

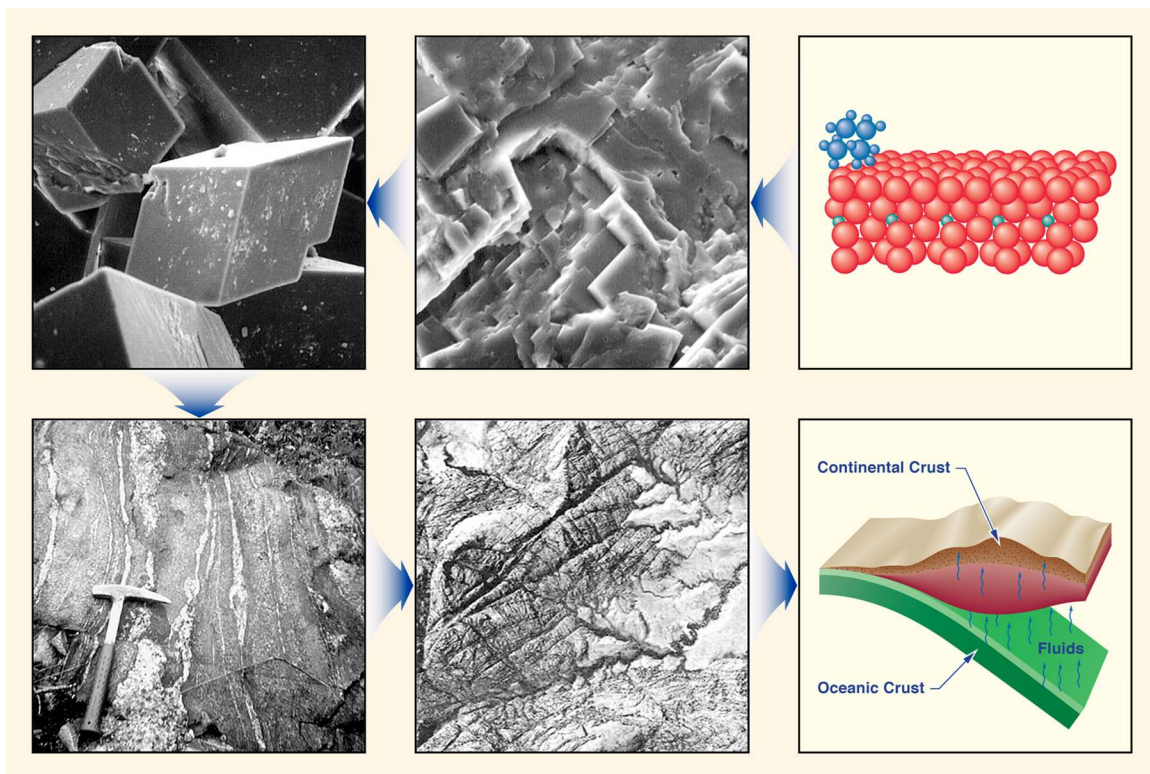
Cole Group – Research Overview

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 CO₂ 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 H₂O, 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 these studies. Access to facilities not available at OSU can be done via collaborative contacts already established or 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:

Nanoscale Control on Geologic CO₂, a DOE Energy Frontier Research Center
(Cole co-PI)

Department of Energy (DOE) Basic Energy Sciences/Energy Frontier Research Center –
Years: 2014-2018

Multiscale characterization of cap rock and reservoir rock

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-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 CO₂ sequestration using isotopes and PF tracers (Cole-PI)

DOE/NETL -/UT-Battelle

Years: 2012-2018

Use of stable isotopes and chemical fingerprints to track fluid behavior in a real-world
CO₂ injection test site

Marcellus Shale Energy and Environment Laboratory (MSEEL) (Cole co-PI)
DOE/NETL via West Virginia University as the lead

Years: 2014-2018

Characterization of organic matter and associated pores in the Marcellus formation of
West Virginia

Sequestration of CO₂ 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

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