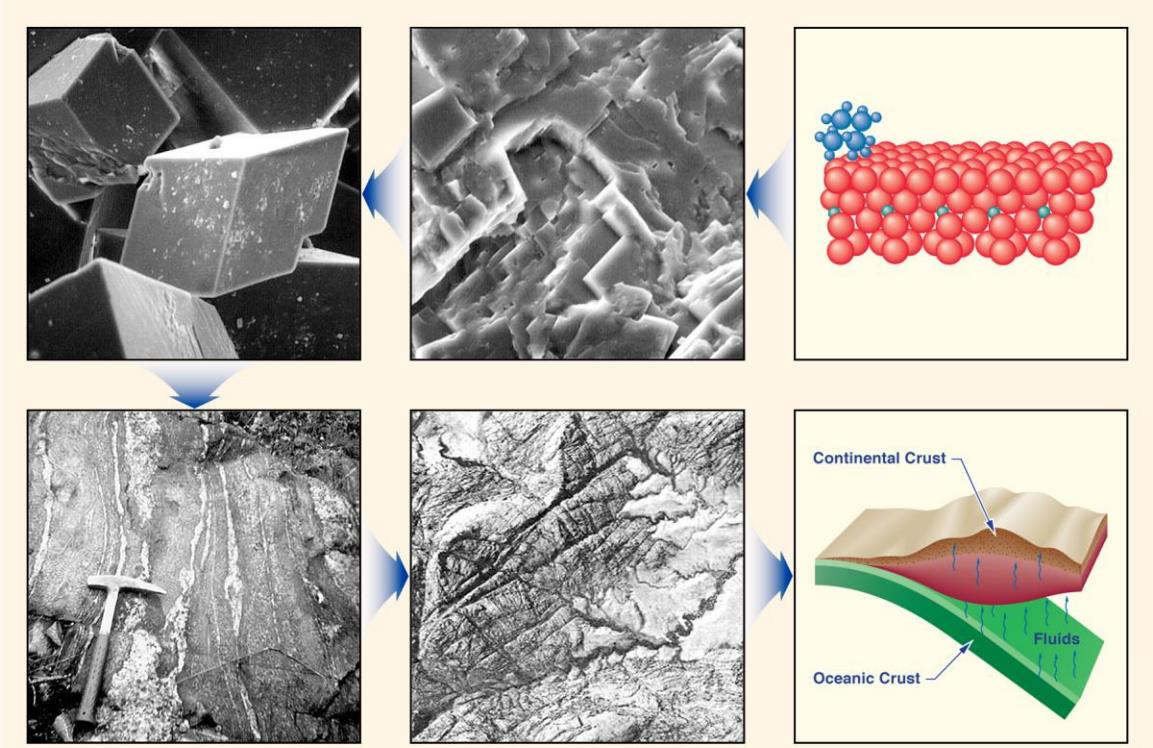
Cole Group – Research Overview

The principal research theme of the Cole group involves the geochemical behavior of fluid/mineral interactions at a variety of length and time scales with an emphasis on analytical, experimental and theoretical aspects of interactions occurring on surfaces, within pores or along planar features such as fractures, grain boundaries or dislocations common to subsurface energy systems. Research efforts impact practical problem areas such as waste water injection, geologic CO_2 sequestration, formation, migration and trapping of hydrocarbons in tight formations, the consequences of hydraulic fracturing of gas shale, and geothermal assessment and exploitation.

A fundamental understanding of interactions of fluids and solids within these types of structures is central to issues such as fluid transport, element mobility, initiation of recrystallization (e.g. calcite mineral trapping), natural chemical chromatography, and catalysis (both natural and engineered) to name a few. Research targets the role of pore-scale confinement on the molecular behavior of fluids (both polar and non-polar); how fluids react at interfaces in a 3-D environment, what controls the dynamics of molecular motion, reactivity and the attainment of equilibrium.

Problems of particular interest that remain largely unsolved include: (a) the reaction mechanism(s) and speciation of C-O-H-N fluids, and their role in the formation of point defects and modification of the structural properties of the solid, (b) the wetting, adsorption, motion and reactivity of H_2O, electrolytes and hydrocarbons under confinement, (c) the mechanism(s), speciation and rates of major, minor and trace element reaction and/or transport on and within clays and non-silicates such as carbonates and oxides, (d) rates and mechanisms of dissolution and precipitation near- and far from equilibrium, and (e) the behavior of light elements (O, H) and cation exchange during coupled reaction-diffusion in silicate and carbonate systems. A number of sophisticated tools are required to quantitatively assess these problems including the ion microprobe, SEM, TEM, NMR, isotope ratio mass spectrometry, neutron and X-ray scattering, etc., some of which can take advantage of isotopic doping (at high enrichments) or labeling of the light elements and select cations. Equilibrium isotope fractionation factors and rates of isotopic exchange (via diffusion or mineral transformation mechanisms) are logical spin-offs from many of theses studies. Access to facilities not available at OSU can be done via collaborative contacts already established or through instrument user proposals (neutron and X-ray scattering).

The Cole Group studies water-rock interactions across many length and time scales.



Currently funded projects and the funding source:

Nanopore confinement of C-H-O mixed volatile fluids relevant to subsurface energy systems (Cole-PI)
DOE/Basic Energy Sciences – Geosciences Research Program
Years: 2018-2021
Study of hydrocarbons and water in nanoporous matrices

Reduced Carbon in Earth: Origins, Forms, Quantities and Movements (Cole co-PI)
Deep Carbon Observatory/A.P. Sloan Foundation
Years: 2017-2019
Investigation of the origin of abiotic methane in the deep subsurface

Monitoring of Geological CO_2 Sequestration Using Isotopes and PF Tracers (Cole co-PI)
Department of Energy/NETL
Years: 2013-2019
Use of stable isotopes and chemical fingerprints to track fluid behavior in a real-world CO_2 injection test site

Marcellus Shale Energy and Environment Laboratory (MSEEL) (Cole co-PI)
DOE/NETL via West Virginia University as the lead
Years: 2014-2020
Characterization of organic matter and associated pores in the Marcellus formation of West Virginia

Sequestration of CO_2 and Co-Contaminants into Geological Formations in Ohio
(Cole PI)
Ohio Coal Research and Development Program
Years: 2018-2020
Modeling and experimental study of how acid volatiles from power plant flue emissions interact with subsurface sandstone and shale

Center for Energy Research, Training and Innovation (CERTAIN)
OSU – Colleges of Arts & Sciences; Engineering; Food, Ag and Environmental Sciences; and Office of Research
Years: 2016-2020
Catalyze transformative research, education and outreach that addresses society's grand challenges related to rapidly growing global energy demands in an environmentally responsible and sustainable manner, while balancing the importance of robust economic development, growth, and resiliency.

Acquisition of X-Ray Photoelectron Spectrometer with Near Ambient Pressure and High Temperature Capabilities for Discovering New Material Phenomena with In Situ Studies (Cole co-PI)
National Science Foundation - Major Research Instrumentation
Years: 2016-2019
Acquisition of an XPS spectrometer; no conflict with the proposed EFRC but more importantly gives us a new technique to use in the proposed EFRC to examine mineral surfaces