Geological Storage of CO_2 In California

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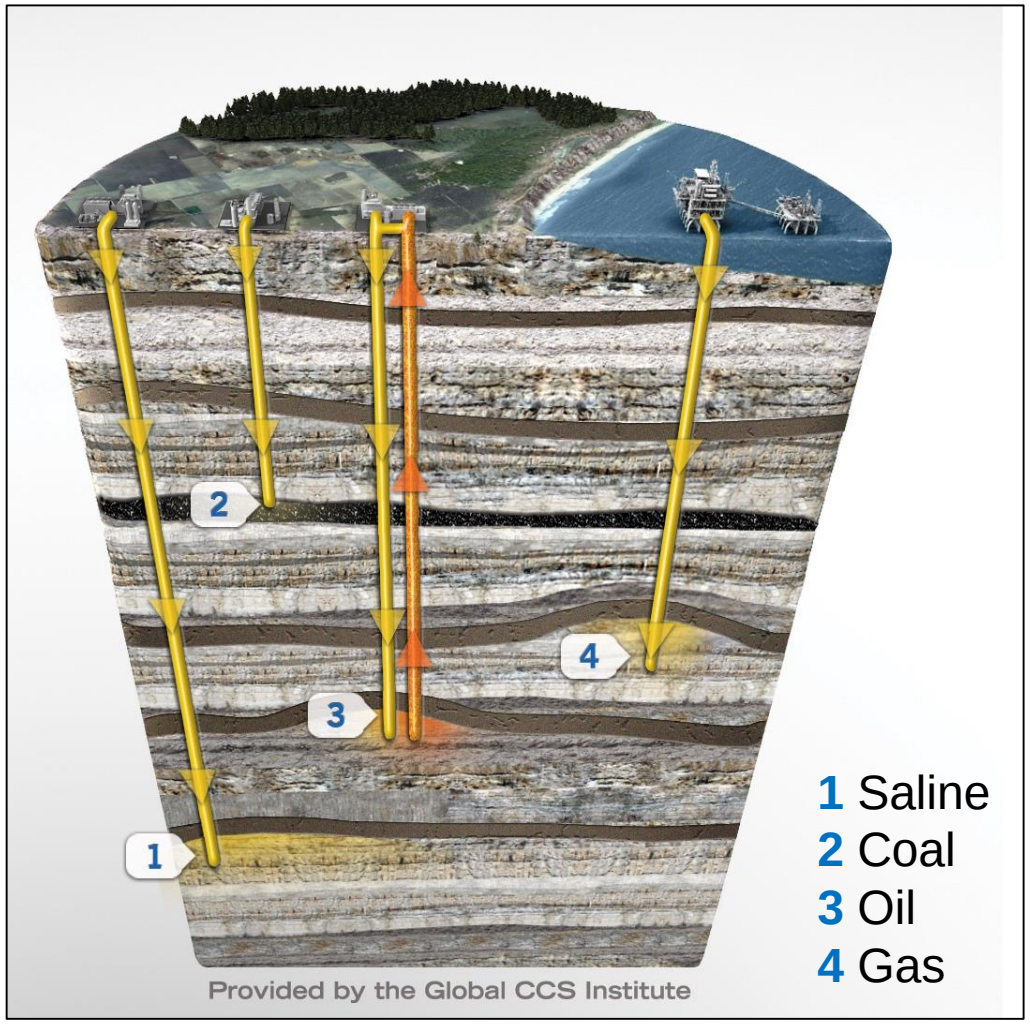
Geological Storage of CO_2

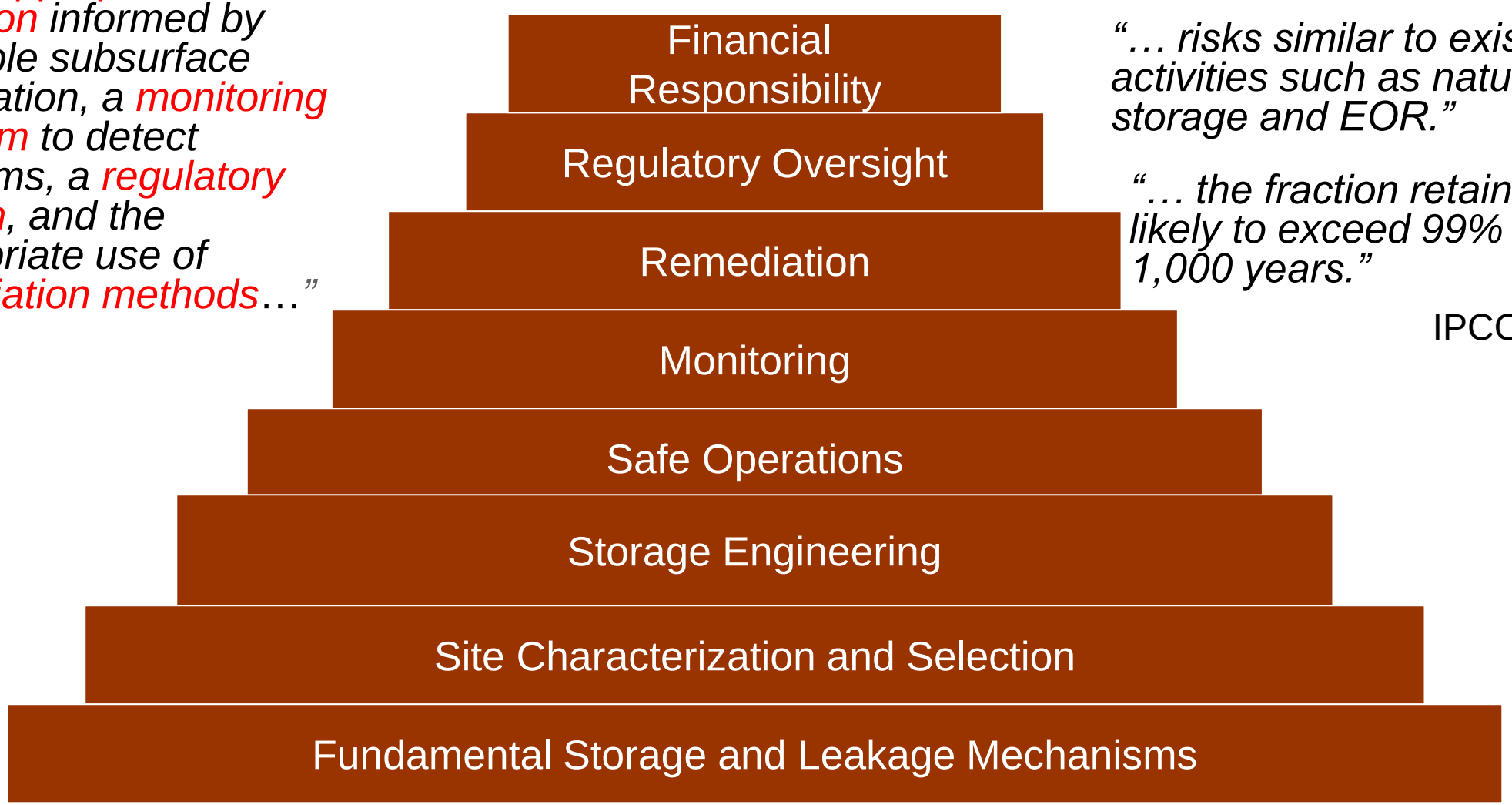


What Makes A Good CO_2 Storage Site?

- Depth greater than about 3500 feet
- Salinity of greater than 10,000 ppm
- Thick and continuous shale rock to permanently trap CO_2 underground
- Large porous and permeable sandstone reservoir to contain the CO_2
- Lack of active or transmissive faults
- Limited number of abandoned wells

Key Elements of a Geological Storage Safety and Security Strategy

" With appropriate site selection informed by available subsurface information, a monitoring program to detect problems, a regulatory system, and the appropriate use of remediation methods…"



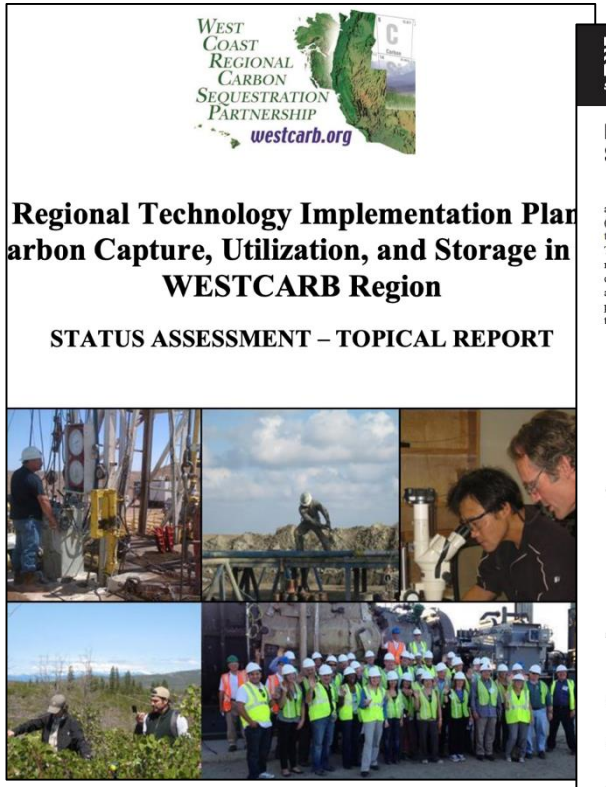
"… risks similar to existing activities such as natural gas storage and EOR."

"… the fraction retained is likely to exceed 99% over 1,000 years."

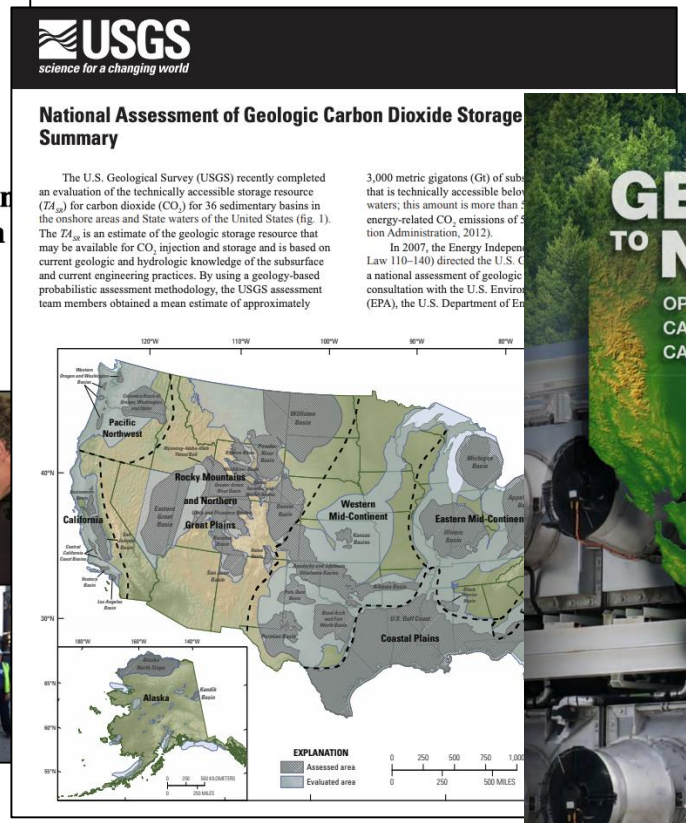
IPCC, 2005

CO_2 Storage Potential In California Is Well Understood

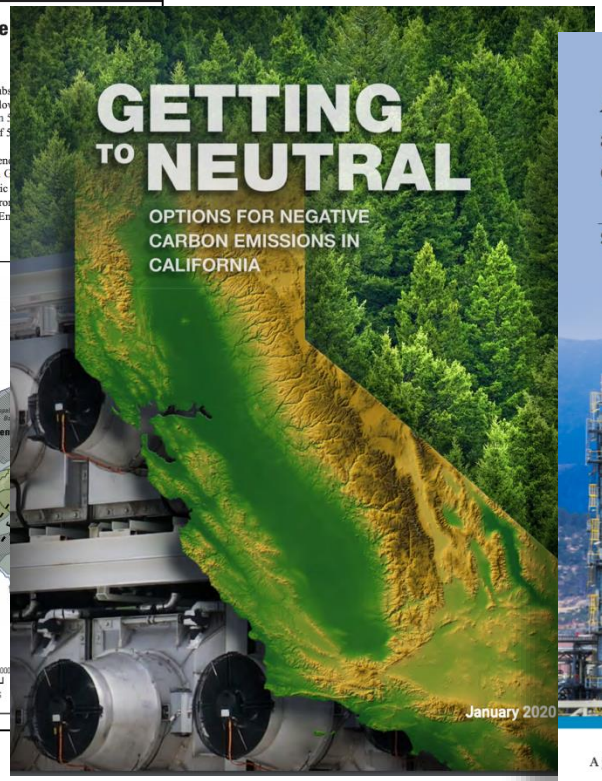
WESTCARB Program (2003-2013)



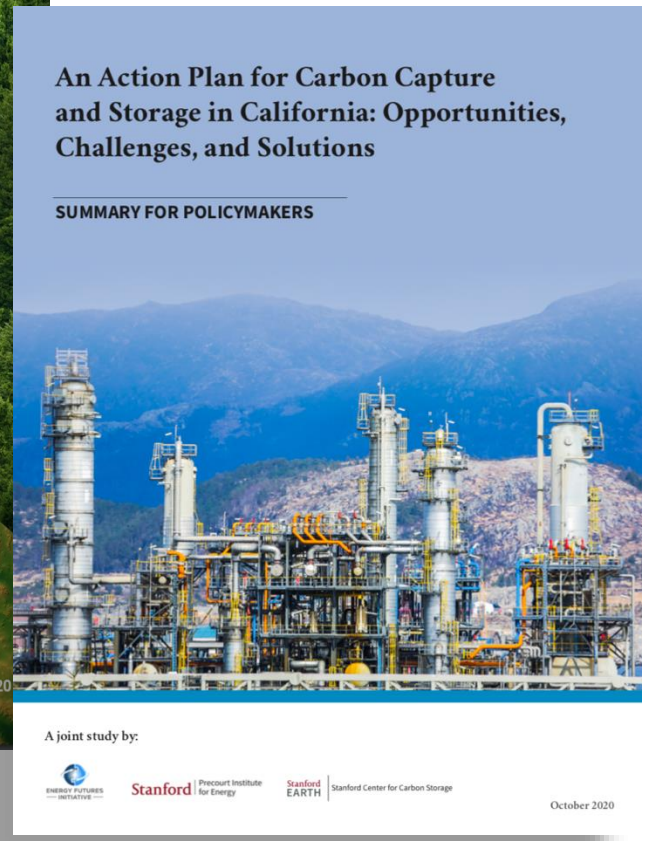
U.S.G.S 2007-2013



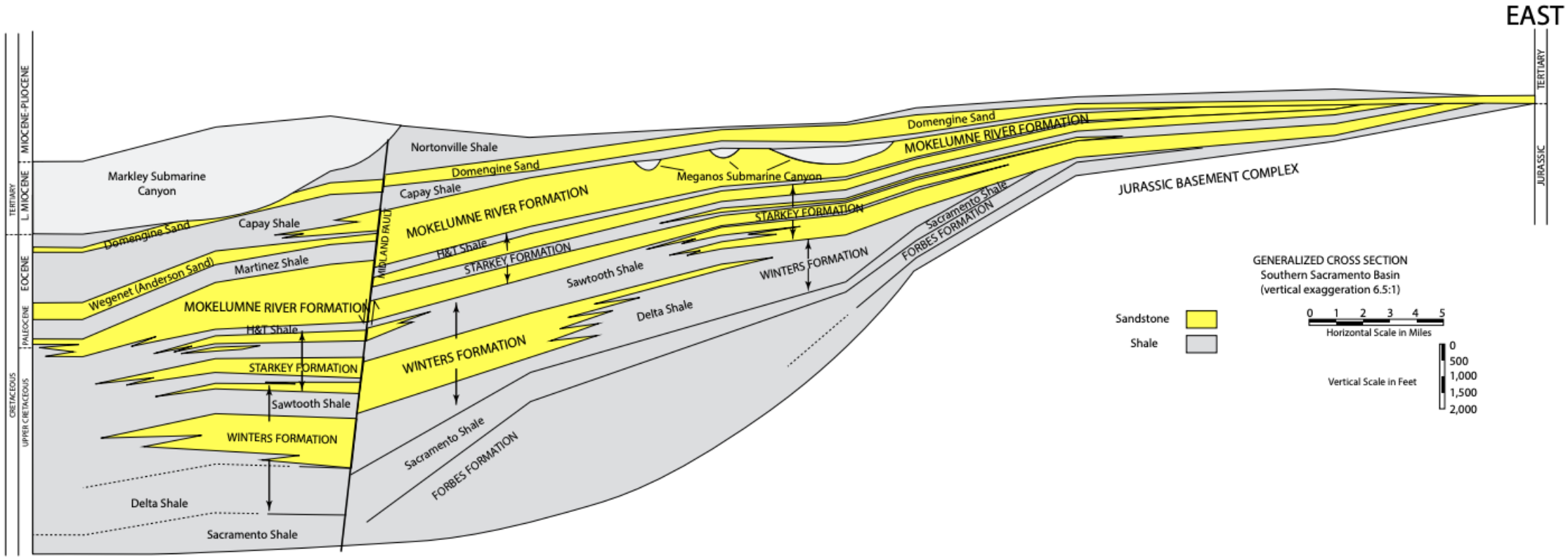
LLNL, 2020



Stanford and EFI, 2020



Cross Section of The Subsurface Geology In Northern California

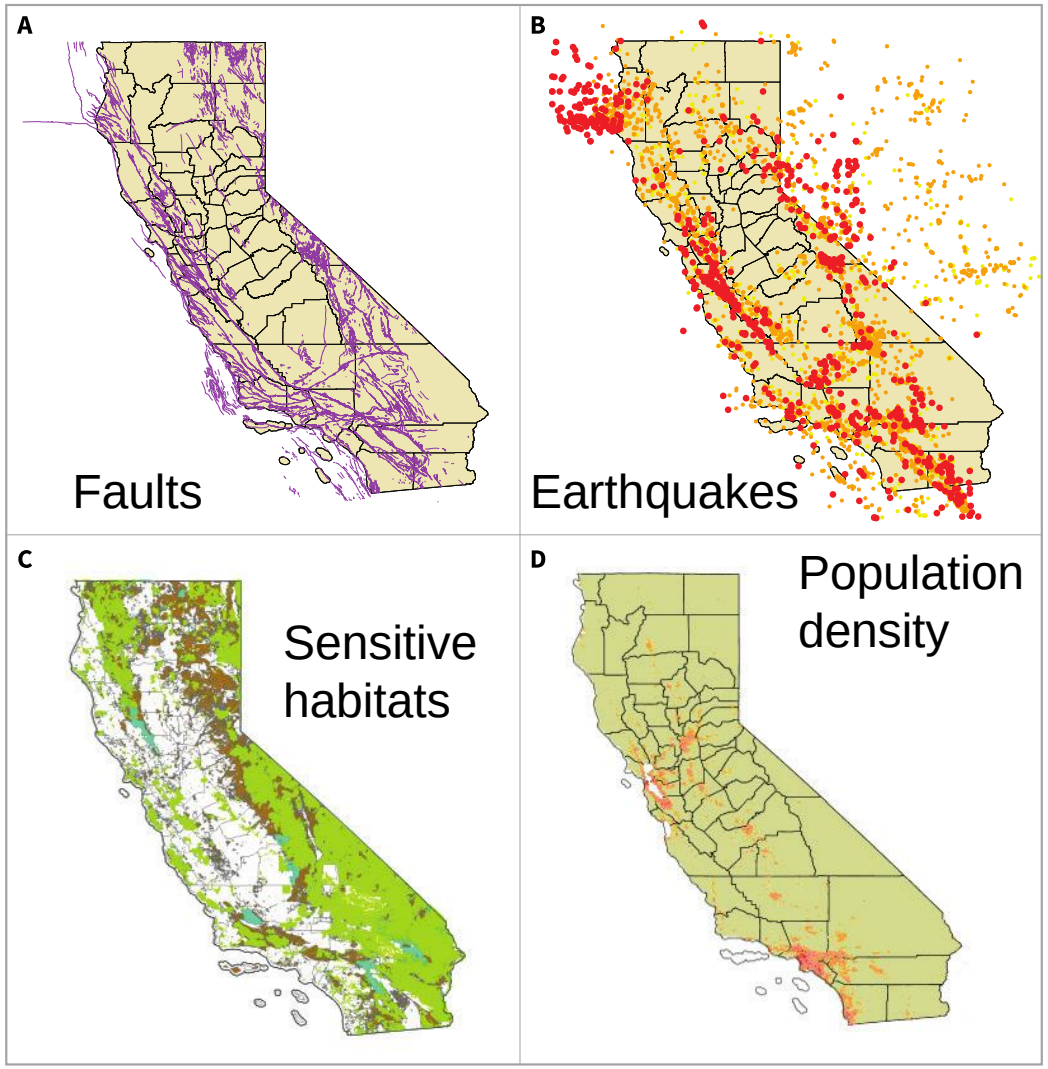


Gray rocks are shale seals and yellow rocks are potential CO_2 storage reservoirs.

From LLNL (2020) Getting to Neutral.

Location of California's Storage Resources and Screening Criteria

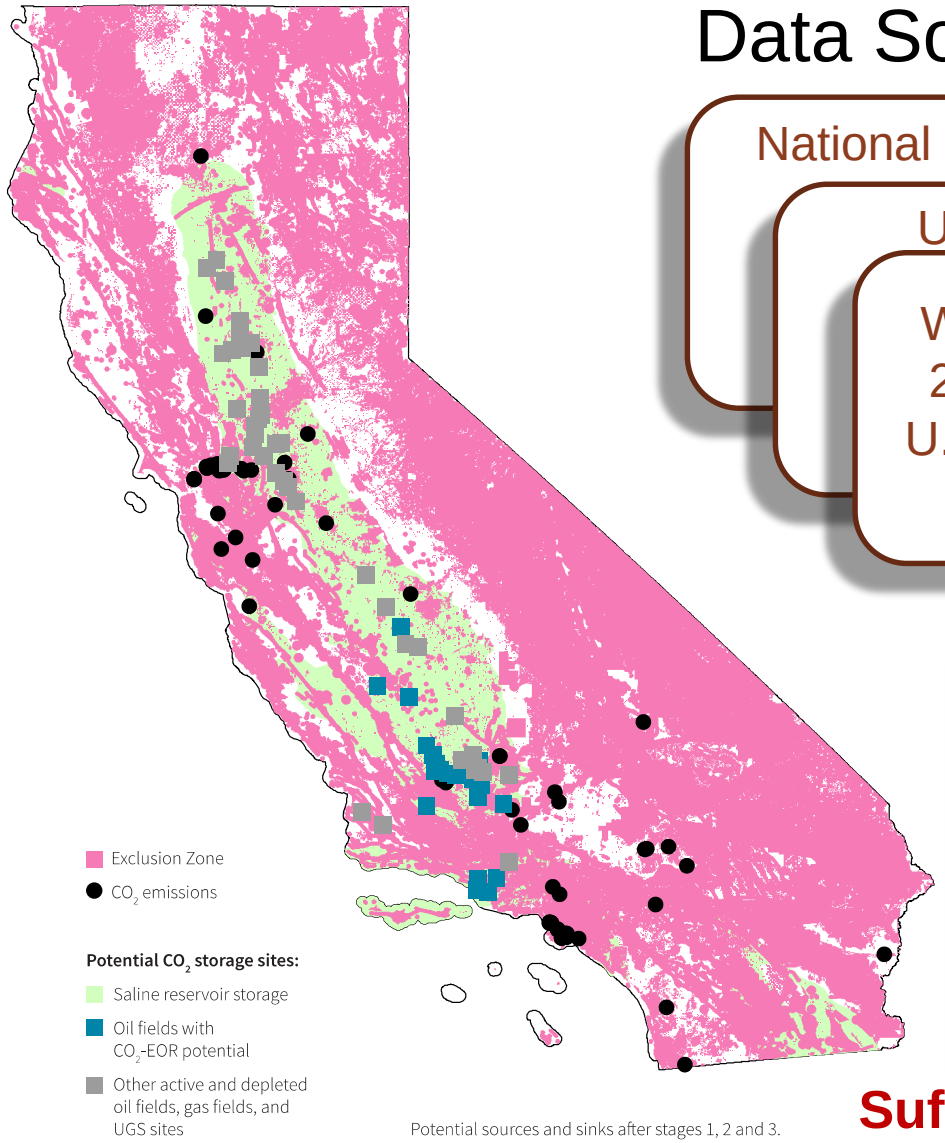
Saline reservoirs (light green), oil and gas fields (green) and USG sites (red) after applying qualifying criteria (stage 1)



https://sccs.stanford.edu/ccs-in-ca

Stanford University

California Has Abundant and High Quality CO_2 Storage Resources



Potential sources and sinks after stages 1, 2 and 3.

Data Sources

- National Labs
- U.S.G.S.
- WESTCARB
- 2003 - 2013
- U.S. DOE and CEC

Screening Criteria

STAGE 1

Qualify sites and saline reservoirs
- Apply LCFS and EPA Class 6 minimum criteria
- Apply additonal "disallowed" conditions

+

STAGE 2

Develop Exclusion Layer consisting of geographic information (e.g. faulting, seismicity, population density, sensitive habitats, restricted lands)

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STAGE 3

Storage Opportunity Identification by merging qualified sites with exclusion layer.

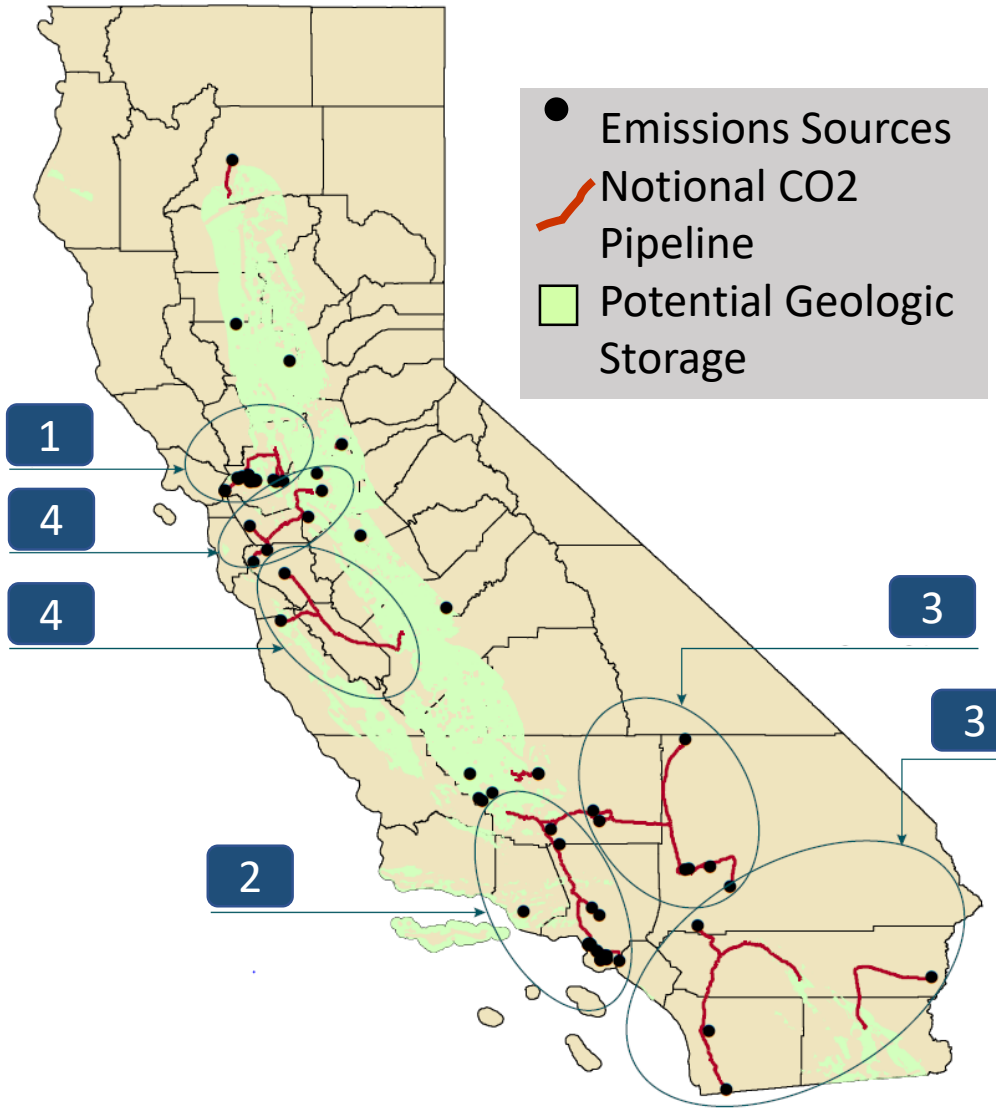
	Storage Capacity (GT CO_2)	
Saline Formations	70	
Oil and Gas	Low	High
	1.1	2.1

Sufficient for more than 1000 years of injection at 60 Mt/year.

Stanford University

Source: Energy Futures Initiative and Stanford University, 2020.

Source Sink Matching for 60 $MtCO_2$/yr CCS



Co-located capture and storage	• 3 ethanol plants, 6 NGCC, 6 CHPs and 1 cement plant
1. Northern California Gathering System and Storage Hub	• 8 hydrogen, 4 refineries, 5 CHPs, and 3 NGCC
2. Southern California Gathering System and Storage Hub	• 8 hydrogen, 5 refineries, 4 CHPs, 1 cement, and 5 NGCC
3. Desert and Salton Sea Gathering Systems	• 5 cement, 1 CHP, 6 NGCC
4. Central California and S. Bay Gathering System	• 1 cement, 5 NGCC

Source: Energy Futures Initiative and Stanford University, 2020.