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MINERAL AND ENERGY RESOURCES ENGINEERING ANNUAL MEETING 2025

BOOK OF ABSTRACTS

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Mineral and Energy Resources Engineering Annual Meeting 2025

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Brazil Nut Effect Simulation for Dry Size Classification under Lunar Gravity Conditions

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This project investigates the Brazil Nut Effect (BNE) – a physical phenomenon where larger particles rise to the top of a vibrating granular mixture - through the creation of physically accurate 3D simulations. Using YADE, an open-source Discrete Element Method (DEM) software, the study explores particle segregation under both terrestrial and lunar gravity conditions. The work is divided into three stages: validation, calibration, and the lunar case study analysis. Validation involved replicating previous BNE studies using an intruder model, while calibration introduced experimental data from tests with varying amplitudes and two different sample types conducted at the Imperial College of London. The final stage focused on lunar gravity, revealing that BNE is more pronounced under reduced gravity, with all tests showing segregation - unlike some under Earth gravity conditions. A key part of the study analysed frequency variation, demonstrating that both extremely low and high frequencies hinder effective particle segregation. Results suggest that the amplitude-frequency relationship follows an inverse proportionality close to 1:1 for the maximization of segregation efficiency. Further findings indicate that more balanced particle mixtures resist overfluidization, maintaining better segregation quality. The simulation results also align with the critical dimensionless acceleration ($\Gamma crit$ = 1) found in literature but suggest the existence of an upper threshold - an optimal Γ - beyond which segregation quality declines. This research contributes valuable insights into particle behaviour in low-gravity environments, with implications for future lunar resource beneficiation.

Impact of Wildfires on Spatial and Temporal Evolution of Groundwater Recharge in an Atlantic Pine Forest: an Integrated Approach Using Field, Remote Sensing and Modeling

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Climate change, including higher temperatures, drier atmosphere and prolonged droughts, increases the risk, extent and impacts of wildfires in Southern Europe. This study investigates extreme wildfires impacts on groundwater recharge in the Leiria Pine Forest, integrating field and remote sensing data with modelling tools to simulate recharge in burnt and unburnt areas from 2001 to 2023. Results show a decline in crop-adjusted potential evapotranspiration due to vegetation loss after the fire, resulting in increased recharge rates. Groundwater recharge increased from 20% of annual precipitation pre-fire to over 40% in the first-year post-fire in the burnt area, gradually stabilizing at around 30% by 2023. This contrasts with the unburnt area, where recharge rates remained stable. This increase is influenced by geological and pedological characteristics, favourable topography which promotes low runoff and high infiltration rates, and specific climatic conditions. The low water-holding capacity of the sandy aerosols in the burnt area, promotes faster infiltration, increasing recharge. Contrary to other studies, soil water repellence seems to have limited influence in this area due to local climate and soil conditions. Predicting the consequences of wildfires in groundwater is complex, nevertheless the application of multiple methodologies increases the reliability of groundwater recharge predictions.

Mapping Green Roofs on Buildings Using Vegetation Indices and Deep Learning Techniques

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The identification of strategies to mitigate climate change and address related urban challenges is nowadays a priority of urban planners. Green roofs installation is recognized globally as part of the solution to adapt urban areas to the effects of climate change. Despite this recognition, most installations result from individual initiatives and systematic mapping and monitoring of these green infrastructures remains absent. Over time, the constructions of green roofs have changed from individual buildings to patterns of a set of buildings, having common areas, such as garages, covered with green spaces. The identification of the green roofs at street level is important and should not be confused with other green spaces. This work provides a methodology for mapping green roofs and for monitoring them through remote sensing, namely using Support Vector Machine classification process, deep learning models and GIS-based spatial analysis. Applied to the Lisbon Municipality, the methodology enabled the identification and validation of 200 green roofs. The results demonstrate the effectiveness and scalability of the proposed approach, which surpasses existing methods and is adaptable to diverse urban contexts without reliance on location-specific characteristics.

Visual Similarity Grouping of Marble Varieties with Cluster-Aware Self-Supervised Vision Transformers

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The commercialization segment of the marble stone industry heavily relies on proprietary commercial names designed to convey perceived value and uniqueness in their products. With a few exceptions, companies typically avoid adhering to objective, appearance-based stone categorizations. From the buyer's perspective, this practice complicates navigation through the vast array of commercial names, making informed purchasing decisions difficult. To address this issue, we propose a self-supervised neural network methodology for unbiased visual grouping of marble varieties based solely on appearance. Our method builds on the DINO Vision Transformer architecture, specifically adopting a "cluster-aware" variant that integrates explicit clustering objectives during representation learning. After training on unlabelled marble images, the learned visual embeddings are extracted and clustered using hierarchical clustering algorithms to identify groups characterized by intrinsic visual similarity. Experimental results on a diverse marble image dataset demonstrate that this pipeline effectively groups stones according to perceptually relevant visual features, such as vein patterns, base coloration, and texture, without any dependency on proprietary names or external labels. The resulting visual groupings align closely with human perception and facilitate the connection between inconsistent commercial labels and standardized naming conventions. This work establishes the effectiveness of self-supervised, cluster-aware Vision Transformers in promoting transparency, consistency, and unbiased stone classification in the natural stone industry.

Hydrogen Storage in Porous Media

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Industrialization, along with economic and population growth, has led to an increased demand for energy and a growing dependence on it. A significant portion of current energy production remains non-sustainable, primarily due to the continued reliance on fossil fuel combustion, which is the main contributor to greenhouse gas emissions. The urgent need to reduce these emissions has elevated the importance of renewable energy sources in global energy transition strategies. In this context, hydrogen has emerged as a promising alternative to fossil fuels. When produced via water electrolysis powered by renewable energy, it is referred to as green hydrogen. However, hydrogen poses challenges due to its low volumetric and gravimetric energy densities, requiring substantial storage capacity. Underground hydrogen storage (UHS) in porous geological formations, particularly in depleted oil fields, offers a potential solution by providing both large storage volumes and natural geological confinement. This research aims to identify and characterize suitable underground hydrogen storage structures in the southwestern offshore region of Sines, Portugal. It also seeks to analyse the dynamic behaviour of hydrogen storage in these formations under various operational scenarios through numerical simulations, offering insights into system efficiency and long-term durability. Furthermore, a business case will be developed for integrating UHS with the Sines Refinery: during periods of low demand, excess hydrogen produced at the refinery could be stored offshore to create a strategic hydrogen reserve. Ultimately, this study aims to assess the feasibility of offshore UHS and support the development of hydrogen-based energy systems within renewable energy ecosystems.

Energy and Mass in Transportation

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This study focuses on the exploration of the relationship between energy and mass in transportation systems and trade-offs presented by the global energy transition. It primarily examines aviation and road transport-two sectors that together account for over 80% of transport-related CO_2 emissions-and analyses how energy and mass interact to influence vehicle performance, efficiency, and sustainability. For the aviation sector, alternative propulsion technologies are investigated within the context of strict regulatory constraints that limit experimentation. Unmanned Aerial Vehicles (UAVs) are used as proxies for fixed-wing aircraft to study powertrain efficiency and scalability. By applying both mechanical (Breguet) and thermodynamic (Bejan) modelling approaches, a comparative framework based on useful energy is developed, enabling propulsion-agnostic performance analysis. The findings show that vehicle mass and useful energy strongly govern energy efficiency, range, and performance, with implications for both UAVs and manned aircraft. In road transportation, the increasing weight of Battery Electric Vehicles (BEVs) is examined and compared with Hydrogen Fuel Cell Electric Vehicles (FCEVs). Using static and dynamic vehicle models and standardized driving cycles, the impact of added mass on energy consumption is assessed. Material requirements for the large-scale deployment of electric vehicles are also analysed, with a focus on critical elements such as cobalt, lithium, nickel, and platinum. This work highlights the systemic consequences of increasing vehicle mass and resource intensity. The conclusion is that sustainable mobility must not only reduce emissions but also address material constraints and mass-efficiency trade-offs, particularly as electrification scales globally. This perspective is essential for informing both technical development and policy planning.

Geothermal Energy Production from Abandoned Hydrocarbon Wells. Case Study: Volve Field, North Sea

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With the growing demand for low-carbon and sustainable energy sources worldwide, there is a increasing interest in repurposing oil and gas wells for geothermal energy applications. The North Sea Volve Field, a hydrocarbon field that was abandoned in 2016, is the subject of this study's investigation into its geothermal potential. taking into account, minimizing all the geological risks and the massive expenses of drilling operation for a new geothermal well, the objective is to evaluate the functionality of repurposing a hydrocarbon reservoir into a geothermal energy application. To capture the effects of subsurface heterogeneity and uncertainty, specifically in porosity and permeability on thermal energy output, the study combines dynamic reservoir simulation using tNavigator with stochastic geological modelling. Due to the detailed sensitivity analysis of significant subsurface parameters enabled by this dual modelling approach, performance predictions are more confident. 41376 enthalpies were produced overall. The dynamic simulation results reveal 4 MWh over a 20-year operating period, proving the technical viability of geothermal repurposing. These results validate the approach and results and are consistent with published case studies of comparable projects in depleted reservoirs. Additionally in addition to reducing the environmental impact of new drilling using existing well infrastructure also significantly reduces capital costs and carbon emissions. Converting oil and gas wells into geothermal energy is a practical and sustainable strategy for the energy transition by combining geological engineering and economic viewpoints.

Geostatistical Seismic Inversion in the Offshore Campos Basin, Brazil

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This work showcases the application of iterative geostatistical seismic inversion for quantitative reservoir modelling and characterization, using pre-, post-stack, and time-lapse (4D) seismic reflection data. We follow a geo-modelling workflow that progresses through acoustic and elastic impedance geostatistical inversion, culminating in time-lapse geostatistical inversion to capture changes in reservoir properties before and after production. The methodology is applied to a real 3-D seismic dataset from the offshore Campos Basin, Brazil, with pre- and post-production data. The study emphasizes the integration of inversion results with rock-physics models to infer lithological and fluid-related properties, enabling improved discrimination of reservoir facies and dynamic changes over production time. Comparative analysis across the different inversion methods highlights the strengths and limitations of each approach in resolving subsurface heterogeneities and capturing production induced anomalies. The results contribute to advancing quantitative modelling and characterization geo-modelling workflows and demonstrate the value of geostatistical seismic inversion strategies in complex geological settings, offering practical insights for reservoir management in mature offshore fields.

Fire as a Risk and a Resource to the Pre-Historic Artists: Through the Lens of Geosciences

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Rock art, considered as human-made images produced by the addition of pigments or the subtraction of bedrock, is one of the oldest forms of human artistic expression. Bedrock outcrops are subjected to environmental agents which are potential threats that can accelerate or initiate new weathering processes. However, this vulnerability of archaeological resources to climate change has been addressed mainly in terms of sea level rise, storm events and glacial retreat. This study focuses on another important factor aggravated by climate change: fires, through a multi-scale approach combining field work at Côa Valley Archaeological Park (CVAP) with laboratorial studies. This involves a characterization of rock engraving samples collected in CVAP along with simulations and evaluation of temperature effects on metamorphic samples like those of CVAP, while looking into previous works that focus on fire damage to rock art sites, which highlight effects of thermal stress such as soot deposition, chemical alterations and fracturing of rock surfaces. The goal is to define future laboratory and field analysis/methodology of fire impacts, to not only aid the implementation of conservation plans and policymaking but also allow for a better understanding of past fire events which occurred in CVAP.

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