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RTX 2024 Abstracts

Making Green Energy Greener: Evaluation of Recycling Methods for Wind Turbines, Solar Panels, and Lithium-ion Batteries in Texas

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Solar panels, wind turbines, and lithium-ion batteries are crucial for providing and storing renewable energy, but they have a functional lifespan of 20 to 30 years (10 to 15 for batteries). They can impact the local environment if abandoned or landfilled. Texas needs to explore recycling options as it has the second-most solar panels and wind turbines in operation in the U.S. This review explores mechanical, chemical, and thermal recycling methods for wind, solar, and battery gate-to-grave disposal by compiling data on overall recycling efficiency from research and review papers to identify different end-of-life strategies for the State of Texas. Mechanical methods are the simplest, fastest, and cheapest for solar panels. Unfortunately, their products are low quality, and the silicon wafer is broken. Thermal methods can recover the silicon wafer but are energy intensive, lead to a loss of other materials, and produce hazardous emissions. While chemical methods are well- established, can recover metals, and offer many reagents, they are also slow, produce effluent waste, and decrease silicon wafer thickness. Traditional mechanical methods are the simplest for batteries with the messiest results. Hydrometallurgy, a chemical method, achieves higher leaching efficiencies than pyrometallurgy, a thermal method. However, it notably produces less profit than pyrometallurgy, which requires less energy. Overall, the most efficient recycling method for batteries is a mechanical process that involves opening battery cells underwater, requires the least amount of energy, and offers the highest revenue. Finally, mechanical grinding methods for wind turbines are inexpensive and simple but don't offer high-quality recovered fibers. High voltage fragmentation is also a mechanical method that cleans more but at a higher cost. Chemical methods offer the best quality of fibers overall. Still, it's a costly process that requires lots of energy and chemicals and could produce hazardous waste. Pyrolysis, a thermal method, is a lower energy (even lower with microwave pyrolysis) and lower cost option that produces useful chemical feedback. Unfortunately, pyrolysis generates dust and weakens fibers. Another thermal method, combustion recycling is easy to scale up and operate continuously but does produce high CO2 emissions.

Geospatial Analysis for the Potential Development of Data Centers in Texas

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As the need for data processing and storage solutions escalates, the demand for data centers is expected to surge, with market analysis projecting a compound annual growth rate (CAGR) of over 10% through the next decade. The inherent need for data centers to operate with uninterrupted power, high redundancy levels, and minimal disruption risk, positions this study as a critical enabler for sustainable and resilient infrastructure development. As part of the Bureau of Economic Geology, we developed a comprehensive Geographic Information System database that maps local energy sources, employment, and environmental factors that impact the decision process of locating data center sites in Texas, with a focus on determining potential sites within the Permian Basin. Our approach began by assimilating data detailing the management of data center infrastructure and energy requirements. The data, along with input from professionals at the Texas Advanced Computing Center (TACC), supported the informed quantification of thresholds per factor deemed most suitable for successful data center development. The input of these suitability thresholds within our GIS database allows for data-driven site selection based on specific criteria such as proximity to potential energy sources (solar, wind, geothermal, and local natural gas), water availability, existing industry employment and household demand, and hazards (flooding, seismic activity, and heat abnormalities). This database narrows the regions of assessment for future economic and environmental analysis regarding the viability of data center development in Texas.

Visualizing an interpolated USDW base across the Texas Coastal Counties

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Carbon capture and sequestration, which can be described as the process of capturing emitted CO2 and injecting it into deep underground formations to reduce emissions and combat climate change, is a heavily regulated process that poses a set of risks. The Underground Injection Control program was founded by the EPA to ensure that fresh water resources are protected and that the wells are operating safely. The fresh water that must be protected is defined by the Underground Sources of Drinking Water which is any aquifer that supplies a public water system or has less than 10,000 mg/l of total dissolved solids. An interpolated depth of the USDW base was created using data collected by the Railroad Commission of Texas that had recorded wells with values for the depth of the base, and then georeferencing these wells with coordinates sourced from IHS queries by using API numbers. These points were then placed into a kriging interpolator in ArcGIS Pro to visualize the depth of the USDW base inside of the study area. The depth was found to vary greatly, with the lower values near the coastline being as shallow as 203 ft below surface to the deepest values being found inland at 2516 ft. The depth to the USDW base determines the length of the surface casing that will be needed to protect fresh water resources as well as the size of the area of review, which is the area on the surface where the injected plume and its pressure may impact fluids. Any legacy wells inside of the area must be reviewed and repaired if needed to ensure that no leakage will occur. The length of the surface casing required and the amount of legacy wells that must be reviewed are both factors in the cost to protect fresh water resources.

Modelling the True Martian Olivine-Magma Fe^{2+}-Mg Exchange Coefficient

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The Fe^{2+}-Mg exchange coefficient, K_D, describes the exchange of Fe^{2+} and Mg between olivine and magma. It is valuable in modelling primary magmas and identifying mantle-derived magmas. As K_D is known to be compositionally dependent, the value changes based on planetary body. While the terrestrial value of K_D has been standardized to 0.30, estimates for Martian K_D have been higher (0.35-0.37) due to the Fe-rich nature of Martian magmas. The Fe^{3+}/Fe^{2+} speciation is dependent upon the redox condition (as oxygen fugacity, f_{O_2}), which is generally assumed to be reduced on Mars and resultant in low Fe^{3+} in Martian magmas. To simplify the approach, previous Martian K_D studies have considered the Martian magmatic Fe^{3+} to be negligible. Therefore, prior Martian K_D values represent the bulk K_D, which erroneously contains magmatic Fe^{3+} as opposed to the true Martian K_D. For this study, we compiled terrestrial and Martian melt and olivine compositional data from experiments in which the f_{O_2} was controlled. We then calculated the experimental Fe^{3+}/Fe^{2+} ratios using the revised Fe redox model by Sun & Yao (2024) and utilized these ratios to determine the experimental true K_D values. A multivariate regression was conducted to parameterize Martian K_D using magmatic composition including FeO and Fe_2O_3 content. This corrected Martian K_D could be used in the future to model primary magma compositions. More detailed findings will be presented at the symposium.

The Emotional Landscape of Carbon Capture and Sequestration: Insights from Social Media and Public Forums

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Carbon Capture and Sequestration (CCS) technologies are increasingly seen as essential tools to mitigate climate change. However, the public's perception of CCS and its potential social, environmental, and economic impacts remains a complex and evolving issue. This research project employs sentiment and emotion analysis to understand public discourse surrounding CCS by examining comments from open-source diverse platforms: the EPA public forum, Louisiana primacy hearing transcripts, and Reddit discussions. Utilizing both TextBlob for basic sentiment analysis and the DistilBERT model for text classification and emotion analysis, this study aims to uncover prevalent emotions and sentiments associated with CCS, identify key themes and concerns within public comments, and potentially reveal shifts in public opinion over time. The findings will contribute valuable insights to policymakers, industry stakeholders, and researchers working to navigate the socio-political landscape of CCS deployment and public acceptance. The findings underscore the need for more sophisticated sentiment analysis approaches, such as fine-tuning transformer-based models like BERT or RoBERTa on CCS-specific datasets. Leveraging transfer learning techniques can help overcome data limitations and capture nuanced emotions within public discourse. Additionally, finding models specifically contrived to analyze public perceptions through online forums, such as SAS Viya ("SAS: Data and AI Solutions") may prove to be more useful.

Sensitivity of Europa's Ice Shell Thickness to Ocean Composition and Ice shell Rheology

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Europa is one of the Galilean moons that orbits Jupiter. It is commonly known as an icy ocean world, which has an exterior ice shell with a thickness yet to be determined as well as an underlying salty ocean. It is also thought to have an iron core and a rocky mantle. NASA's upcoming Europa Clipper mission is set to fly by Europa 49 times while collecting data about its interior, geology, and composition. The overarching goal of the mission is to evaluate the habitability of Europa.

Properties of the ice-ocean interface greatly affect the habitability of the satellite. However, the interface is affected by several parameters, such as the basal temperature, pressure, topography, and more. Additionally, these parameters may vary spatially and evolve over time.

This project analyzes hypothesized variations of ice shell thickness to assess the sensitivity to ocean composition via the assumed basal ice temperature and to ice shell rheology via the assumed basal ice viscosity. As a result, it has been seen that the ice thickness is not that sensitive to basal ice temperature; however, its rheology can have implications as the ice thickness has relatively significant changes with changing viscosities. Understanding more about the ice-ocean interface of Europa not just from theory and modeling but alongside Clipper data will provide invaluable insight into Europa's interior and further constrain whether this world may be hospitable for life beyond Earth.

Investigating the Aluminum Oxide Mole Fraction to aid in Boron Adsorption Modeling

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Boron adsorption onto phyllosilicate-rich minerals is pH, temperature, and lithology dependent. These characteristics underpin the utility of boron adsorption in understanding geochemical cycles and water systems. Previous models establish that boron adsorption onto natural clay sediments is controlled by Al-O surface sites, and boron adsorption can be predicted by the number of these surface sites on natural clays. However, this model has been tested on a limited number of phyllosilicates and natural clays. This study investigates using the predictive model for boron adsorption to find the number of Al-O sites on montmorillonite, an end member phyllosilicate, and montmorillonite-rich trench sediment from the Hikurangi Subduction Zone. Boron adsorption experiments were performed on this clay across a pH range of 6.5-9.3 at 22°C, conditions relevant to Earth's surface and subsurface. Preliminary results indicate montmorillonite clays exhibit a more basic pH and higher buffer capacity when acids are added, suggesting more negatively charged surface sites, and lower aluminum oxide sites compared to silica oxide. This work will report the aluminum oxide mole fraction of montmorillonite-rich trench sediment by applying the theoretical model to boron adsorption data normalized for surface area. These findings expand the applicability of previous boron adsorption models by elucidating the aluminum oxide mole fraction on montmorillonite, a phyllosilicate common in Earth's surface and subsurfaces. This contributes to more accurate fluid tracing in subduction complexes, paleoclimate reconstruction, agriculture, soil science, water treatment, geochemical modeling, and environmental remediation.

Automated classification of methane super emitters using satellite data

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Methane emissions originate from numerous natural and human-made sources spanning various industries. While measurement and monitoring efforts in the oil and gas sector are well-established, comprehensive methane emission mitigation requires addressing emissions across sectors like agriculture, landfills, and wastewater treatment [1]. To effectively mitigate Methane's impact on climate change, identifying and mapping super emitters is crucial [2,3]. Remote sensing technologies play a pivotal role in this effort by providing unbiased, accurate data across diverse landscapes. We propose an innovative approach that enhances methane emissions data from satellites, focusing on identifying super emitters and automatically classifying their sectors or industries (e.g., upstream, midstream, downstream, coal mine, landfill, agriculture). Our methodology leverages NASA's Earth Surface Mineral Dust Source Investigation (EMIT) mission data and satellite imagery to pinpoint methane emission sources in real-time. A core component of our approach involves the development of a specialized app designed to assist with image labeling and the creation of a robust machine learning algorithm. This app facilitates the manual labeling of 47 gigabytes of imagery data from various methane-emitting sectors. Utilizing this labeled data, a deep learning model is trained to recognize and classify images according to their respective industries. Once trained, the model can automatically label new super-emitters and identify their associated sectors. This automated classification process is crucial for estimating emission contributions from specific industries and infrastructure, providing a clearer understanding of major methane sources on a global scale. Our tools and data will enable the evaluation, validation, and improvement of datasets like the GLOBALVIEWplus CH4 ObsPack dataset of surface sites [3], significantly enhancing our ability to anticipate and mitigate emissions across various industries.

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[3] US EPA, "Importance of Methane," US EPA, Nov. 01, 2023. https://www.epa.gov/gmi/importance-methane

Establishing Early Cretaceous chemostratigraphy in southern Patagonia to assess the impact of ocean gateway evolution on organic carbon burial in the emerging South Atlantic

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The South Atlantic during the early Cretaceous was a restricted ocean and much smaller than the Atlantic we see today that observed ocean gateway evolution and holds records of ocean anoxic events (OAE) through trends in organic carbon burial. OAEs provide insight on the state of the climate during that time as the two phenomena are always observed at the same time, with records of organic carbon to show for it. Using samples collected from the Rocas Verdes basin in southern Patagonia located on the gateway of the South Atlantic, we can utilize total organic carbon (TOC) and x-ray fluorescence (XRF) analyzation techniques to observe trends of organic carbon and elemental composition across time. With this approach, the aim is to determine where in the rock record we can locate the OAE known as OAE-1a according to the International Ocean Discover Program (IODP). That said, the IODP is the leading group in the study of this area and has conducted its own set of research with several drilling sites across the South Atlantic and has not solidified an exact date for OAE-1a. Hence, we also look to compare our data in the form of chemostratigraphic columns and stratigraphic height-element ratio graphs to theirs and observe any trends or contradictions in our data, but most importantly we intend to find the exact date of OAE-1a. Shortcomings may fall under the umbrella of data inaccuracy through error of analysis of TOC and XRF techniques. Though, my data has not yet been completed so I cannot state any conclusions or findings as of right now. However, data should be fully organized into proper form to analyze and compare within a few days. Our findings will be able to fill knowledge gaps of the timing of OAE-1a and provide insight into other aspects of geology across the globe during that timeframe aside from the insight that it will be providing for studies of the South Atlantic.

Impacts of Dredging and Storm Events on Subaqueous Estuarine Dunes in Port Aransas, Texas

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Subaqueous estuarine dunes in Aransas Pass and Lydia Ann Channel, Port Aransas, TX are impacted by tides, routine dredging, and major storm events. Previous data collected in this location make it ideal to look at changes in dunes over time. Observing and quantifying changes in bedforms contributes to a greater understanding of how dunes are impacted by both human-driven and natural events.

Using data collected from multibeam echosounder surveys over the past fifteen years, we created subtraction maps to observe changes in bed elevation between the dates of collection. When compared with turbidity data, we see greater sediment deposition in years with high turbidity by contrast to years with low turbidity where we see more erosion. We also see erosion following dredging of the Corpus Christi Ship Channel in Aransas Pass. We observe substantial deposition and erosion following Hurricane Harvey (2017) and Hurricane Nicholas (2021), respectively. Using BAMBI, a bedform analysis program, we extracted dune statistics (height and wavelength). To understand changes in the dunes through time, we subsampled our bathymetry grids into three regions (R1- upper, R2- middle, and R3- lower) of the Lydia Ann Channel and one region (R4- middle channel) from Aransas Pass. In 2017, smaller median dune heights were observed in regions 1, 2, and 3.

When turbidity is high, deposition is more likely due to the greater supply of sediment in the water column. There is also greater erosion following dredging projects, so it is not surprising that these are both reflected in the subtraction maps. In general, we see temporal variability in the number of dunes and height distributions across all regions. We can attribute some of this variability to Harvey in 2017, but because data was collected in the same time range for the other years, it is unlikely that variability is seasonal. Rather, this variability could be attributed to dredging, tides, or storm events. The findings from BAMBI suggest that although there is deposition following Harvey, high energy flows flattened the bed, wiping out dunes.

Acid mine drainage seeps at gibbon's creek

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From 1992 to 1996, Gibbons Creek Lignite Mine extracted two seams of lignite. After mining concluded, four end-pit ponds were constructed to install limestone dams that neutralized the acidity of groundwater, as well as raising the water table and decreasing the groundwater gradient, thus decreasing rate of flow of the acid seep water. The high elevation of the ponds (200 to 340 feet above sea level) created a new hydrologic gradient such that water flows through the mine spoil until it reaches an impermeable clay unit and seeps to the surface. At present, four acid seeps have been identified downgradient of the ponds, all of which exhibit a decrease in pH and an enrichment in iron, sulfate, and Rare Earth Elements (REEs). While water chemistry indicates lignite remains in the spoil material, the volume of which is unknown. Therefore, this research seeks to constrain the volume of lignite material that exist on site, specifically within the -A2 Mining Block Section prior to mining, and what the economic value of lignite was in “USD”. For this project to be conducted the main tools used were Google Earth Pro to visualize what the mine block looked like to visualize the elevation difference between the ponds and the seep sites, as well as ArcGIS to locate the different well sites that were installed in the mine block to test the TDS (Total Dissolved Solids) of the groundwater to study the geochemical perspective prior to mining. We then proceeded to determine a rough estimate of the area to calculate the volume of lignite that had been extracted using the distance between the A2 /A3 mine block wells. Once the volume of both 4500 and 3500 Lignite was found, the economic value was then quantified using total RRE (Rare Earth Element) tables that were provided by the CORE-CM department of energy. Conversions were made, along with the use of different websites, to find constants needed for the calculations. Once both calculations were finished, the total volume of lignite that had been mined out for the 4500 lignite was about 25,243,212 ft3 and for the 3500 lignite was about 55,683,555 ft3. The total economic value of all the lignite was $23,512,126.93.

The white Gold for energy revolution: Discovering Lithium in Oilfield waters

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Lithium, often called the "white gold" of the energy revolution, is important for modern technology and renewable energy storage. This study investigates the geochemical characteristics of produced water samples from oilfield companies across Texas focusing on lithium concentration and isotopes. The 100 samples collected from various wells covering the Permian basin, Anadarko basin, and Gulf Coast South (GCS) Basin within Texas were analyzed using inductively coupled plasma mass spectrometry (ICP-MS). Lithium concentration and isotopic compositions were analyzed, alongside other species (SO_4, NH_4) concentration and estimated total dissolved solids (TDS). Our analysis revealed distinct lithium enrichment patterns and isotopic variations across the basins. Highest lithium enrichment occurred in GCS Basin. In the South of Texas and GCS samples, the lithium concentrations decrease with the presence of halite but increase with greater depths, higher TDS values, and trace elements (K, B, Mg). We generated a comprehensive geochemical profile of the produced water. These findings not only increase our understanding of the geochemical processes affecting lithium on produced water, but also shows which minerals (e.g., clay) have higher lithium concentrations. The aim is also to develop a more efficient method for lithium discovery and extraction, focusing on its co-occurrence with other elements. For instance, a high concentration of boron often indicates the presence of lithium, whereas high concentrations of equimolar of sodium and chloride typically suggest lower lithium levels. This research gives us a valuable understanding of the oilfields industry, revolutionizing lithium sourcing and contributing to the growing demand for substantial energy solutions.

The Impacts of Prescribed Burns on Plant and Soil Microbial Communities in Travis County, Texas

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The effects of prescribed burns on soil microbiology are not fully understood, with the relationship between prescribed burns and ecology restoration being the focus of ongoing studies. Prescribed burns are conducted for several different reasons, including controlling the spread of invasive species, reducing downed woody fuel loads, and restoring natural ecology and fire cyclicity. However, if prescribed burns are conducted under nonideal conditions or during the incorrect season, some invasive species will reestablish with greater abundance than prior to the burn, the opposite effect to the burn objective. Therefore, it is important to understand the phenology of the plant community in a biome so invasive species are impaired by the burn.

We acquired soil samples, visible image data, and vegetation stress indices from the Indiangrass Wildlife Sanctuary, Austin Water Quality Protection Lands, and an urban wooded area near the Montopolis Practice Field. These sites were chosen because both prescribed and wildland fires occurred at these sites in 2024 and the sites represent a variety of biomes in the wildland-urban interface. In total, the study analyzed eleven soil samples, >40 visible ground-based images, and indices pre- and post-fire. Soil samples were analyzed for microbial biomass carbon and fungal bacterial ratio. The survey of the flora communities at the sites resulted in the identification of less than three invasive species, including the dominant King Ranch Bluestem and Brome grasses. The soil analysis revealed no differences in microbial biomass carbon between the burned and unburned plots (<105 ug C / g), which is expected a year after a burn. Visual surveys revealed a higher abundance of native prairie plants and insects. Overall, controlled burns have no long term negative effects on soil microbiology and summer burns at Indiangrass would be more conducive for inhibiting the establishment of King Ranch Bluestem.

Identifying patterns of hot springs from Earth using geomorphology for future compassion to Mars

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The goal of this research is to determine if it is possible to recognize hot springs on Mars through the use of orbital instruments such as satellites by using geomorphology to identify them. We believe that by quantifying identifiers for hot springs we will be able to better recognize them in observations on Mars, but it is unknown if current instruments have sufficient resolution to resolve them. This work would allow for a more accurate and efficient way of mapping Mars in search of its previous water features and geological history. We hypothesized that hot springs contain patterns that are recognizable such as; shape, coloration, features, slope, etc., and as such we will be allowed to more effectively identify them via remote sensing. In order to test this hypothesis, we observed four hot springs in Iceland; Namafjall, Sulten, Hveravellir, and Haukadalur of which we analyzed satellite data and then compared to one another. We also tested the effects of resolution scale in identifying features and collecting data. Of course, this type of data collection comes with the obvious pitfall of subjective observation; however, this could be aided by the use of AI to identify patterns and features and with the use of spectrometers for more tangible data. With the data we were able to observe found that on average these hot springs have a similar area, low circularity, and median slopes. We also found that these hot springs tend to have similar features such as; spots with high reflectiveness which show up white in imagery, and grey spots which may be areas that are muddy or wet. With the given data we conclude that a high resolution allows for better identification of the hot spring's features, but more research is needed to determine whether theses hot springs contain pattern that are recognizable.

Hydro-stratigraphy of the active layer in riparian valley bottoms of an arctic watershed

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The active layer describes the ground above permafrost that seasonally thaws, allowing for groundwater flow in an otherwise frozen subsurface. The transport of carbon through groundwater flow in the active layer influences its decomposition to greenhouse gasses. Thus, the groundwater flow and storage regime of soil carbon has consequences on the global climate because of the large amount of carbon stored in arctic permafrost soils. Understanding the factors that affect groundwater within the active layer is therefore important, but observations regarding these factors are lacking. Previous studies have identified three main strata within the active layer, acrotelm, catotelm, and mineral soil, which have different hydrologic properties. This research characterizes active layer soils of an arctic watershed through the measurement of saturated hydraulic conductivity, porosity, and bulk density, all of which affect the flow and storage of groundwater. Soil samples were collected throughout a portion of the Imnavait Creek Watershed on the North Slope of Alaska and classified by their strata. The thickness of each stratum was observed directly in the field and samples were collected from each stratum. Falling-head tests were done to estimate saturated hydraulic conductivity of the samples. Porosity and bulk density were measured gravimetrically through sequentially saturating and oven-drying the samples. Statistical analysis will be employed to compare how the measured values vary between soil types and across the spatial extent of the study site. The results of this study will help bound soil parameters needed for groundwater and Earth system models to predict the fate of carbon in permafrost.

A comparison between fluid- and shear-induced laboratory earthquakes on a 1-meter fault

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Earthquakes are natural phenomena resulting from the sudden release of energy within the Earth's lithosphere. While most earthquakes are triggered by the abrupt release of elastic-strain energy from far-field plate tectonic loading, others can be induced by human activities such as fluid injection below the Earth's surface. In this work, we document similarities and differences between shear and fluid-induced earthquakes through meter-scale laboratory experiments. We generated shear-induced laboratory earthquakes by shearing the fault at a prescribed loading rate of 10 μm/s while maintaining a constant normal stress. Fluid-induced earthquakes were created by first increasing the shear stress on the fault to ~ 90% of its shear strength, followed by injecting fluid into the fault at 5 ml/min. The fluid-injection caused the fluid-pressure to increase in a small region along the fault, reducing the effective normal stress and promoting fault reactivation. Co-seismic properties, such as slip and slip rate, show minimal discernible differences between shear-induced earthquakes and those induced by fluid injection. This suggests that the physical processes associated with fluid-induced and regular earthquakes may be similar, which could have potential implications for seismic hazard assessment and mitigation strategies.