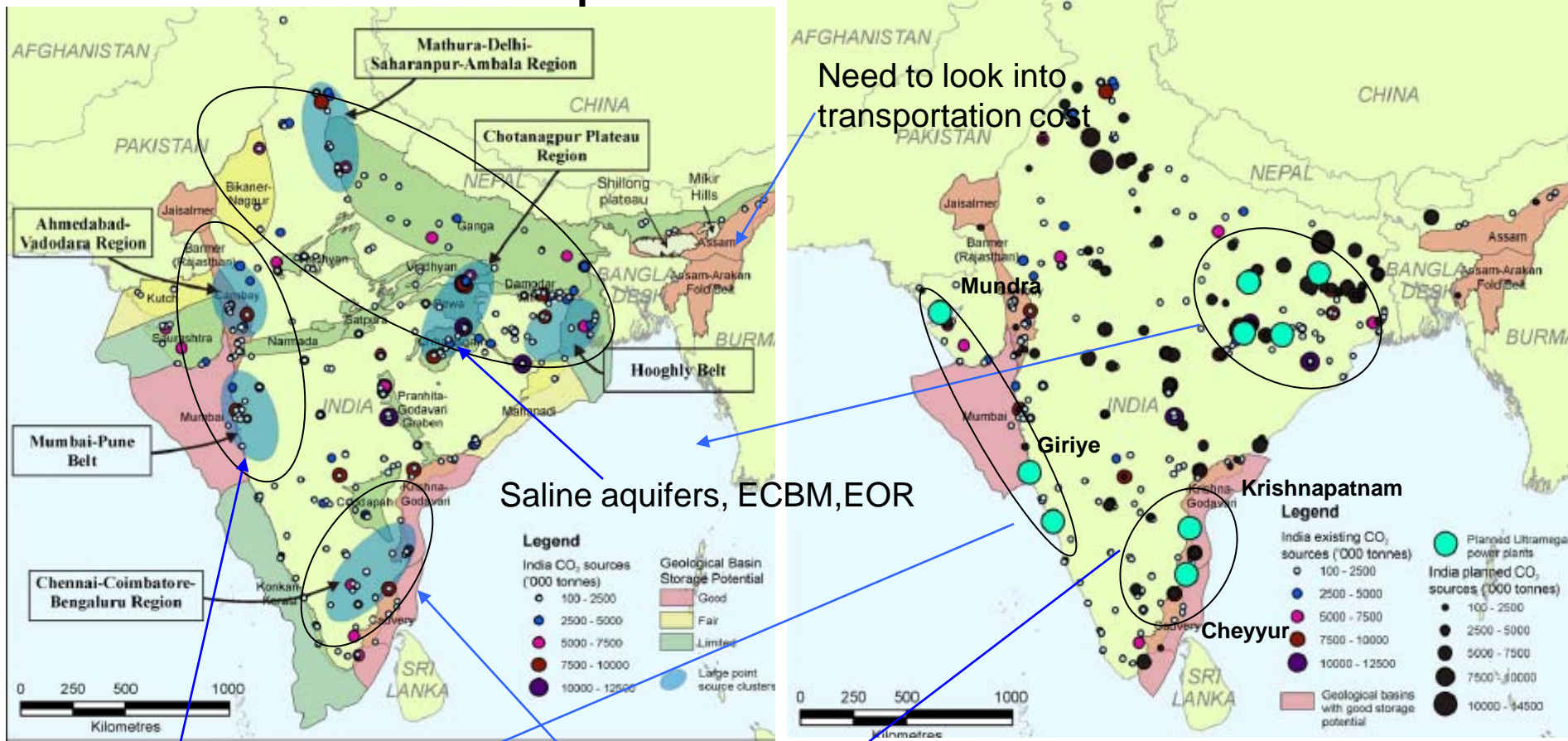


International Conference on Greenhouse Gas Control Technologies (GHGT-10)

Research Overview

Mr. Amit Kumar Verma
Research Associate
Center For Research on Energy Security
The Energy and Resources Institute (TERI)
Habitat Place, Lodhi Road
New Delhi 110 003

India's Storage Capacity and existing or planned LSP's



Need to look into transportation cost

Saline aquifers, ECBM, EOR

Basaltic sequestration, EOR, Saline aquifers

EOR, Saline Aquifers

Source: IPCC 2007

Research and Review of Preliminary Results for CCS Global Components, India

- **Objective:**

1. General Framework for CCS
2. CO2 sources analysis
3. Assessment of CO2 sinks
4. Source-Sink-Matching
5. Integrated assessment

- **Sponsor:**

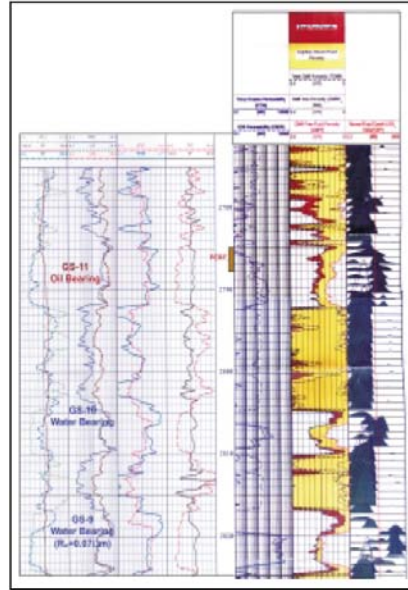
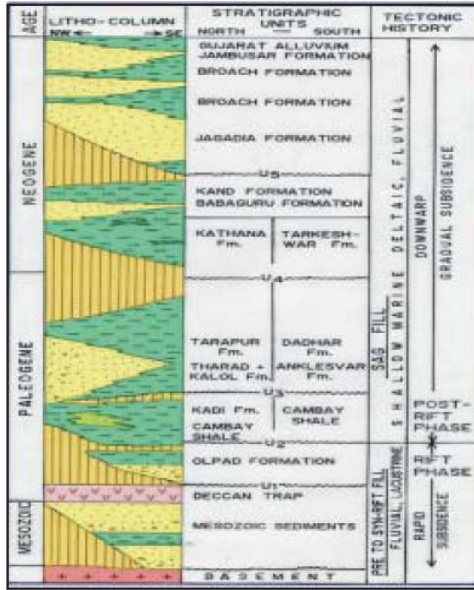
Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ) GmbH

- **Output:**

Phase1- White paper for “Position of Carbon Capture and Sequestration (CCS) key stakeholders in India”

Stakeholders	
Public Authorities	Ministry of Finance Department of Science and Technology Ministry of Forest and Environment, Ministry of Power Ministry of Petroleum & Natural Gas
Industry	ONGC, NTPC, BHEL, GAIL
Societal Players	IRADe, WWF-India, Grrenpeace, TERI
Research Institutions	Institute of Reservoir Studies; Ahmedabad, NGRI, Hyderabad; Geological Survey of India
Financial Institutions	ICICI, IFCI, IDBI, ADB, World Bank

CO₂-EOR for Cambay Basin in India



Well log for GS-11 low resistivity pay which produced oil @35m³/d and associated gas @6000m³/d

Number of Model Layers	5
Dykstra Parson's Coefficient	0.8236
permeability	10-250md
Reservoir Temperature	262.4 F
Average Reservoir Pressure	4281.2263 psia
Minimum Miscibility Pressure	380.58 psia
Oil Formation Volume Factor	1.8 RB/STB
Solution Gas-Oil Ratio	760 scf/stb
Oil Gravity	42 degrees API
Gas Specific Gravity	0.79 (air = 1)
Water Viscosity	0.8 cp
Water Salinity	100,000 ppm
Area	40 acres
Net Pay Thickness	10 feet
Porosity	0.22 (fraction)
OOIP	0.2
Injection rate	8051 bbl/day of water until 2.0 pore volumes have been injected (co ₂ injection = 90,000m ³ /day)

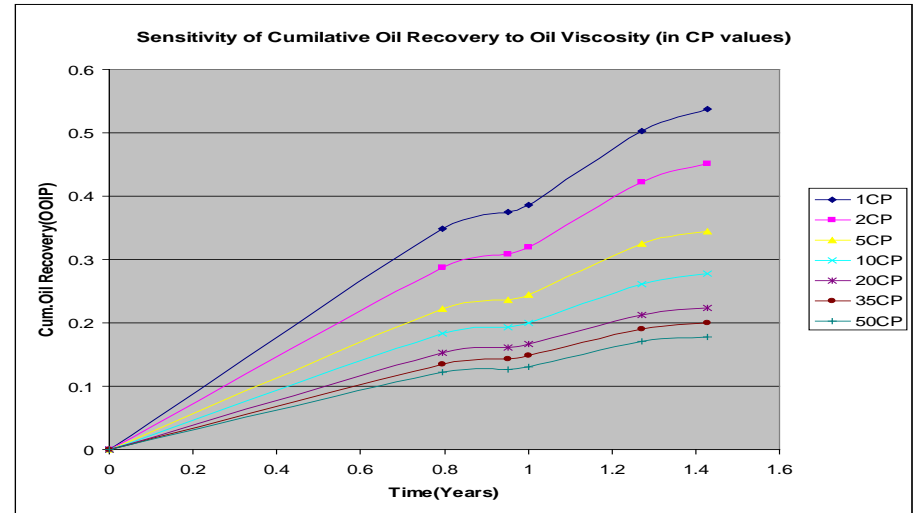
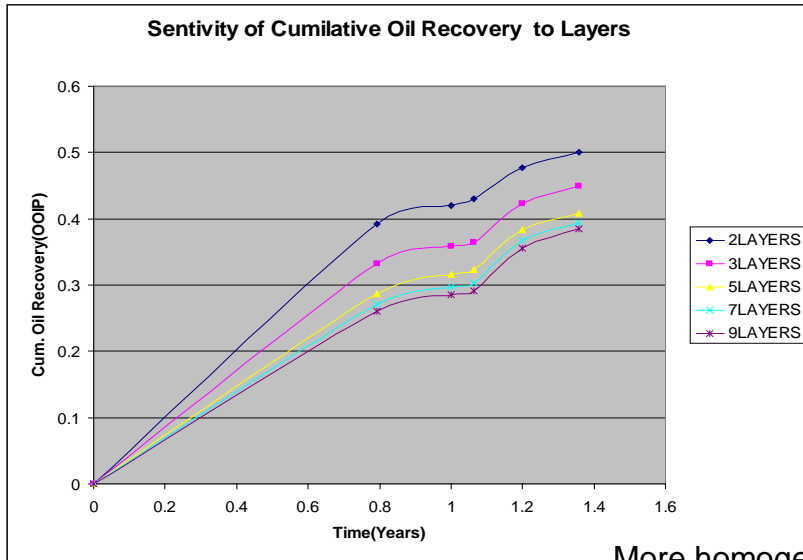
MMP is determined by [Alston et al. \(1985\)](#) correlation

$$(CO_2MMP)LO=6.05 \times 10^{-6} (1.8 TR+32) 1.06 (MWC5+) 1.78 (Xvol/Xint) 0.136$$

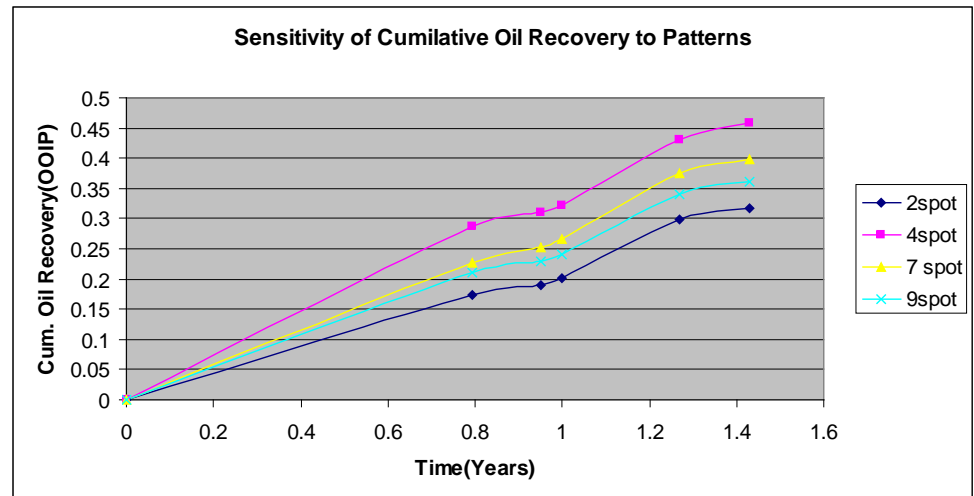
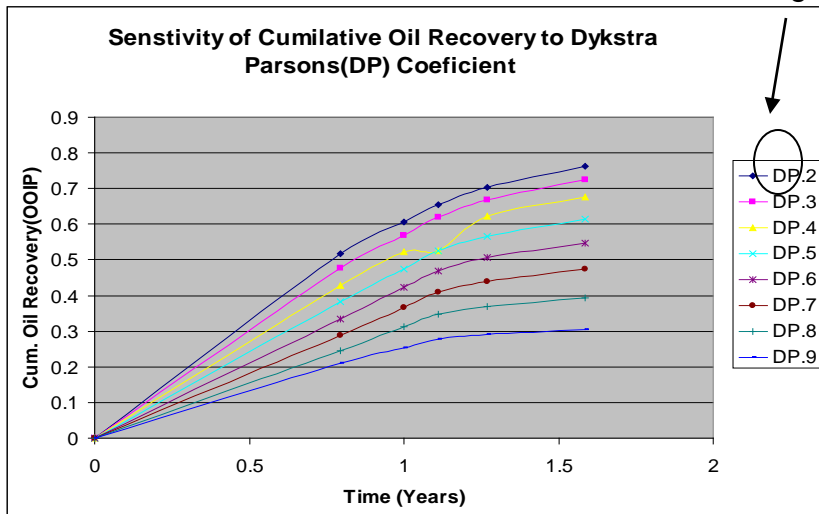
where
 (CO₂ MMP)LO=CO₂ minimum miscibility pressure for live oil (MPa),
 TR=reservoir temperature (°C),
 MWC5+=molecular weight of the C₅+ fraction (g/g mol)
 Xvol=volatile oil fraction consisting of C₁ and N₂ (mol%)
 Xint=intermediate oil fraction consisting of C₂, C₃, C₄, CO₂, and H₂S (mol%).

At 128 C, MMP = 2.624 Mpa = 380.58 psia

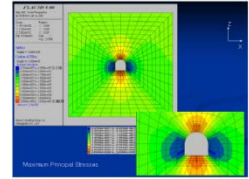
Results



More homogeneous reservoir

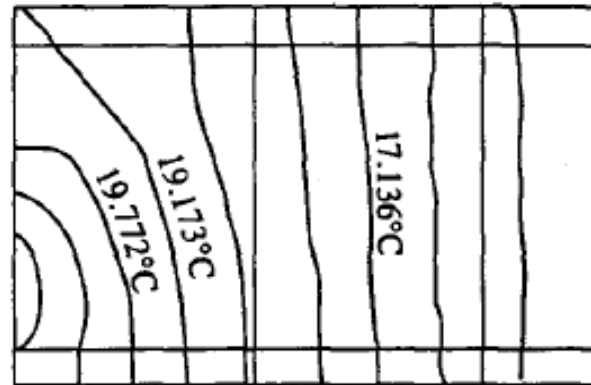
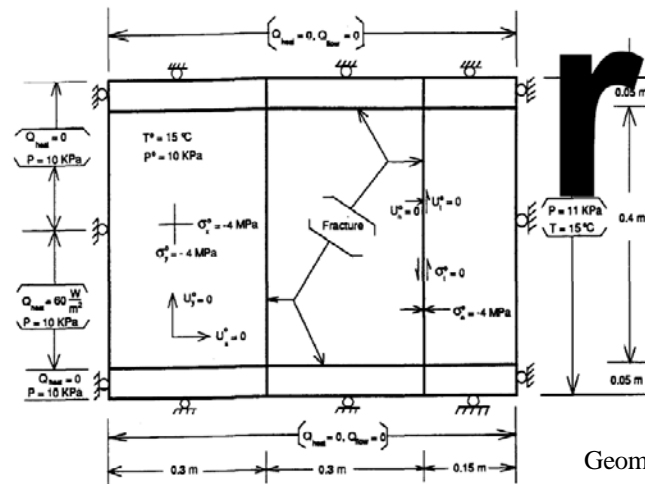
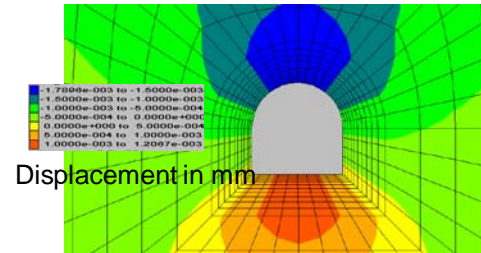


Highlights of modeling work related to Underground Research Laboratory



Prof. T.N. Singh - Principal Investigator
Mr. Amit Verma - Research Fellow
Dr. R.K. Bajpai - P.C., BARC

1. Rockmass is competent enough at 450m depth without much support
2. Damage zone is minimum in case of Horse shoe shaped tunnel
3. Displacements are well within safe limits (0.5-1.7mm)
4. Stresses do not exceed >25MPa at any point in tunnel
5. Results to be used in design and excavation of URL tunnel/chamber
6. Circular shaped tunnel has the least convergence while square shaped tunnel has the largest convergence



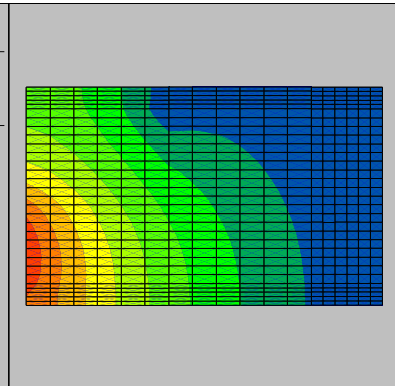
FLAC3D 3.00
Step: 157980 Model Perspective
21:37:40 Mon Sep 29, 2008

Center: X: 3.750e+01 Rotation: X: 0.00
Y: 5.000e+03 Y: 0.00
Z: 2.250e+01 Z: 0.00
Dist: 2.079e+00 Mag: 1
Avg: 22500

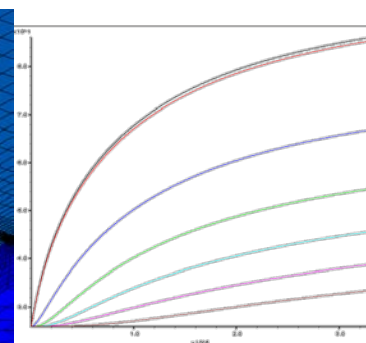
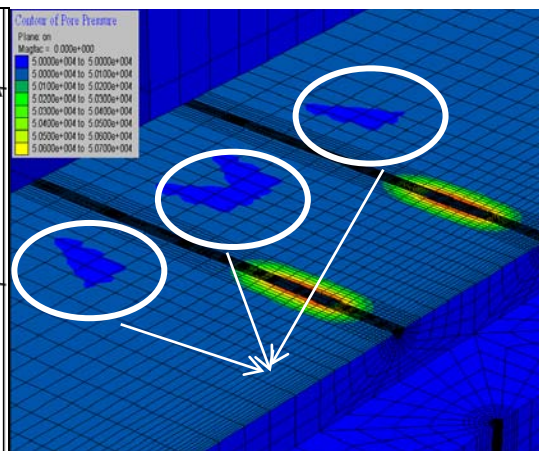
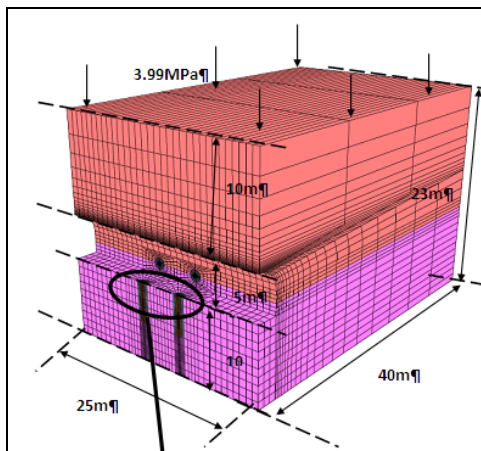
Surface
Magfac = 0.000e+00
Contour of Temperature
Magfac = 0.000e+00

1.5000e+01 to 1.5000e+01
1.5000e+01 to 1.5000e+01
1.5000e+01 to 1.6000e+01
1.6000e+01 to 1.6000e+01
1.6500e+01 to 1.7000e+01
1.7000e+01 to 1.7500e+01
1.7500e+01 to 1.8000e+01
1.8000e+01 to 1.8000e+01
1.8500e+01 to 1.9000e+01
1.9000e+01 to 1.9499e+01
Level = 50x01

Itasca Consulting Group, Inc.
Minneapolis, MN USA



Geometry and boundary conditions for the multiple fracture model, bench mark test 2 (BMT2), DECOVALEX Phase I.

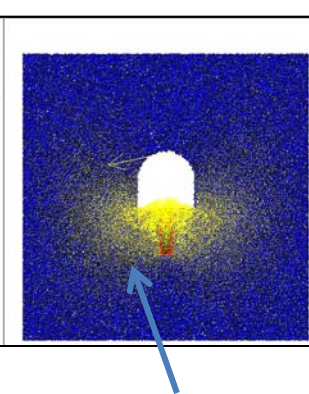


PFC2D 3.10
Step: 599416 03:03:02 Tue Jun 16 2009

View Size:
X: -1.416e+01 to 1.493e+01
Y: -1.784e+01 to 1.571e+01

Ball
Group
granite
clay
cementite

Maximum = 4.717e-002



FLAC3D = Maximum displacement is 3.5mm after 1e6 sec
PFC2D = Maximum displacement is 4.717cm after 0.35e6 sec