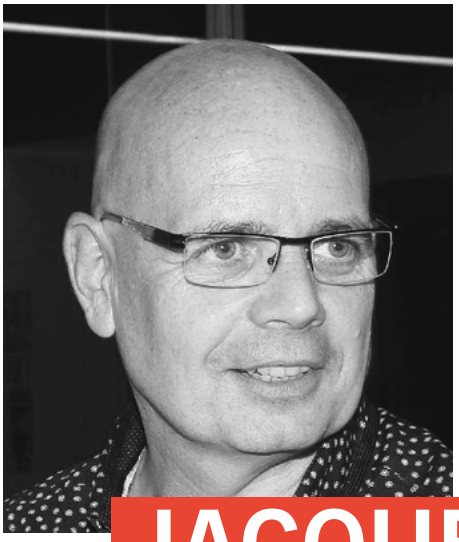

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DEEPSURF Conference is a forum for scientific, political and societal debate arising from the need to manage natural resources in a more sustainable way in the context of climate change and transition to green and renewable energies. Questions and challenges emerging from the Green Deal promoted by the European Union will be at the heart of the Conference.

How to reduce greenhouse gases emissions and enhance carbon dioxide sequestrations?

How to improve our knowledge of complex ecosystems involved in ecological transition?

How to contribute to the debate on sustainable resource management?

The Conference aims to bring together scientists from a range of disciplines: geosciences, environment, soil, forest sciences, applied mathematics, geography, history, economics, and social and legal sciences. Such diversity is necessary in order to debate the major challenges posed by the European Green Deal.

This first "DEEPSURF Conference" at the heart of a major issue for the planet aims to continue and become an essential meeting for scientists from all disciplinary backgrounds.

DEEPSURF CONFERENCE

DEEPSURF Conference aims to focus on improving knowledge on complex ecosystems and contribute to the debate on ecological and energy transition. The Conference will tackle the question of heat transfer and mass flow (water, hydrocarbons, pollutants and gases) between subsurface, soil, biosphere and atmosphere, as well as impacts on the environment and society's perceptions.

The Conference will focus on new projects on exploitation of soil, underlying rock and biomass (Carbon Capture, Utilization and Storage - CCUS), management of energy vectors (hydrogen, compressed air, water and gases), geothermal energy, mineral resources, nuclear waste storage, biomass energy production, wasteland reclamation, etc.

DEEPSURF Conference proposes to combine approaches to geosphere, biosphere and atmosphere monitoring, as well as modelling in order to minimize related uncertainties and risks, including compensation and remediation mechanisms.

DEEPSURF Conference will comprise plenary sessions on state of the art researches on:
> Carbon storage in the biosphere, soil and underlying bedrock,
> Matter and heat transfer through the critical zone and underlying geological compartments,
> Use of land and subsurface for energy transition purposes.

Specific sessions will also address such topics as data sciences (mathematics applied to geosciences and/or environmental sciences), geological storage (gases, waste, etc.), the role of low-emission hydrocarbons in energy transition strategies, biomass production and soil ecosystem services, optimization in forest management, agricultural land and wasteland, and metal for energy transition.

Four field trips in the Grand Est region will cover the themes of fossil resources from past to present (coal, oil and gas), salt and its age-old history, geothermal energy, radioactive waste storage and forest monitoring. Field trips are included in the Conference Pack.

The objective of the conference is to mix together scientists from diverse disciplines: Geosciences, Environment, Soil, Forest Sciences, Applied Mathematics, Geography, History, Economy, and Social and Legal Sciences. Such diversity is necessary in order to debate the major challenges posed by the Green Deal.

SCIENTIFIC COMMITTEE

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Peter Doerrenbächer

Peter Wirth

Philippe de Donato

Marie-Odile Simonnot

Christophe Schwartz

Radu Stoica

Michel Deshaies

Florence Delprat-Jannaud

TABLE OF CONTENT

SCHEDULE

	MONDAY 11th	TUESDAY 12th	WEDNESDAY 13th	THURSDAY 14th
Morning		Plenary session	Field trips in the Grand Est region	Thematic sessions
Lunch		Lunch	Lunch	Lunch
Afternoon		Thematic session	Field trips in the Grand Est region	Plenary session
Evening	Icebreaker at École des Mines de Nancy, Campus Artem	Gala dinner in the Grands Salons of the City Hall of Nancy		

TUESDAY
12nd OCTOBER

DAY OF CONFERENCE

DAY 01 - MORNING

09:00		**Opening ceremony**
09:15		**KEYNOTE** | **Samuele Furfari** What are the impacts of energy transition on the geopolitics of energy?
09:45		**KEYNOTE** | **Jean-Daniel Bontemps** Forest monitoring in France and Europe - overview and challenges
10:15		**Coffee break**
10:30		**KEYNOTE** | **Olivier Vidal** What are the impacts of energy transition on the geopolitics of energy?
11:00		**KEYNOTE** | **Denis Angers** (online) Carbon sequestration in agricultural soils: a Canadian perspective, but not only!
11:30		**Panel discussion** Animated by Pascal Bigarré (INERIS) and Erwin Dreyer (INRAE) - chairmen
12:30		**Lunch**

What are the impacts of energy transition on the geopolitics of energy?

Samuele Furfari [1]

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The EU has embarked on a very ambitious strategy to decarbonise the economy, which is a proxy for an energy transition policy. It aims to reduce CO_2 emissions by 55 % by 2030 and 100% by 2050. The European Commission recognises that this will be difficult and very expensive. The impact on energy prices is starting to be felt. Will non-EU countries, and in particular non-developed countries, adhere to this vision and are they prepared to spend the same financial resources? It will be seen that their socio-economic situation does not allow for optimism about their willingness to embrace the energy transition as most of them are not yet in the energy world. As a result, the world will continue to rely on cheap and abundant energy for the foreseeable future.

The cheapest energy is coal and it is therefore key to put coal back into the global energy picture even if it is banned in the EU. As the most indispensable energy is oil, the Middle East will remain a focal point for the future supply of oil products essential for all transport and petrochemicals. The most versatile energy is natural gas and therefore countries with large reserves - Russia, Iran, Qatar but also Uzbekistan - will have a bright future in the supply of non-EU countries, a place the US covets. The new geopolitics of gas now includes new entrants like Israel, Canada and Australia. The expected deep electrification of modern societies will give the nuclear industry a renaissance, with a race already underway between Russia, China, the US and other countries.

The question is therefore not only whether the EU will succeed in its energy transition strategy, but what its place will be in a global energy race for increased and cheap energy demand.

THEMATIC SESSION

AUDITORIUM 200 — 09:15 — TUESDAY 12th

Forest monitoring in France and Europe - overview and challenges

Jean-Daniel Bontemps [1*]

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Context. Forest ecosystems occupy one-third of land area in both Europe and France, and have been managed for wood provision for centuries, with ancient concern for forest sustainability. Along with global economic development, the environmental and climatic crises have also fostered the more recent but significant acknowledgement of the multiple environmental services forests deliver. Both perceptions have played a major role in the emergence of forest survey and monitoring tools. Forest transitions and environmental disturbances (storms, heatwaves, and bio-aggressor outbreaks) have last contributed to make the rapid dynamics of forests and the need for reactive monitoring systems more salient.

Overview of monitoring approaches. Spatially systematic and representative assessments of forests have arisen in the early 20th century in Europe, embodied in the concept of statistical national forest inventory (NFI), implemented in most European countries to date, and fuelling major European and global reporting processes (MCPFE/Forest Europe and UN/Forest Resource Assessment). These inventories have also strongly diversified their outputs and collaborated for information harmonization in Europe. Environmental threats to forests of atmospheric pollution in Europe have also led to implement independent monitoring-oriented systems of forest vitality and health at a European level (ICP forests) in the 1980s, making the trade-off between the spatial and temporal accuracies of these systems obvious. Last, the growing availability of remote sensing technologies has fostered the emergence of new hybrid multisource forest inventories (Wallenberg prize 1997) and other significant forest mapping tools (e. g. Global ForestWatch based on Landsat and Sentinel imagery), with spatial resolution as a major target. This strong diversification of sources has yet confused forest assessment, as illustrated by the Summer 2020's debate on forest harvest intensification in Europe.

Challenges, developments and perspectives. Within the new framework of the EU bioeconomy (2015) and Forest (2021) strategies, the request for an integrated and legally enforced hybrid monitoring of European forests under the FISE (Forest Information System in Europe) umbrella, that targets forest resource and health and supports forest adaptation to CC is now on the agenda. In this uncertain context, recent developments in forest inventories (multisource inventory, CC impact monitoring, resource projection under changing environments) are presented that will strengthen these programs and should make them significant contributors of this new monitoring scheme.

THEMATIC SESSION

AUDITORIUM 200 — 09:45 — TUESDAY 12th

The energy-mineral resources nexus in the context of energy transition

Olivier Vidal [1]

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The Paris Agreements (COP21) call for achieving global carbon neutrality by 2050. New energy production, storage, transport and use infrastructures will have to be built to replace those currently based on fossil fuels. These new infrastructures consume large quantities of base and rare metals, the availability of which is a real concern. In addition, the production of raw materials requires large amounts of energy, so issues related to raw materials and energy are inseparable and need to be addressed in a common framework. The expected shift towards low-carbon energy will take place in a context of growing global demand due to the rapid emergence of developing countries, increasing urbanization and the development of high technologies. The consumption of most metals has doubled since the beginning of the 21st century and if the increase in consumption observed over the last 100 years continues (+3 to 5 % / year), more metals will have to be produced by 2050 than since the beginning of humanity. In this context of anticipated tension, some anticipate shortages resulting from the depletion of natural reserves during the century, while others argue that technological improvements and the exploitation of deeper or offshore resources and recycling will help maintain the increase in production at the level observed over the last century.

We will present and discuss the results of a dynamic model linking the expected demand in metals for different scenarios of GDP, population and energy with the production capacity constrained by geological and technological parameters. The results of modelling provide a better understanding of the coupling between reserves - mineral resources production - cost and price - energy. The results are used to define the conditions for a sustainable supply of mineral resources in a changing world.

THEMATIC SESSION

AUDITORIUM 200 — 10:30 — TUESDAY 12th

Carbon sequestration in agricultural soils: a Canadian perspective, but not only!

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At the global scale, soils contain the largest C pool of the terrestrial biosphere and therefore have a crucial role in the global C cycle. Soil C contributes to a range of functions and services such as maintaining soil structure and water retention, preventing erosion, providing essential nutrients, and overall, contributing to agroecosystem resilience. However, agriculture has led to significant loss of C to the atmosphere. Land use and management practices exist that can contribute to restore soil C, especially in contexts where it has been severely depleted. Maintaining a permanent ground cover is essential to the optimization of C sequestration in soils but represents a significant agronomic challenge in some contexts. Canada has an extensive cropland, and examples will illustrate the significance of past and current soil C sequestration induced by changes in management practices, especially in the Canadian Prairies. To conclude, in support of public policy development, much effort is currently devoted to evaluating the potential for additional C sequestration in agricultural soils at regional, national and global scales, and examples will be presented showing that this potential can be significant.

THEMATIC SESSION

AUDITORIUM 200 — 11:00 — TUESDAY 12th

CO_2 production well of Air Liquide (Montmiral - France), on which they performed a project related to the monitoring of CO_2 storage. © Jacques Pironon

DAY 01 - AFTERNOON

SESSION I - USE OF UNDERGROUND FOR ENERGY TRANSITION PURPOSES

13:45 — **KEYNOTE - Franz Lahaie** (chairman)
Safety as a core challenge of hydrogen industry deployment

14:15 — **Sasha Perroux**, et al.
Underground hydrogen storage for energy transition: actors, resources and territorial projects in Provence and Moselle

14:35 — **Aurélien Reys**
Between eco-responsibility and territorial fitting: at the heart of French junior mining company's strategy

14:55 — **Michel Cathelineau**, et al.
Will there be enough metals for energy and digital transitions?

15:15 — **Jannes Kinscher**, et al.
Origin and hazard of induced seismicity at the Balmatt geothermal doublet (Belgium)

15:35 — **Coffee break**

15:55 — **Xuan Liu**, et al.
Traceability of copper minerals and metals: concept and challenges

16:15 — **Christophe Reype**, et al.
Gibbs point process for Bayesian statistical analysis of hydrogeochemical data applied to source detection in multicomponent mixtures

16:35 — **Luc Désiré Omgba**, et al.
Energy transition and export diversification in oil-dependent countries: The role of structural factors

16:55 — **Antoine Boubault**
Understanding the debate around mineral resource depletion

17:15 — **Poster session**

19:30 — **Gala dinner at the City Hall of Nancy**
Place Stanislas

Safety as a core challenge of hydrogen industry deployment

Franz Lahaie [1]

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Decarbonated hydrogen is seen as an essential pillar of the energy transition needed to combat climate change. Today hydrogen is mainly produced from fossil fuels and used as feedstock in the industry. This sector is responsible for 2.5% of global greenhouse gas emissions. The perspective of producing hydrogen from renewable energies or low-carbon processes opens the route for using hydrogen as an energy carrier to (1) decarbonize many sectors relying on fossil fuels (transportation, heating, off-grid electricity production) (2) better integrate renewable energies into the energy mix by compensating their intermittency and (3) improve air quality.

Achieving the ambitious objectives set by many countries for the development of decarbonated hydrogen requires meeting major challenges: the cost of electrolytic hydrogen, a very insufficient production capacity for renewable (or low-carbon) energies, the need for natural resources (rare metals, water), the competition from other energy sources or carriers (electricity, e-fuels) and, of course, safety. Hydrogen is indeed a very specific gas that present dangers, among which a high flammability. The risks associated with hydrogen are well known and have been properly managed for decades in the industry. However, the multiplication and diversification of actors who will handling hydrogen tomorrow calls for an awareness and training of these new actors to the hydrogen risks.

In this presentation, we will review the main safety issues related to the production, transportation, storage, distribution and use of hydrogen in the context of the new hydrogen applications. Beyond the need for training and informing people on hydrogen risks, we will insist on the need to manage the risks related to emerging hydrogen production processes (biomass gasification, methane cracking, natural hydrogen extraction...), to the installation of hydrogen systems closer from end-users (including in the domestic field), to the coexistence of hydrogen with other energy sources or carriers, potentially generating domino effects, the necessity of adapting transport infrastructures (tunnels, subterraneous car parks, ports, airports) to hydrogen, the emergence of new forms of hydrogen storage and transport (liquid or solid hydrogen, ammonia, organic liquid carriers, underground storage, injection of hydrogen into gas networks, etc.), and to a risk governance that will be share by a raising number of stakeholders. Examples of results illustrating the progress of knowledge and the barriers that remain to be overcome in terms of risk management will be provided.

Underground hydrogen storage for energy transition: actors, resources and territorial projects in Provence and Moselle

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France's multiple commitments at the national, European and international levels in favor of the environment and the climate have had the effect of accelerating the energy transition process on French territory. This transition, while strongly promoted and supervised by the various institutions and governmental bodies, is experienced and implemented by the territories themselves (Fournier, 2012). However, the massive development of renewable energies raises the question of the stability of electrical networks, and therefore requires finding solutions to the intermittency of these energies. The realization of hydrogen projects, which offer a possibility of electricity storage, thus appears as much as an ecological imperative as an opportunity of socio-economic development for the territories.

We will study here two hydrogen storage projects, which take advantage of the geological specificities of their territory: the presence of saline cavities already exploited for the storage of other gases. The underground thus becomes a resource for the development of new activities. The first project (HyGreen) is located in the Alpes de Haute-Provence department, in the South of France, and is jointly supported by the Durance Luberon Verdon Agglomeration and Engie. The second project (Emil'Hy) is located in Moselle, in the Grand Est Region, and is supported by Engie and Gazel Energie, a branch of the Czech energy company EPH. This project is part of the Warndt Naborien Territorial Pact, which provides a framework for the closure of the coal-fired power plant there and supports the conversion of the region.

Through these projects, we can see the emergence and structuring of a whole energy ecosystem, which goes far beyond the technical and economic aspects alone. These projects are part of a more general context of structuring the hydrogen industry at the regional and even national level, which brings together a whole network of public and private players, generates synergies between different projects and participates in the energy interconnection of territories. Different resources are mobilized in the realization of these projects, whether material or immaterial (renewable energies potential, industrial culture, human capital, geological specificities...). Finally, the development of hydrogen storage goes hand in hand with the deployment of production units and new uses (mobility, industry), thus completing the creation of a new production and value chain for the territories. These hydrogen storage projects, interesting for their innovative aspect, contribute to making these spaces «energy territories» (Souami, 2009) whose complexity can only be apprehended by a holistic and ecosystemic approach.

References:
Fournier, M., Grison, J.-B., & Rieutort, L. (2012). Les enjeux du développement des énergies renouvelables : Les enjeux territoriaux. Droit de l'environnement, hors-série « les énergies renouvelables », 4-8.
Souami, T. (2009). Conceptions et représentations du territoire énergétique dans les quartiers durables. Flux, 76-77, 71-81.

THEMATIC SESSION

AUDITORIUM 200 — 14:15 — TUESDAY 12th

Between eco-responsibility and territorial fitting: at the heart of French junior mining company's strategy

Aurélien Reys [1*], Sylvain La Berre [2], Yann Gunzburger [3]

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In the early 2010s, market changes and geopolitical tensions spawned a new interest in mining in France after having been neglected for nearly 20 years. This new ambition for a «French mining renewal» is notably marked by the launch of a vast program to encourage investment in the sector and a revision of standards and guidelines defining the national Mining Code. The objectives sought were to ensure a better security for the financial investments of project owners, to take better account of potential environmental issues, and to improve the dialogue between investors and local stakeholders (Galin, 2016). However, despite all efforts, most of the projects that have been carried out since have generated strong local or national protests, increasing the politicization of subsoil exploitation (Chailleux & Merlin, 2018).

Social acceptability to mining projects has thus revealed to be a major question for the extractive industry in Europe and North America (Fortin & Fournis, 2014; Bergeron et al., 2015). The legitimacy to local population and their political representatives of such projects is dependent on compromises that integrate, beyond strict economic interests, environment protection concerns and territorial integration of industrial activities (Beauloye, 2020). In this respect, the example of 45-8 Energy, a French junior mining company seeking to exploit helium and carbon dioxide deposits located in the French department of Nièvre, is insightful. It offers us an original and constructive look at the current mining context in France. It also enables us to better understand the barriers faced by a mining company wishing to exploit resources from a historically non-mining territory, the communication strategies implemented and the communication strategies employed in order to support the success of the project.

References:
Beauloye, Y. (2020) « L'ancrage territorial d'un projet d'exploitation de gaz de charbon au sein d'un espace en mutation: l'ancien bassin houiller lorrain », Thèse de Doctorat de géographie, sous la direction de Michel Deshaies et de Yann Gunzburger, Université de Lorraine.
Bergeron, K., Jébrak, M., Yates, S., Séguin, C., Lehmann, V., Le Meur, P.-Y., Angers, P., Durand, S., Gendron, C. (2015) « Mesurer l'acceptabilité sociale d'un projet minier: essai de modélisation du risque social en contexte québécois », VertigO, vol. 15, n°3
Chailleux, S., Merlin, J. (2018) « Unconventional oil and gas in France: from popular distrust to politicization of the underground », The Extractive Industries and Society, vol. 5, n°4, p. 682-690
Fortin, M.-J., Fournis, Y. (2014) « Vers une définition ascendante de l'acceptabilité sociale: les dynamiques territoriales face aux projets énergétiques au Québec », Natures Sciences Sociétés, vol. 22, n°3, p. 231-239
Galin, R. (2016) « Le renouveau minier français et les matières premières stratégiques », Annales des Mines - Responsabilité et environnement, n°82, p. 77-80

Will there be enough metals for energy and digital transitions?

Michel Cathelineau [1,2*], Agnes Samper [2]

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The energy and digital transitions are set to consume an extensive range of metals (from "rare metals" REE (Nd, Dy) to Li and base metals (Cu, for instance)), the sufficiency of which is in question. With the concept of ore reserves often challenging to handle, too many simplistic calculations have led to sensational and alarmist trends forecasts aiming at diffusing largely the idea of resource depletion, introducing the concept of the possibility of occurrence of a "peak metal" similar to the concept of "peak oil". Such a statement makes little sense as it is based on miscalculations or false concepts. A proven mineable reserve corresponds to the tonnage of metal of a deposit or ore formation demonstrated by drilling data and subsequent numerical modelling, with more than 90 % probability.

All these exploitable resources are calculated with an indicator named "cut-off grade" representing the part of ore within the "waste rock", i.e. the lowest acceptable grade above which a rock formation is considered an economically exploitable ore, i.e. not in deficit. Since the 70', Skinner introduced the concept of a "geological barrier" existing between exploitable ores and other common rocks.

Economies operate differently based on regional specificities. Profitability in the western world is about paying back shareholders for initial investments and then making annual profits, which requires profitability yearly. Other economic systems operate with lower cut-off grades or larger volumes and ultimately greater output (China, for instance). The cut-off grade will vary accordingly to the stock market, which is primarily dependent on demand. For example, in gold deposits, due to regular price surges, cut-off grades have progressively been lowered to very low values (a few grams per ton).

However, it is understandable that generally, the exploitable reserve is not a fixed figure but depends on the price of the metal and associated specific exploitation costs linked to location or the technicalities of extraction and processing. The generalization of depletion calculations is therefore hampered by the heterogeneity of cut-off grades for the same metal. Improvement in mining techniques has brought down the low values and cut-offs. For example, in the case of uranium, it is much more profitable to exploit low-grade U concentrations of a few hundred mg/kg by in situ recovery (ISR) than hyper-rich deposits containing several per cent of metals, as depth, radio-protection, and environmental concerns bring their exploitation down to the limit of profitability. As concentrations in the hundreds of mg/kg in ISR operations are only 3 to 5 times higher than natural formations (granites), the notion of a barrier, in this case, becomes irrelevant, as low-grade ores may be easier to process than metal-rich ores and this leads to consider reserves as much more significant. Similar analyses can be made for lithium, part of whose reserves are in the form of liquid ores, not only in salars but also in basin brines and thermal waters.

Origin and hazard of induced seismicity at the Balmatt geothermal doublet (Belgium)

Jannes L. Kinscher [1*], Matsen Broothaers [2], Francesca de Santis [1], Ben Laenen [2], Jean Schmittbuhl [3], Emmanuelle Klein [1]

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The Flemish Institute for Technological Research (VITO) initiated a geothermal project on the former Balmatt industrial site near Mol (northern Belgium) with the aim to demonstrate the technical, economic and environmental feasibility of developing a deep geothermal plant in the Campine Basin. Drilling commenced in 2015 and operations (production and injection) were started in 2018. To mitigate associated seismic hazard and risk VITO operates a microseismic monitoring system coupled to a local traffic light system (TLS). Several seismic events with magnitudes -1 < ML < 2.2 have been recorded since December 2018. The strongest event occurred on the 23rd of June 2019 (ML 2.2) was felt by the population in the adjacent towns of Dessel and Mol. It triggered a red-light status of the TLS. Based on the recorded seismic data set an extensive analysis has been performed in order to better understand the main driving forces of seismicity and to assess related hazard and risk. Analysis involved detailed seismic source characterization including an evaluation of absolute event location, source mechanism and parameter determination, cluster analysis and relocation. From the results, we conclude that fluid injection and pressure diffusion seem to be the driving force in triggering seismicity. However, the seismic rate cannot be entirely explained using linear hydromechanics models based on homogeneous fluid pressure diffusion models and Mohr-Coulomb failure criteria. Indeed, evidence was found documenting the presence of non-linear fluid flow along pre-existing fault zones and seismic triggering related to post-rupture static stress transfer. Beyond that it was emphasized that aseismic slip and seismic triggering from fault creep seem to play a key role at Balmatt. In terms of seismic hazard and risk the results suggest that the maximum expected magnitude (Mmax) ranges most likely between 3 and 4. However, given the presence of significant uncertainties related to the performed analysis, hazard scenarios with Mmax larger than 4 or 5 cannot be totally excluded. Based on a preliminary ground motion prediction equation model, we suggest that damage on the buildings of the nearby nuclear installations might be expected for Mmax close to 5 while light damage at private houses with Eurocode 8 standards (zone 3 Belgium) seem to be likely for Mmax around 4. In the framework of a follow-up research project, involving resumed production and a reinforced seismic network, the results are currently revaluated and specified with focus on the hydrological reservoir characterization and geothermal potential as well as to better understand the (a)seismic response to fluid injection and the implied seismic hazard.

THEMATIC SESSION

AUDITORIUM 200 — 15:15 — TUESDAY 12th

Traceability of copper minerals and metals: concept and challenges

Xuan Liu [1,2*], Jacques Pironon [1], Clément Roignant [1], Alan Butcher [2]

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Traceability refers to the ability to identify and trace the history, location, distribution and application of product, part, and material in each step reversing supply chain. Traceability technology for industrial minerals and metals is instrumental in improving transparency and ensure proper behaviour in the supply of metals. It is a key enabler for energy and ecological transition of the human society. Up to date, the commonly practised management approaches are limited by corporative ambition, vulnerable to fraud and passive to material mixing. Geochemical fingerprinting technique is considered a complementary solution but has only been applied to upstream chains of specific metal ores (e.g., the conflict metals tin, tungsten, tantalum, gold known as 3TG).

With a financial support of the DEEPSURF program, we explored the possibility of achieving a whole-chain traceability of metals by utilising geochemical fingerprints that are naturally embedded in ore minerals. Through this exploratory project, we hypothesized that traceability-effective fingerprints should meet three requirements, i.e., deposit-scale homogeneity, global-scale uniqueness, and along-chain trackability. Homogeneity means that the fingerprints should be invariable across different generations (time) and locations (space) within the deposit; uniqueness means deposits across the world have differing magnitudes of the fingerprints; trackability means that the fingerprints are conservative along the supply chains.

The three requirements pose enormous challenges in terms of analytical capacity and natural availability. Taking copper as an example, we conducted a comprehensive bibliographic survey which reveal that Pb isotopes cannot meet the uniqueness requirement due to large overlaps among global deposits. The overlaps may have been caused by data scatters in relation to the existence of uranogenic / thorogenic lead, mixture of different sulfides, and the bulk methods used. To probe into this issue, we analysed trace elements and Pb isotope compositions of pyrite and chalcopyrite of the Tongchang porphyry Cu deposit by using a double-focusing single collector LA-ICP-MS. Most elements are very low in concentrations (< 2 ppm), other elements are variable both intra- and inter- generations, thus violating the homogeneity requirement. However, some elements are in appreciable concentrations (>5 ppm) and are worth of further isotopic investigations (Ti, Cr, Zn, Ge, Se, Ag, Pb). Pb isotope analyses have just been finished, a preliminary interpretation suggests that low Pb contents in chalcopyrite compromises the precision and accuracy of measurements, and thus more sensitive instrument should be used if more precise and accurate Pb isotopes are to be analysed. In addition, pyrite and chalcopyrite possesses distinctive Pb isotope compositions, supporting the idea that bulk analysis of sulfide mixtures or non-Cu sulfides is not representative of Cu ores. More works have been designed and will be carried out in the near future.

Gibbs point process for Bayesian statistical analysis of hydrogeochemical data applied to source detection in multicomponent mixtures

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Mixing of water from different sources is a widespread process in surface and subsurface environments. However detecting the number and the composition of water sources from hydrogeochemical data is challenging. This is solved either manually or via statistical analysis. Both approaches are heavily supervised in order to overcome the unknown number of sources, the geological/hydrological constraints and the multi-dimensional character of the data.

A new Bayesian approach to detect sources, that relies less on the user, is implemented in this work.

The probabilistic model is based on Gibbs point process and models the number and the positions of the sources in the space made by the hydrogeological parameters. The composition and the number of the sources are estimated by the pattern of points that maximises the probability density of the point process. This probability density integrates the followings criteria:

1. the number of sources should be low
2. the composition of the sources should be close to the data
3. the composition of sources should be significantly different from each other
4. the convex hull of the sources should encloses the data

The maximum of the probability density is searched through a simulated annealing algorithm that uses a Metropolis-within-Gibbs algorithm to deal with the multidimensional character of the data.

THEMATIC SESSION

AUDITORIUM 200 — 16:15 — TUESDAY 12th

Energy transition and export diversification in oil-dependent countries: The role of structural factors

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Climate change is having profound impacts on global economy, and the extractive sector is no exception. Countries that export fossil fuels are facing major challenges relating to energy transition. Under the 2015 Paris Climate Change Agreement, countries are expected to undergo a structural shift and transition to low-carbon, resilient models of economic development. A clear pathway for oil-dependent countries to mitigate carbon risk is to diversify their economies. Many oil-dependent countries have embarked on this transformational journey that aims at reducing dependence on oil revenues and increasing economic diversification. However, export diversification appears particularly challenging for a number of oil countries. A question of interest that naturally arises is why some oil-exporting countries have managed to diversify their economies while others have not? We hypothesize that this difference in diversification patterns among oil countries may be associated with differences in their structural characteristics. Such differences may generate a divergence in countries' diversification trends. Some countries having initially similar characteristics may converge towards the same steady state. But they may also diverge from each other to converge towards different equilibriums along with other countries having different initial characteristics. To investigate this, we examine whether all countries converge towards the same diversification level or their diversification efforts diverge as a whole but create separate convergence clubs. The results show that structural and institutional factors play a central role in the diversification process. In particular, improvements in infrastructure, human capital, and research and development efforts increase the odds of being in a high diversification club providing thus greater resilience in turbulent times and successful energy transition.

Understanding the debate around mineral resource depletion

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Mineral resource depletion does not have the same meaning to every person. John Tilton insisted on two opposing views, looking at mineral resource depletion: one that is the 'fixed-stock paradigm' and a second one coined the 'opportunity-cost paradigm'. While the first one tends to view mineral resources as a given stock that is irremediably depleting by extraction and will eventually exhaust, the second one tends to have a more optimistic view considering new techniques, variable prices and substitution for cheaper alternatives will always prevent mineral resource exhaustion have the economy adapt to available resources.

Here, I will try to reconcile the two views, showing that they are not mutually exclusive and that mineral resource depletion might be a perception more dependent on the dynamics of mineral resource consumption than supply.

First, the word 'depletion' may apply to different aspects of mineral resource stocks. It can be the decrease of their quantity, their quality, their nature, etc. Generally, depletion applies to a fixed stock. Second, we need to recognize the various scales of time and that mineral resource depletion might occur temporarily at a given scale and not at other ones, for some resources, depending on society's choices and economic twists and turns.

Third, any stock may change over time more or less rapidly as we live in a dynamic system. This applies to the stocks of fish and trees, but also to copper and petroleum on a much wider timescale. Talking about mineral resource depletion is thus always implying various hypotheses regarding the future of our dynamic system, and not every person might consider the hypotheses valid. The dynamics of stock change depends on the magnitude of inflows and outflows, consumption driving the latter.

The fixed stock paradigm tends to account for all crustal resources, for which the mass in- and outflows are very small compared to their size. However, biogeochemical processes acting on this stock may transform or regenerate the quality and nature of mineral resources.

In the opportunity cost paradigm, the coming depletion of a mineral resource stock is revealed by shortages and price increases pushing producers to increase material efficiency and consumers to reduce demand, find substitutes, or opt for cheaper alternatives, hence preventing a full depletion. All options come with techno-economic and environmental consequences.

WEDNESDAY 13rd OCTOBER

DAY OF FIELD TRIPS

Fossil resources from past to present: from coal to coalbed methane in northern Lorraine

© Musée Les Mineurs Wendel

EXPLORE WENDEL PARK

Shaped for more than a century and a half by mining activity, the landscapes of the Lorraine coalfield bear deep traces of coal mining: slag heaps, headframes, old mine tiles, quarries and workers' housing estates still bear witness to the past importance of this activity. With the decline, and then the complete cessation of mining in 2004, the former mining sites have evolved very differently according to the conversion projects that may or may not have been developed there.
Only the site of the Wendel pit in Petite-Rosselle has been almost completely preserved for the mine museum, which opened in 2006. In addition to the preservation of four headframes, the coal washing facilities and the former offices, a reconstruction of the underground workings has been created (the red structure in the shape of an open book in the background). The Wendel Miners Museum, now the Explor Wendel Park, is being redeveloped as a place of memory and economic development.

THE WENDEL MINORS MUSEUM

At the very heart of the former administrative building of the Wendel headquarters, discover the history of coal mining in Lorraine while revealing the place occupied by miners

© Laëtitia Vançon

in these emblematic settings. In a modern and attractive presentation spanning over 1,800 m^2, over 160 objects and models, 25 audiovisual documents as well as countless photos, documents and audio terminals immerse you in the history of coal in Lorraine, the daily life of the miner and his family, the social policies of mining companies...

REGALOR

Despite the closure of coal mines in 2004 in the coal basin of Lorraine, gas is always present under our feet, coalbed methane, tapped in the coal veins that were not exploited by miner. The Regalor research program aims to define the impacts of a coal bed methane exploitation on the environment, the territory, the socio-economic actors and the population.

The industrial partner of the project provides an ancient exploration drilling site for the scientists. Researchers were able to install tools to measure gas in the underground, on the surface and in the atmosphere.

A new stage has been overcome on July 2021, with the installation, in great depth, of advanced measure tools. These new disposals aims at quantifying continuously the gas at several depths, and especially in coal veins.

FRANÇAISE DE L'ÉNERGIE

La Française de l'Énergie is an SME with a negative carbon footprint, specializing in the production and use of energy in short circuits. It supplies gas, green electricity and heat to Lorraine, Hauts-de-France and Wallonia, thus replacing imported energy.
As part of its coal gas development project, the company, established in Lorraine since 2006, has built several appraisal wells to validate the feasibility and marketability of local CBM production.

A CORE COLLECTION USEFUL FOR SCIENTISTS

A significant part of the data is collected from the drill cores. They make it possible to visualize the sedimentary layers in order to retrace the local and regional geological history. The measurements made on these cores are incorporated into all 3D geological models. In addition, these cores make it possible to work on avenues for innovation in gas storage (CO_2 and H_2). They therefore have an inestimable technical and scientific value and are part of the geological heritage of the region.

La Française de l'Énergie built what is now the largest core collection in the Grand Est region, which also serves as a workspace for scientists within the framework of research programs such as Regalor and DEEPSURF.

Geological storage of radioactive waste and forest management in response to climate change in southern Lorraine

© ANDRA

ANDRA facilities

Andra has been tasked with the design and development of the Cigeo underground facility for the disposal of high-level waste (HLW) and intermediate-level long-lived waste (ILW-LL), mostly resulting from spent fuel processing. If licensed, operation at the Cigeo Facility will start with an industrial pilot phase, expected to begin in around 2025.

Research on the Cigeo Project is mainly conducted at the Meuse & Haute-Marne Centre (CMHM) that houses an Underground Research Laboratory, a Technological Exhibition Facility and an Environmental Specimen Bank.

Andra's Underground Research Laboratory, operating in Bure in the Meuse area since 2000, is a research facility unlike any other in France. Around 1.7 km of drifts situated at a depth of 490 metres below the surface are used by scientists to carry out research on the 160 million year-old claystone formation.

Built in 2009 in Saudron, in the Haute-Marne area, the Technological Exhibition Facility is a visitor information centre. It includes a permanent interactive exhibition on radioactive waste and the Cigeo Project.It also houses a 3,000 m^2 exhibition hall where prototype waste containers and robots used to prepare the industrial phase of the Cigeo Project are on display.

DROUGHT DEVICE

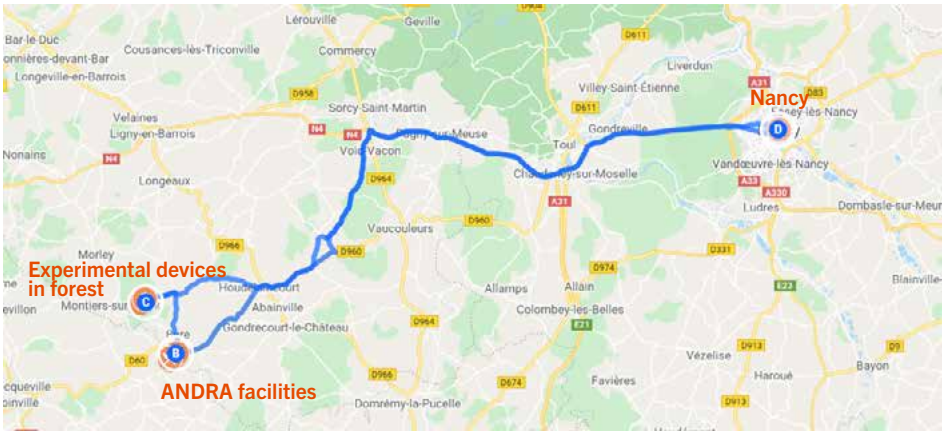
According to climate models, drought events are likely to increase in frequency and intensity during the coming decades (IPCC, 2013). These events are going to disturb forest ecosystems and to affect the many services forests provide. The Drought Device was set up in 2019 in the aim of improving understanding of the biogeochemical and biological functioning of a forest facing intense drought events (no water during 2.5 months) repeated each year. This device consists of 400 m^2 of sliding roof underneath canopy, corresponding to the Drougth plot (D) and a Control plot (C) of the same surface. The two plots are equipped to carry out precise monitoring of the biogeochemical cycles of nutrients.

FLUX TOWER

The flux tower of the Montiers site is a free-standing metal pylon of 45 meters high (15 - 20 meters above canopy) and equipped with various instruments to measure the exchanges of CO_2, water and energy between the atmosphere and a beech forest ecosystem. This tower allows to estimate the productivity of this ecosystem. Three types of automatic sensors are installed at different height (between 5 meters and 45 meters): an Eddy Covariance System (fast-response anemometers and fast gas analyzers) to monitor the net flows of CO_2, water vapour, CH_4, N_2O and latent heat; micrometeorological sensors (temperature, humidity, wind speed and direction, rainfall, atmospheric pressure…) ; and radiation sensors (NDVI, PRI, PAR, solar, infrared).

SOIL GAS STATION

In situ and continuous monitoring of soil gases (CO_2 and CH_4) has been carried out since 2019 in a forest ecosystem. The monitoring system is made up of 3 connected modules: Module 1 is made up of two specific completions placed in 2 dedicated boreholes at -6 m and -1 m deep. Module 2 is devoted to the process of gas circulation. Module 3 concerns the sensor part with a portable infrared Fourier transform spectrometer using a gas measurement cell suitable for short optical path. Other physical parameters are also continuously measured in the various boreholes (T °, pressure, gas flow, piezometric level, etc.). In order to prevent any type of degradation, all this equipment is grouped together in a forest shelter.



Salt and its age-old history in Lorraine

© Mine de Varangéville

LAST ACTIVE SALT MINE

The rock salt deposit is linked to the invasion of the sea and to evaporation phenomena occurring in the Triassic (Muschelkalk and Keuper). This deposit extends over 200 km. It outcrops 50 km east and north of Nancy, and extends to Champagne, to the west, where it then reaches a depth of 1500 m.

Known since antiquity in the form of salt springs, the salt deposit was only exploited industrially from the 19th century. In 1819, it was discovered that the rock salt was located at a depth of between 70 and 200m in Nancy area in the form of flat and extensive layers, the thickness of which allows exploitation in galleries.

The Varangéville mine will open in 1855. In Varangéville, the CSME extracts salt in the Saint-Nicolas mine, the last salt mine still in operation in France (One of the very last French mines...); as this salt is not pure enough to be used in the chemical industry, it is intended exclusively for snow removal.

The salt is also extracted by in situ dissolution (injection of fresh water and withdrawal of the brine) and used, among other things, for the manufacture of soda ash and bicarbonate according to the process developed by E. Solvay from rock salt and limestone in 1861.

MARSAL AND ITS SALT HISTORY

The salt meadows of the Seille River represent an exceptional natural heritage and are extremely rare in France as well as in Europe. The valleys of the Seille River and the Nied River are the only halophilic valleys in France. The valley of the Seille River extends over approximately 2000 ha spread over twenty municipalities, which most densely populated are Dieuze, Château-Salins and Vic-sur-Seille. The features of the halophilics valleys of the Seille River and the Nied River are explained because they are above a salt deposit of geological origin (210 million years ago, Keuper), which supplies the associated alluvial groundwater of these rivers with salts. Salt sources are expressed locally on the surface, due to superficial factors, and allow the existence of quite exceptional ecosystems in a continental context, made up of species usually present on the coast, while the study area is located more than 400 km from the sea! The "halophilic" (salt-loving) species known to date cover various taxonomic groups: vascular plants (15), algae, bryophytes (1), fungi (1), spiders (3), insects (34). The originality of these salt marshes and meadows was already known by naturalists of the 17th century. The whole is now enjoying international recognition with the establishment of the European Natura 2000 network, justified by the presence of continental salt meadows of priority interest. Nevertheless, 33% of the halophilic habitats of the Seille River disappeared between 1967 and 2000. The Conservatory of natural areas of Lorraine (CEN Lorraine) acquires and manages lands since the 1980s in order to preserve the original biodiversity of 12 sites covering an area of 175 ha, including 97 ha of salt meadows. The lands are operated by farmers who harvest the fodder while respecting specifications intended to preserve conservation issues. In addition to the actions of CEN Lorraine, the Lorraine regional nature park (PNRL) continues to coordinate the program of agri-environmental measures at the level of the Natura 2000 site of the upstream Seille River. But this natural heritage would not exist without the preservation of the hydrological functioning of the salt sources, the safeguarding of the alluvial functioning of the valley, or the pursuit of a compatible agricultural activity and a conducive environment to its expression. Thus, the development of an ecological and functional approach to salt meadow ecosystems has made it possible to (1) observe a heterogeneous resilience of these ecosystems in relationship with the ecological and socio-economic contexts of this valley and to (2) remedy hydraulic malfunctions as much as possible. Finally, for the past ten years, climate change has required adaptation of agricultural specifications. Continuous scientific survey and territorial coordination are essential to support the conservation of these networks of salt meadows.

Past oil exploitation and present geothermal energy in northern Alsace

source : Musée Français du Pétrole

FRENCH OIL MUSEUM

Since the dawn of time, wild boars have known that the best way to get rid of vermin was to wallow in the oily outcrops of the North Alsace forest. They represent undoubtedly the first users of Pechelbronn's oil, soon to be followed by humans. For centuries, they collected this fatty substance floating on the surface of the "Baechel-Brunn" spring to lubricate the wheels of their carts and to cure toothache, gout or wounds...
From the 18th century onwards, mining acquired an industrial dimension until the refinery closed in 1970. The geology of the Rhine Graben explains a unique deposit which was exploited by wells, drilling, pumping and even by mine galleries. Technical innovations have made Pechelbronn famous in the oil industry.

The museum retraces 500 years of oil history in Northern Alsace: the extent of the mine galleries and the refinery, the birth of the ANTAR company and the Institut Français du Pétrole, and the first electric core drilling are some of the highlights of this unique saga. It also presents a complete overview of the geological formation of this oil and its unexpected uses.

© Laurie Tchang-Tchong

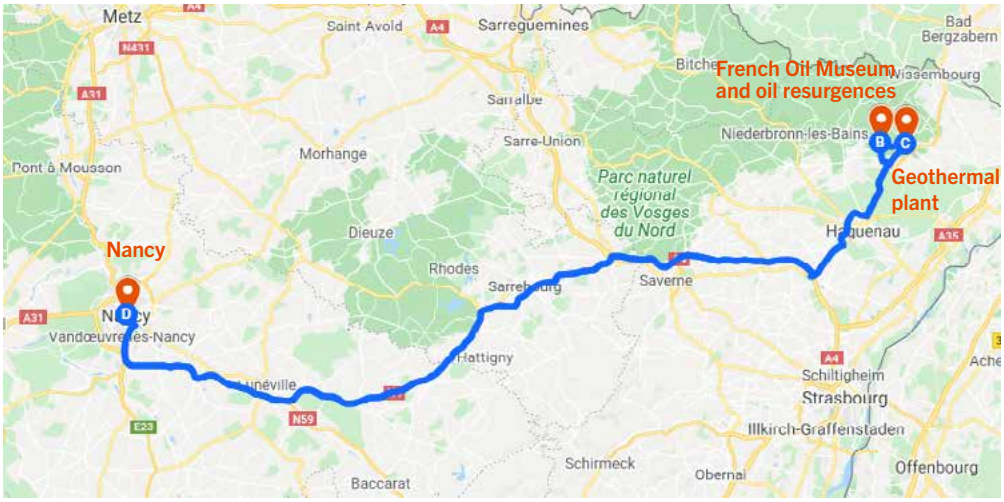
source : ÉS

GEOTHERMAL PLANT

Alsace has considerable energy potential in its subsoil, as it consists of naturally faulted rocks (Rhine collapse basin). In these areas, the temperature rises by an average of 8 to 10°C every 100 m. This is three times higher than the average in the continental crust. Deep geothermal energy is thus a natural local asset for Alsace. Whether for electricity or heat production, it fits perfectly into the Alsatian energy mix.

Allowing the production of heat or electricity, deep geothermal energy of the EGS (Enhanced Geothermal System) type exploits the hot water (over 150°C) naturally present in the subsoil between 2,500 and 3,000 metres below ground. The water is pumped via a "producer" well. Its calories are recovered through a heat exchanger. The geothermal water is then reinjected into its natural environment via an "injector" well.

From the Soultz-Sous-Forêts research site to the commissioning in 2016 of the first French industrial EGS project applied to industry, ÉS is a forerunner in this technology.



THURSDAY 14th OCTOBER

DAY OF CONFERENCE

DAY 03 - MORNING

SESSION II - WHAT IS THE ROLE OF SOILS IN THE ECOLOGICAL TRANSITION?

AUDITORIUM 100

08:30 — **Keynote | Christophe Schwartz** (chairman)
Ecosystem serices provided by soils: do not forget urban and industrial ecosystems

09:00 — **Clémentine Chirol**, et al.
Mapping soil ecosystem services bundles in forested and agricultural lands to optimize regional land planning

09:20 — **Julien Sainte-Marie**, et al.
C-STABILITY an innovative microbial model of soil carbon dynamics integrating the continuous representation of organic matter

09:40 — **Maelys Cadel**, et al.
Evaluation of ecosystem services linked to soil functioning in temperate agroecosystems: a literature analysis

10:00 — **Coffee break**

Ecosystem serices provided by soils: do not forget urban and industrial ecosystems

Christophe Schwartz [1*], Victor Allory [1], Aurélie Cambou [1,2], Patrice Cannavo [2], Stéphanie Ouvrard[1], Geoffroy Séré [1], Laure Vidal-Beaudet [2]

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If the storage of organic carbon in urban soils is essential and determines many ecosystem services essential to the well-being of citizens, assessments of urban soil organic carbon stock (SOCS) are scant because citywide data are scarce. Urbanization is at the heart of environmental concerns today. This phenomenon has accelerated since the industrial revolution. On a planetary scale, it is expected that between 2000 and 2030, the equivalent of the surface area of the city of Paris will be urbanized every day.

To enable urban soils to provide ecosystem services, one of the levers of action is the maintenance, or even the increase, of the amount of organic matter in the soils (SOM). Indeed, SOM plays a preponderant and positive role on the physical fertility (aggregation, aeration, water retention, root development), chemical (buffering capacity, pH regulation) and biological (activity and microbial, animal and plant diversity) of soils. In addition, since SOM is mainly composed of carbon (on average 58%), the phenomena of storage / release of organic C in soils therefore have a direct effect on the concentration of CO_2 in the atmosphere, and consequently, on the climate.

Studying the SOCS, and de facto in urban soils then becomes essential. Urban soils, like agricultural and forest soils, constitute an essential but limited and non-renewable resource on human time scale. However, the interest shown in urban soils by the scientific community is only very recent (since the 1990s in France). One of the limitations in the study of these soils is due to their strong spatial and temporal heterogeneity, making any generalization difficult. Thus, current knowledge on SOCS in urban soils is mainly based on ad hoc case studies. What then do we know about these soils and their capacity to store C? The presentation will (i) describe the results of a meta-analysis highlighting the strong originality and diversity of Technosols, compared to other soils and (ii) highlight which factors mostly explain SOCS spatial and temporal variations in urban open soils.

References:
Allory V, Séré G, Ouvrard S, 2021. A meta-analysis of carbon content and stocks in Technosols and identification of the main governing factors. European Journal of Soil Science, 1-17, DOI: 10.1111/ejss.13141
Cambou A, Shaw RK, Huot H, Vidal-Beaudet L, Hunault G, Cannavo P, Nold F, Schwartz C, 2018. Estimation of soil organic carbon stocks of two cities, New York City and Paris, Science of the Total Environment 644 (2018) 452–464, https://doi.org/10.1016/j.scitotenv.2018.06.322

Mapping soil ecosystem services bundles in forested and agricultural lands to optimize regional land planning

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Soils provide multiple ecosystem services (ES): they are crucial to the production of food, biomass-energy and materials; they support infra and superstructures; and they provide regulation services from the local scale (e.g. flood mitigation) all the way to the global scale (e.g. biodiversity support and contribution to climate change regulation through carbon trapping, especially in the case of forest soils). Since some of these services are mutually exclusive, competition between different land uses may arise, leading to trade-offs when making decisions for land planning[1]. Therefore, there is a need for new land planning approaches that consider bundles of services to inform these trade-offs and optimize overall ES delivery. Such an approach should be based on an understanding of the variability of soil bio-physico-chemical properties, both spatially within a given region and vertically across a soil profile, since these properties affect the delivery of ES[2].

This study integrated topography, land occupation and soil indicators to estimate the spatial repartition of soil functions and ES delivery within a 900 km^2 region dominated by agricultural and forested lands (Perennial Environnement Observatory, Meuse / Haute-Marne, France). Based on expert opinion, information from a 1/50000 pedological map and the description of 84 soil profiles, 8 main soil types were defined as representatives of the functional variability of the soils within the region studied. For each class, a paragon soil profile was designed to infer the median bio-physico-chemical properties of each soil horizon. Soil, land occupation and topography indicators were then used to separate the study site into homogenous zones. In each zone, soil functions and ES were semi-quantitatively rated (on a scale of 0-3) using the DESTISOL decision support tool[3].

Outputs are provided in the form of maps of ES ratings, and radar charts showing the ES ratings in each zone. Our results provide a holistic visualisation of the ecosystem services trade-offs that arise for various combinations of soil types and land occupation, and pave the way for land planning scenarios that optimize ES delivery at the regional scale.

1. Turkelboom, F. et al. When we cannot have it all: Ecosystem services trade-offs in the context of spatial planning. Ecosyst. Serv. 29, 566–578 (2018).
2. Martín, M. Á. et al. Soil structure and function in a changing world: Characterization and scaling. Geoderma 287, 1–3 (2017).
3. Blanchart, A. et al. Towards an operational methodology to optimize ecosystem services provided by urban soils. Landsc. Urban Plan. 176, 1–9 (2018).

C-STABILITY an innovative microbial model of soil carbon dynamics integrating the continuous representation of organic matter

Julien Sainte-Marie [1*], Matthieu Barrandon [2], Laurent Saint-André [3], Eric Gelhaye [4], Francis Martin [4, 5], Delphine Derrien [3]

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Soil contains the largest active reservoir of terrestrial carbon and is viewed as a key component to mitigate climate change by enhancing the storage of additional carbon in the form of soil organic matter (SOM). SOM dynamics is regulated by complex processes at interplay. Its understanding, which has considerably advanced in recent years, involves different disciplines. In the field of biogeochemistry, the emerging view considers SOM as a range of polymers continuously processed into smaller molecules by decomposer enzymes. Knowledge in the field of microbial ecology has also greatly been enhanced during the past decade, with detailed information now available about decomposers functional diversity and about their role in SOM cycling.

Models provide a very useful tool to aggregate these novel multidisciplinary knowledges so as to improve our global understanding of the functioning of soil. But mainstreaming the new paradigms in current models is challenging because of their ill-adapted framework. The C-STABILITY model (Sainte-Marie et al., 2021) proposes to address this issue. It synthesizes knowledge arising at the interface of soil sciences and microbiology and allows the prospection of key processes of SOM decomposition and stabilization.

The model relies on a combination existing modelling approaches. One of its innovations is the description of substrate chemistry, and in particular the continuum of OM forms with different levels of polymerization within any biochemical species. C-STABILITY makes also a distinction between enzyme and microbe accessibility to substrate, reports how the level of polymerization of the substrate evolves under enzyme action to make it accessible to microbes, and makes enzymatic and microbial biotransformations of substrate explicit.

Theoretical simulations provide new insights on how depolymerization and decomposers ecology impact SOM chemistry and amount during decomposition and at steady state. They also reveal that the joint action of enzymes regulates complex substrate degradation. They show that microbial community successions are key drivers of SOM nature and quantity during substrate decomposition.

The operational description of SOM chemistry and decomposer catabolic activity in the C-STABILITY framework represents an asset to strengthen our mechanistic knowledge of SOM dynamics and storage. It offers a platform to identify knowledge locking points, to shape interactions between soil scientists and microbiologists, and to stimulate discussions on the mechanistic controls of SOM cycling. The flexible structure of C-STABILITY is open to further developments for exploring new mechanistic hypotheses and supporting the design of future experiments.

Sainte-Marie et al. (2021). C-STABILITY an innovative modeling framework to leverage the continuous representation of organic matter. Nature communications. 12(1), 1-13.

Evaluation of Ecosystem Services linked to soil functioning in temperate agroecosystems: A literature analysis

Cadel Maelys [1,2*], Redon Paul-Olivier [1], Therond Olivier [3], Cousin Isabelle [2]

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Soils are key components of ecosystem multifunctionality. They provide multiple ecosystem services (ES) such as climate mitigation via carbon sequestration, water quality and flow regulation and are the support of agricultural production. However, most arable cropping systems are still intensively managed focusing on productivity, often promoting economic performances rather than ecological sustainability. Many studies showed that conventional farming practices are great at maintaining high yields but at the expense of the provision of most regulating services, reducing, over time, the ability of soil to function and leading to environmental issues. Also, some studies tend to show that more sustainable practices (e.g. organic farming, ley incorporation) could enhance microbial activity, nutrient cycling and the maintenance of soil structuration without a systematic significant reduction of agricultural performances. Following agroecological transition, it is of great importance to design sustainable production systems that maintain high cropping performances with lower use of chemical inputs and intensive tillage regime. The objective is to perform systems based on agroecosystems multifunctionality that enhance synergies and that reduce the trade-offs usually observed between provisioning and regulating services. To improve our knowledge on soil processes that support the delivery of ES to understand how to maximize them, we thus decided to perform a systematic literature review on the relationships between soil ES provided by arable systems. We focused especially on annual field crops within temperate regions to avoid the comparison of very different systems in terms of soil processes. We used the ISI Web of Science bibliometric database with a specific combination of keywords that allowed the gathering of almost 40 relevant studies over 867. We noticed all types of relationships between pairs of ES assessed in the studies (synergy, trade-off and independent), according to the scenarios tested. We also reviewed the effects of the analysed drivers on the provision of ES. We designed a specific ontology of services to deal with the semantic differences between the naming of ES and to allow the comparison of all the results. We demonstrated that agricultural production, Soil Quality, nutrient provision to crops and water quality regulation are the most studied services. Studies usually perform scenario-based (e.g. organic VS conventional; rotation diversification; incorporation of cover crops) or spatial snapshot analyses. Globally, the ES pairs do not exhibit specific trends (either synergy, trade-off or independent) implying that the functioning of the ecosystem clearly depends on the crop management.

Scan of wood samples
© Clémentine Ols

DAY 03 - MORNING

SESSION III - FOREST IN TRANSITION, FROM INCREASED BIOMASS PRODUCTION TO CARBON SEQUESTRATION

AUDITORIUM 100

10:20 — **Clémentine Ols**, et al.
Towards a systematic and continuous monitoring of climate change impacts on forest productivity in Europe

10:40 — **Claudia Oliveira**, et al.
From the forest to the forge: charcoal production in northeastern France lowlands (XVII-XX centuries)

11:00 — **Miguel Rivière**, et al.
Mapping territorial vulnerability to forest fires to orient risk-reduction planning and improve resilience in south-eastern France

11:20 — **David Shanafelt**, et al.
If a tree falls in a forest, why do people care? An analysis of the United States national woodland owner survey

11:40 — **Salomé Fournier**, et al.
Balancing carbon stock and flows in French forest stands: which silvicultural strategy to mitigate climate change?

12:00 — **Nikola Besic**, et al.
Modelling the impact of the climate change on the forest: towards a new framework for the comparative analysis

12:30 — **Lunch**

Towards a systematic and continuous monitoring of climate change impacts on forest productivity in Europe

Clémentine Ols [1*], Thomas Gschwantner [2], Klemens Schadauer [2], Jean-Daniel Bontemps [1]

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Climate change mitigation and energy transition are becoming priorities on many political agenda across the world, and especially in Europe. Forests, through their capacity to sequester carbon and produce renewable materials, are key assets to reach these environmental goals. European forests are encountered across wide biogeographic gradients and have recently shown contrasted productivity responses to climate change. Maximizing the climate benefits of European forests requires to precisely track forest productivity trajectories across regions in a continuously changing growing environment.

National Forest Inventories (NFIs) perform systematic forest surveys across space and time and are powerful tools to monitor forest productivity dynamics and climate controls upon forest productivity at wide geographical scales. Building upon the ongoing pan-European harmonization of NFI data and information, we developed an original and promising modeling framework to extract large-scale climate-driven productivity dynamics and confront them to silvicultural and environmental attributes. With its simple and versatile design, it can be easily applied to diverse NFI schemes (annual vs. periodic field campaigns, permanent vs. temporary plots, radial increment vs. diameter measurements). To illustrate its promising potential to monitoring forest productivity dynamics, we consecutively applied it to study pure and even-aged conifer forests (1) in France over the 2006-2016 and (2) in France and Austria over the 1996-2016 period.

Results highlighted in both cases a strong control of water resources on recent productivity trends, particularly in plains where fast-growing conifers species have been massively introduced during the XX^{e} century and where sequestration dynamics have been the least favorable. Greater forest structural complexity was also identified as a driver of greater forest resilience to climate change. These results are of major concerns when conifer plantations have been largely encouraged these last decades, notably through state financial programs.

Harmonized NFI data at the transnational level provide reliable information to i) survey carbon sequestration dynamics of different regional forest sinks; (ii) alert on the weakening of these sinks, (iii) implement large-scale climate-smart forest management; and (iv) adapt carbon sequestration strategies (ex. tree species substitution). The application of the present framework to other NFIs in Europe would support an integrative and continental monitoring of forest resources, in line with current EU strategies.

From the forest to the forge: charcoal production in northeastern France lowlands (XVII-XX centuries)

Cláudia Oliveira [1*], Jonathan Bouquerel [1], Xavier Rochel [2], Simon Devin [1], and Vincent Robin [1]

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Wood was an essential source of energy in pre-industrial times for several activities ranging from domestic needs (e.g. cooking or heating) to production of goods such as glass or metal products. The exploitation of forest resources to produce charcoal, essential for high-temperature demands for metal smelting were widespread in forest areas all over Europe, leaving traces behind that can be studied today. These traces - charcoal kilns or charcoal production sites - contain the remnants of the use of wood for charcoal production and they can be analyzed to understand in which way the resources were used in the past.

An interdisciplinary study is being conducted in Northeastern France lowlands in order to assess the extent of former charcoal production activities in the forest and the legacies left in the environment and in the landscape. The main goals of this study are: (1) quantification of the number of kilns in the area and their distribution, (2) taxonomic identification and dendrological evaluation of the taxa present in the charcoal assemblage, (3) pointing to a chronology of charcoal production, (4) propose a former structure and composition of the forest and (5) assess the legacies on the soil and forest massif resulting from the former resources' exploitation.

A forest area covering around 57km^2 in Meuse (Grand Est, France) was investigated and more than 2600 kilns were detected through the analysis of LiDAR (Light Detection and Ranging) images. Along with the detection, more than 400 kilns were field-validated aiming to prove their correct detection in the images and, additionally, contribute to a robust dataset for automatic detection of charcoal kilns (Oliveira et al., submitted).

Concerning the diversity of taxa used for charcoal production, a set of 48 kilns was analyzed. Small caliber Carpinus betulus (hornbeam) was the most frequent taxa observed, along with Fagus sylvatica (beech) and Corylus avellana (hazelnut tree). A set of radiocarbon dating was already performed and the results point to a large diachrony of charcoal production of over 300 years.

The legacies on soils and forest structure and composition and vegetation dynamics connected to the presence of charcoal kilns are still being investigated where the impacts of these components within and outside of the charcoal kilns are being compared.

The completion of the goals proposed for this study will allow a better understanding of the dynamics, changes and evolution of the resources' exploitation, landscape and the legacies of charcoal production over space and time putting into perspective the sustainable use of wood in the era of energy transition.

References:
Oliveira, C., Aravecchia S., Pradalier, C., Robin, V. and Devin S. (submitted). "The use of remote sensing tools for accurate charcoal kilns' inventory and distribution analysis: comparative assessment and prospective".

PARALLEL SESSION

AUDITORIUM 100 — 10:40 — THURSDAY 14th

Mapping territorial vulnerability to forest fires to orient risk-reduction planning and improve resilience in south-eastern France

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Global warming induces an increase in extreme natural hazards events in many regions of world. Forest fires are one of those hazards, which, even though they are part of natural processes, may have adverse impacts for economic, human and environmental assets (Bowman et al. 2020). In order to effectively prevent and react to wildfire events, local communities and authorities need relevant knowledge of both fire dynamics and their potential impacts.

In this article, we assess the vulnerability of territories to the wildfire phenomenon, taking into account three types of exposed assets: infrastructures, human populations and ecosystems (forest ecosystem services). Our study case is Mediterranean France, a region routinely affected by wildfires today and where wildfire activity is expected to increase significantly in the decades to come (Dupuy et al. 2020).

We adopt a hierarchical framework where vulnerability is decomposed into exposure, sensitivity and adaptive capacity for each asset category, and we construct a network of factors and indicators for each vulnerability component and exposed asset combination (Lecina-Diaz et al. 2020). Indicators are computed using land-use and socio-economic data from available public data and the specialised scientific literature and mapped onto a GIS software.

The relative importance of indicators to each vulnerability component and overall vulnerability is determined by using Analytical Hierarchy Process (AHP, Saaty 2004), a participative method for multiple-criteria decision making. A set of 20 field and scientific experts participated in the process. Results showed a good consistency in reported relative importance for factors, and aggregation was carried out to obtain vulnerability maps for populations, infrastructures and ecosystems.
The several maps produced for individual indicators, intermediate vulnerability components, assets' vulnerability and overall territorial vulnerability enable the establishment of a sound and informed discussion among local stakeholders and with the scientific community to improve fire prevention and suppression, as well as the allocation of necessary economic and human resources; The next steps in the project involve feedbacks with experts who participated in the participative process, as well as discussions with local stakeholders on a wider basis.

References
Bowman, D.M., Kolden, C.A., Abatzoglou, J.T., Johnston, F.H., van der Werf, G.R. and Flannigan, M., 2020. Vegetation fires in the Anthropocene. Nature Reviews Earth & Environment, 1(10), pp.500-515.
Dupuy, J.L., Fargeon, H., Martin-StPaul, N., Pimont, F., Ruffault, J., Guijarro, M., Hernando, C., Madrigal, J. and Fernandes, P., 2020. Climate change impact on future wildfire danger and activity in southern Europe: a review. Annals of Forest Science, 77(2), pp.1-24.
Lecina Diaz, J., Martínez Vilalta, J., Alvarez, A., Banqué, M., Birkmann, J., Feldmeyer, D., Vayreda, J. and Retana, J., 2021. Characterizing forest vulnerability and risk to climate change hazards. Frontiers in Ecology and the Environment, 19(2), pp.126-133.
Saaty, T.L., 2004. Decision making—the analytic hierarchy and network processes (AHP/ANP). Journal of systems science and systems engineering, 13(1), pp.1-35.

If a tree falls in a forest, why do people care? An analysis of the United States National Woodland Owner Survey

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At its heart, forest management is grounded in valuation, with questions regarding what, how, and how much individuals value the forest being fundamental for efficient management. In this paper, we try and understand why private family forest owners value their woodland, and how these drivers vary depending on the type of value. We estimate the demographic and socio-economic factors behind a suite of stated reasons for owning forest, from tradition market-value reasons to less-traditional, non-market reasons, among others. For our analysis, we use the United States National Woodland Owner Survey (NWOS), a nationwide survey of private forest and woodland ownerships of greater than one acre. We find that we are able to identify different groupings of reasons for owning that share similar drivers. While our results are generally in agreement with the literature, we find some notable discrepancies, which highlight potential differences between stated and actual preferences. We believe that our results are useful when designing and disseminating information for policy, such as for promoting endangered species conservation or targeting individuals for enrollment in conservation easement, green certification, or cost-share programs.

Balancing carbon stock and flows in French forest stands: which silvicultural strategy to mitigate climate change?

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By drawing atmospheric carbon (C) and trapping it into wood, forest ecosystems are considered one of the essential C sink in the strategies to mitigate climate change. An evaluation of C storage in standing stocks of managed public forest stands was made from growth and yield models for 11 species and 9 regional contexts using the National Forests Office (ONF) silvicultural guides to highlight strategies impact on C storage and substitution.

On one hand, maximising the forest C stock by adapting silvicultural schedules is a short-term solution to effectively offset human greenhouse gas emissions. The comparison of 3 silvicultural schedules for douglas-fir showed that shortening or extending the revolution length changes of respectively - 22 % and + 18 % the C standing stock relatively to the reference scenario. However, in the short term, storage in forest ecosystems is maximised when forest stands are left in free evolution, which implies stopping wood production. Furthermore, as standing stocks do not grow endlessly, a state of balance will eventually be reached.

On another hand, shortening the rotation length can maximise C flows by repeatedly benefiting from the productivity peak of young stands for fast-growing species. This long-term strategy consists in accumulating harvested wood products (HWP) and using them as substitutes to other C-emitting building materials and energy sources. The comparison of the 3 same silvicultural schedules for douglas-fir showed that a shorter rotation length maximises the mean annual volume increment, HWP storage and substituted C flow.

This work challenges these two commonly-presented strategies in the face of complex integrated issues. The potential compromise between short-term and long-term mitigation is highly dependent on productivity and potential use of wood products and the comparison of 3 different species (douglas-fir, sessile oak, scots pine) showed the mitigation potential to prioritise for each. Ultimately, transforming certain silvicultural systems to maximise biomass production for species with short-term uses might not be a viable scenario to tackle rapidly global warming, while on the contrary leaving stocks of fast-growing species with long-term uses exposed to natural hazards could prevent us to shift our economy to more bio-sourced materials. On another note, these evaluations built on the ONF silvicultural guides represent only one side of forest management, as climate mitigation is only one of the many amenities provided by forest stands.

Lastly, these current predictions do not take into account the consequences of global warming to forest stands. Standing stocks are directly exposed to natural hazards, which affect mortality and growth in an unpredictable way. This summer, forests from all over the world have burnt, releasing tons of C into the atmosphere. Consequently, protecting and adapting forests to climate change is essential to prevent forest from becoming net C emitters in the future.

Modelling the impact of the climate change on the forest: towards a new framework for the comparative analysis

Nikola Besic [1*], Julien Sainte-Marie [1], Alexandre Piboule [4], Christian Piedallu [1], Céline Perrier [5], Hedi Kebli [5], Vincent Badeau [2], Nicolas Picard [3] and Myriam Legay [1]

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The climatic projections as well as the ongoing manifestations of changing climate, remind us that aside the urgency concerning the mitigation of further changes, there is also the absolute and imminent necessity for the well-timed adaptation to the consequences, which are already to a certain extent inevitable. Due to the crucial role of forests as carbon sinks, the adaptation activities in the domain of forest management are of particular importance even for the climate change mitigation.

This contribution is part of our efforts to make use of all modelling tools at our disposal in order to support an efficient decision-making process in terms of forest management, adapted to the changing climate reality. Properly speaking, our aim is not to compare different forest and vegetation models, and to be able to declare a “winner” which should be used for the decision making. The goal is rather to be able to uniquely evaluate differences between different models, at different spatial scales, in order to help ensuring that the choice of model is well suited to the particular circumstances and issues addressed. Another possibility potentially arising from our efforts would be establishing a base for the mixing of different available models and the creation of a “super” spatially-adaptable decision-making tool.

The evoked unique evaluation is performed through a new framework for the comparative analysis, which relies significantly on retroactive simulations and the observations i.e. the forest inventory. Namely, comparing the wide selection of models able to project, directly or indirectly, the silvicultural suitability of species implies comparing models defined in different spaces i.e. using different “output” and external variables (including climatic variables). This makes their direct mutual inter-comparison difficult and often even impossible. We therefore envisaged the approach where the output of every considered model is statistically reduced to the binary variable reflecting the presence of the species - a variable nearly equivalent to the “output” of the forest inventory. That variable can be further on represented, for a mixture of spatiotemporal retro-projections, as a function of the model external variables, showing how the latter influence the simulated output (presence of the species -possible or not). In the equivalent manner, we can project the forest inventory on the same axes corresponding to the model external variables, and see how these influence the observed output. We established the metric based on the Principal Component Analysis and the Co-inertia analysis which, at different spatial scales, quantifies the mismatching between the simulated and the observed output and explains this mismatching in terms of model external variables, notably the climatic ones.

In the proposed presentation we present the methodology in details and illustrate the functioning of our framework using some of the models the study relies on.

Drilling of the instrumental well in the pilot site of the Regalor project in Folschviller © Laëtitia Vancon

DAY 03 - MORNING

SESSION IV - PILOT SITES AND DEMONSTRATORS

AUDITORIUM 200

08:30 — **KEYNOTE | Jordi Bruno** (chairman)
CO_2 and hydrogen storage projects in the Spanish energy transition: perspectives and reality check

09:00 — **Aurélien Randi**, et al.
A new concept combining CO_2 geological storage and geothermal heat recovery: results of experimental simulations

09:20 — **Mohammad Iktiham Bin Taher**, et al.
New HEMT based gas sensors for in situ bio-geochemical analysis

09:40 — **Jeanne Touche**, et al.
Five successive years of rainfall exclusion induce a double stress on a mature beech stand

10:00 — **Coffee break**

10:20 — **Giorgia Bressan**, et al.
Exploring landscape changes in coal seam gas host regions: insights from Australias

10:40 — **Philippe de Donato**, et al.
Continuous in situ monitoring by Raman and infrared spectroscopy of dissolved gases (N_2, O_2, CO_2, H_2) prior to H_2 injection in an aquifer (Catenoy, France)

11:00 — **Peter Wirth**, et al.
Regional identity and social acceptance in processes of structural change. Insights from the lignite phase-out in Lusatia (Germany)

11:20 — **Jacques Pironon**, et al.
The survey strategy of the on-shore CCS pilot of Lacq

11:40 — **Florian Auclair**
What is the BECCS prophecy?

12:30 — **Lunch**

CO_2 and hydrogen storage projects in the Spanish energy transition: perspectives and reality check

Jordi Bruno [1]

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According to the last International Energy Agency (IEA) in-depth review in 2021, Spain has solved a long-standing issue of tariff deficits in its electricity and gas sectors and closed all of its coal mines This has allowed it to prioritise the issue of climate change on its national agenda and align its goals with European Union (EU) objectives and ambitions. As a consequence, Spain has placed the energy transition at the forefront of its energy and climate change policies.

The current Spanish framework for energy and climate is based on the 2050 objectives of national climate neutrality, 100 % renewable energy in the electricity mix and 97 % renewable energy in the total energy mix. As such, it is centred on the massive development of renewable energy, particularly solar and wind; energy efficiency; electrification; and renewable hydrogen.

The current situation though indicates that these ambitious goals are far away from reality.

In this context, I will analyse the role of geological gas storage, particularly hydrogen and CO_2 storage to achieve the energy transition goals.

A new concept combining CO_2 geological storage and geothermal heat recovery: results of experimental simulations

Aurélien Randi [1*], Christophe Kervévan [2], Jérôme Sterpenich [1], Jacques Pironon [1], Vitaliy Privalov [1,3], Christophe Morlot [1]

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In view of our current reliance on industrial processes that emit a significant amount of CO_2, the Carbon Capture and Storage (CCS) technology appears as an essential decarbonization tool for achieving carbon neutrality by 2050 and fitting the Paris agreement. However, the conditions for implementing, securing and monitoring massive storage facilities raise scientific, technical, economic and societal questions that hinder short-term deployment. The implementation of small-scale storage facilities close to emission source could become a complementary solution enabling a larger deployment of CCS.

The CO_2-DISSOLVED project proposes a new hybrid CCS concept combining injection of CO_2 under dissolved form (rather than supercritical CO_2) in a saline aquifers located near an industrial emission source and recovery of the geothermal heat from the extracted brine via a standard doublet system. The addition of dissolved CO_2 in the injected saline solution generates new constraints which must be taken into account in the environmental impacts study, the risk assessment and the design and sizing of the entire system. The effects of the injection of acidified water on the reservoir and the hydro-geochemical behavior of the CO_2 plume should be studied based on reactive transport, lab experiment and on-site measurements.

This study outlines the results of experimental alteration of a reservoir rock following the injection of a CO_2 laden solution at the scale of a laboratory pilot. They are based on the spatial interpretation of the morphology of the induced dissolution networks in order to maximize the lifetime of the geothermal installations and CO_2 sequestration.

A dedicated experimental device named MIRAGES.2 was developed to mimic the continuous radial injection of a CO_2-enriched solution under realistic conditions of a geological reservoir. Several experiments performed at 120 bars and 60°C demonstrate the non-uniform propagation of the CO_2-rich solution from the injection point in the form of preferential pathways called « wormholes ». The close relationship between the distributions of structural defects of the host rock generated during sedimentation and regional tectonics and the orientation of the dissolution network observed in the experiments was established from a multi-scale structural study. The results demonstrate the control of the discontinuities in the rock on the dissolution pathways.

At the geothermal doublet scale, the scientific and technical contributions of this study provide information about the optimization of the positioning of the “producer” and “injector” wells. Indeed, the knowledge of the local geology will allow to implement a future industrial pilot far from potential fractures in order to minimize the breakthrough of the system and increase the lifetime of the doublet as well as the efficiency of the long-term storage.

PARALLEL SESSION

AUDITORIUM 200 — 09:00 — THURSDAY 14th

New HEMT based gas sensors for in situ bio-geochemical analysis

Md. Iktiham Bin Taher [1*], Yacine Halfaya [2], Rouba Alrammouz [1], Mathieu Lazerges [1], Aurélien Randi [1], Tarik Moudakir [2], Nossikpendou Yves Sama [2], Thomas Guermont [3], Nicolas Pelissier [3], Thomas Pichler [4], Médéric Piedevache [4], Jacques Pironon [1], Simon Gautier [2]

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The High Electron Mobility Transistors (HEMT) has been recently proposed as a novel generation of semiconductor gas sensors. Their application for the detection of CO_2, CH_4, ethane, propane, butane, H_2, N_2, H_2S, SO_2, and He remains at an early stage and is currently under development. In this work, we propose to use the AlGaN/GaN HEMT sensors for geological context with the main purpose to investigate specifically the mass transfers of these gas from the underground to the earth's atmosphere.

AlGaN/GaN HEMTs gas sensors are characterized by the use of wide bandgap materials, high density of electrons (in the order of 1013 cm^2) known as Two-Dimensional Electron Gas (2DEG) serving as a channel, and high carrier mobility in the range of 1300 cm^2/V.s which leads to having an excellent thermal stability, a high saturation velocity, and a high transconductance compare to Silicon or GaAs competitors. The 2DEG in the channel modulates according to the number of ions and charged atoms (positive or negative) that originated from the external medium accumulated on the device gate surface with the help of a functionalized layer. Technically, the HEMT sensors fulfill the essential key features for the detection of gases in the geological context like a capacity of miniaturization, mechanical robustness, a low fabrication cost with mass production compatibility, and in particular resiliency with the complex geological environment (high temperature, humidity, pressure, and corrosive ambient).

The detection mechanism of the AlGaN/GaN HEMT-base gas sensor is driven by the type of material used as the sensitive layer and the type of gas itself. In this work, we have deposited gates made of Pt, Pd, IZO, and ITO.

For a typical H_2 gas measurement application, Pt/AlGaN/GaN devices were investigated under synthetic air atmosphere, applying at first stable air exposure baseline followed by successive exposure steps of given concentrations of H_2. Significant and repeatable current changes have been observed with the step-up concentrations of H_2 (1000-10000 ppm) under air (H_2: N_2: O_2) and for step-down condition, demonstrating promising usages of such sensors for H_2 detection.

A similar approach is currently applied to elaborate and characterize an upgraded class of devices utilizing Pd, IZO, and ITO sensitive layers, tailored for underground CO_2, CH_4, He gases detection applications.

PARALLEL SESSION

AUDITORIUM 200 — 09:20 — THURSDAY 14th

Five successive years of rainfall exclusion induce a double stress on a mature beech stand

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Repeated intense drought events in the coming decades will alter the forest ecosystems and the many services they provide. Thus, forest managers have to adapt their practices to limit the deterioration of forest ecosystems in the coming decades. This management adaptation is particularly needed for forest ecosystems in mesic conditions with shallow soil, subject to severe water deficit during drought events. In addition, despite the importance of nutrient availability for the good functioning of forest, there is a lack of information on nutrients and nutrient deficiency induced by drought. Taking nutrient cycling into account would allow a better understanding of the impact of drought events and soil water deficit on forest ecosystems.

To determine the consequence of recurrent water shortage in a mature European Beech forest developed on shallow limestone soil, a rainfall exclusion experiment (REE) was set up in 2015 in the forest of Montiers-sur-Saulx, Meuse, France, and an artificial drought event of 0 mm of precipitation during 3.5 months (from May to August) was applied every year from 2015 to 2019. The response of beech trees to these five consecutive years of intense water shortage was annually quantified by monitoring stem growth and by estimating crown condition and mortality rates at the end of the experiment. In addition, to highlight the effect of the rainfall exclusion on nutrient concentrations on the different compartments of the ecosystem, nutrient contents in green leaves, senescent leaves, holorganic horizons, fine roots and soil were also measured.

After five years of spring and summer drought, we observed a decrease of 51% in growth and a sharp deterioration in the crown condition with 67 % of Leaf Loss compared to local standard tree. Moreover, two years after the end of the experiment (in 2021), 33 % of the trees in the REE were considered dead while no mortality was identified in Control trees. Concerning the nutrient contents, potassium was the most affected with a significant decrease in all compartments studied and a K deficiency was established in green leaves.

Five consecutive years of water shortage on calcareous soil with limited extractable water and K reserves induced a double water and nutrient stress. Potassium is involved in multiple physiological tree functions and is essential for tree resistance to soil water deficit. Thus, K deficiency induced by the artificial drought events in the REE, coupled with the intense water stress, could enhance the tree sensitivity (i.e. severe growth reduction and Leaf Loss) and the mortality risk in the following years. In order to limit the impact of future drought events on this type of sensitive ecosystem, forest managers should consider K-fertilisation and/or rational and K-efficient management.

PARALLEL SESSION

AUDITORIUM 200 — 09:40 — THURSDAY 14th

Exploring landscape changes in coal seam gas host regions: insights from Australia

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The economic benefits related to the exploitation of unconventional gas in the United States have encouraged other countries to consider this energy resource. This choice is not without consequence, as commercial production involves a series of environmental, social and economic impacts whose extent and long-term implications are largely unknown. In Australia, where abundant coal seam gas reserves lie underground, the repercussions of such an industry on the host region are even more complicated to assess. This is because extraction implies the withdrawal of water from coal beds which, according to legislation, should be exploited for beneficial uses. This contribution aims to examine what we can learn about the local impacts of this mining industry by analyzing how the regions hosting coal seam gas wells in Australia have been changed over time.

To study how the landscape has changed with the establishment of the coal seam gas industry, aerial imagery from Google Earth Engine is employed. The possibility of going backwards in time and comparing old pictures with the most up-to-date imagery allows the detection of new features that appear in the local landscape. The analysis is also supported by the availability of detailed spatial datasets concerning the location of wells drilled in Queensland and New South Wales, specifically targeting coal seam gas. The overlay of aerial imagery with the georeferenced data on wells makes it possible to identify the specific portion of land subject to extraction. Information about the study areas was retrieved from a desktop review of mass media websites to clarify the observed landscape changes.

The exploration of unconventional gas in Queensland has not only resulted in a high concentration of wells in a limited portion of land, but it has led to a surge of new land uses. Water treatment facilities and feedlots in the proximity of wells are now quite common landscape features and witness to the fact that the associated water can be considered sometimes a “welcomed” by-product, as it is used locally for other purposes. In New South Wales, where there is strong opposition to gas exploration and wells are scarce compared to Queensland, no major change to the landscape is found. The analysis suggests how the coal seam gas industry can create opportunities for local development outside the mining sector. However, the life cycle of the industry should be more carefully considered in agricultural investment decisions, as the current water supply is not sustainable in the long term.

References
Hamawand I., Yusaf T., Hamawand S.G., 2013. Coal seam gas and associated water: A review paper. Renewable and Sustainable Energy Reviews. 22, 550–560.
Mehreen S.U., Underschultz J.R., 2016. Coexistence Opportunities for Coal Seam Gas and Agribusiness, Journal of Industrial Ecology. 21(5), 1344–1355.

PARALLEL SESSION

AUDITORIUM 200 — 10:20 — THURSDAY 14th

Continuous in situ monitoring by Raman and infrared spectroscopy of dissolved gases (N_2, O_2, CO_2, H_2) prior to H_2 injection in an aquifer (Catenoy, France): Geochemical baseline establishment in a geological purpose.

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Establishing a geochemical benchmark prior to all industrial activities is a key element for monitoring and securing underground storage operations such as carbon dioxide storage (carbon capture and storage: CCS), methane or hydrogen. An innovative metrological approach based on the combination of Raman and infrared sensors has been applied for in-situ and continuous quantification of dissolved gases (CO_2, O_2, N_2, CH_4 and H_2) in a shallow aquifer, on the site of Catenoy (Paris Basin). Monitoring was carried over more than 6 months, prior to H_2 injection simulation. Dissolved gases were collected from the aquifer through a specific half-permeable polymer membrane positioned below a packer in a 25-meter deep well. Collected gases were analyzed simultaneously at the surface by fiber Raman (CO_2, O_2, N_2, CH_4 and H_2) and infrared sensors (CO_2). Under these conditions, it was possible to follow the evolution over time of gas concentrations. In the time period investigated (from May 7, 2019 to November 19, 2019), the dissolved gas concentrations were about constant with averaged values of 31-40 mg/L (CO_2), 8 mg/L (O_2), 17 mg/L (N_2), and 0 mg/L (H_2, CH_4) indicating very low variability in the aquifer. Such quantitative data allow the definition of a base line of dissolved gases for rapid detection of any abnormal variation in concentration, in particular linked to an accidental arrival of gas such as hydrogen in a geological storage purpose.

Regional Identity and Social Acceptance in Processes of Structural Change. Insights from the Lignite Phase-out in Lusatia (Germany)

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All too often, the importance of social aspects in transformations, especially in the energy sector, is underestimated. Such socio-ecological transformations usually represent serious changes in the everyday life of those affected. For these transformation efforts, which often involve enormous financial outlays to be successful and produce the desired effects, acceptance of these measures by those affected is essential. If it is not possible to achieve this acceptance, or if the implementation of transformations fails to take into account the limits of what local people are prepared to accept, this will have a negative impact on the whole transition process. Therefore, it is essential for such regional structural changes to analytically deal with the question of social acceptance and its formative factors. This includes, first and foremost, identifying the spatial, socio-economic, or even political acceptance factors. Findings from the Lusatia region in Germany, which has been in a state of transformation for three decades, are very informative in this regard and will be presented in this contribution.

The Lusatia region in eastern Germany is a rural, peripheral area that has been shaped industrially but also socio-historically by lignite mining for two centuries. The huge opencast mines as well as the power plants for electricity generation have left deep traces not only in the landscape but also in the regional identity of the local population. Thus, the regional identity created also links many inhabitants of Lusatia biographically with lignite - be it in a positive or negative sense - and so today still has an influence on their perception of the political decision by the federal government to phase out lignite mining by 2038.

Our contribution addresses this transformation process and its specific regional context conditions using a social-constructivist approach. Following basic theoretical conceptions of reality-construction (Berger/Luckmann 1966), we show how historically shaped regional identity, ‘inherited’ from generation to generation, is able to influence the course of transformation processes in the present through the lever of social acceptance.

Drawing on current and past research, we show how spatial and socio-economic characteristics of a region contribute to a specific regional identity. We describe how this 'mortgage of the past' affects the acceptance of the current lignite phase-out process and the chances of the parallel process of structural change to develop a decarbonized, sustainable economic and social structure in the region. The paper argues that especially in normatively charged transformation constellations, aspects of acceptance and fit are of high importance for the success of the transition. Additionally, it demonstrates how regional experiences from the past continue to have an impact even decades later through regional identity narratives, resulting in path dependencies, lock-ins and mental frames. This creates transformative hurdles that must be taken into account in future process design. Consequently, the acceptance of politically motivated structural change is to be increased through intensive participation of those affected - and in this point, the causal effects described reach beyond Lusatia and can also be applied to transformative constellations elsewhere.

References:
Berger, Peter L. / Luckmann, Thomas (1966): The Social Construction of Reality. A Treatise in the Sociology of Knowledge. London/New York: Penguin.

PARALLEL SESSION

AUDITORIUM 200 — 11:00 — THURSDAY 14th

Survey strategies around an industrial CCS demonstrator in France

Jacques Pironon [1*], Odile Barres [1], Philippe de Donato [1], Pierre Faure [2], Aurélien Randi [1], Jérôme Sterpenich [1]

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The capture, storage and use of CO_2 is still in a transitional phase, between research and pilot experiments. Nevertheless it has demonstrated technological know-how, and the large-scale commitment of states or industries to operate sites of significant importance in order to contribute to the reduction of greenhouse gas emissions.

Université de Lorraine and CNRS was involved in CCUS for several projects in France as in EU in connection with industrial partners. One of the most important was the TotalEnergies project of Lacq-Rousse. Between 2006 and 2013, TotalEnergies developed the unique on-shore CCS demonstrator in EU in the Southwest of France. CO_2 was produced in a boiler using oxy-combustion technique and transported by pipeline on 30 km before to be stored in a deep dolomite reservoir of Jurassic age. The main objectives of this experiment were 1) to demonstrate the technical feasibility of an integrated chain coupling capture, transportation and storage into a depleted gas reservoir, 2) to acquire operating experience for oxy-combustion process and 3) to develop and apply geological storage with efficient monitoring technologies for long term including regulatory aspects and risk assessment [1]. The objective of this paper is to show some scientific results acquired on the CCS demonstrator by the academic teams of Nancy throughout a series of research projects supported by the French Research Agency (ANR), CNRS, Université de Lorraine and TotalEnergies.
Research investment around the Lacq pilot which is the first in Europe to implement an end-to-end CO_2 capture-transport-storage chain led to several important results:

- Development of new remote sensors for survey of industrial sites and reconstruction of gas plumes above a CO_2 storage site,
- Combination of equipment for baseline acquisition showing high variations of CO_2 with time and locations,
- New completion/sensor combinations for in situ on-line gas measurements with acquisition of chronicles over time allowing to establish prediction law for CO_2 content in soil,
- First simulations of annex gas injection in carbonate gas reservoir. SOx, NOx behaviors in deep environment was described for the first time,
- Mechanisms of oxidation of CH_4 were quantified, improving geochemical models used for combustion risk assessment.

All these results must be applied to facilitate the capture of CO_2 in a variety of industrial installations, to develop the infrastructure required to transport CO_2 from the capture site to a storage site and to qualify geological formations to store the quantities of CO_2 necessary to achieve carbon neutrality.

Acknowledgements:
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PARALLEL SESSION

AUDITORIUM 200 — 11:20 — THURSDAY 14th

What is the BECCS prophecy?

Florian Auclair [1*]

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The latest IPCC report envisions that global warming is worsening bringing in a near future more famines, droughts and flooding. So, if we don't tackle it quickly negative emissions technologies could be our last resort. Among them BECCS (Bio Energy Carbon Capture & Storage), which puts together a biomass power plant with an underground carbon storage, has the benefit of removing CO_2 from the atmosphere and generating electricity.

Despite this advantage, this technology rises a lot of controversies both on the surface use and on the underground storage. Beyond those controversies directly aimed at the operating mode of the plant, my research investigates, through the prism of sociology of science and specifically the Actor-Network Theory, the representations of the world and the technique carried by the BECCS. In other words, what is the definition, and consequently the vision of the future, of the ecological transition given by the implementation of the BECCS?

BECCS, for the time being, is still an engineer's dream. Except the Drax power plant in the North of England, which is not yet profitable, there is no other plant elsewhere. Hence, we could interrogate its economic credibility and its legitimacy in the energy transition. As I plan to conduct fieldwork in 2022, my communication will present an analytical framework to determine whether BECCS is a way to continue extracting resources to feed world markets with cheap energy or is a genuine solution to recycle the GHG byproducts of industrial processes supporting human development.

PARALLEL SESSION

AUDITORIUM 200 — 11:40 — THURSDAY 14th

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DAY 03 - AFTERNOON
PLENARY SESSION

14:00 —— **KEYNOTE | Alan Butcher**
Unifying the need for new battery mineral sources, novel carbon sequestration strategies, and the protection of soils, whilst at the same time managing public expectations & opinions - a Finnish perspective

14:30 —— **KEYNOTE | Michel Deshaies**
Geographical issues of the European Green Deal

15:00 —— **Coffee break**

15:15 —— **KEYNOTE | Laurent Saint-André**
Forest and biomass within the energy transition: a SWOT analysis

15:45 —— **KEYNOTE | Noémie Fayol**, et al.
Building a new path: from materiality to ecological transition in training - MOOC “Mineral resources and transitions”

16:15 —— **Panel Discussion**
Serge Garcia (INRAE) & Samuele Furfari (Free University of Brussels (chairmen)

17:15 —— **Closing ceremony**

Unifying the need for new battery mineral sources, novel carbon sequestration strategies, and the protection of soils, whilst at the same time managing public expectations & opinions - a Finnish perspective

Alan R. Butcher [1*]

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Finland contains mineral resources that are the envy of other European countries. It has significant occurrences of most of the minerals that we require for the production of current battery technologies (e.g., graphite, lithium, nickel, copper, cobalt, and PGMs). There is also a rich history of mining and exploration for minerals that stretches back over 100 years. It is therefore no surprise that Finland also currently hosts Europe's largest gold and chrome mines. This legacy, of course, comes with some downsides - historic and current waste rock piles for one, which if left abandoned and unmonitored, can be harmful to the environment. However, significant effort is now underway to valorize such materials, and even make use of them to sequester carbon. The country has also recently pioneered technologies that allow radioactive waste materials to be stored safely underground.

Contrast this with the other natural wonders that Finland is known for. It is the most sparsely populated country in the European Union, with only 16 inhabitants per km^2. It has thousands of freshwater lakes (estimated at 188,000 or so) and an archipelago (more than 70,000 islands) -both of which are world records. In the northern most part of Finland, Lapland is home to the only indigenous people of Scandinavia as recognized by the European Union. The Sámi people speak an endangered language and are known for their reindeer herding. Furthermore, Finland is a very green country, with over 70% of its land planted with forests, making it by far the largest producer of wood-based products in Europe.

How, then, can we harmonize these different (sometimes conflicting) activities, all of which are needed and valued? Can Finland lead Europe, if not the world, in becoming the first country to be carbon neutral (or even negative) by 2035. This paper will attempt to review how this might happen, the complex interplay of the different (commercial) activities, how minerals might just make the difference, and what possibly stands in the way of progress.

PLENARY SESSION

ROOM 200

14:00

THURSDAY 14th

Forest and biomass within the energy transition: a SWOT analysis

Laurent Saint-André [1*], Antoine Colin [2], Jean-Luc Peyron [3]

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French forests cover 31 % of the territory, ⅔ private-owned, ⅔ are made of hardwood with a strong regional heterogeneity. They represent 400,000 direct jobs (same amount of the industry automotive). France is the third largest wood stock in Europe. Both stocks and growth have been increasing during the last 100 years. Considering biodiversity, ten of the 13 ecoregions in Europe are on the metropolitan territory. About 90 million tons of CO_2 are sequestered each year in the vegetation and in the forest soil (20 % of French emissions). These forests are regulating biogeochemical cycles (CO_2, nutrients), hosting large biodiversity panel (above- and below-ground), and providing drinkable water. However, they are highly impacted by climate change (storms, bio-aggressors, droughts, high temperatures) and are highly solicited for the decarbonization of the economy through an increased demand for products and services, especially for energy purposes. There are then concerns on forest durability in France. In this presentation, we will analyse forest biomass stocks and availability within the energetic transition through a SWOT analysis. This analysis includes several aspects such as soil sustainability and climate change impacts on forest tree species. A special focus will be made on the Grand Est French region (biomass/soil/subsoil) which could be a good case study to design smart energy strategies.

PLENARY SESSION

ROOM 200 — 14:30 — THURSDAY 14th

Geographical issues of the European Green Deal

Michel Deshaies [1*]

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By setting very ambitious objectives to be reached from 2030 and aiming to achieve carbon neutrality by 2050, the Green Deal appears to be a considerable outbid in relation to the commitments made by the EU at COP 21. The communication shows the multiple inconsistencies that exist between the objectives stated in the Green Deal and the reality of the evolution of the energy system in Europe since 1990. Due to multiple technical and geographical constraints, the increase in intermittent renewable energies and the project to produce renewable hydrogen are unlikely to allow the EU to achieve the emission reduction target set for 2030. The communication thus raises the question of the realism of the Green Deal objectives in relation to the resources available in Europe.

PLENARY SESSION

ROOM 200 — 15:15 — THURSDAY 14th

Building a new path: from materiality to ecological transition in training - MOOC "Mineral resources and transitions"

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How to contribute to the debate on sustainable resource management? As scientists, involved in the training of engineers, this question appears to be a key point to link research, education and the place of sciences in the society. In fact, the necessary ecological transition makes us think about the role of the next engineers' generation in that process and how we can give them the key to face these challenges.

On that way to a more sustainable world, people need to have access to a global, transdisciplinary, understanding of the system and therefore, the training programs have to evolved in order to facilitate this understanding. We need to go from a disciplinary teaching to a more systemic based approach. To initiate this change, engineering schools are on the way to change their programs. Going from disciplinary to more systemic and from knowledge to skills teaching is difficult and appears to be transition, or even then a small revolution itself. The difficulties that we can face to achieve that, made us think about a more progressive, or step by step, way to engaged that training transition. When looking on how to teach the ecological transition, we face at least two challenges: (1) students have a vision of the decarbonisation process based on the energy transition and numeric technologies, however this is often disconnected from the materiality of that transition; (2) there is a need to defined the engineers' skills related to the ecological transition specific issues.

In order to develop learners' critical mind and ensure a high technicity level, the authors have created a MOOC "Mineral resources and transitions" in which we handle the materiality impacts of the energy and numeric transition. This course is based on two axes: (1) a perspective change in order to go from transitions issues to a more global system, (2) a pluridisciplinary approach from geology to sociology, from materiality to territories along the material cycle.

In this course, we handle the use of underground for energy transition purposes from different points of view: geological, mining, environmental, social and geopolitical issues, etc. We also propose some encouraging perspectives based on circular economy, and life cycle assessment. Along this MOOC, while exploring the global system, some social, regulatory and economic issues of the ecological transition are presented.

At the end, we aim that learners will be able to take them part in the ecological transition, whether as citizens, engineers, decision makers or any other stakeholders position they can have in these transitions.

This MOOC "Mineral resources and transitions" is funded by the Institut Mines Télécom and the first session is to begin in fall 2021.

PLENARY SESSION

ROOM 200 — 15:45 — THURSDAY 14th

Drought device in Montiers forest © Barbara Brenachot

POSTER SESSIONS

POSTER SESSION

An investigation of the fate of soil petroleum contaminants (LNAPL) under fluctuating groundwater table levels induced by climate change

Amélie Cavelan [1*], Fabrice Golfier [2], Catherine Lorgeoux [2], Stéfan Colombano [3], Jacques Deparis [3], Hossein Davarzani [3], Anne-Julie Tinet [2], Constantin Oltean [2,] Noële Enjelvin [4], Pierre Faure [1]

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The global water demand for industrial, agricultural, and drinking water needs increases but so is the number of soil and groundwater contaminations. Light Non-Aqueous Phase Liquids (LNAPLs) which come from the accidental release of refined petroleum products (diesel or fuel…) represent 40 % of these contaminations. After their infiltration in the unsaturated zone, part of LNAPLs reaches and accumulates above the top of the water table as a mobile liquid phase able to be displaced by water table level variations. Hence, pump-induced or seasonal variations in the groundwater level lead to the significant vertical spreading of these light petroleum hydrocarbon contaminants at the capillary fringe that can temporarily favor their release into the air and groundwater. In the coming decades, an intensification of these groundwater level variations is expected in response to extreme climatic events and variations in precipitations patterns and water needs. This context may strongly impact the mobilization of these organic contaminants, impacting their release in the air and water and attenuation rates. It is, therefore, essential to better understand the impact of the groundwater level fluctuation patterns on the fate of LNAPLs. To this end, an innovative system was developed this year at the GISFI station (Homécourt, France). This device is composed of two lysimetric columns of soil equipped with in-situ sensors that combine indirect geophysical (complex electrical conductivity, permittivity), physical-chemical (pH, Eh, temperature), and geochemical measurements. This device permits to assess and compare the evolution of the LNAPL saturation distribution in soil, the nature and the amount of LNAPLs release into the air and groundwater during two groundwater level fluctuations and precipitation scenarios of 14 months: one based on the current rainfall and groundwater fluctuation patterns calculated after the last ten years regional climate records; the other based on the most extreme predictions of IPCC climatic models. The remobilized hydrocarbons will be collected from lysimeters via suction probes (dissolved phase) and gas collection chambers (vapor phase) and regularly analyzed (µGC, GC-MS, FTIR) using the analysis protocol established in the laboratory for these pollutants. To prepare these experiments, laboratory tests are also conducted on laboratory decametric columns and 2D tanks of soil under controlled soil saturation of air/LNAPL, water/LNAPL, and air/water to calibrate the signals of in-situ sensors. The complementarity of these monitoring techniques should provide a better understanding of the current and future behavior of these organic pollutants and the evolution of the associated environmental risks (water/air quality) at contaminated sites under various climatic conditions. Preliminary results concerning the migration of the pollution through the unsaturated zone of the columns after their release will be presented to illustrate the capability of this new instrumental system.

Bringing up the underground for the energy transition

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The phrase 'Bringing up the underground' refers to the idea of politicizing the underground, by raising a subject that is usually unseen, unknown and unreachable - since it underlies us - and debating it in society, at the surface. Different actors are bringing it up because now it appears to hold part of the answer to allow society to make its desired energy transition.

From an STS (Science, Technology and Society) Underground perspective - where the underground does not simply exist, but instead "comes to be" through a complex relation between its characteristics and society - I'm interested in understanding how the underground "comes to be" in different projects of energy transitions.

The idea of 'coming to be' is an allusion that draws attention to the ways in which society defines how, when, whom and in which purposes a "resource" is going to be explored. Knowledges will play a powerful role in shaping the future of the underground because it will help to guide decisions and to construct possible futures.

In four controversial energy transition projects in metropolitan France (nuclear waste disposal, geothermal energy, carbon storage and tungsten extraction), I plan to follow the circulation of knowledges through their production, mobilization and marginalization. My focus relies on the relation between knowledges production, their use (or not) by different actors and institutions, and finally their transformation in policies. Through these analyses, I aspire to demonstrate what roles different types of knowledge play, which possible futures are being constructed and which ones are being dismissed.

$^{3}He/^{4}He$ tracing of crustal fluids transfer related to hazards

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Noble gases occur in low concentration in the Earth and are relatively inert, making them good tracers of fluid interactions. Contrary to most stable isotopes or major elements commonly used as geochemical tracers, noble gases are less susceptible to water/rock interactions. In the crust, noble gases originate mainly from the atmosphere, mantle, and radioactive decay within the crust. Due to their widely variable ratios among these reservoirs, the He and Ne isotopic systems are of particular interest, providing information on the source of fluids. For this reason, their ratios have been used to trace fluids in hydrothermal systems associated with volcanoes and seismic zones, and in aquifers potentially disturbed by shale gas exploitation or CO_2 storage leakage [1]. $^{3}He/^{4}He$ ratios from groundwater in Italy are monitored by the INGV (Istituto Nazionale di Geofisica e Vulcanologia) through discrete sampling at seismically and volcanically active zones. From the data collected, researchers identified correlations between variations in $^{3}He/^{4}He$ ratios and earthquakes and eruptions, prior and/or during their occurrence [2,3]. Their sampling frequency varies from seasonal to twice a week at most. An uninterrupted sampling system has the potential to improve the monitoring at sites of interest, providing key information on processes of short timescales. Continuous sampling is possible using SPARTAH, an apparatus designed for automatic groundwater sampling aiming future He analysis in the laboratory [4]. We aim to comprehend the exchange and transfer of fluids to the surface in short timescales. With this knowledge, we hope to better constrain the sources and mechanisms involved in volcanic and seismogenic systems and potentially improve the forecasting of such hazards. This approach is also possible in the context of anthropogenic disturbances. Our current targeted areas are in northern (borehole HA-01) and southern (boreholes BA-01 and TH-13) Iceland. In the latter sites, monitoring is recent and we do not yet have any results. At HA-01, we started discrete weekly sampling in June 2020, shortly after an earthquake swarm, and continuous sampling with SPARTAH in September 2020. HA-01 shows both mantle and air components. $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$ results from discrete sampling are similar to values from 2015-2016 when there were no M > 4 earthquakes. Samples from 2020 present slightly higher $^{3}He/^{4}He$ and $^{4}He/^{20}Ne$ ratios than 2015-2016, displaying a trend further from the air component. In addition to the monitoring, we surveyed the area around HA-01 for $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$, $^{3}He/^{4}He$, $^{4}He/^{20}Ne$, and major and trace elements to better characterize the region and interpret our monitoring data.

[1] Lafortune et al. (2009), Energy Procedia 1, 2185–2192 [2] Caracausi et al. (2005), Ann. Geophys. 48, 43-53 [3] Rizzo et al. (2009), J Volcanol Geotherm Res 182(3), 246–254 [4] Barry et al. (2009), G-cubed 10, 1–9.

Woodstock - Historical reconstruction of wood stocks and fluxes

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Wood is a renewable resource providing fuel and timber. Forests take part in today's bioeconomy and biomass removals rise. The short-term effects on forest ecosystems of increased removals are quite well studied (1) but little is known about long-term impacts of intensified wood harvestings (2). Historically, it is known that the wood resource used to be under a strong pressure during the past centuries in Europe (3). The Woodstock project proposes to combine human sciences (geohistory) and biological sciences (ecology) to study this question. We aim to quantify some past levels of wood harvesting in the Grand Est region in France, based on the analysis of 18th and 19th centuries archives relating to forest management and exploitation.

Historical research has established that forests were intensely exploited for fuelwood during past centuries (4), a resource mandatory to many proto-industrial and domestic activities: heating, manufacture of metals, glass, terracotta, ceramics, gunpowder, or salt production. The needs were particularly intense during the 18th and 19th centuries because of large demographic rise and industries development. The pressure on fuelwood eased around the middle of the 19th century in France with the introduction of mining coal as main energy resource, and rapidly, its generalization.

Our analysis considers forests at a local scale as well as at a larger regional scale. Our goal is to calculate levels of biomass exports that happened several centuries ago and ended more than a century ago. We aim quantified evaluations, based on the data extracted from archives, to foster a better characterization of the long-term consequences on ecosystems of wood harvesting. The quantification of extracted biomass and, if possible, of mineralomass, will allow us to better assess past intensity of forest exploitation. Results can also serve a quantified comparison between past forests exploitation levels and existing or planned levels of biomass removals in forests today.

References:
(1) Landmann G., Gosselin F., Bohême I. (coord.), Biomasse et Biodiversité forestières. Augmentation de l'utilisation de la biomasse forestière : implications pour la biodiversité et les ressources naturelles. MEEDM - GIP Ecofor, 2009.
(2) Rochel X., Une biogéographie historique. Forêts et industries dans le comté de Bitche au XVIIIe siècle. Histoire & Mesure, 32 (2), 2017.
(3) For a review at a European scale, see for example: Warde P., Fear of Wood Shortage and the Reality of the Woodland in Europe, c.1450-1850. History Workshop Journal 62 (1), Oxford Academic, 2006 and Mather A., The Transition from Deforestation in Europe. In: Agricultural Technologies and Tropical Deforestation, CIFOR - CABI Publishing, 2001, p.35-52.
(4) See for example: GHFF, Le Bois, source d'énergie : naguère et aujourd'hui. Journée d'Études Environnement, Forêt et Société, XVIe-XXe siècle. La Ville, troisième partie. Cahier d'Études n°10, IHMC-CNRS, 2000.

Sensitivity analysis, a statistical tool for a green roof model analysis

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Green roofs are sustainable solutions to manage water runoff from rain events in urban areas. They allow to decrease the peak flow from 22 % to 93 % in water system and delay it by 0 to 30 min [Li and Badcock Jr (2014)]. The overall performances are directly associated to the green roof characteristics (substrate retention, dimension, type of vegetation, etc.). In order to better understand the hydrological dynamics, the water retention capacity of the substrate is often modelled by the Van Genuchten – Mualem equations coded in the software Hydrus-1D© [Simunek et al. (2008)]. However, the model parameters, as soil parameters or vegetation variables, are challenging to determine as they are difficult to measure accurately through experiments.

Thus, the uncertainties of these parameters are propagated to the water retention capacity simulated and need to be analysed to calibrate the model. Global Sensitivity Analysis (GSA) is a statistical tool which allows to analyse these uncertainties. Global sensitivity analysis can be used to verify and better understand the model behavior, help for calibration and target parameters to focus on. Based on variance decomposition of model output, GSA quantifies effects of parameter uncertainties on the output [Saltelli et al. (2008)]. It explains which parameter variations are responsible for the output variations by highlighting both the influential and the not-influential parameters. In this study, global sensitivity analysis is used to calibrate the model and quantified the influence of the soil and vegetation parameters on the water retention capacity over time in-situ data, boundary conditions, meteorological data come from an in-situ experimental green roof platform located in Tomblaine (France).

This work is part of a collaboration between Cerema [3] and the Research Center for Automatic Control [4].

References:
[3] Centre d'études et d'expertises sur les risques, l'environnement, la mobilité. www.cerema.fr
[4] Research Center for Automatic Control (CRAN - CNRS). www.cran.univ-lorraine.fr

Decipher the evolution of the Permo-Carboniferous Lorraine-Saar basin (France, Germany) by constructing a regional 3D geological model

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3D geological model is a representation of subsurfaces and associated structures. It integrates both existing and new data in a region (lithological boreholes, geophysical logs, seismic lines, cross-sections, etc). Such model enables 3D geometrical coherency of the different stratigraphic units in relation with the major faults controlling the basin depocentres. Besides the research dedicated to the tectono-stratigraphic evolution, basin kinematics, and paleo-environmental reconstructions, the modelling results are powerful for reservoir characterisation, fluid flow simulation, storage and resources evaluation for energy transition. The presented work focuses on the Permo-Carboniferous series of the Lorraine Basin buried below the Paris Basin, in the southwestern continuation of the exposed Saar basin in Germany.

The Permo-Carboniferous Lorraine-Saar Basin (LSB) was formed during the late Variscan orogeny as part of the Saxo-Thuringian retrowedge. In Lorraine, this basin consists of thick continental series (up to 6 km) deposited from Late Mississippian to Early Permian, over about 70 My. Despite the investigations dedicated to coal and petroleum explorations over the last century, there is no coherent regional stratigraphy and tectonic history between both Lorraine and Saar regions. In Saar this basin is considered as an inverted half-graben with a strike-slip component, whereas the Lorraine part displays a stronger compressive imprint, with a fold and thrust belt developing during the Pennsylvanian (i.e. Asturian) and Early Permian (i.e. Saalian phase). Moreover, 2D seismic lines in the Lorraine show evidences of inverted thrusts, allowing the accumulation of the Stephanian (Late Pennsylvanian) series in some half-graben structures. These tectonic phases are characterised by rapid subsidence, migration of depocentres (towards the NE along the Metz-South Hunsrück fault system), significant erosion and changing sediment sources.

To date there is no 3D representation and coherency between the buried structures and established stratigraphy. In the frame of the DEEPSURF project, existing structural cross-sections, interpretation of newly reprocessed 2D seismic lines, borehole data and geophysical logs are used to build a GOCAD 3D model of the Permo-Carboniferous series and controlling faults. The resulting 3D geometry of the series will enable to analyse spatial variations of subsidence and uplift across this intramountain basin, thereby providing new constraints on the slab dynamics along the bounding Rheno-Hercynian suture zone.

The slow and difficult rehabilitation of polluted sites and soils: the legal obstacle

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A vulnerable but indispensable resource

Soil is a non-renewable natural resource that provides important ecosystem services that should be protected. However, this physical element of nature, which constitutes an interface between the subsoil and the surface, is very vulnerable to human use. It suffers impacts of a quantitative order: erosion, soil artificialization (of 9 % in France in 2018)[1], as well as impacts of a qualitative order: pollution. Since the 1990s, France has set up inventories of polluted sites and soils[2], evidence of past or current industrial activities.

Many industrial wastelands still polluted

"Installations classified for environmental protection"[3], in that their activities are likely to generate dangers or inconveniences for the protection of the environment, must be rehabilitated when the site is closed. This responsibility is incumbent on the operator for a period of 30 years, in accordance with the polluter-pays principle enshrined in the Environmental Code.
In the absence of financial guarantees, many industrialists prefer to freeze the site rather than clean it up. This is how the majority of industrial wastelands are still polluted. To limit «orphan» sites, a 2014 French law sets up a third-party claimant procedure that carries out site remediation. Without this, it is the "ADEME" that will be in charge of the operations, which are very costly.
We will see that the decree (n° 2021-1096) of August 19, 2021 modifies various provisions relating to polluted soils and the cessation of activity of classified installations for the protection of the environment.

Sites to be upgraded: towards better legal protection of the soil

However, the reclamation of these sites, via restoration, seems essential in a context of environmental transition (land to limit urban sprawl, reintroduction of biodiversity, etc.).
For this reason, it is urgent to change the legislation concerning soils, in order to include their protection in French law. A draft framework directive on soil protection was proposed by the European Commission in 2006 and then abandoned in the face of local particularities in certain Member States.
Today, soil remains attached to private property, which distances it from a concept of common good, a status that should be rethought. One may wonder what legal perspectives could be offered for a better protection of soils, in a context of climate change?

References:
1. Agreste, enquête Teruti-Lucas.
2. Basias: inventory of former industrial sites and service activities that may be the source of soil pollution (300,000 to 400,000 sites); Basol: sites subject to soil management measures to prevent risks to people and the environment (4000 sites).
3. Installations classées pour la protection de l'environnement.
4. 20 December 2007: negative votes (Germany, Austria, Great Britain, Netherlands); abstention (France).

The forest ponds: potential role facing the ecological transition?

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In the energy/ecological transition, actions favouring carbon sequestration and habitat conservation/restoration are keys goals. They constitute priority stakes for the sustainable management of the socio-ecosystems, pointed out by several institutions at national and international level. In such context, forest systems are “hotspots” because they are among the ecosystems that present the most of biomass and they host a large part of the biodiversity, at global scale. Nevertheless, the reginal scale, and even the local one, appear to be the key scales to act for the carbon sequestration and habitat conservation/restoration. Therefore, such scales are crucial, although they present specific stakes and challenges for the energy/ecological transition. However, among these regionally/locally specific stakes and challenges some are still poorly documented until now. This is the case of the forest ponds in the lowland temperate biogeographic domain. These forest ponds are wetland about some hundred m^2 and few meters depth, which might be present locally in high density. Thus, considering their frequency at reginal level, the forest ponds are significant ecological entities, although they might be in very much different ecological states, from waterlogged to terrestrialized states. This probably explain why they are still not well characterized as specific ecological system. Nevertheless, empirical observations allow us to postulate that these forest ponds might play a significant role in the energy/ecological transition, providing local solutions for carbon sequestration and habitat conservation/restoration. This is what we try to demonstrate in the hereby presentation.

Our demonstration is based on results from two on-going research project, about the origin of the forest ponds, on two areas on the Lorraine lowland in north-east of France. On these areas forest ponds have been inventoried, using notably LIDAR prospection. They have been characterized in terms of long-term ecological trajectories and of present-day ecological state. Their distribution has been characterized according topographical position and geomorphological features. Our analyses permitted to stress the significant synchronicity of origin of the investigated forest ponds, and to confirm the large variation of localization and geomorphological features. This is support by the observation about their divergences of long-term dynamic, providing much divers state of sedimentary patterns, from nearly no sediment to several meters of organic sediment. Finally, we highlight the role of the last century forest management as main factor influencing the state of the forest ponds today.

Thus, as conclusion, rise here prospective questions (among others) about the place of the forest ponds: what biodiversity the presence of ponds permits to maintained in the matrix of the managed forest? What states of forest ponds to promote to obtain the most of habitat heterogeneity? And also permitting to optimized carbon sequestration?

Estimation of the thickness of eroded Mesozoic formations in the Pechelbronn area (Alsace) using basin thermal modelling and organic geochemistry

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The Upper Rhine Graben (URG) is a Cenozoic intracontinental rift 300 km long and 30-40 km wide, NNE/SW trending. Its sedimentary filling is composed of a serie of Permian to early Upper Jurassic formations separated from syn-rift Cenozoic deposits by a major unconformity. While the Mesozoic sediments are very similar to those encountered in the Paris Basin, the Cenozoic deposits are typical of the URG. The study area corresponds to the Pechelbronn sub-basin which holds most of the petroleum reservoirs of northern Alsace (France), in the western central part of the URG.

In the Pechelbronn sub-basin, it is noticed that the unconformity reaches the Middle Jurassic formations. Compared to the Paris Basin sedimentary successions, this questions why Upper Jurassic and Cretaceous formations are missing. Especially for the Cretaceous sediments, it remains uncertain whether their absence is related to a sedimentary hiatus or a period of erosion. This uncertainty is problematic to rebuild the burial history of Mesozoic sedimentary formations.

Rock samples of Tertiary and Jurassic ages were collected in the Pechelbronn area and analysed for their organic geochemistry. The geochemical analyses of the Jurassic outcrops show that the Mesozoic formations are immature. If we consider that the pre-tertiary sedimentary column was not sufficiently buried before the Cretaceous to reach the oil window then a maximum thickness of eroded formations can be proposed. This estimation is made using 1D thermal models (PetroMod) from wells located in the Northern Alsace for which geological and Ro % data were published.

The aim of this presentation will be to show evaluation of oil generation and maximum paleo-burial in the Pechelbronn area by using molecular markers, vitrinite reflectance and kinetic properties of source-rocks. The comparison between the values simulated by the 1D thermal basin models (PetroMod) and the measured values from the organic markers of thermal maturity allows calibration for these wells. The calibration consists of fixing both time and temperature so that only the thickness of the formations varies. Special attention will be given to possible local heat anomalies linked to hydrothermal fluid circulations, well known in the URG.

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Mastering plant-plant-microorganisms interactions to improve the phytomanagement of trace elements-contaminated sites

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Soil pollution by trace elements (TEs) and land-use competition for production of food and non-food crops are pan-European concerns. Developing eco-innovative technologies able to limit the risks related to contaminants while providing valorizable biomass for the bio-economy is a priority and is particularly of high concern in Lorraine. Phytomanagement combines a set of techniques using plants that contribute to rehabilitate and revalorize contaminated sites. The selection of relevant plant associations and their inoculation with plant-growth promoting (PGP) microorganisms such as endophytic fungi is recognized to actively participate to phytomanagement by improving plant growth and fitness and by modifying the mobility of TEs in the soil. The PPMI project focuses on two plant associations i) Urtica dioïca and Populus spp. for the production of fibers and ii) Salix aquatica-grandis and Noccaea caerulescens in a strategy of Cd and Zn phytoextraction. The project aims at evaluating the effects of the co-culture on the plant development, at characterizing the fungal microbiome associated with the two plant associations and at testing the effects of potentially PGP endophytes on their performances in a context of phytomanagement.

Based on mesocosm studies, our results highlight that the two plant associations are relevant, as we did not detect any negative effects of the co-culture on the plant development. The co-culture of S. aquatica-grandis and N. caerulescens improved the biomass production (number, area and biomass of leaves) of N. caerulescens, while the development of S. aquatica-grandis was not influenced. Microscopic observations performed on various populations of U. dioïca and N. caerulescens collected in various TE-contaminated or non-contaminated sites revealed that endophytic fungi in natural conditions actively colonize their roots. Among the wide panel of isolated fungal strains, some of them exhibited PGP abilities according to in vitro tests (i.e., ability to solubilize phosphate, to produce auxin and siderophores).

Mesocosm studies were performed to assess the effect of fungal endophytic strains on the development and the fibre content and quality of U. dioïca and on the phytoextraction potential of N. caerulescens. For both plants, we identified fungal strains with positive effects on their respective performances. Non-indigenous (Leptodontidium sp. and Phialophora mustea) and indigenous (Alternaria thlaspis and Metapochonia rubescens) strains significantly improved the amount of Cd and Zn extracted by N. caerulescens from contaminated soils. This improvement of phytoextraction induced by endophytes seemed to be related to a better mineral nutrition of the plants. Concerning U. dioïca, three indigenous endophytic strains positively influenced plant biomass and global soil activity. At the contrary, Phomopsis columnaris, which was the most frequently isolated species in our study, had a detrimental effect on nettle when reinoculated. We are now investigating the effects of the inoculation on the structure of root-associated fungal communities.

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