UNIVERSIDAD POLITÉCNICA DE MADRID

Expression of Interest – UPM Supervisor

Marie Skłodowska Curie Action –Postdoctoral Fellowship 2025 (MSCA-PF-2025)

Contact Person/Scientist in charge	**Name**	Diego
	Surname	MANZANAL
	Email	d.manzanal@upm.es
Department /Institute /Centre	**Name**	Continuum Mechanics and Structures Department / Civil Engineering School (ETSI de Caminos)/ R+D+i Center for Intelligent and Sustainable Civil Infrastructures
	Address	Calle Prof. Aranguren 3, 28045, Madrid
	Province	Madrid
Research Area		Information Science and Engineering (ENG) Environment and Geoscience (ENV) Mathematics (MAT)
Brief description of the Centre/Research Group		The **Centro I+D+i en Infraestructuras Civiles Inteligentes y Sostenibles (CIVILis)** at the **Universidad Politécnica de Madrid (UPM)** focuses on advancing **intelligent and sustainable civil infrastructures**. The center integrates **cutting-edge technology, sustainability principles, geomechanics for environmental and energy applications, and computational geomechanics** to address modern infrastructure challenges. **Key Research Areas:** • **Intelligent Infrastructure:** Smart systems for real-time monitoring, predictive maintenance, and resilience enhancement. • **Sustainable Design:** Eco-friendly materials and circular economy approaches for low-carbon infrastructure. • **Geomechanics for Environment & Energy:** Soil and rock behavior modeling for **CO_2 sequestration, geothermal energy, and underground storage**. • **Computational Mechanics:** Development and application of **numerical modeling techniques** (FEM, MPM, DEM) to analyze **complex geotechnical problems**, such as **landslides, subsidence, and reservoir geomechanics** in underground energy storage and CO_2 injection projects. • **Hydraulic & Environmental Engineering:** Water resource management, flood control, and conservation strategies. • **Structural Engineering:** Experimental and numerical research on durability and performance of materials and structures.

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Project description	Climate change is accelerating due to human dependence on fossil fuels. Spain's PNIEC 2021-2030 aims for a 23% reduction in CO2 emissions by 2030, yet 2022 emissions reached 305 Mt CO2eq, a 5.17% increase from 1990. **Underground CO2 storage** is a key mitigation strategy. Simultaneously, the need for **renewable energy storage** is rising, with **hydrogen (H2) storage** in geological formations offering a potential solution. Ensuring the **permanence of stored CO2 and H2** requires an understanding of **reservoir and caprock integrity**. The main concerns include: • **Leakage risks** via faults, fractures, and wellbore defects. • **Surface uplift and induced seismicity** from fluid injection. • **Hydromechanical and chemical interactions** affecting rock properties. **Research Objectives** This project aims to **improve numerical characterization of leakage risks** through **wellbore micro-annuli, rock discontinuities, and faults**. It focuses on: 1. **Mathematical Modeling:** Coupled **thermal-chemical interactions** in **geomaterials and fluids**. 2. **Constitutive Modeling:** Stress-path-dependent **rock and discontinuity behavior**. 3. **Numerical Modeling: phase-field variational numerical tool** for **fracture evolution** in deformable media in FEM and MPM. **Hypotheses** • **Supercritical CO2 alters** mineral composition, affecting **mechanical stability**. • **Phase-field multiphysics models** capture **fluid-driven fracture propagation**. • **MPM overcomes mesh distortion issues** seen in FEM for complex fractures. • **Reservoir pressure thresholds** critical for **mechanical stability and leakage risks** can be identified. **Expected Outcomes** • **Enhanced constitutive models** for **geological storage**. • **Predictive tools** for **leakage risks, stability, and seismicity**. • **Operational guidelines** for safe **CO2 and H2 storage**. This research advances **climate mitigation strategies** by improving **underground gas storage safety and efficiency**.
Applications: documents to be submitted and deadlines	Interested candidates should submit a **CV, a cover letter detailing relevant experience, and contact information for references**. For more information, please reach out to **Dr. Diego Manzanal (UPM). Deadline: 30th April 2025**