Subsurface Carbon Mineralization Resources in Hawai'i Basalt

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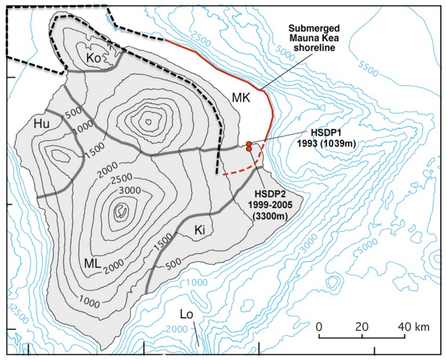
Cost share from U. California Berkeley and Par Pacific Holdings

Concept for large scale CO_2 disposal

Concept is based on the subsurface geology and hydrology of the NE portion of the island of Hawaii, for which there is direct information available from previous drilling and coring



A 3.5 km deep well was drilled and cored in 1999 – 2006 as part of an NSF funded project.

Because of this drilling we have extensive information on the stratigraphy and some on porosity and permeability.

The well will be re-entered in summer 2024 and a winch used for running instruments as deep as possible up to 3300 meters.

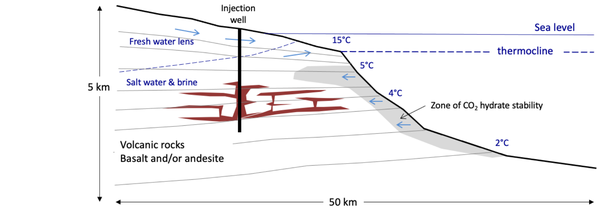
Potential advantages of submarine basalt for CO_2 disposal:

(1) Lower temperatures make CO_2 less buoyant

(2) Large formation thicknesses (>3 km) and heterogeneity provide structural trapping

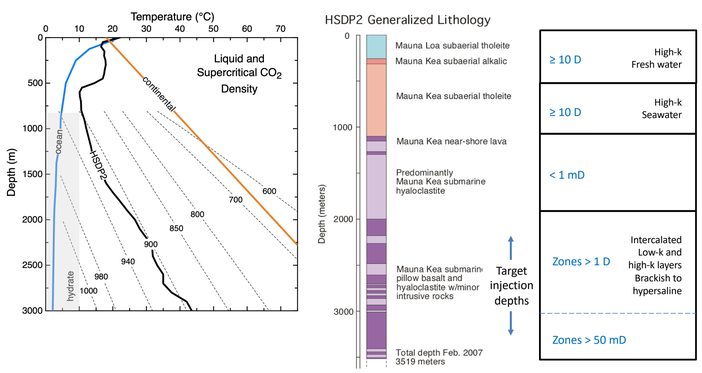
(3) Pure CO_2 could potentially be injected from onshore wells

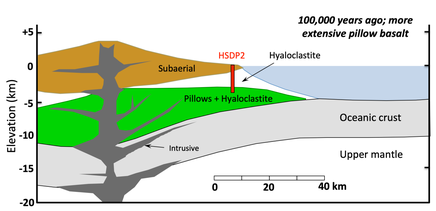
(4) Dissolution, capillary, and mineral trapping, as well as CO_2-hydrate formation, could contribute to immobilizing CO_2



Stratigraphy and preliminary permeability estimates

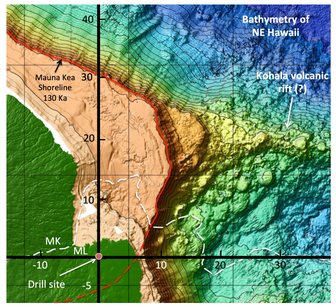
Fluid geochemistry (Sr isotopes and radiocarbon) was used to infer permeability in top 1000 meters. Water level – Earth/ocean tides analysis was used for depth below casing (> 3000 meters). Permeability in the target injection interval is poorly constrained and is an objective of the current project

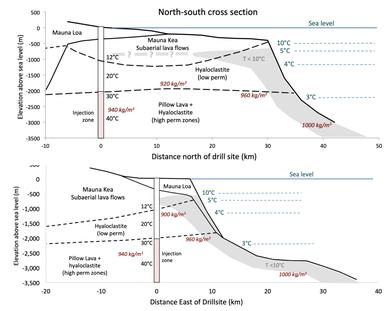




Facies model for the interiors of Hawaiian volcanoes is useful for predicting stratigraphy and likely hydrological properties at other locations in the islands

Current site model has 3-layer stratigraphy with a potential seal (indurated hyaloclastite) at 1.1 – 1.9 km depth

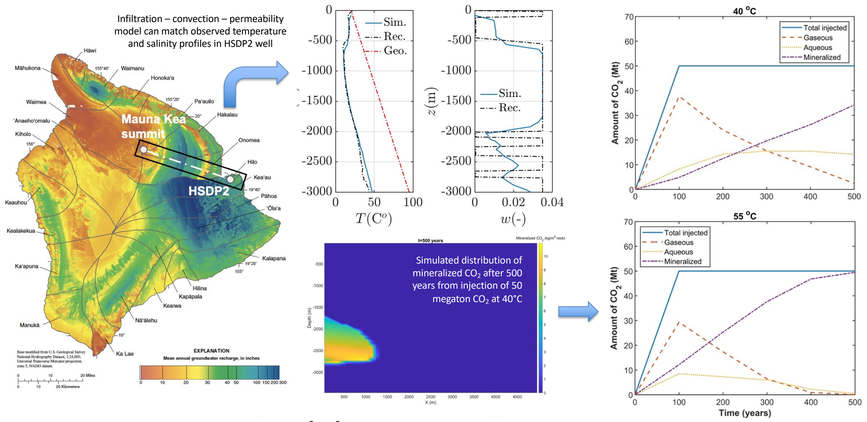




Reactive transport and hydrological modeling

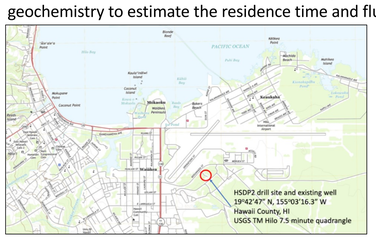
Modeling is being used to evaluate the regional flows of meteoric infiltration water and seawater and how they would affect and be impacted by large scale injection of supercritical CO_2. High rainfall on the windward slopes of Mauna Kea produces unusual groundwater hydrology, as does thermohaline convection involving ocean water.

Reactive transport modeling will help us evaluate mineralization timescales in relation to physical and capillary trapping, and relationships between large scale permeability, permeability heterogeneity, mineralization rates, and the pressure response to injection. Dual permeability models result in more mineralization than single-permeability models.

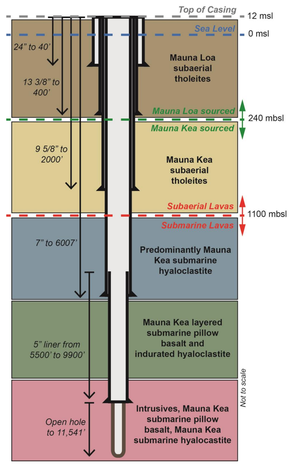


Downhole measurements program

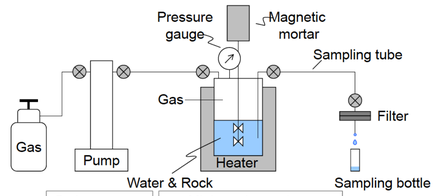
Flowmeter, fluid sampler, and a pressure/temperature tool will be run individually, or connected to make a tool string for simultaneous data collection. Data will be acquired with and without flow to infer where there are water entries and to use geochemistry to estimate the residence time and fluid-rock interactions associated with formation fluids.



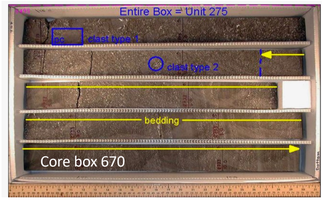
If time and funding allow, we will perforate casing and carry out a pull-push-pull test to derive more direct information on permeability and mineralization rates. Perforation and packers may also be used to obtain fluid samples from specific depth intervals. A custom winch equipped with 6000 meters of 3/16" 4 conductor cable is being used.



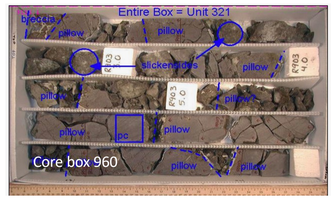
Hydrothermal experiments 80°C, 100 bar CO_2



1. 15g solid with 300g fluid
2. Fluid has seawater Na, Cl, Mg (no Ca, Fe, Si, Sr …)
3. Fluid sampled at varying intervals, 10 samples per experiment up to 275 days



1900 m depth, indurated basalt sand w/glass
7% olivine phenocrysts in glassy clasts

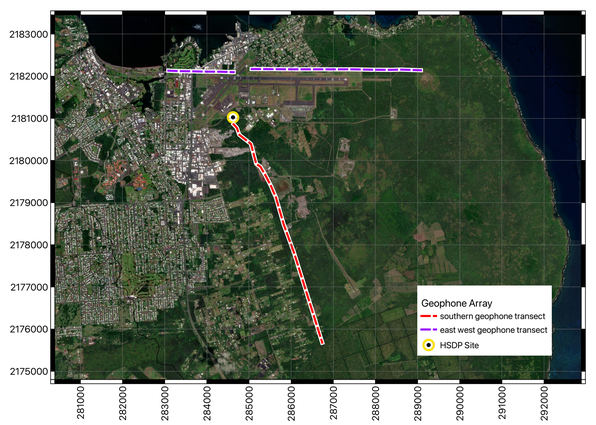


2780 m depth, pillow basalt
No glass, 7% olivine phenocrysts

As of July 20, 2024, experiments had been running for 28 days. Pillow basalt appears to be dissolving (releasing Mg and Si) about 10x faster than the glassy basalt sand despite both having about 7% olivine. Pillow basalt reaction rates are already slowing with time. Reactive transport simulations with TOUGHREACT are being used to help interpret results.

Passive seismic imaging experiment

Passive seismic imaging will take advantage of local and teleseismic events to image the inferred volcanic stratigraphy. The seismic survey is composed of two almost-perpendicular lines, each 5km in length. Average spacing between geophones is 50m, requiring 200-250 geophones. We will be using Magseis Fairfield ZL and 3-axis geophones with a 5Hz corner frequency. These geophones will be deployed simultaneously for 3-4 months, with deployment estimated to take place in winter 2024 or spring 2025, depending on instrument availability from Earthscope PASSCAL. A magnetotelluric station will also be deployed at the well site to determine if MT could be used as a monitoring tool for CO_2 injection



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Opportunities for large-scale CO_2 disposal in coastal marine volcanic basins based on the geology of northeast Hawaii

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