Planning of a CO_2 Geological Sequestration Pilot Project in Basalt Formations of North Western India

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Pacific Northwest National Laboratory
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Objective

Plan the design and demonstration of deep injection and sequestration of CO_2 in the Basalt formations of North-Western India, as a model project for carbon sequestration in the Indian sub-continent.

Develop a preliminary road map to guide the siting process, by screening and ranking of India's geological formations for sequestration of CO_2 using nationally available databases and literature, coupled with results of modeling and risk assessment.

Selection Criteria

Sufficient reservoir volume (porosity) to allow storage of the required volumes without exceeding pressure constraints.

Satisfactory containment of the CO2 by competent upper and lower sealing caprock.

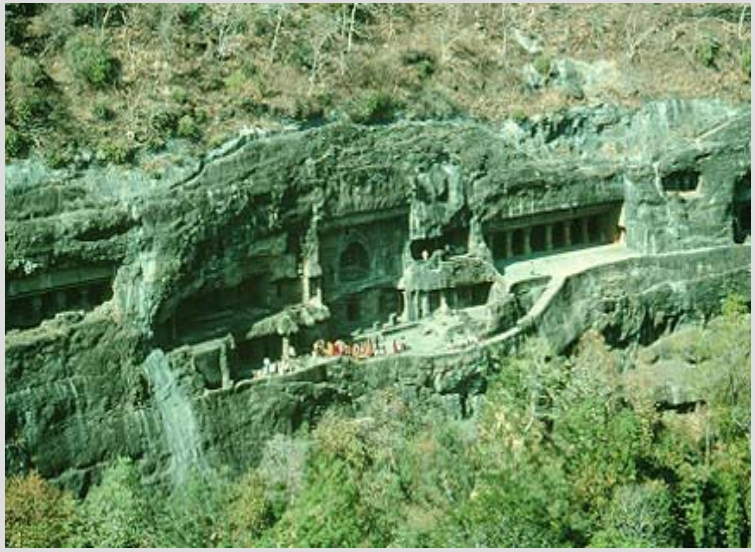
Sufficient inherent permeability to allow injection at required rates, without compression to high pressure levels

Representative regional geology

Proximity to CO2 sources and operational equipment.

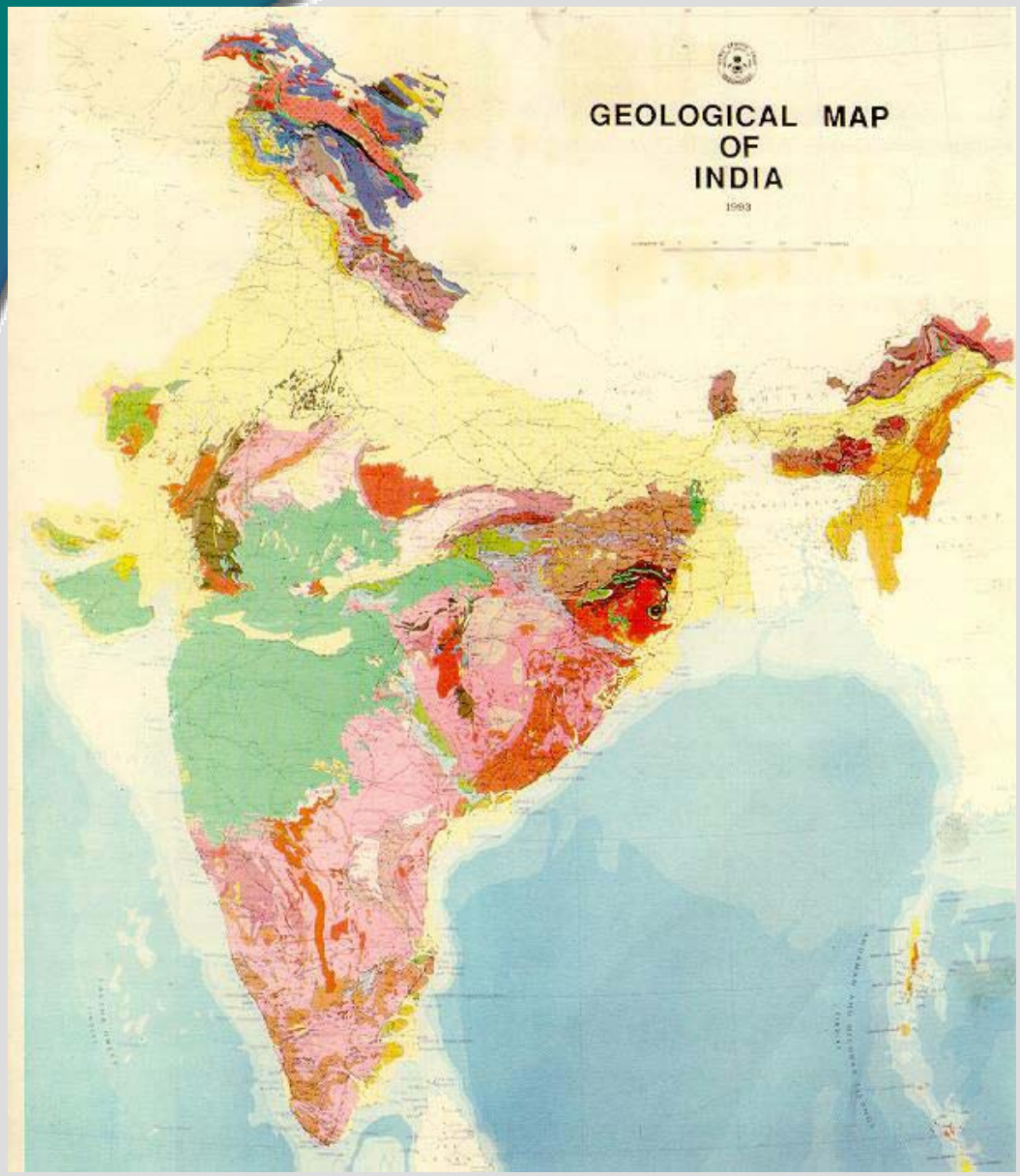
Deccan Traps: Overview

The Deccan Traps are flood basalts similar to the Columbia River basalts. Cover 500,000 square km, roughly the size of the states of Washington and Oregon combined.



Ajanta Cave Temples carved in Deccan Basalts

Source: http://volcano.und.nodak.edu/ (Lazlo Keszthelyi, 1996)



Deccan Trap is believed to be the result of sub-aerial volcanic activity associated with continental divergence in this region of the earth during Mesozoic.

The Deccan basalts may have played a role in the extinction of the dinosaurs. Most of the basalt was erupted between 65 and 60 million years ago.

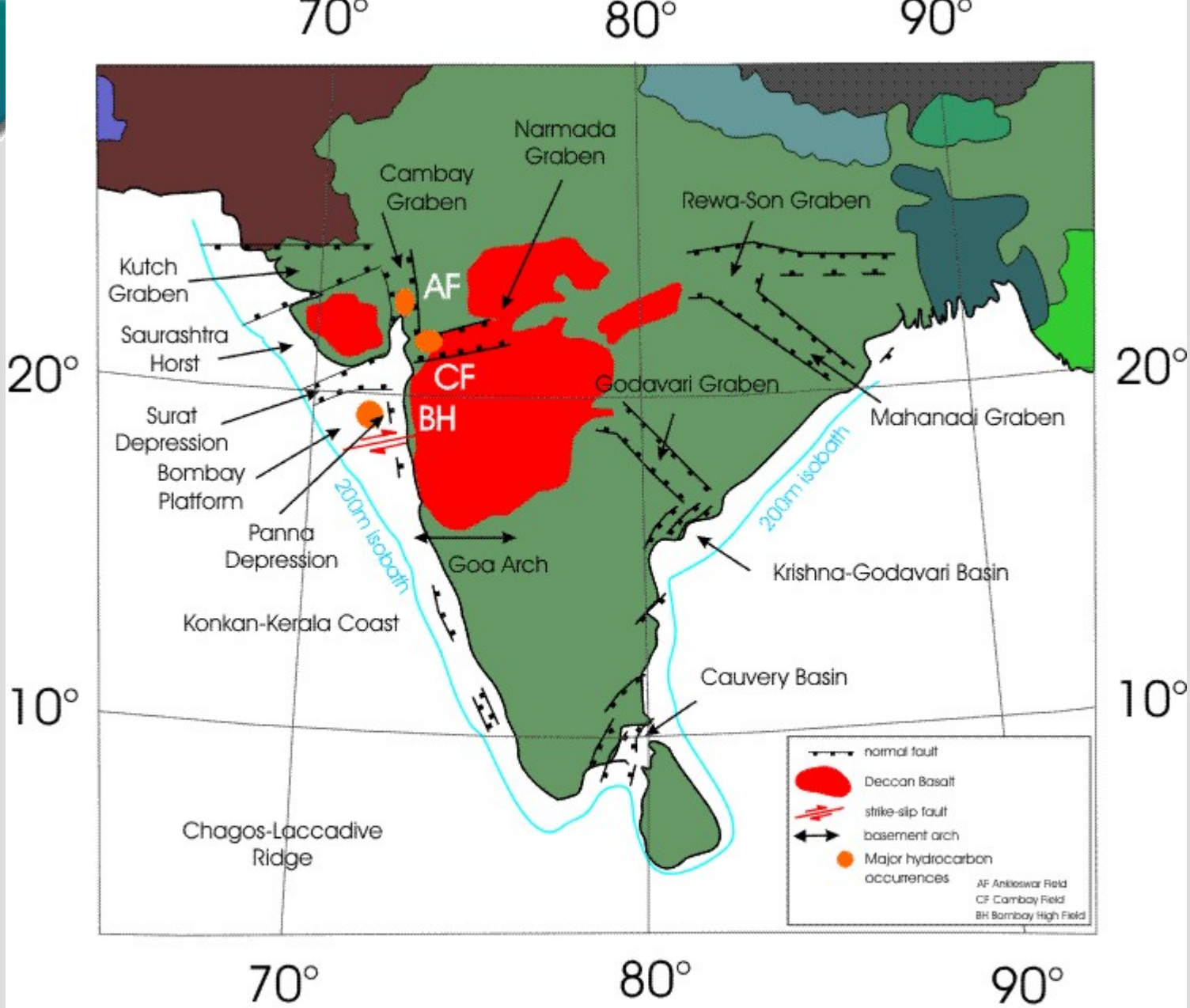
Gases released by the eruption may have changed the global climate and lead to the demise of the dinosaurs 65 million years ago

(U. North Dakota Volcanology Group)

Deccan Traps, Western India

Mesozoic-Cenozoic Cover Major flood basalts forming the Deccan Traps in India are probably the most important in terms of climate change mitigation (McGrail, 2005). Approximately 25% of India's current coal-fueled power plants are located on or in close proximity to the Deccan Traps, which may play a very important role in a suite of geological sequestration options in India.

Maharashtra is almost entirely covered by the basaltic lava flows of the Deccan Trap. The Traps have a thickness of about 2000 m near the western edge and thin out towards east. The lava flows extend into neighboring Madhya Pradesh, Gujarat and Karnataka. Within the basaltic lava flows, numerous sedimentary beds (the Intertrappeans) of carbonates and cherts occur in the east and Gujarat.



Gombos et al. (1995):
The tectonic evolution of western India and ist impact on hydrocarbon occurrences: an overview. - Sedimentary Geology, 96, 119-129

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National Geophysical Research Institute

India's Premier geophysics & geoengineering research center. Conducts field experiments, surveys, geochemical and geophysical prospecting with international collaboration. e.g. Equatorial Magnetic and Micropulsation Observatory, Network Seismic stations in North East Region; Mobile Observatories at Dam sites.

Indo-French Centre for Groundwater Research (IFCGR/CEFIRES www.ifcgr.org)

Developing methods for accurate measurement of the Earth's physical parameters like Electrical Resistivity, Electrical Polarisability, Elastic Wave Velocity, Magnetic Susceptibility

Feasibility Assessment

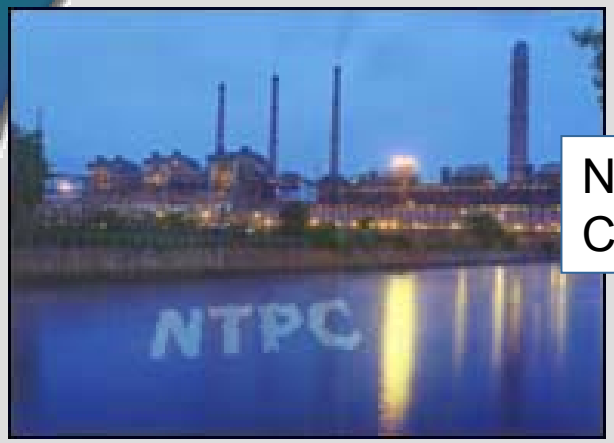
NGRI is currently assessing the feasibility of geological formations of Western India for suitability of a demonstration project, in terms of geological integrity, proximity to industrial CO_2 sources and interested operators, impacts, permitting and costs.

Extensive geochemical prospecting of selected regions of deccan traps was conducted.

SCIGIL Ltd., Chennai, is a likely supplier of CO_2, and injection operations support.

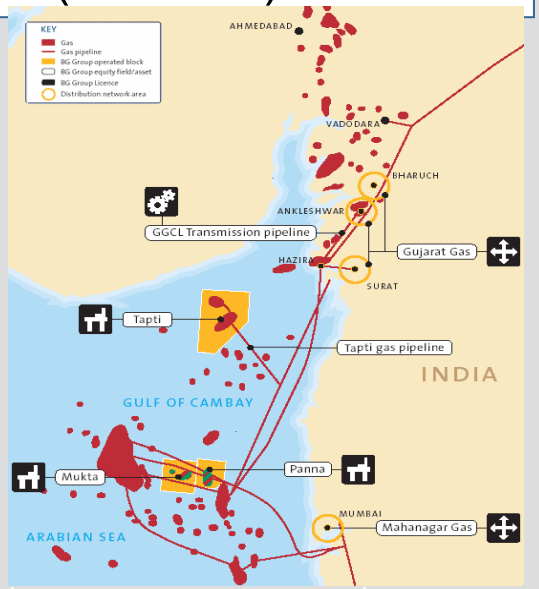
Potential Collaborators/Sponsors

Dept. Science & Technology (DST)

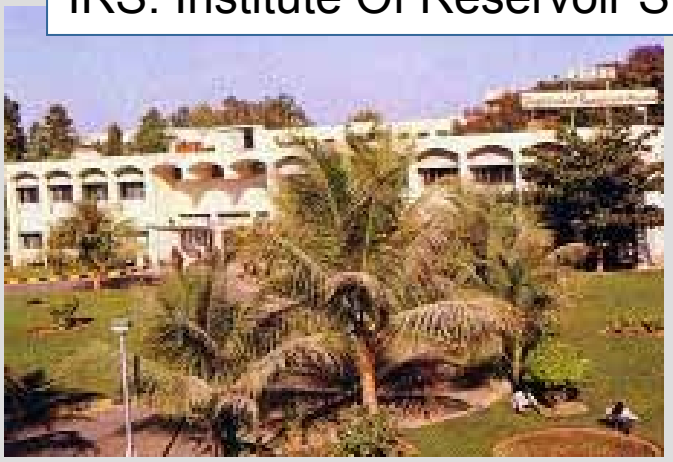


National Thermal Power Corporation Limited (NTPC)

BG Exploration & Production India Ltd. (BGEPIL)



IRS: Institute Of Reservoir Studies



Pilot Injection Project: Summary

150-200T CO2 injected per day.

Duration of the test is 2 to 3 weeks.

Depth of injection is about 1000-1500 feet.

Total CO_2 needed = 2000-3000 Ton.

Area of review of the bubble is ~ < 1 KM radial distance.

CO2 obtained from commercial supplier (SCIGIL)

Base case Simulation: An Idealized Field Case

Base Case Injection and Formation Parameters

Well radius = 1 ft

Drainage radius = 30000 ft

Porosity = 12%

Injection rate (constant) = 3914 cum/day

Far-field boundary pressure, P_e = 3300 psi

Injection pressure, P_i = 3350 psi

Depth to top of host formation = 7800 ft.

CO_2 density = 0.68 gm/cc

Formation thickness = 50-100 ft

Permeability = 1-50 mD

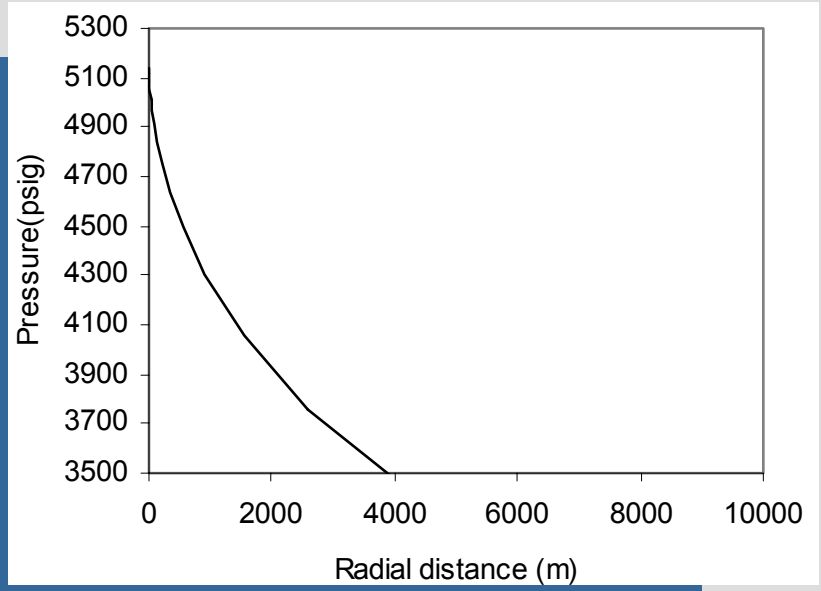
Caprock permeability = 0.0001 – 0.001 mD

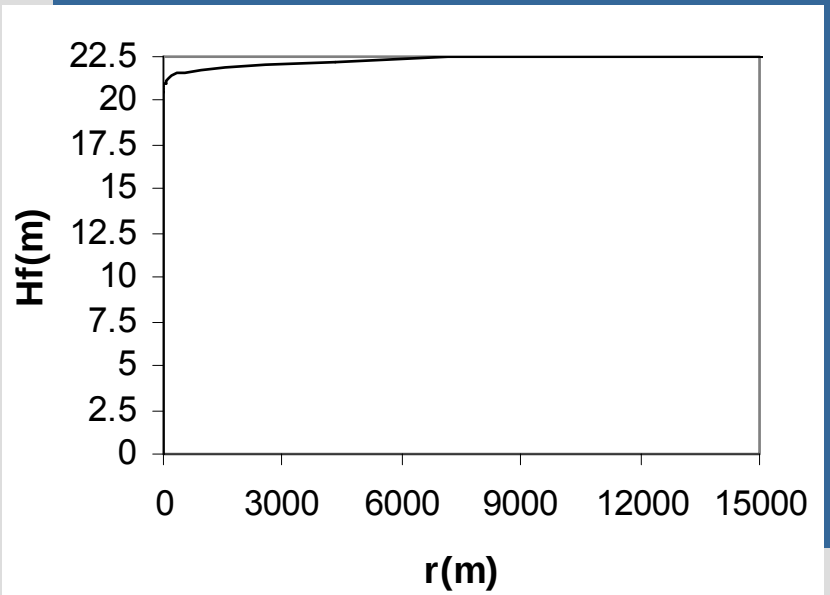
Viscosity of CO_2 phase, μ_g = 0.000043 Pa.s

Viscosity of water, μ_w = 0.00043 Pa.S

Thickness of cap rock = 6300 ft.

Base case: Pressure and Free phase Bubble Profiles



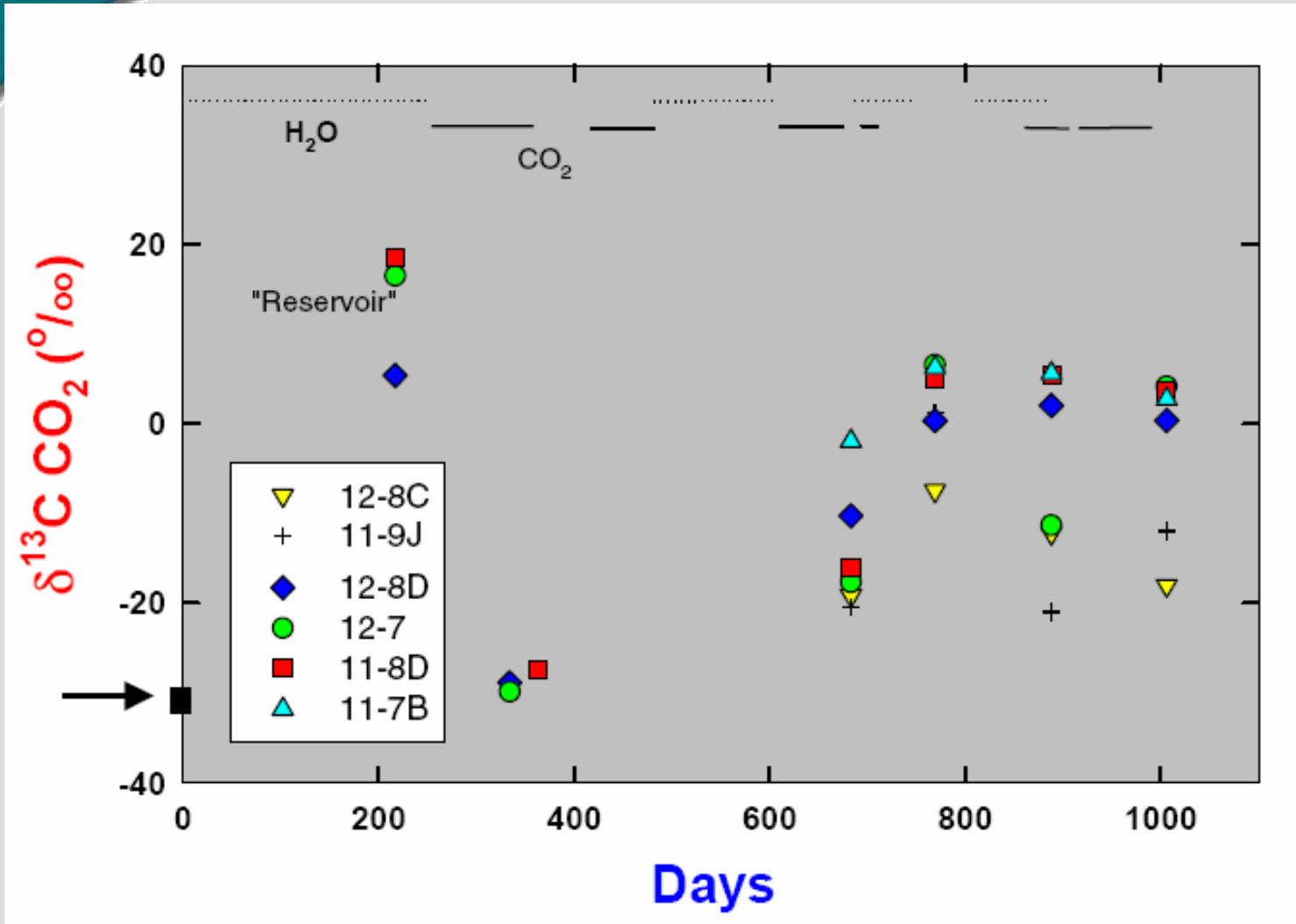


Monitoring of CO_2 Sequestration

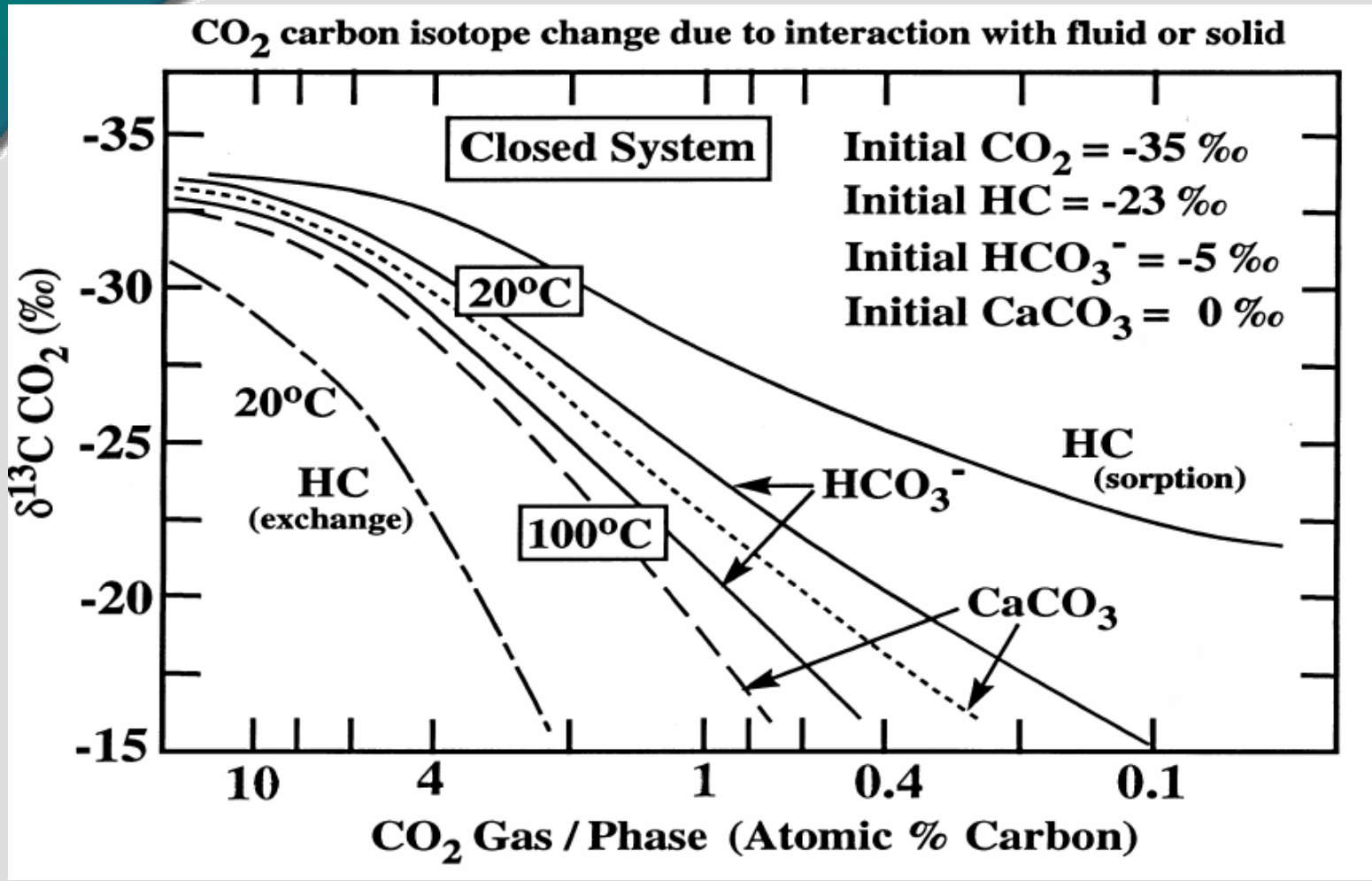
To ensure that i) CO_2 does not leak back into the atmosphere,
ii) groundwater and ecosystems are protected and
iii) local population is not exposed to unsafe CO_2 concentrations

Geochemical and isotope tracer methods are useful for monitoring the movement of CO_2 and understanding the reactions between CO_2 and the reservoir fluids and minerals.

Geochemical Tracers	Isotope Tracers
Na, K, Ca, Mg, Mn, Cl, HCO_3^- and SO_4, pH and Alkalinity etc.	**^{13}C, ^{15}N, ^{18}O, ^{2}H, ^{14}C, ^{36}Cl etc and isotopes of noble gases (He, Ne, Ar)**



Carbon isotope compositions of CO_2 over time for the Lost Hills system. The injectate CO_2 has a δ13C value of roughly –31%.



Changes in CO_2 isotopic composition due to fluid/rock interactions. Movements along the x-axis from left to right indicate predicted changes during subsurface transport.

- Tracers provide insight about the underground movement of CO_2; reactions between CO_2 and the geologic formation and leakage of reservoir CO_2 to the subsurface and atmosphere.

- They offer a method to uniquely identify the source of CO_2

- Stable isotope tracers (13C and 18O) can characterize the injected gas stream and detect the changes during sub-surface transport of CO2. These changes are large enough and can be interpreted in terms of multiple carbon sinks.

- Geochemical and isotopic tracers can help in estimating CO_2 residence time, reservoir storage capacity and storage mechanism.

Summary

- A pilot injection and sequestration demonstration in Western India is being planned, with NGRI as the lead PI. If successful, it will be the first sequestration demonstration in India. It has several common features with the Columbia river bassalts of WA. Planning and design of the test are now underway.
- Modeling results from base case injection scenario indicate that, under a moderately worse cap rock integrity (1 continuous fracture in 1000 m2 area; 1 Darcy permeable zones), the effusive leakage fluxes for the pilot test may negligible.
- Monitoring is planned using geochemical surface surveys and tracers.