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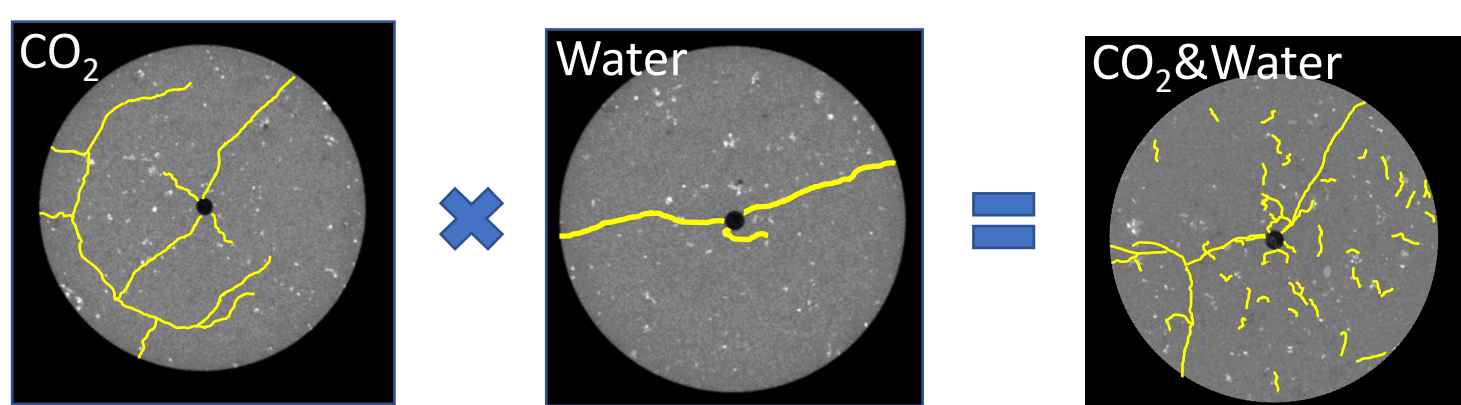


We conducted various research in energy resources, environmental sciences, and engineering. They include environmental risk assessments, geosciences and geoengineering in light of energy resource production, and geo-informatics for a sustainable future. Recently, our work has focused on the sustainable and profitable production of petroleum and geothermal energy, as well as CO₂ sequestration and mineralization.



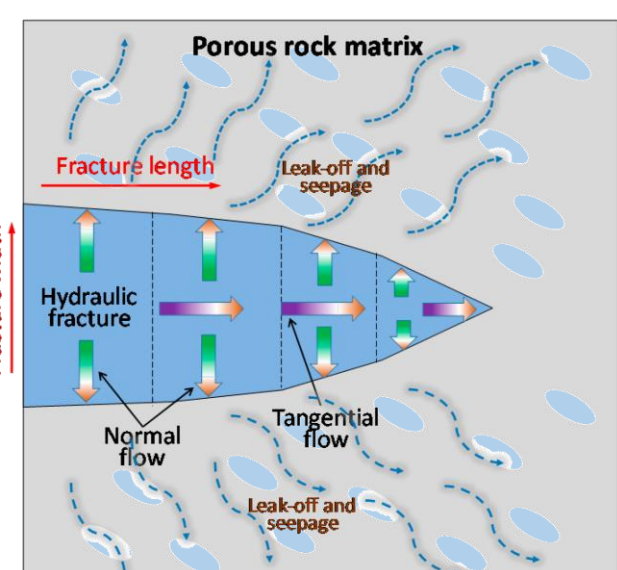
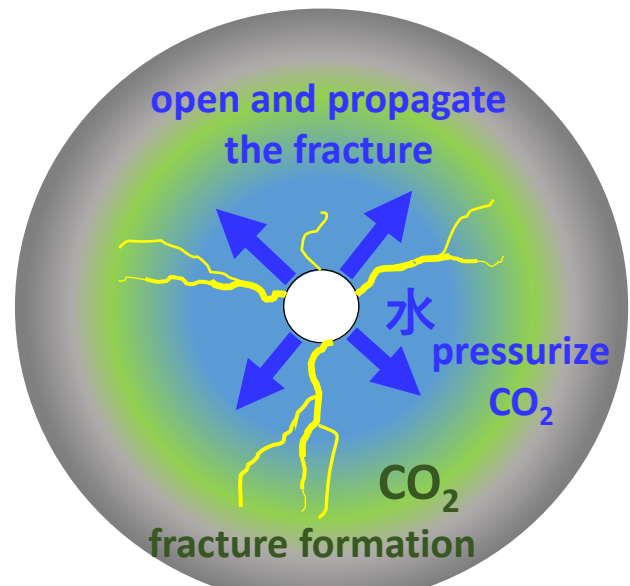
Carbon Recycle CO₂ Geothermal Power Generation

New fracturing method combining CO₂ & water injection

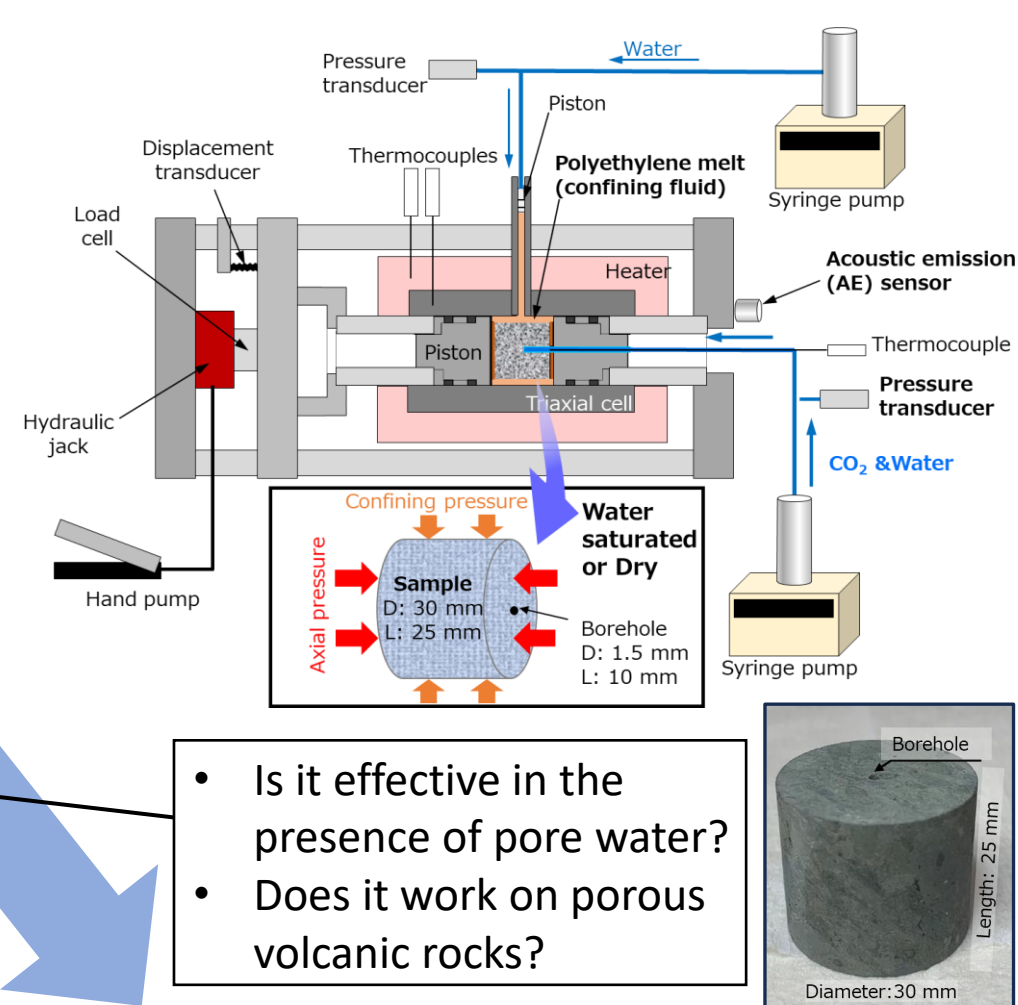


CO₂ & water fracturing mechanism

pore water in rocks inhibits fractures opening and propagation

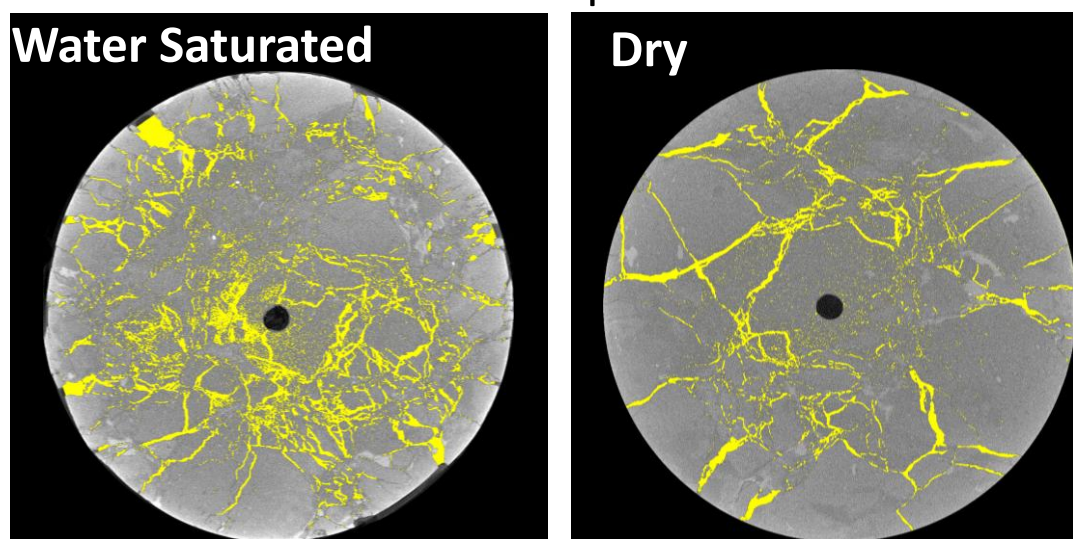


CO₂ & water fracturing is still effective with the pre-existing pore water and is particularly effective in porous volcanic rocks.



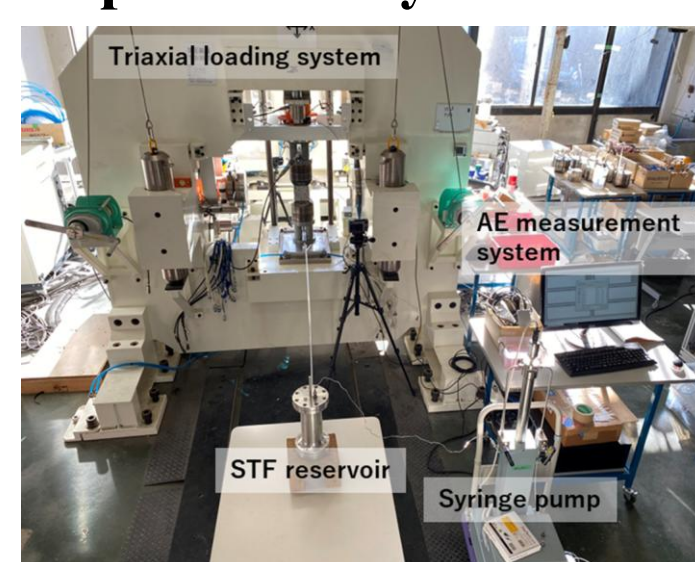
- Is it effective in the presence of pore water?
- Does it work on porous volcanic rocks?

andesitic lapilli tuff



Multidirectional fracturing of rock using shear thickening fluid

Experiment System

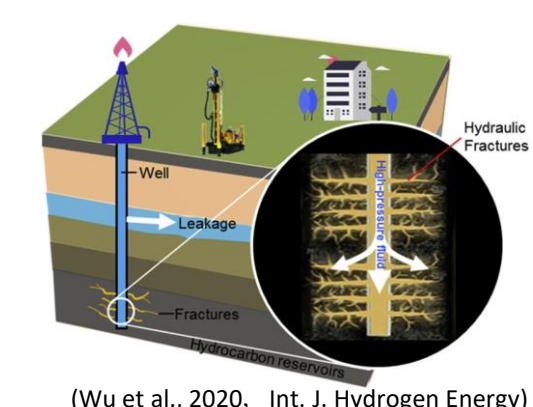


Hydraulic fracturing

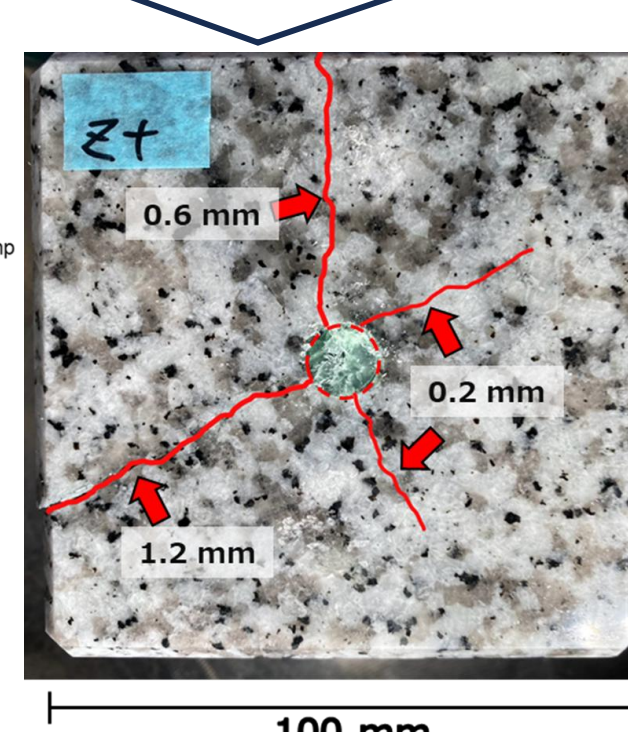
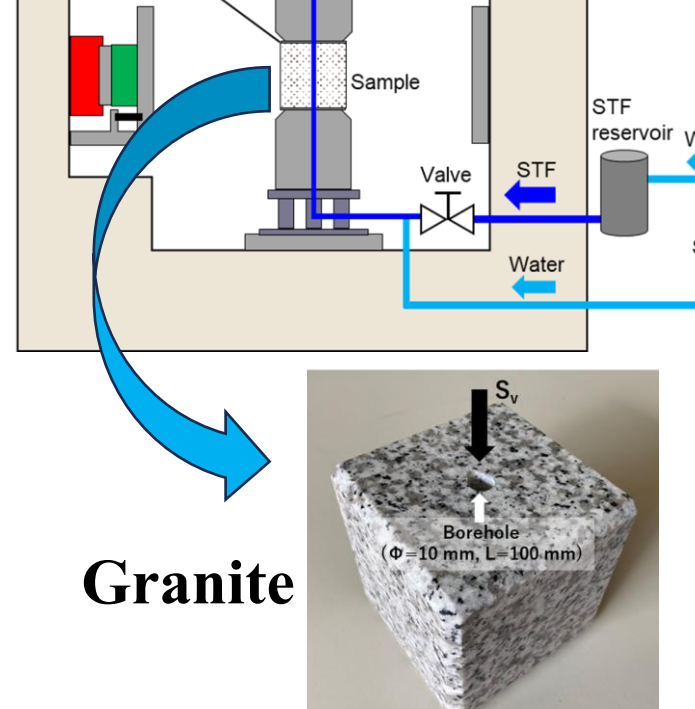
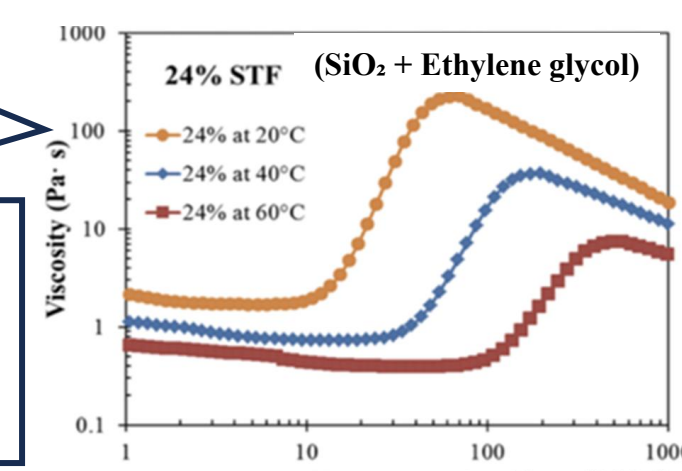
Fracture nucleation improves the permeability only in a certain direction.
How does the fracturing manner change by the **shear thickening fluid (STF)**?

High flow rate and narrow fracture width
→ **Increase in viscosity**

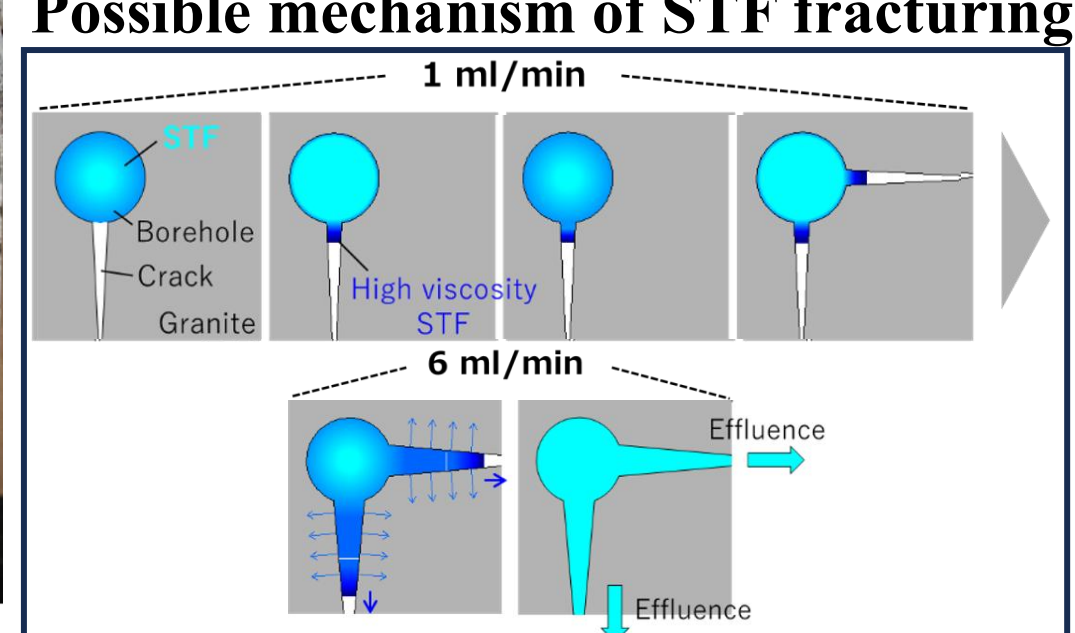
We have produced **multidirectional fractures and larger aperture fractures**, which improve rock permeability.



(Wu et al., 2020, Int. J. Hydrogen Energy)



Possible mechanism of STF fracturing



Enhanced CO₂ geological storage and mineralization using biodegradable chelating agents

CCS, in which CO₂ is injected into underground rocks and fixed as a carbonate mineral, has been attracting attention in recent years.

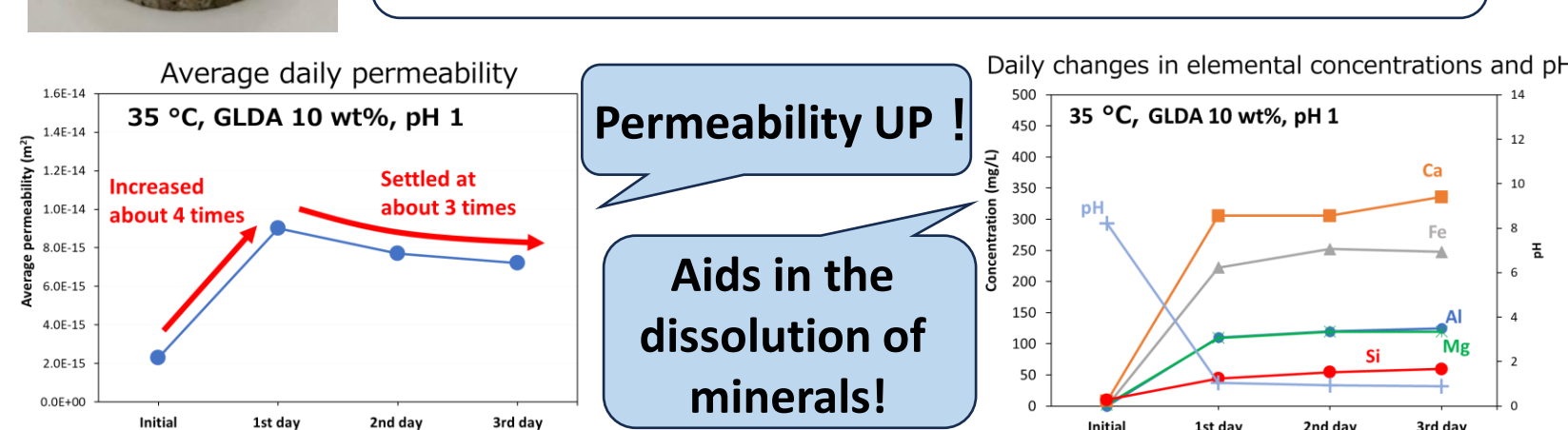
In order to utilize reservoirs in the most efficient, safe, and secure manner, we invented a method to promote CO₂ geological storage and mineral fixation. [patent application 2023-51335]

What is the applicability to basaltic volcanic sandstone containing clay minerals?

Challenge: Clay minerals clogging channels and poor permeability

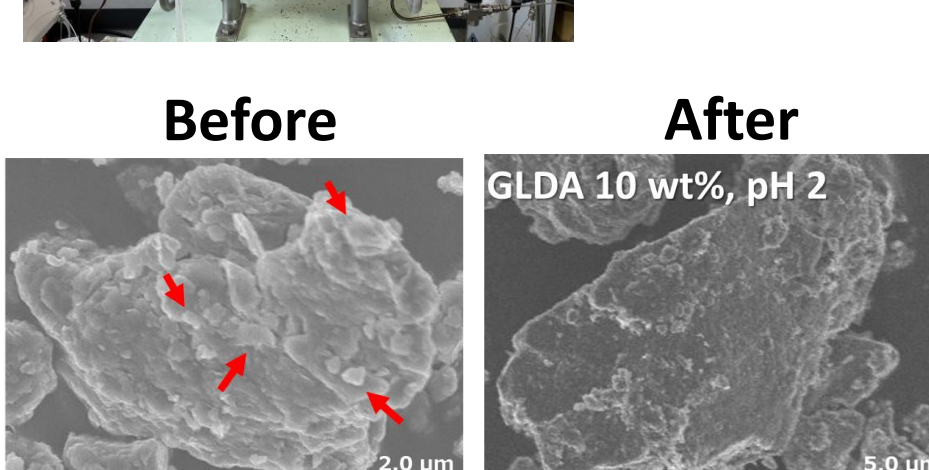
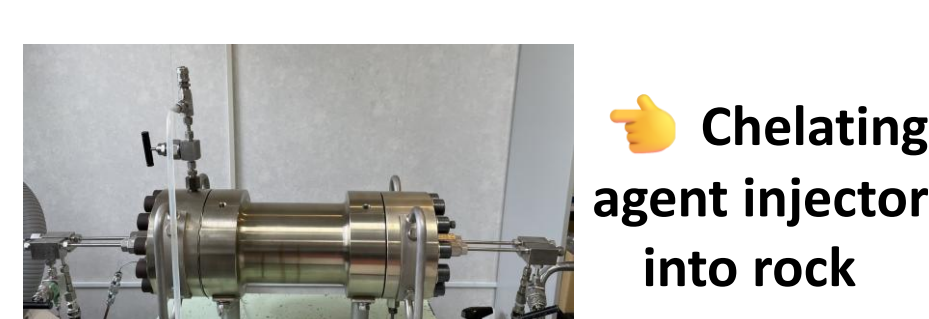
Rocks that have undergone clayey alteration and oxidative alteration
Contains the clay mineral montmorillonite

Biodegradable chelating agent GLDA dissolves minerals to improve permeability

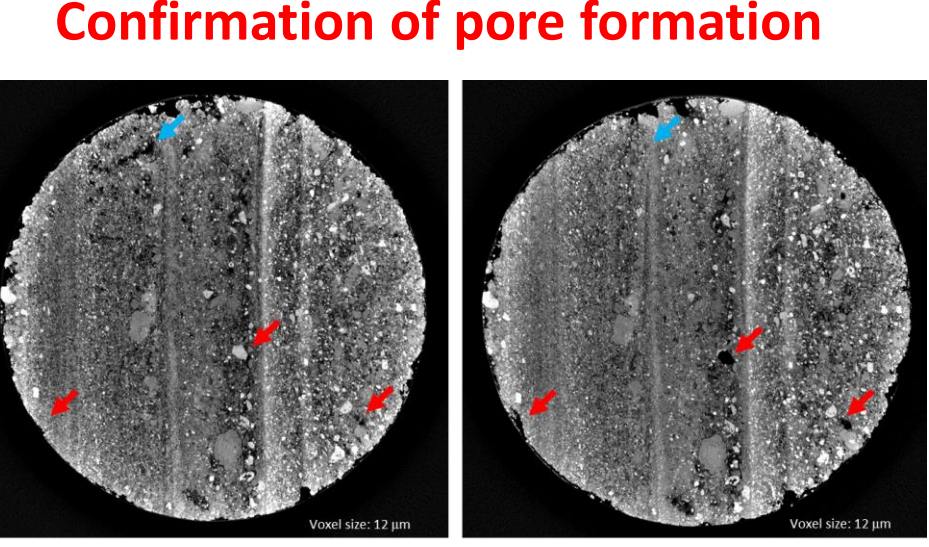


Permeability UP!

Aids in the dissolution of minerals!



Montmorillonite dissolved in GLDA
Confirmation of pore formation



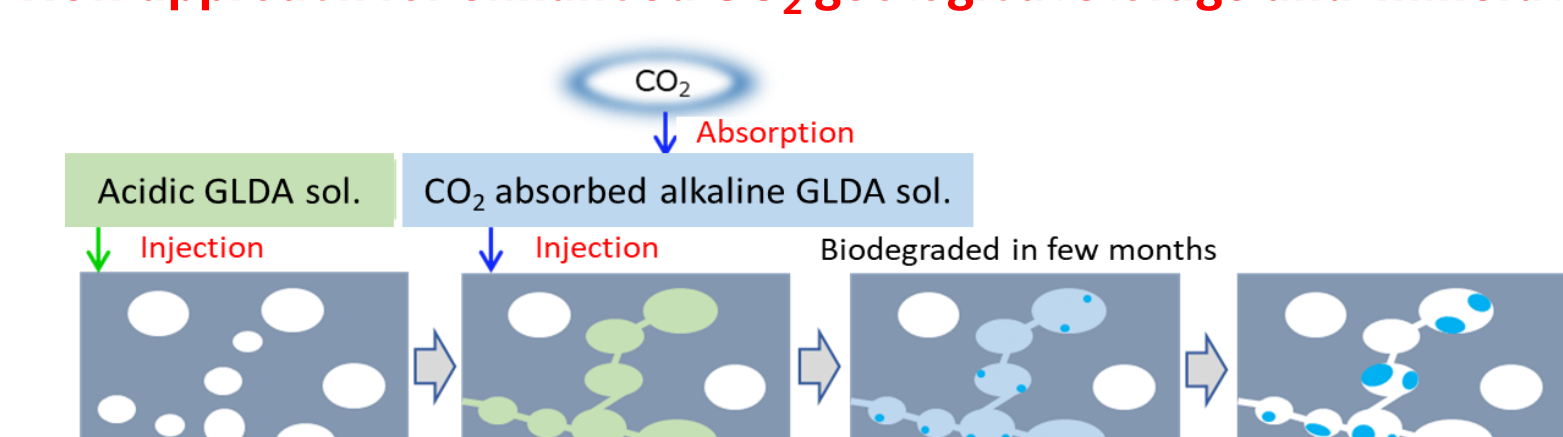
Modeling of accelerated mineral dissolution for enhanced CO₂ geological storage and mineralization using biodegradable chelating agents

Challenges of CO₂ geological storage and mineralization in basaltic rocks:
Porosity, pore connectivity, permeability and reactivity of basalts are not always high enough

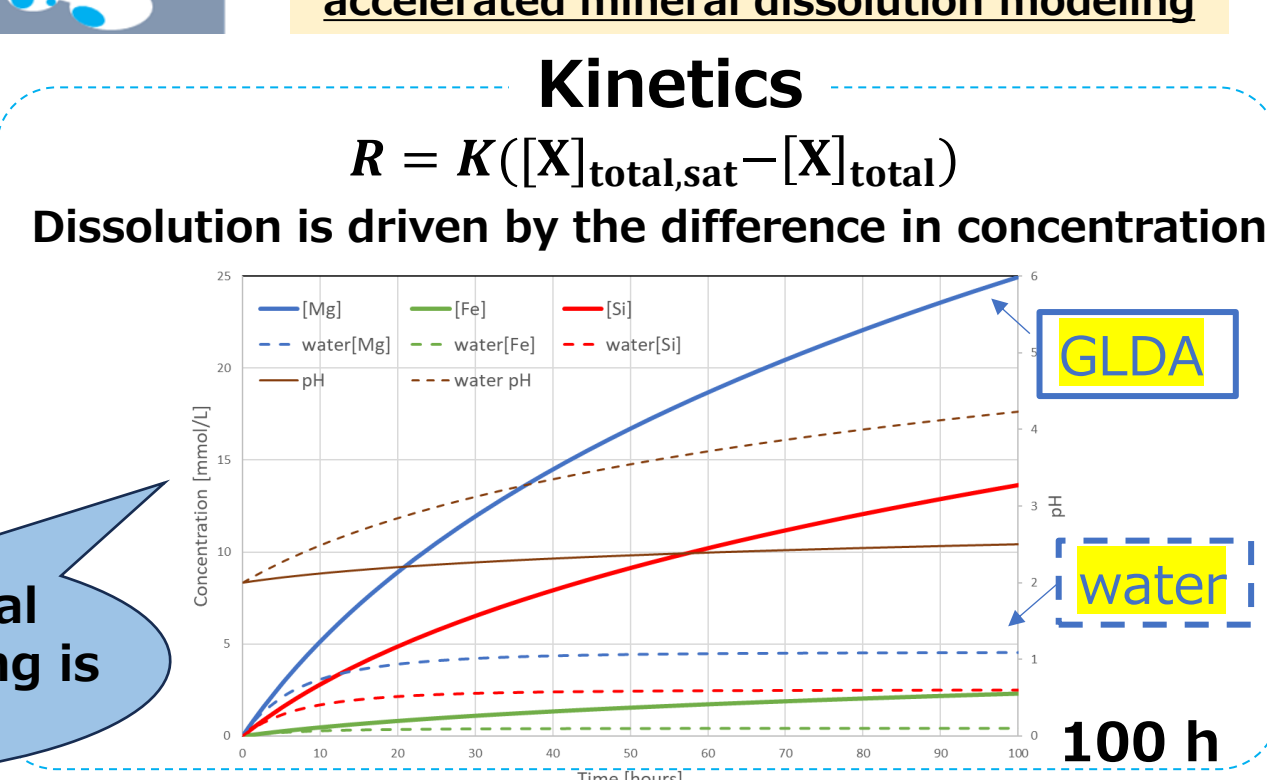
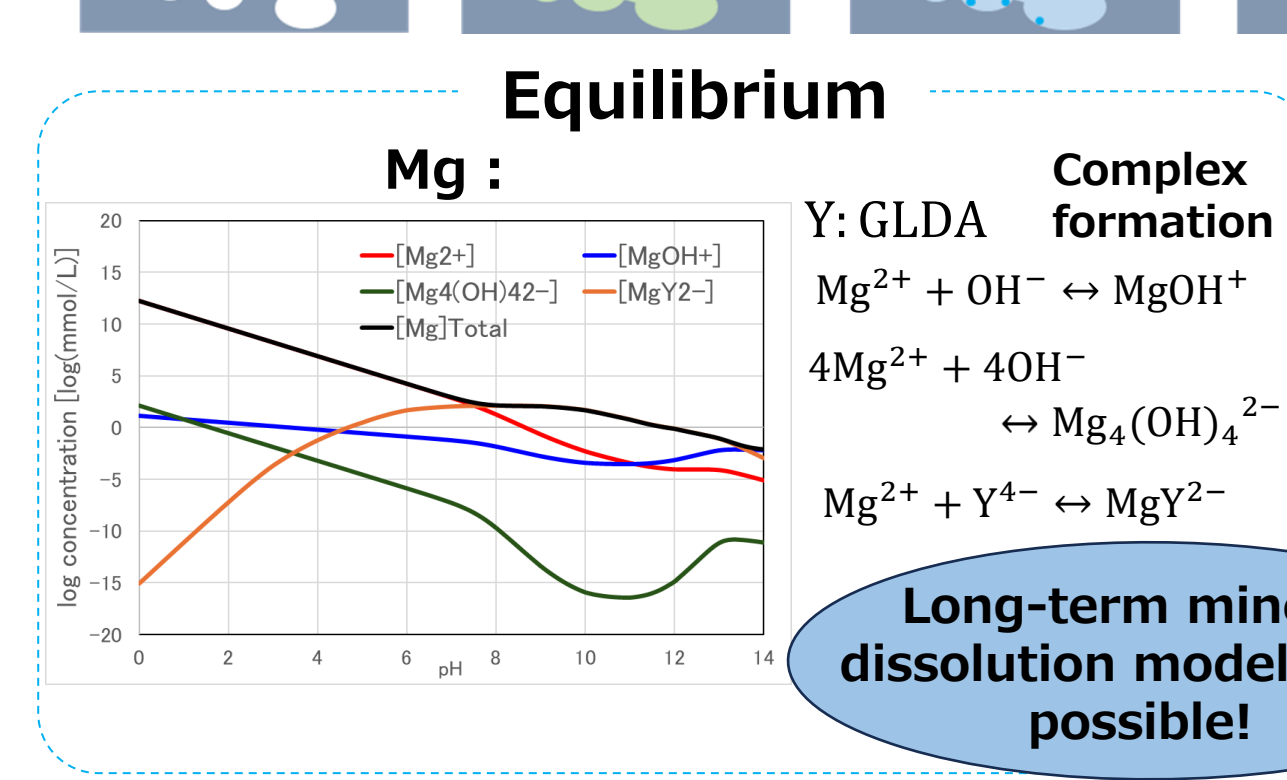
New approach for enhanced CO₂ geological storage and mineralization

Effectiveness of the method is...

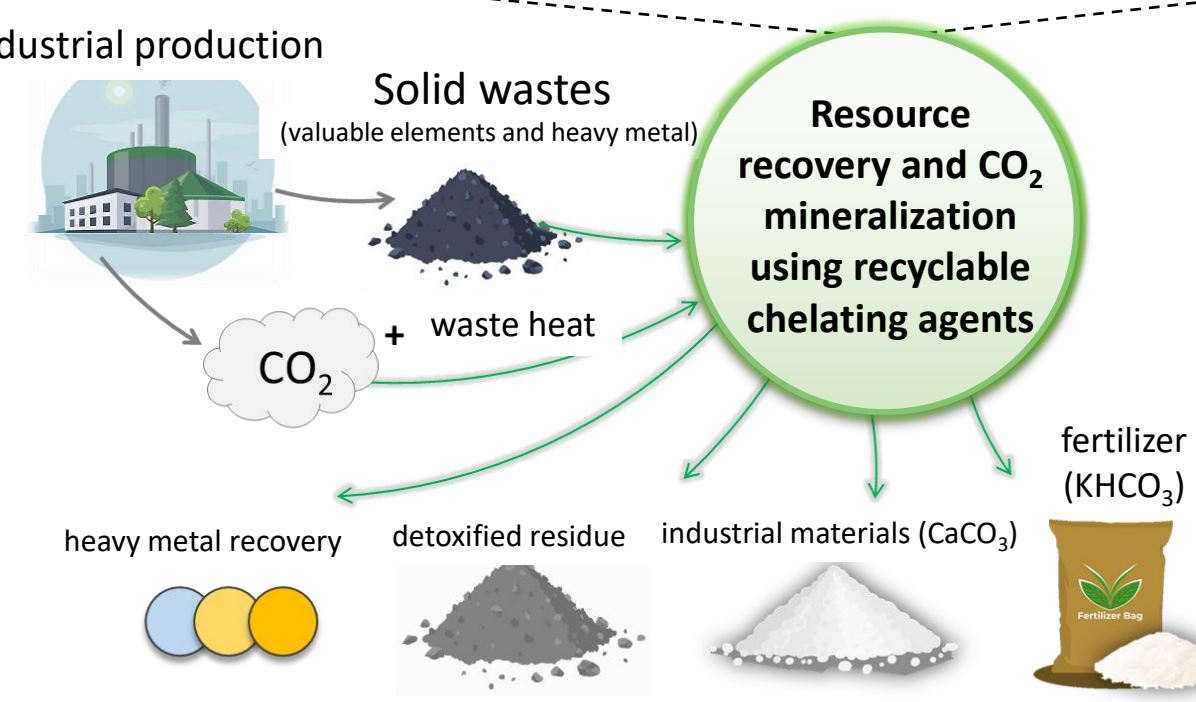
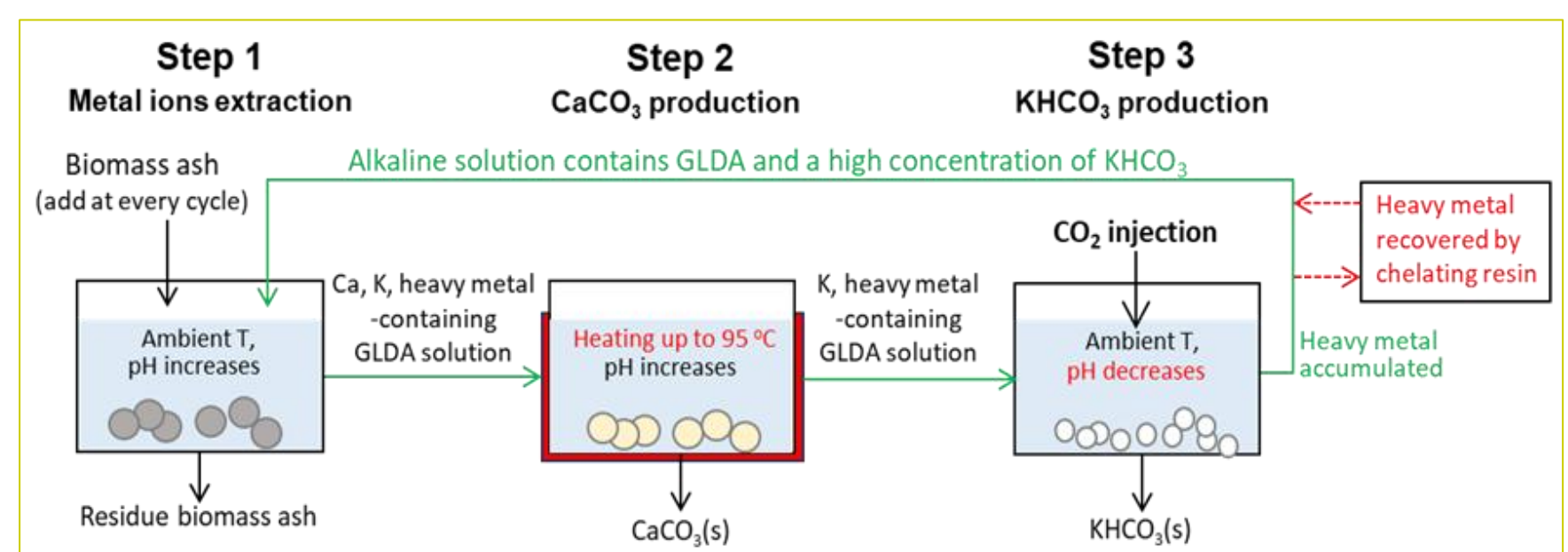
Proved by lab experiments
→ Actual **space-time scale** evaluation is necessary
Let's create a simulator!!



1st step: accelerated mineral dissolution modeling



Metal resources recovery and CO₂ mineralization using industrial solid wastes



Recyclable chelating agents assisted-CO₂ mineralization process

- Low cost : industrial waste utilization, chelating agent is recyclable, use low to moderate T and ambient P
- High returns : valuable products (e.g., CaCO₃, KHCO₃)
- Environmentally friendly : few wastewater generation, biobased, biodegradable chelating agent utilization

Joint research with earth development and environmental studies

Development of construction and quarrying systems with intelligent construction equipment using sensing technology such as work tools of construction equipment and on-board cameras

