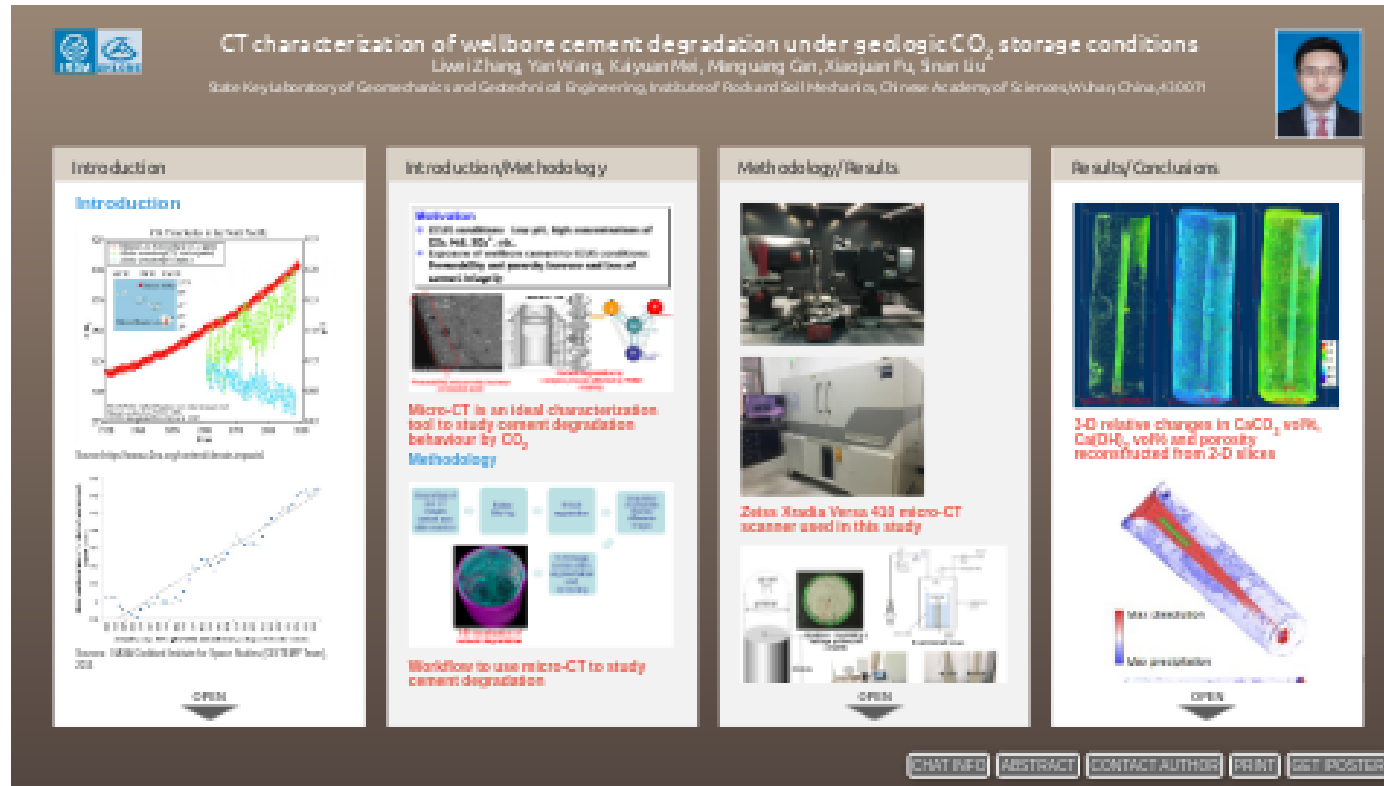


CT characterization of wellbore cement degradation under geologic CO₂ storage conditions

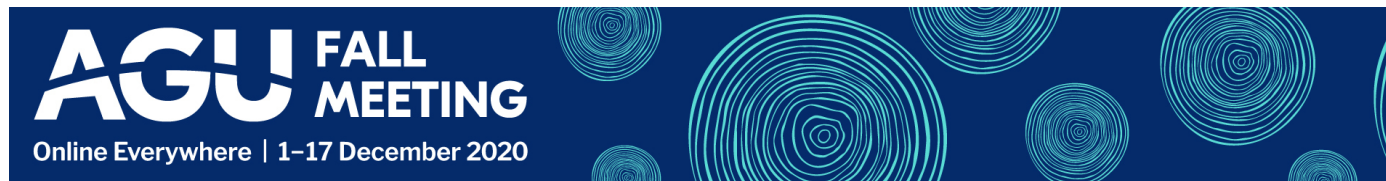


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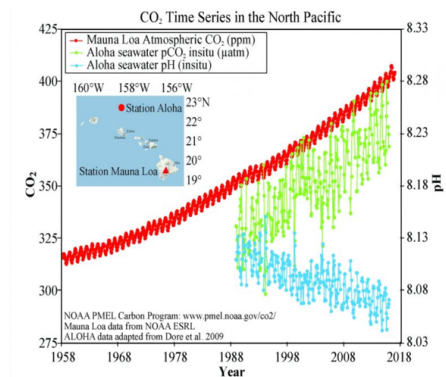


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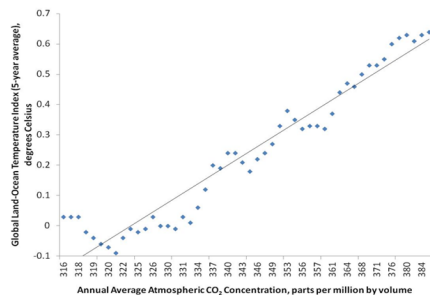


INTRODUCTION

Introduction

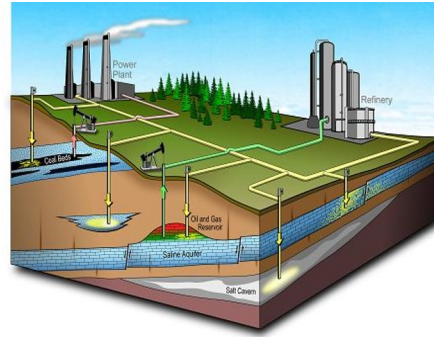


Source: <https://www.c2es.org/content/climate-impacts/>



Sources: NASA Goddard Institute for Space Studies (GISTEMP Team), 2016

Greenhouse Gas Effect: elevated CO₂ concentration in the atmosphere and global temperature rise



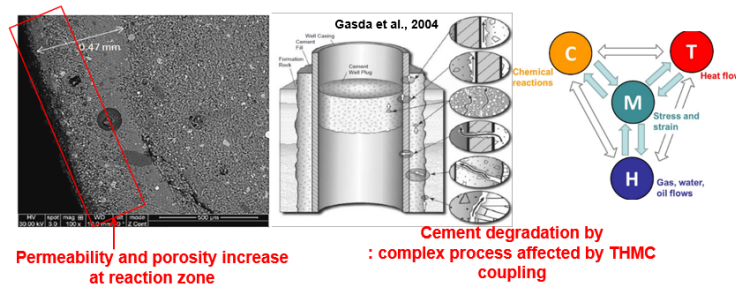
Source: Global CCS Institute, 2017

Carbon Capture, Utilization and Storage (CCUS)—a promising technology to reduce atmospheric CO₂ concentration

INTRODUCTION/METHODOLOGY

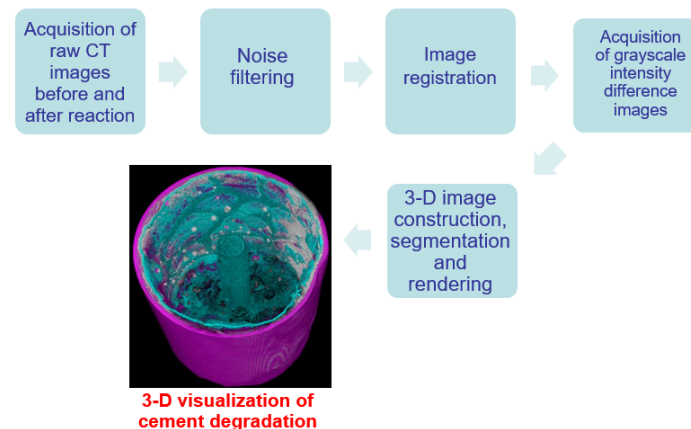
Motivation

- ❖ CCUS conditions: Low pH, high concentrations of CO_2 , H_2S , SO_4^{2-} , etc.
- ❖ Exposure of wellbore cement to CCUS conditions: Permeability and porosity increase and loss of cement integrity



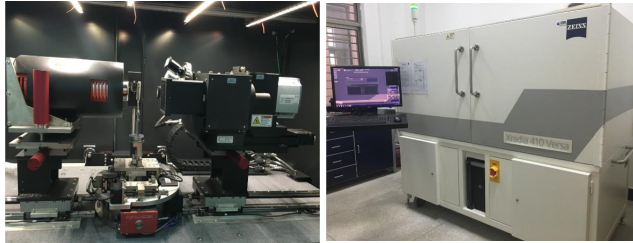
Micro-CT is an ideal characterization tool to study cement degradation behaviour by CO_2

Methodology

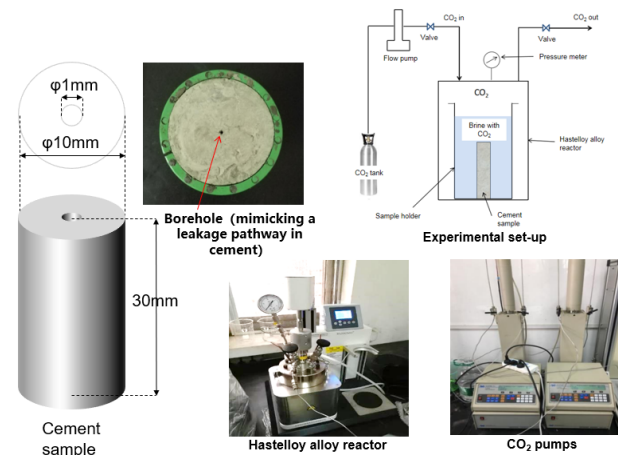


Workflow to use micro-CT to study cement degradation

METHODOLOGY/RESULTS

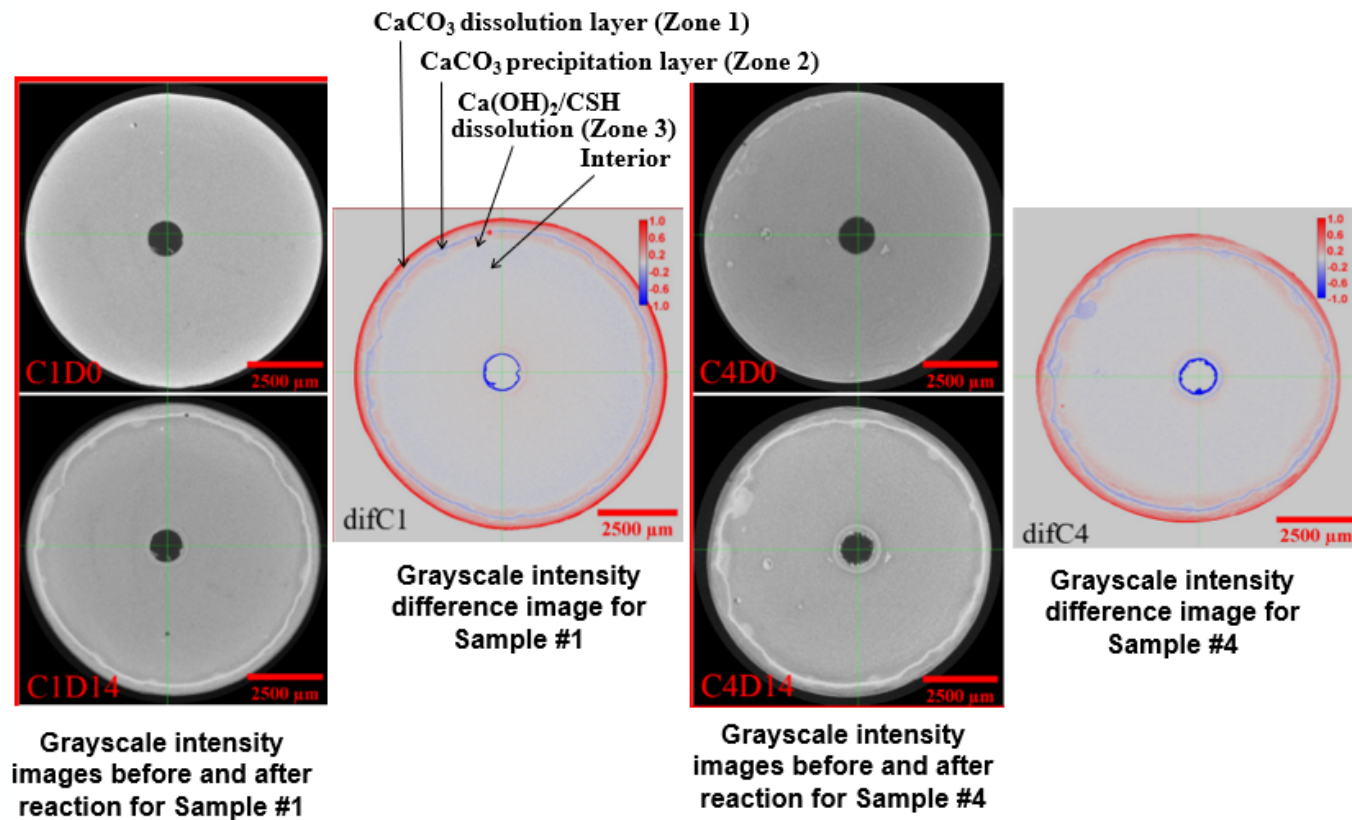


Zeiss Xradia Versa 410 micro-CT scanner used in this study



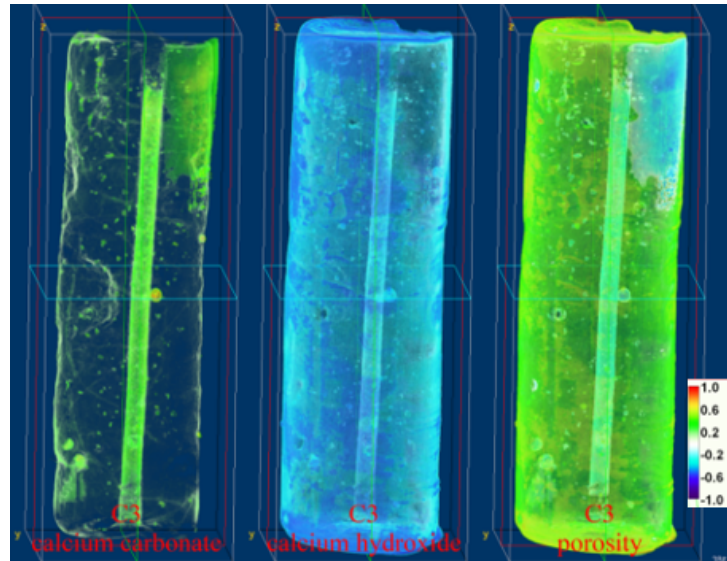
CO₂ exposure experiment

Results

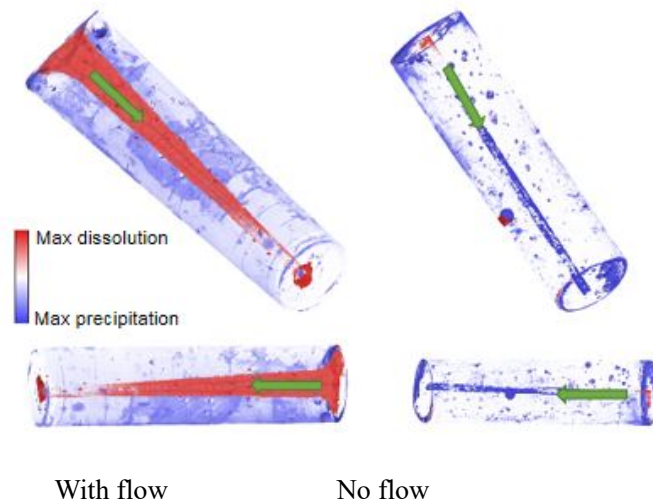


2-D micro-CT slices of the cement sample after exposure to CO_2

RESULTS/CONCLUSIONS



3-D relative changes in CaCO₃ vol%, Ca(OH)₂ vol% and porosity reconstructed from 2-D slices



Flow within cement fracture accelerates cement dissolution

Conclusions

- **CT imaging of the cement after reacting with CO₂ reveals 3 reaction zones and the dissolution-precipitation-dissolution “sandwich” pattern**
- **Dissolution mainly occurs in the exterior, and no dissolution is observed in the fracture (no flow case)**
- **When there is flow within the fracture, dissolution of cement occurs surrounding the fracture.**

ABSTRACT

This presentation demonstrates a CT scanning and image analysis workflow to characterize wellbore cement degradation under corrosive geologic CO₂ storage (GCS) conditions. The workflow includes 1) acquisition of raw CT images of the cement sample (before and after exposure to CO₂); 2) application of rigid registration to align raw CT images; 3) acquisition of grayscale intensity difference images; 4) application of noise filtering technique to obtain images with good quality; 5) acquisition of 3D pore structure change of the cement sample after CO₂ exposure from grayscale intensity difference images, showing degradation of wellbore cement. To demonstrate an application of the workflow, an experiment of reaction between CO₂ and wellbore cement under corrosive GCS conditions was conducted and the wellbore cement samples used in the experiment went through aforementioned CT scanning and image analysis procedures. CT image analysis results demonstrate a region with increased porosity in the exterior of the cement sample (Zone 1) and a region with decreased porosity next to Zone 1 due to CaCO₃ precipitation (Zone 2). Next to Zone 2, a region with increased porosity due to Ca(OH)₂ and C-S-H dissolution (Zone 3) was observed. In summary, this study proves feasibility to use 3D CT scanning and CT image analysis techniques to investigate CO₂-induced degradation of wellbore cement.