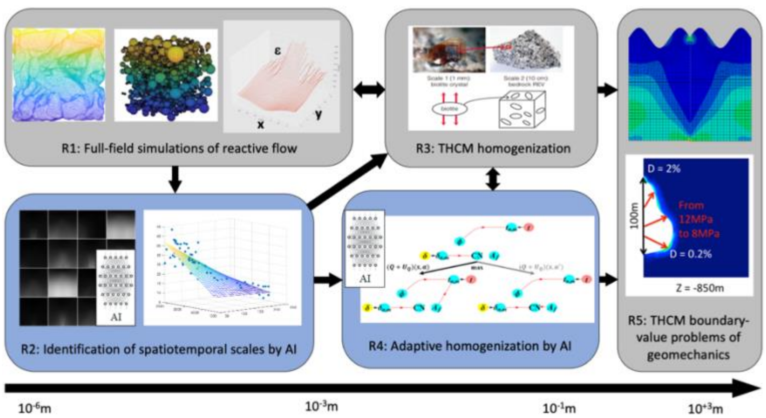
Postdoctoral position at Cornell University

Muti-scale modeling of reactive flow enhanced by Artificial Intelligence

Reactive flow is key to geomechanical instabilities that occur over spatio-temporal scales spanning several orders of magnitude. It is particularly challenging to formally link the microstructure changes induced by chemical reactions and pore deformation to physical and mechanical properties that are measurable in the laboratory or in situ, because the key microstructural features that govern macroscopic fluid flow differ from those that dominate elastic, plastic and brittle behaviors. The goals of this project, therefore, are to deploy Artificial Intelligence (AI) strategies to predict the spatio-temporal scales of thermo-hydro chemomechanical (THCM) instabilities and automatically adapt the representation of the microstructure as localizations occur. The proposed modeling strategies will be conceptualized and tested for problems of rock weathering, which are crucial to the assessment of critical zones in geomorphology, the modeling of geological underground storage and the prediction of geotechnical erosion-induced hazards.



The postdoctoral researcher will collaborate with a group of doctoral students to meet the five following scientific objectives: (1) Construct a data base of virtual experiments of confined reactive flow with a full-field method; (2) Train and test a deep convolutional neural network (CNN) to recognize microstructural features that attract high spatio-temporal variations of field variables; (3) Enrich Eshelby's homogenization theory with inclusion-specific life spans (called characteristic times); (4) Train and test a deep CNN to adapt the homogenization scheme as a function of the microstructure changes and localizations that occur after characteristic times have elapsed; (5) Solve coupled THCM boundary-value problems of geomechanics with the adaptive homogenization method.

The proposed integration of AI with the homogenization theory will spearhead impactful advances in applied mechanics. The prediction of probabilities of occurrence of THCM processes as functions of past events at the scale of different statistically representative neighborhoods will enable the modeling of open thermodynamic systems in ways that are not possible with current analytical homogenization schemes. One of the key scientific questions that will be addressed in this project is: "Does a Representative Elementary Volume exist?" – a long-standing issue in poromechanics and engineering mechanics in general. The transformative integration of coupled time and space scales in the homogenization theory will pave the way for the development of a new class of adaptive micro-macro models that will be tested over a wide range of spatiotemporal scales to design secure geological storage facilities and understand the evolution of the landscape with climate change.

Desired background: computational mechanics, deep learning, homogenization theory, poromechanics

Start date: ideally, Fall 2023; no later than Spring 2024

Duration of the appointment: 1 year renewable once, i.e., up to two years

Advisor: Professor Chloé Arson, currently at the Georgia Institute of Technology until 06/30/2023 and starting at Cornell University on 07/01/2023. See Arson's website and Google Scholar page.

If you are interested, please send a CV, a 1-page statement of purpose and 3 representative publications to Professor Chloé Arson (cfa36@cornell.edu).