

Taller de Secuestro y Captura de CO₂ (CCS)



MÉXICO D.F.
9 Y 10 DE JULIO DEL 2008



INSTITUTO DE
INVESTIGACIONES
ELÉCTRICAS



CFE

Comisión Federal de Electricidad



PEMEX



INSTITUTO MEXICANO DEL PETRÓLEO



GE imagination at work

ALSTOM



Cemex
Construyendo el futuro



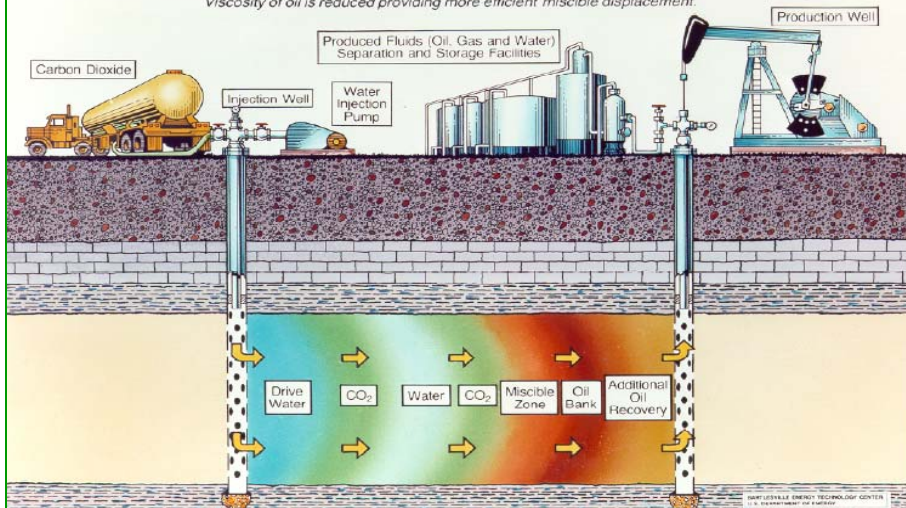
CONSEJO NACIONAL DE ENERGÍA
ATÓMICA

Enhanced Oil Recovery by CO₂ injection

CARBON DIOXIDE FLOODING

This method is a miscible displacement process applicable to many reservoirs. A CO₂ slug followed by alternate water and CO₂ injections (WAG) is usually the most feasible method.

Viscosity of oil is reduced providing more efficient miscible displacement.



presented by

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Project Leader*

Oil Recovery Department

INSTITUTO MEXICANO DEL PETRÓLEO



- ◆ *EOR concepts*
- ◆ *Mexican Reservoirs*
- ◆ *EOR in Mexico*
- ◆ *IMP projects on EOR- CO₂-N₂*
- ◆ *IMP EOR Future*
- ◆ *Conclusions*

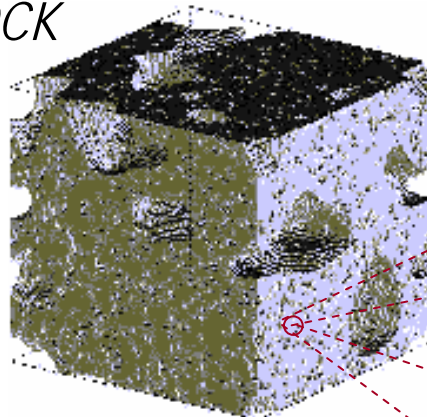
EOR- Mechanics



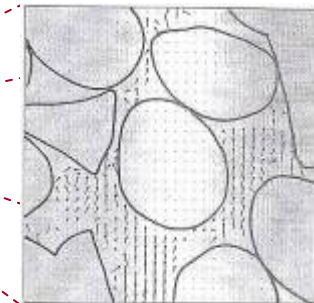
Forces

- Viscous → Pressure
- Gravitational → Density
- Capillary → IFT

ROCK

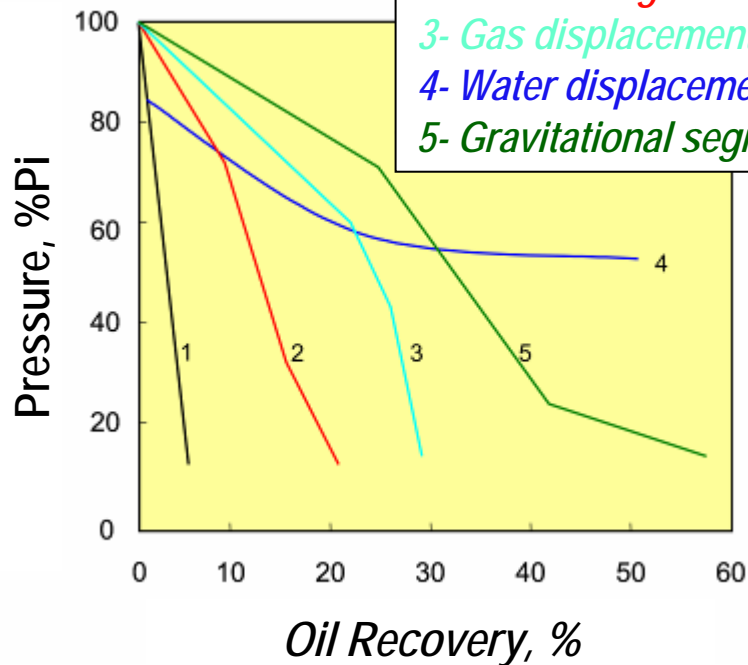


Pores



Mechanics

- 1- Rock and fluids expansion drive
- 2- *Disolution gas drive*
- 3- *Gas displacement drive*
- 4- *Water displacement drive*
- 5- *Gravitational segregation drive*



F_{rec}
"Oil recovery factor"

PRIMARY Recovery

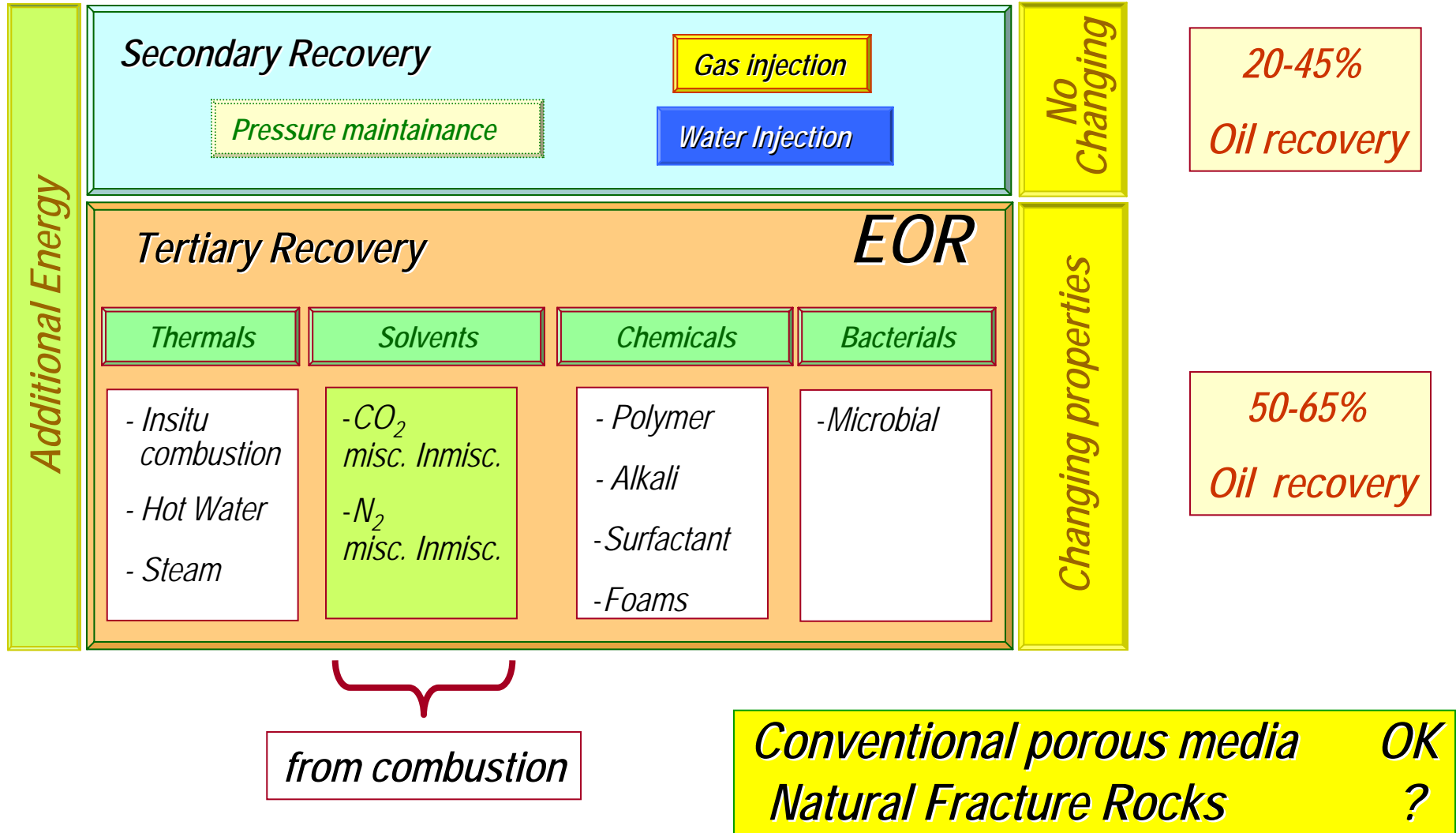
5 - 20 %
Oil recovery

EOR- process



Additional oil Recovery Process

IFP, Introduction to EOR, 2003



Increasing F_{rec}

CO₂

Advantages

- Oil Viscosity reduction
- Oil Swelling
- Low pressure for miscibility

Disadvantages

- "Availability"
- GC separation
- Corrosion

MISCIBILITY

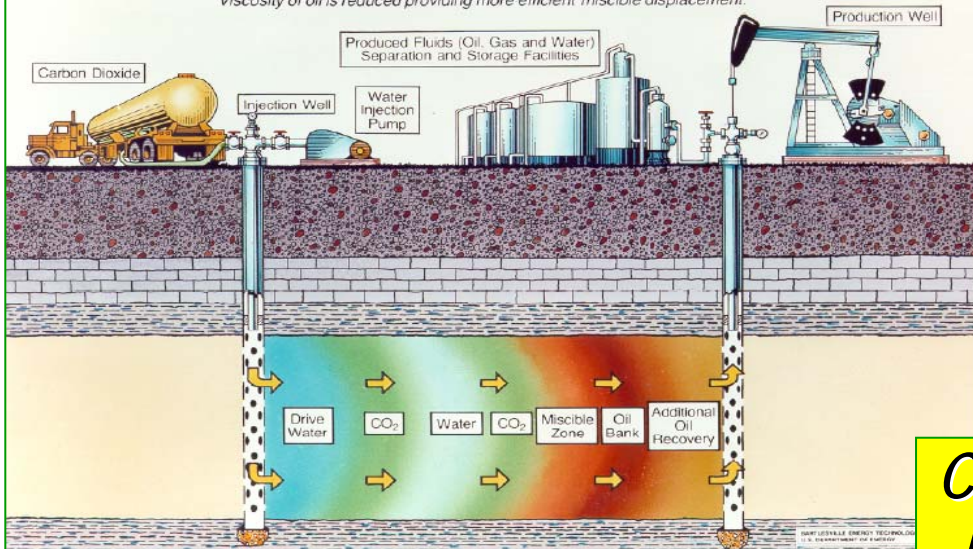
First contact $S_{or}=0$

Multiple contact $S_{or} > 0$

CARBON DIOXIDE FLOODING

This method is a miscible displacement process applicable to many reservoirs. A CO₂ slug followed by alternate water and CO₂ injections (WAG) is usually the most feasible method.

Viscosity of oil is reduced providing more efficient miscible displacement.



Screening
Criteria

- Oil Viscosity
- Depth
- °API
- Temp
- Width
- Permeability

Conventional porous media
Natural Fracture Rocks

OK
?

EOR - CO₂ Projects in the world



EOR worldwide

Process	CO ₂		STEAM	POL	IC	SAP	N ₂		HW	GAS HC		BAC
	M	I					M	I		M	I	
Planning	12	4	7	6	1	2						
USA	101	5	45		12	2	1	3	3	1	12	
CANADA	7		14	1	3			1		1	22	
Out Side	1	10	82	21	1			1			3	1
Total	121	19	148	28	17	4	1	5	3	2	37	1

**TOTAL
386**

EOR report, OGJ, 2008

CO ₂	140
N ₂	6
Others	240
Total	386

**146 projects for CO₂ and N₂
(96% CO₂)**

México, Akal

61% in the world are CO₂ and N₂

Geographical Distribution of Reserves



Basins

- Sabinas
- Burgos
- Tampico - Misantla
- Veracruz
- Southeast
- Deep waters
- Yucatán platform

4 Regions

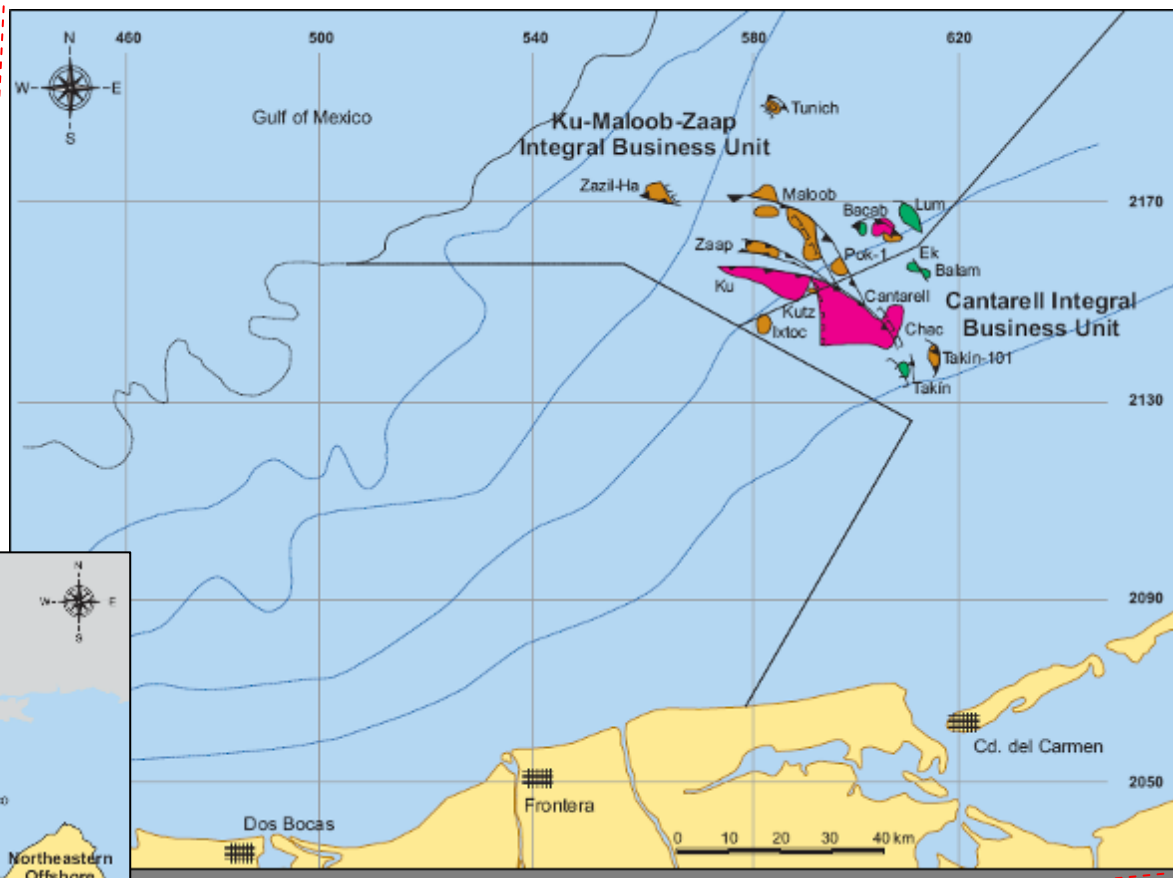
*Administration
of Reservoirs*

Northeastern Marine
Southwestern Marine
Southern
Northern

Mexican Reservoirs



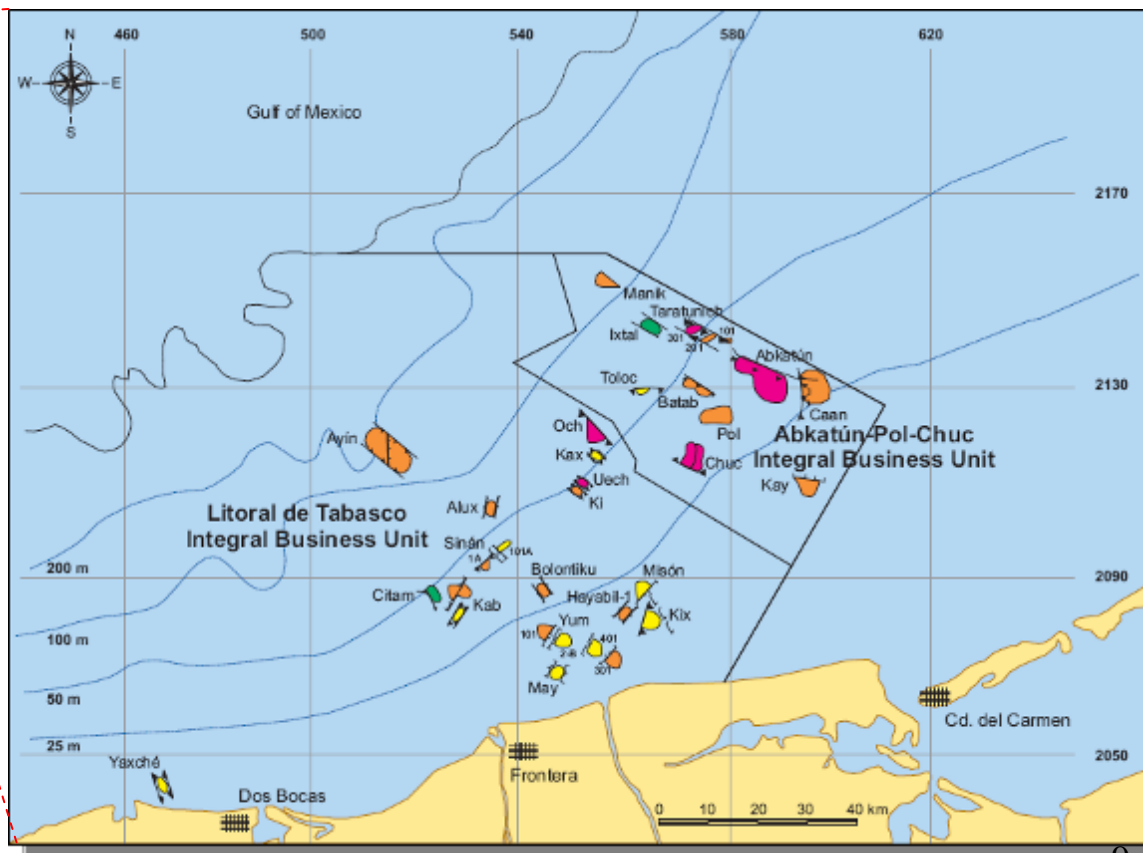
Northeastern Marine Region



Mexican Reservoirs



Southwestern Marine Region



Mexican Reservoirs



Northern Region

EOR in México



Oil rate on fields submitted to a secondary/enhanced oil recovery process

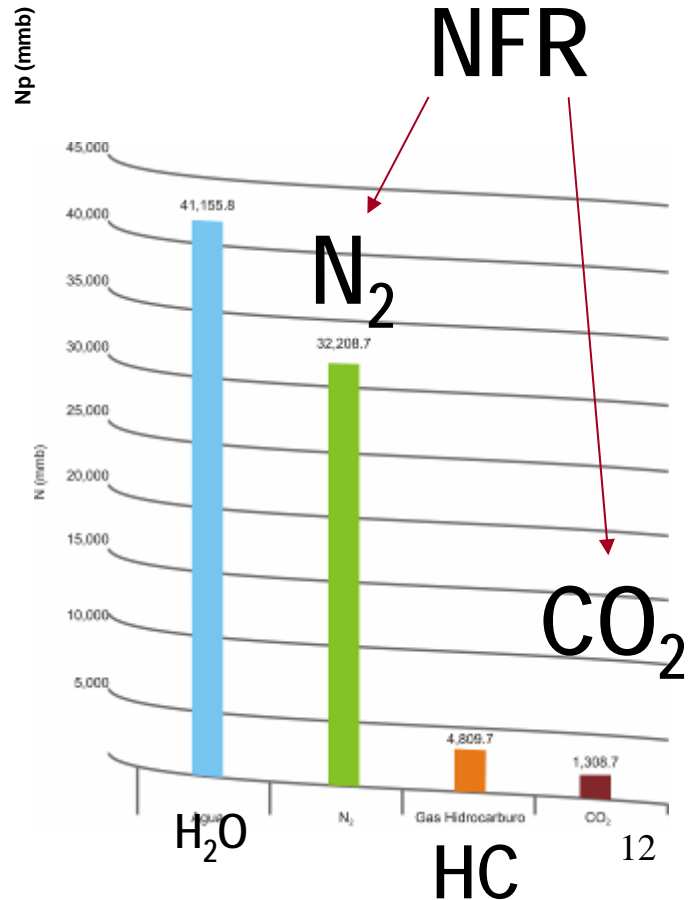


Water, HC gas

N₂
CO₂

CO₂ Injection

- Artesa
- Sitio Grande



IMP Projects on EOR



<i>Project</i>	<i>Year</i>
* Natural sources of CO ₂	1985
* Study of the use of CO ₂ from Oxiacaque plant	1980
* CO ₂ injection in Southern Region fields. Factibility analysis	1990
* Technical and economical analysis of EOR process in national fields.	1989-1991
* Technical and economical analysis of EOR process in Filo Morado field	1991
* Technical and economical analysis of EOR process in Cactus, Jiliapa, Sitio Grande	1993-1994
* Technical and economical analysis of EOR process in Ek Balam Field	1996
* Field characterization of Carmito field	2002
* Integral study of Artesa field	2003-2004
* Yearly report of the secondary and enhanced oil recovery projects in Mexico, 2006	2006
* Yearly report of the secondary and enhanced oil recovery projects in Mexico, 2007	2007
* Effects of CO ₂ in PVT properties, well Cuichapa	1981
* Experimental studies of oil recovery by CO ₂ injection in Artesa field.	2001
* Additional recovery by CO ₂ injection in NFR	2006-2009
* Experimental studies of gas injection in the field KU	2007-2008
* Experimental studies of gas injection in the field Cantarell	1998-2008
* EOR studies in the fields of Northeastern Marine Region	2008-2010

• *Sources of CO₂*

• *Technical and economical EOR studies*

• *CO₂ Modeling and simulation NFR*

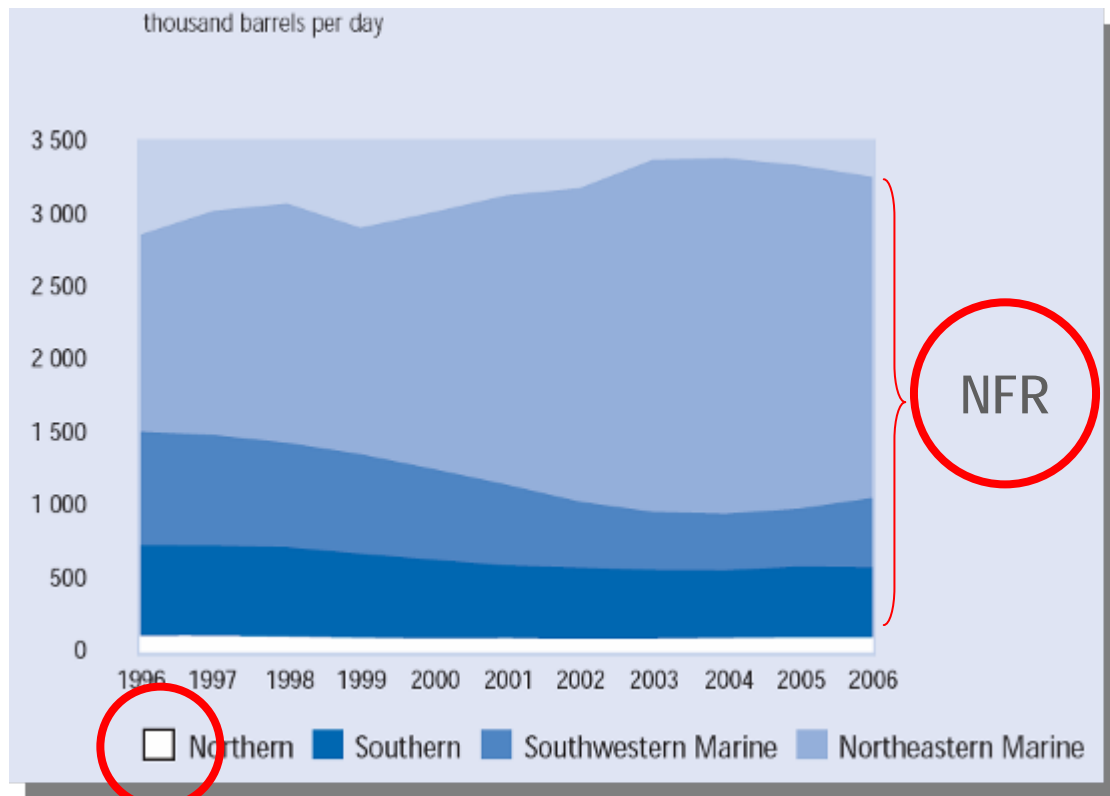
• *Data base on AOR projects*

• *Oil characterization in presence of CO₂ and N₂*

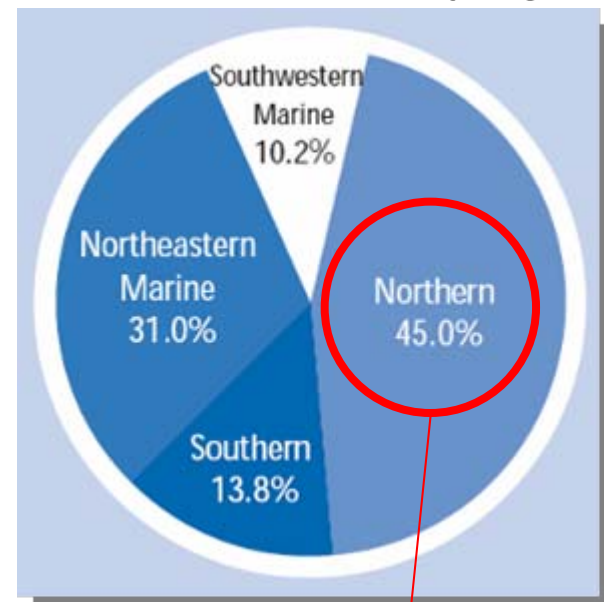
• *Oil recovery by CO₂ injection in NFR*

Production vs Reserves

Oil rate production by region



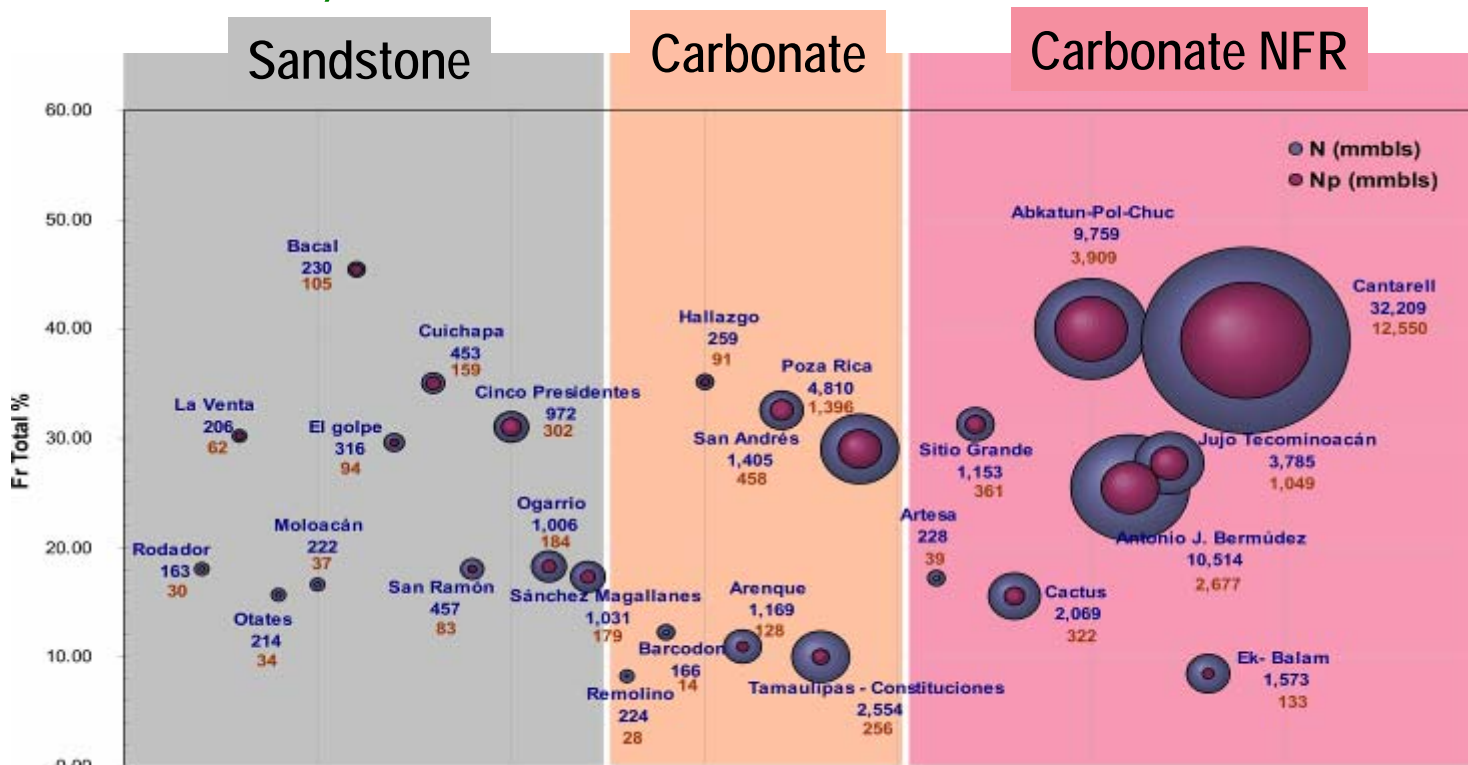
Reserves by region



IMP EOR Future



Reserves 1P, 2007



Conventional CO₂

Challenges on NFR for CO₂

Recuperación Secundaria 49.23%

Recuperación Mejorada 0.94%

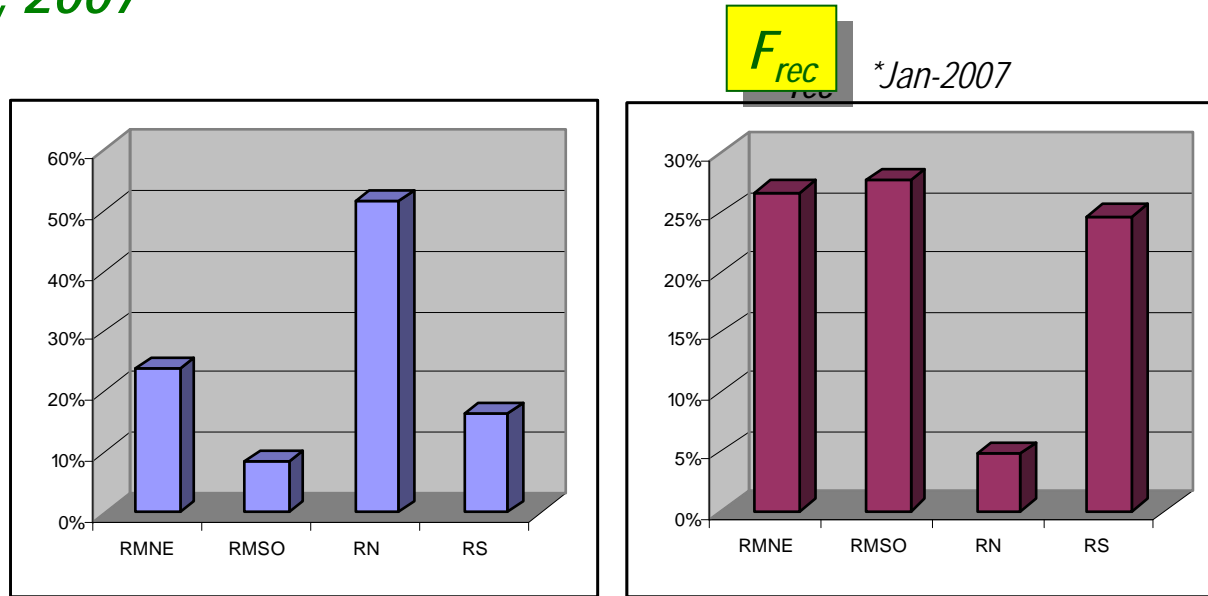
Sin Proceso de Recuperación Adicional 49.83%

Water, gas or PM

EOR-CO₂

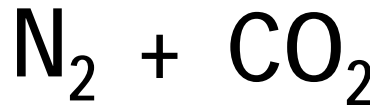
None AOR

Reserves 2P, 2007



Anuario estadístico de proyectos de recuperación, 2007

Proyecto
Ku-Maloob-Zaap
Antonio J Bermudez
Jujo Tecominoacán
Abkatun Pol Chuc



New technologies with non-conventional process in NFR

Akal, Ku-Maloob-Zaap

Northern Zone, conventional but complex reservoirs.

Conclusions



◆ *Challenges with NFR*

CO₂

◆ *Implement EOR process with GC*

CO₂

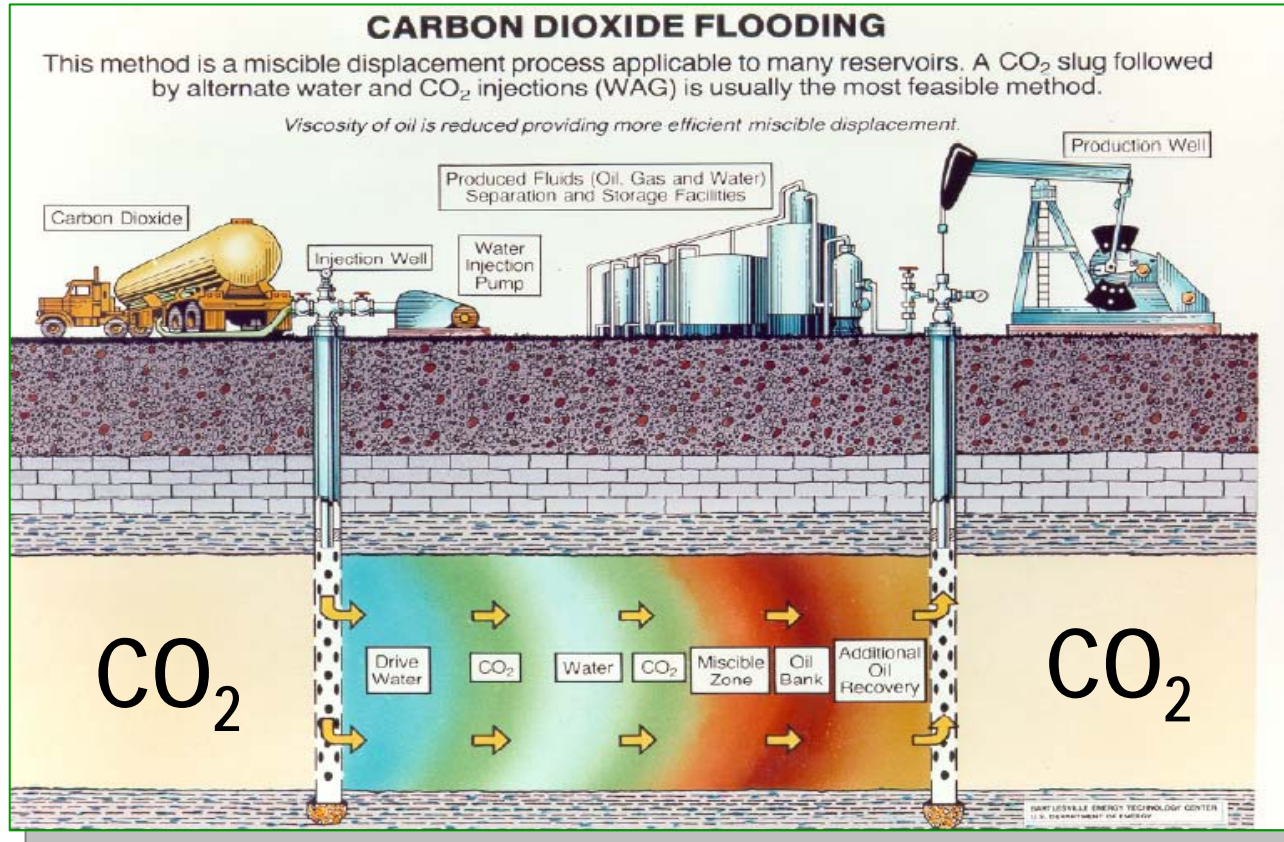
◆ *New technologies with non-conventional process:*

CO₂

- *Combustion gas injection (CO₂, N₂, O₂)*
- *N₂-CO₂ mix*
- *Foams (CO₂)*

CO₂ Sequestration

Enhanced Oil Recovery by CO₂ injection



DOE, 1986

Thanks for your attention