CO_2 UTILIZATION FOR EOR AT OIL FIELDS IN INDONESIA

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Research and Development Centre for Oil and Gas Technology "LEMIGAS"

Outline

- **Background**

- **CO_2 Sources**

- **Oil Fields Selection**

- **Laboratory Evaluation**

- **Simulation Study**

- **Plan for Implementation**

- **Conclusions**

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Background

## World Energy-Related CO_2 Emissions by Fuel Type
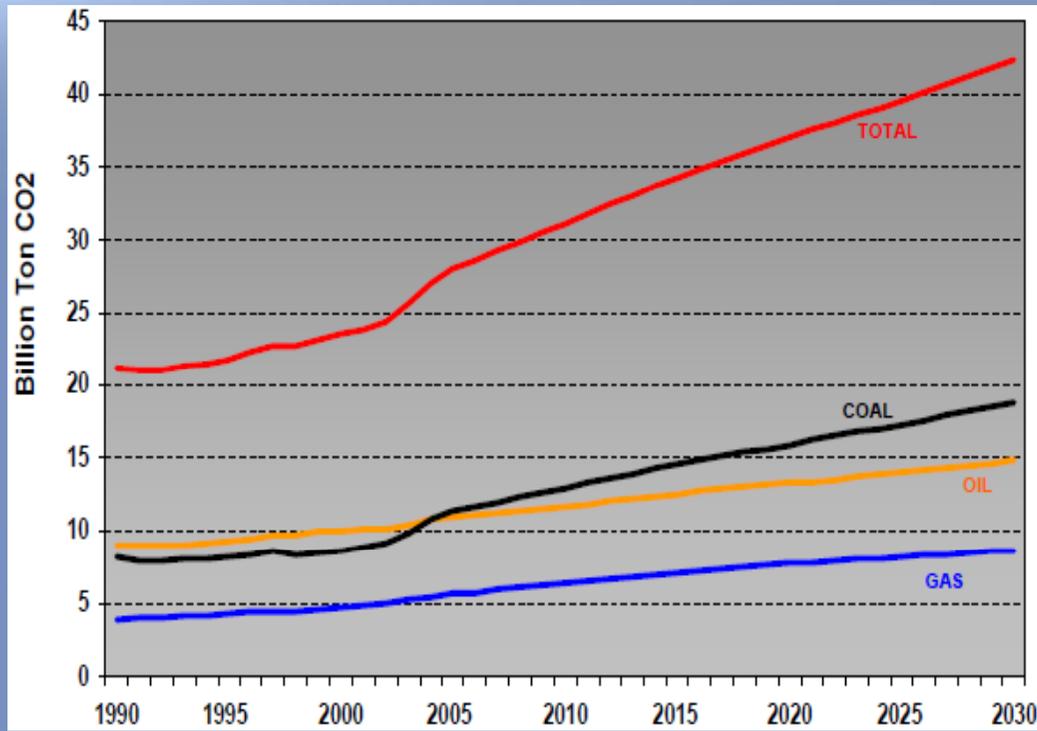
Source: IEA - International Energy Outlook 2008

- ■ The rising of CO_2 emissions:
  - ▪ The Increasing Petroleum Industry
  - ▪ The heavy reliance on fossil fuels
  - ▪ Deforestation
  - ▪ Population and economic growth

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Background (cont'd)

Remaining Reserves of Primary Recovery 4.8 BSTB 8%

Cummulative 19.9 BSTB 32.6%

EOR Target 36.5 BSTB 59.6%

Total OOIP: 61.1 BSTB
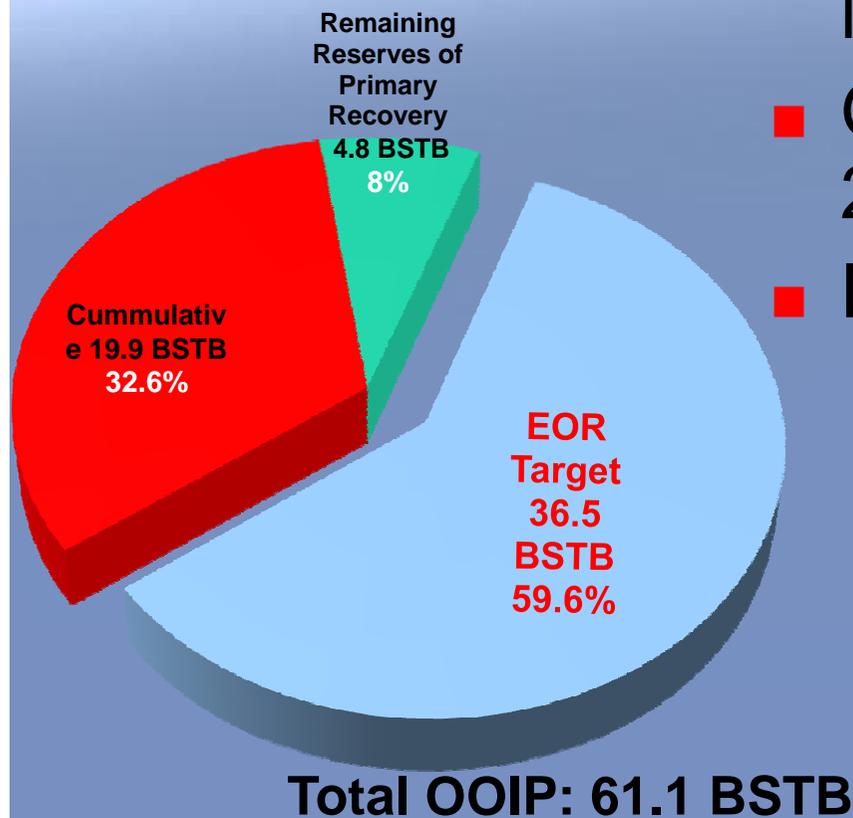
- The declining of oil production in Indonesia
- GOI's oil production target for 2010 is only 1.1 Million Bpd
- Depleted oil and gas reservoirs

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Background (cont'd)
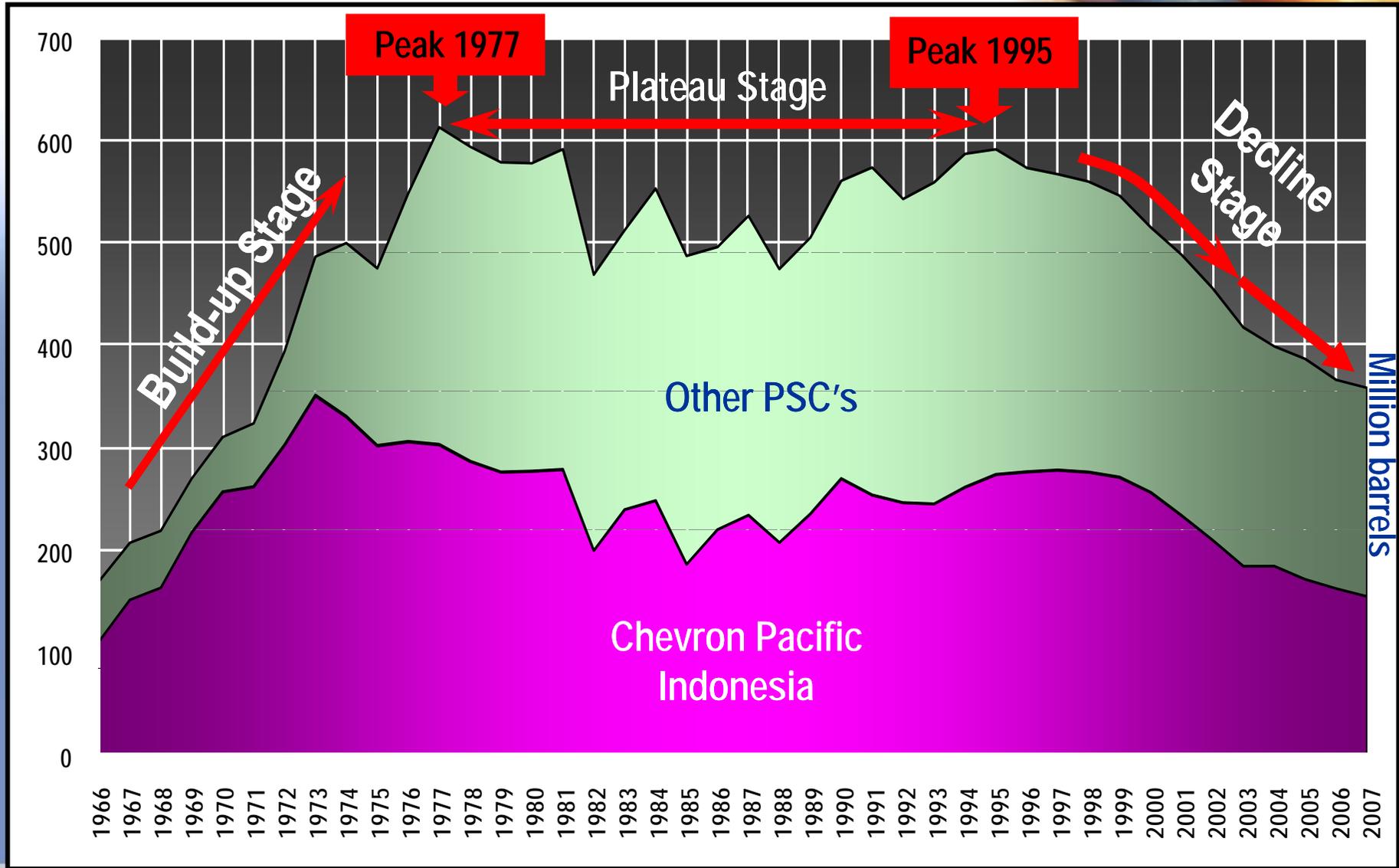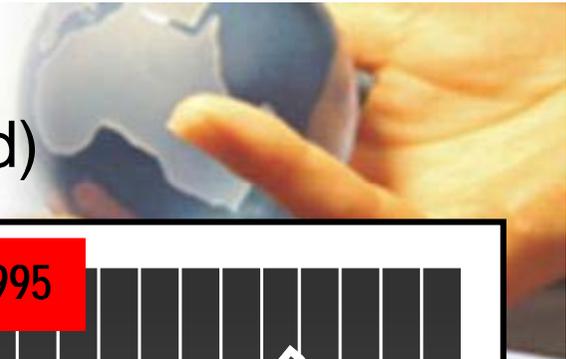
Background (cont'd)

IOR Concepts

Primary phase   **Secondary phase**   **Tertiary phase (EOR)**

Incremental secondary

Incremental Tertiary

Extrapolated primary

Extrapolated secondary
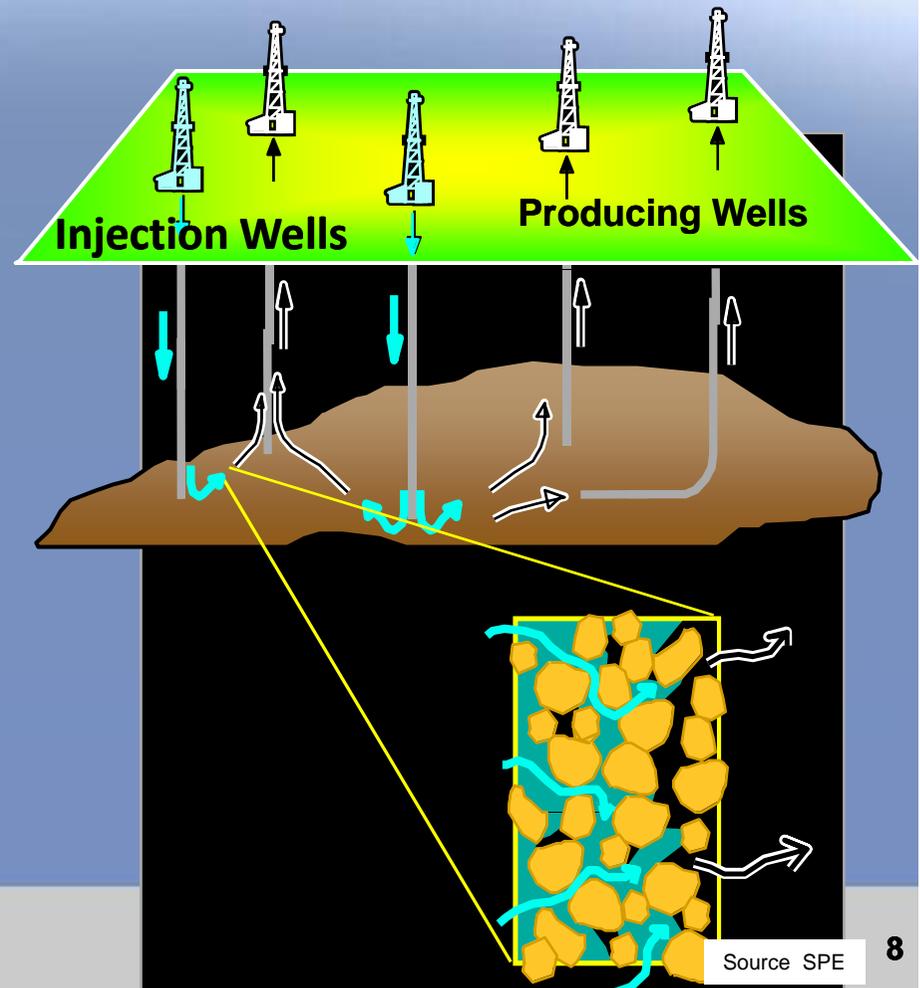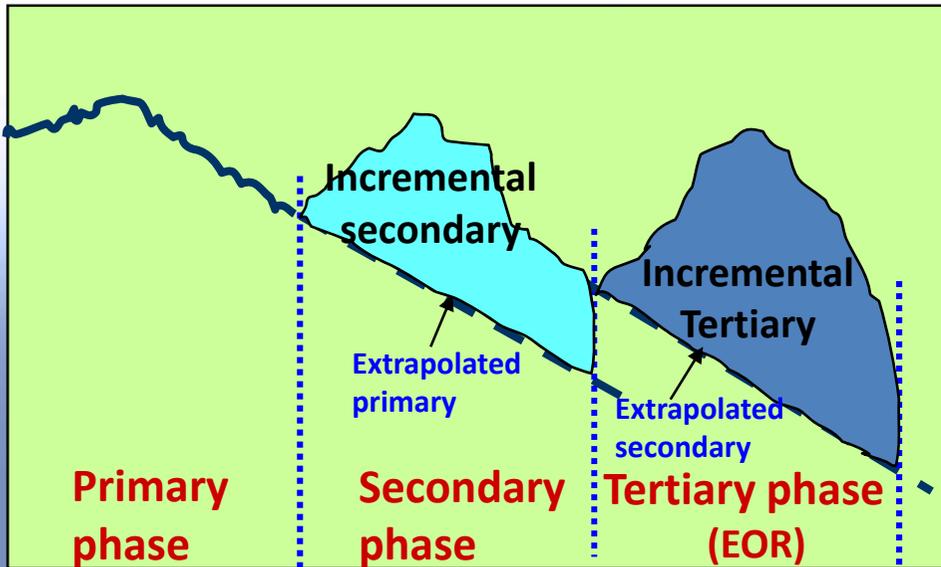
Effort to force additional petroleum out of the pores in the reservoir rock

Water
Gas
Steam
Chemical
Technology

Injection Wells   Producing Wells

Source SPE

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Background (cont'd)

Advantages of CO_2 EOR

■ **Dramatic Improvement of Oil Recovery**

■ **CO_2 is Ultimate Injectant with Proven Effects／Superior to Gas & Water**

             Ultimate Oil Recovery (Typical)

               ・Secondary Recovery   30 % of OOIP

                                 ↓

               ・CO_2 Injection   45 % of OOIP

■ **Saving Natural Gas Consumption**

■ **Environmental and Economic Effect**

     Reduction of CO_2 Emission ⇒ New Initiative (Kyoto Protocol)

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CO2 Sources

Depleted Oil Reservoirs

Natuna

East Kalimantan

Kontang LNG Plant

South Sumatra

West Jawa

CO_2 Separation

Storage Capacity: 38 – 152 $MtCO_2$
Oil Recovery: 265 – 531 Million bbl

Storage Capacity: 18 – 36 $MtCO_2$
Oil Recovery: 84 – 167 Million bbl

PHILIPINES
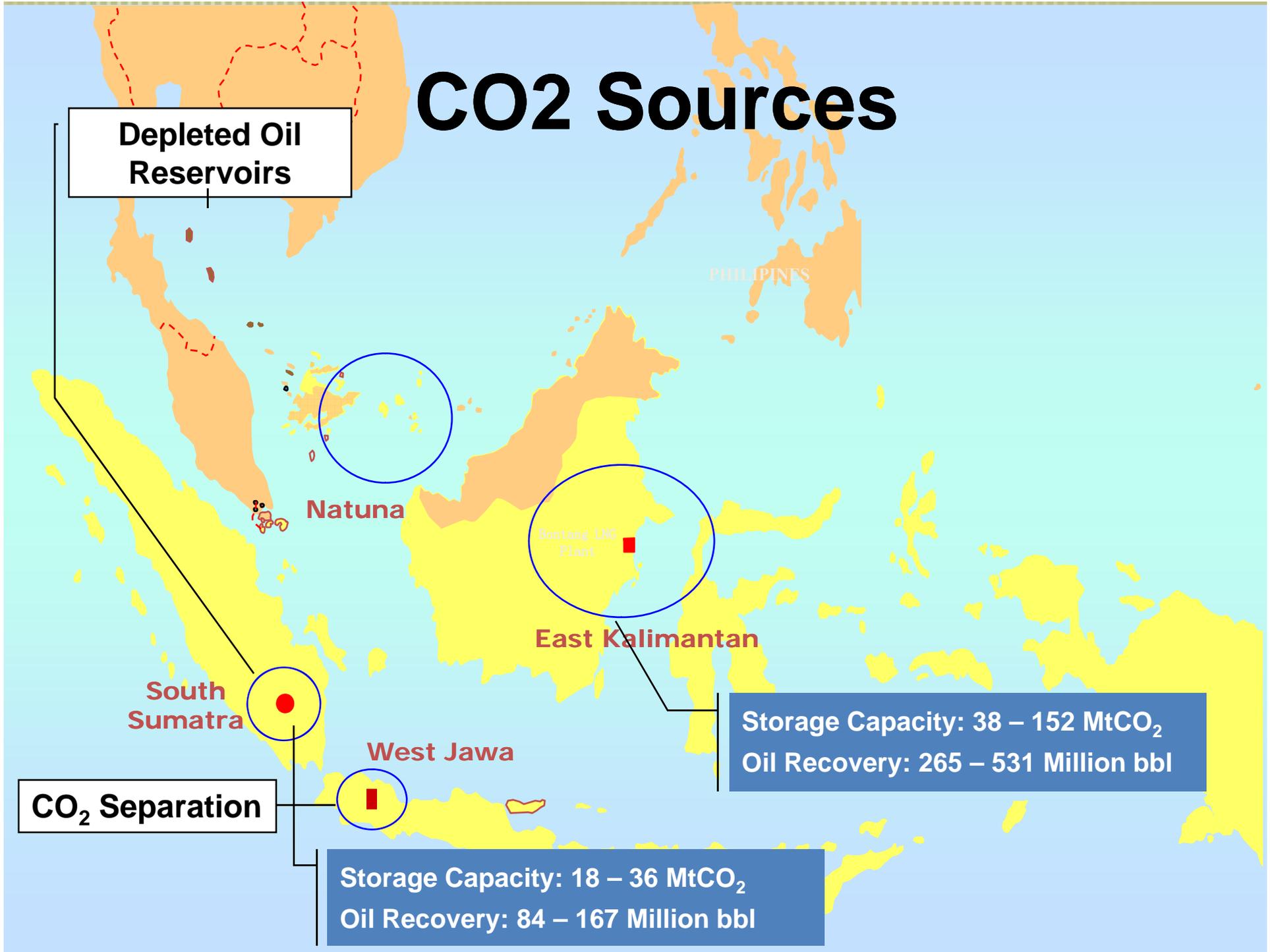
Project Activity Diagram

Laboratory Tests

- Miscibilities Studies
- PVT Studies
- Extraction Experiments
- Core Flooding Experiments

Study of CO_2 Sources, Capture and Transportation

Simulation of Laboratory Experiments

Reservoir Simulations

Reservoir Data & Geological Data from Oil Field

Economic Analyses, Summary & Conlcusions

Oil Fields Selection FOR CO_2-EOR

Reservoir Parameters

o Viscosity

o Gravity

o Composition

o Oil Saturation

o Formation Type

o Net Thickness

o Ave. Permeability

o Depth

o Temp

Choose the best method

EOR Methods

■ Nitrogen and Flue Gas

■ Hydrocarbon

■ CO2

■ Immiscible gas

■ Micellar/ASP/Alkaline

■ Polymer

■ Combustion

■ Steam

■ Surface Mining

Oil Fields Selection (cont'd)

Reservoir Parameter		Screening Criteria
Oil Gravity	API	> 22 ↗ 36 ↗ a
Viscosity	Cp	< 10 ↘ 1.5 ↘
Composition		High percent of C5 to C12
Oil Saturation	%PV	> 20 ↗ 55 ↗
Formation Type		Sand St. or Carbonate
Net Thickness	ft	Wide Range
Average Permeability	mD	NC
Depth	ft	> 2.500 a
Average Temperature	oF	NC

Oil Fields Selection (cont'd)

INDONESIA PETROELUM WORKING AREAS 2008

as of January 2008

Scale > 1 : 12.000.000

Sangata & Attaka

Kaji Semoga & Jene

Jati Barang & Tugu Barat
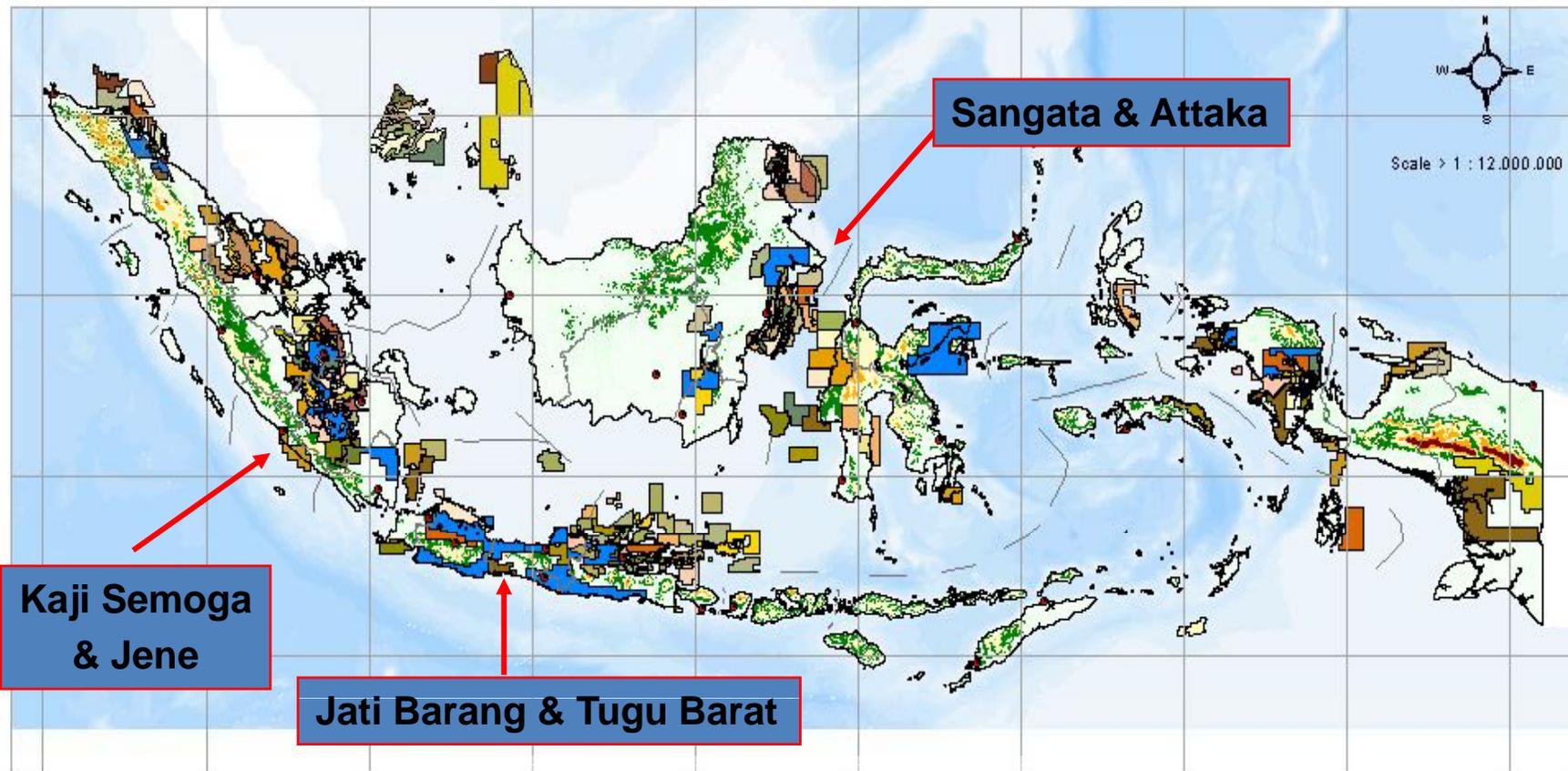
Total Working Areas = 200

Oil Fields Selection (cont'd)
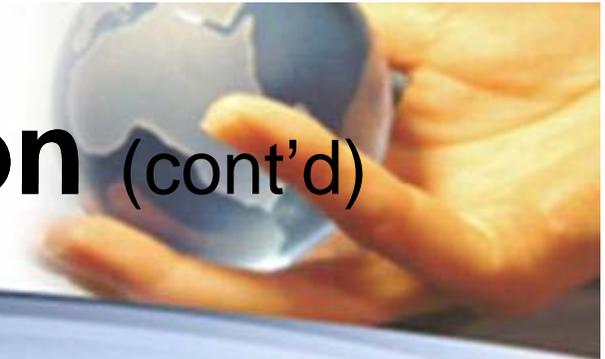
NO.	COMPANY	FIELD	LOCATION
1	CHEVRON	ATTAKA	SOUTH KALIMANTAN
2	PERTAMINA	SANGATTA	SOUTH KALIMANTAN
		JATIBARANG	WEST JAWA
		TUGU BARAT	WEST JAWA
3	MEDCO	KAJI SEMOGA	SOUTH SUMATERA
		JENE	SOUTH SUMATERA

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Laboratory Evaluation

- **MMP Determination**
- **Viscosity Reduction**
- **Swelling of Oil**
- **Oil Composition Lighter**
- **RF Incremental Determination**

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MMP Detemination

SLIM TUBE

MMP Determination

MMP = 2150 psi

Recovery Factor (Fraction)

Injection Pressure (Psi)

Legend:
- 1.2 PV OF CO2 INJECTED
- BLOW DOWN
- GAS BREAK THROUGH

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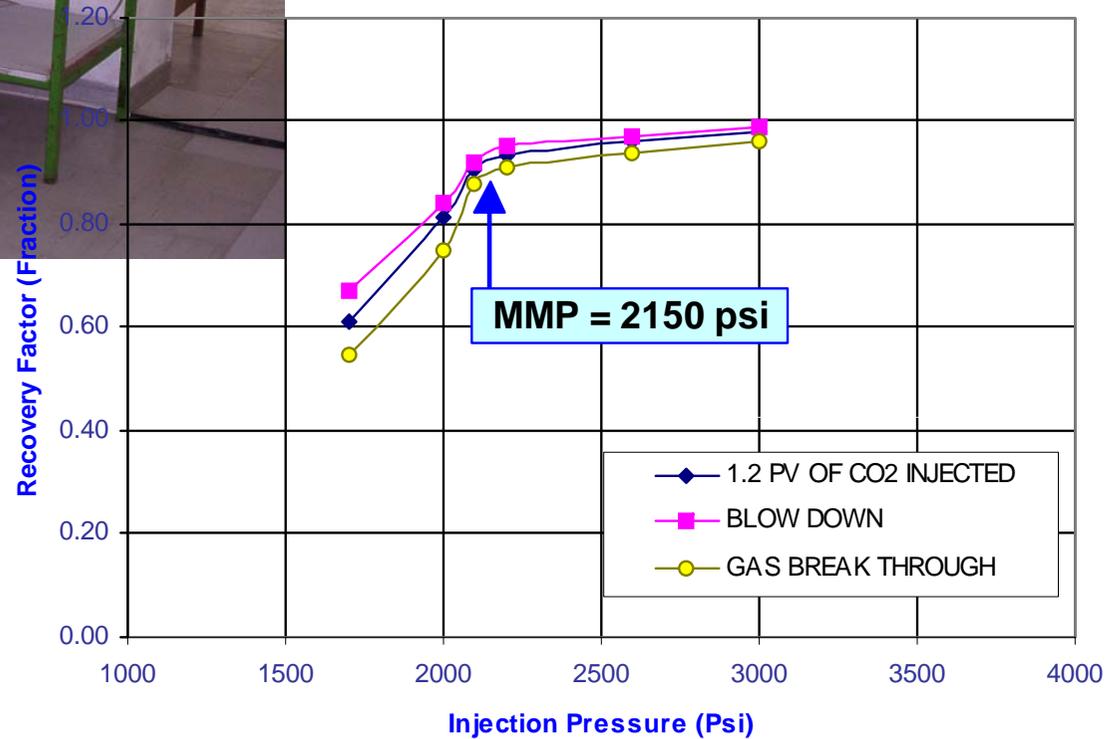
Increasing Ps and Swelling of Oil

SATURATION PRESSURE VS CO2 INJECTION RELATIONSHIP

SWELLING OF OIL

Viscosity Reduction

Viscosity of CO_2 Oil Rich

Legend:
- Ps=835
- CO2 Ps=1250
- CO2 Ps=1380
- CO2 Ps=1500
- CO2 Ps=1658
- CO2 Ps=1850

Y-axis: Viscosity Cp
X-axis: Pressure Psig

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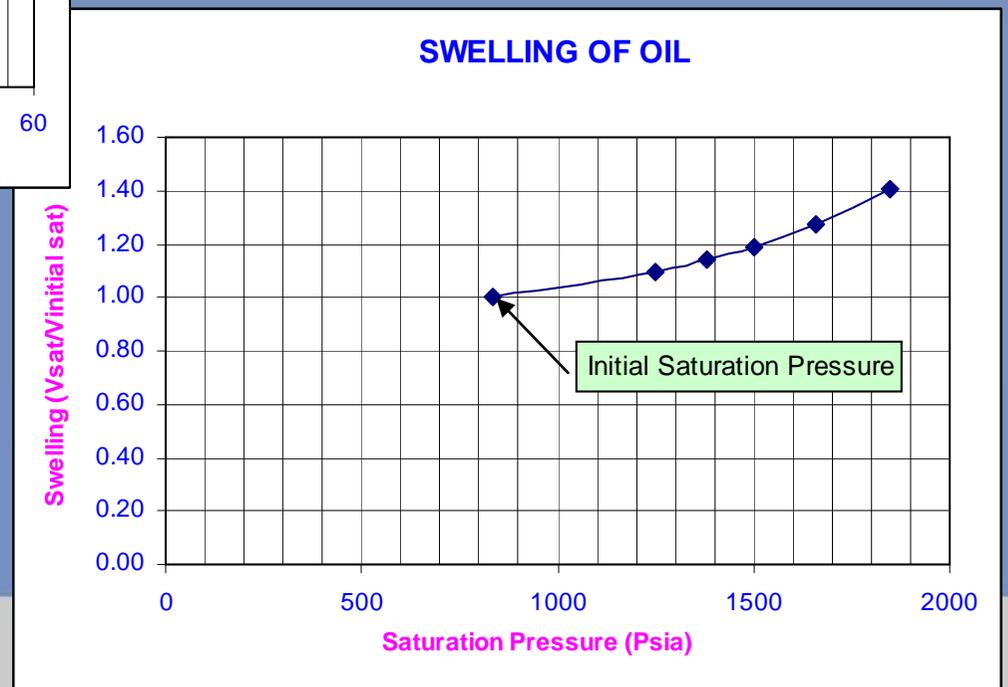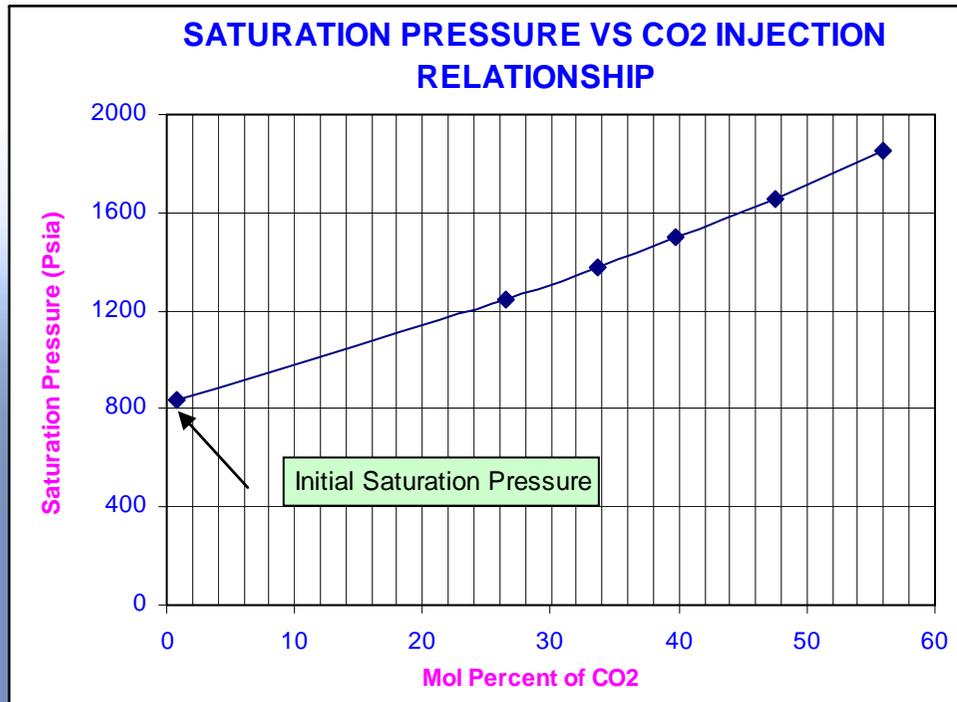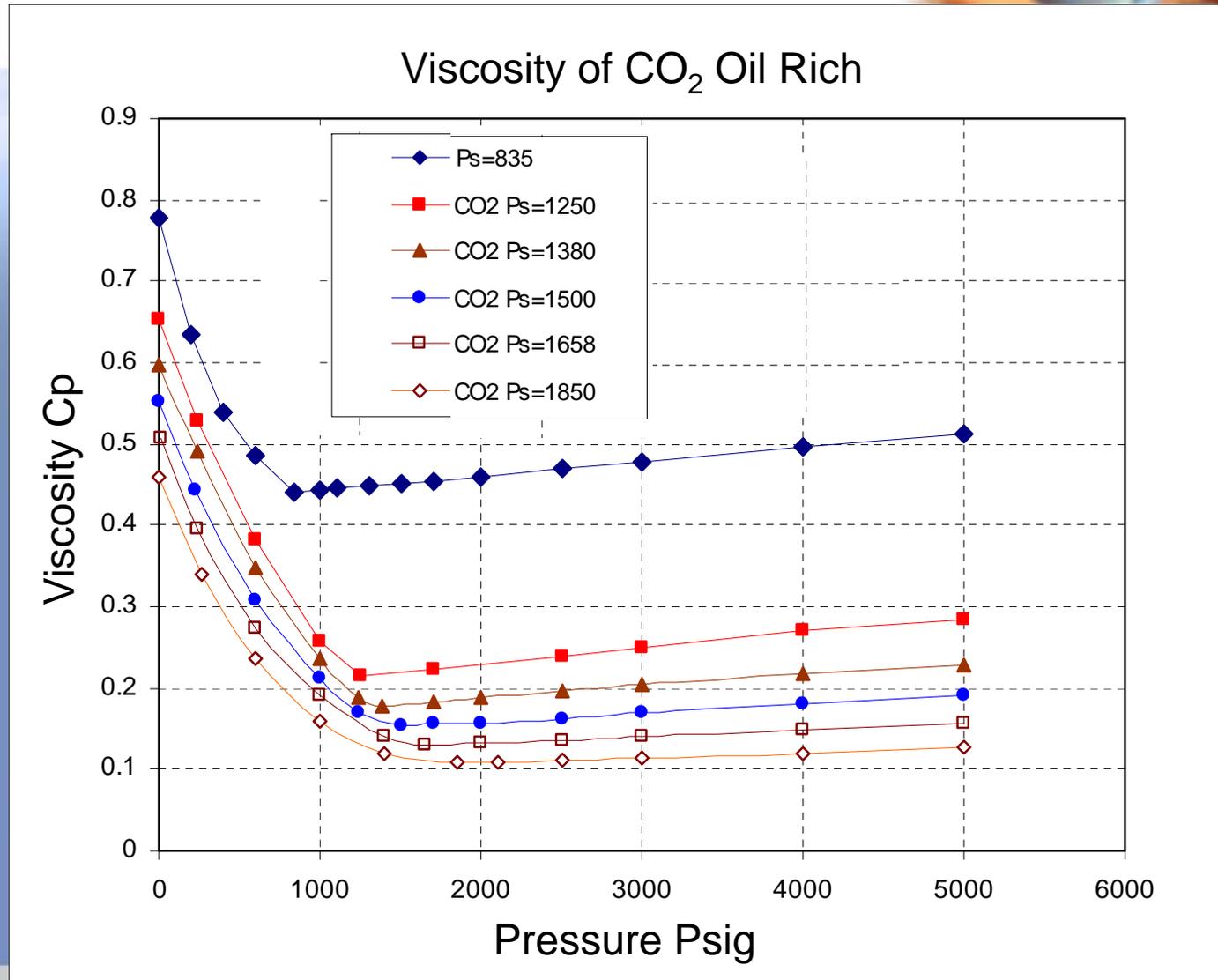
Oil Composition Lighter

Components	Original Reservoir Oil Mol %	CO_2-Oil System I Mol %	CO_2-Oil System II Mol %	CO_2-Oil System III Mol %	CO_2-Oil System IV Mol %	CO_2-Oil SystemnV Mol %
Carbon Dioxide	0.770	26.558	33.687	39.778	47.494	55.958
Nitrogen	0.010	0.007	0.007	0.006	0.005	0.004
Methane	17.260	12.774	11.534	10.475	9.133	7.661
Ethane	3.300	2.442	2.205	2.003	1.746	1.465
Propane	4.820	3.567	3.221	2.925	2.550	2.139
i-Butane	1.960	1.451	1.310	1.190	1.037	0.870
n-Butane	2.770	2.050	1.851	1.681	1.466	1.229
i-Pentane	2.010	1.488	1.343	1.220	1.064	0.892
n-Pentane	1.540	1.140	1.029	0.935	0.815	0.684
Hexane	2.760	2.043	1.844	1.675	1.460	1.225
Heptane+	62.800	46.479	41.968	38.113	33.230	27.873
	100.000	100.000	100.000	100.000	100.000	100.000

RF Incremental Determination

Core Holder

Core flooding Rig
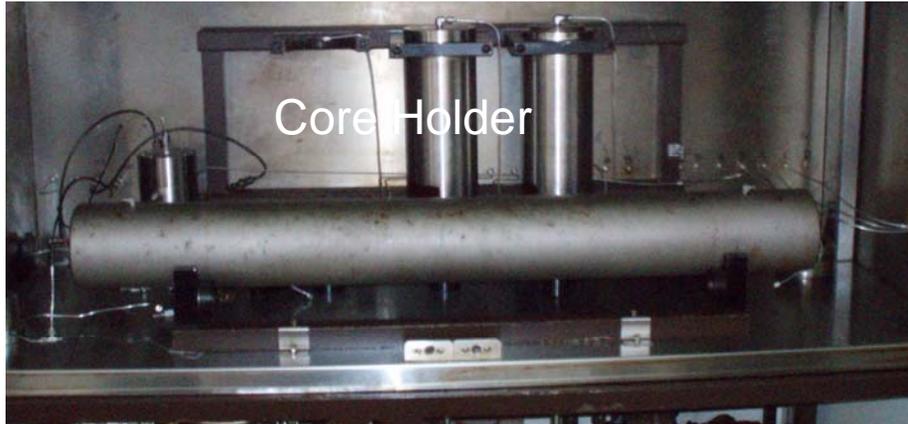
RECOVERY FACTOR OF COREFLOOD TEST AT INJECTION PRESSURE OF 2250 PSIG

- Waterflood
- Initial Gasflood
- Gas Breakthrough
- Cumm. Oil Production
- Cumm. Gas Production
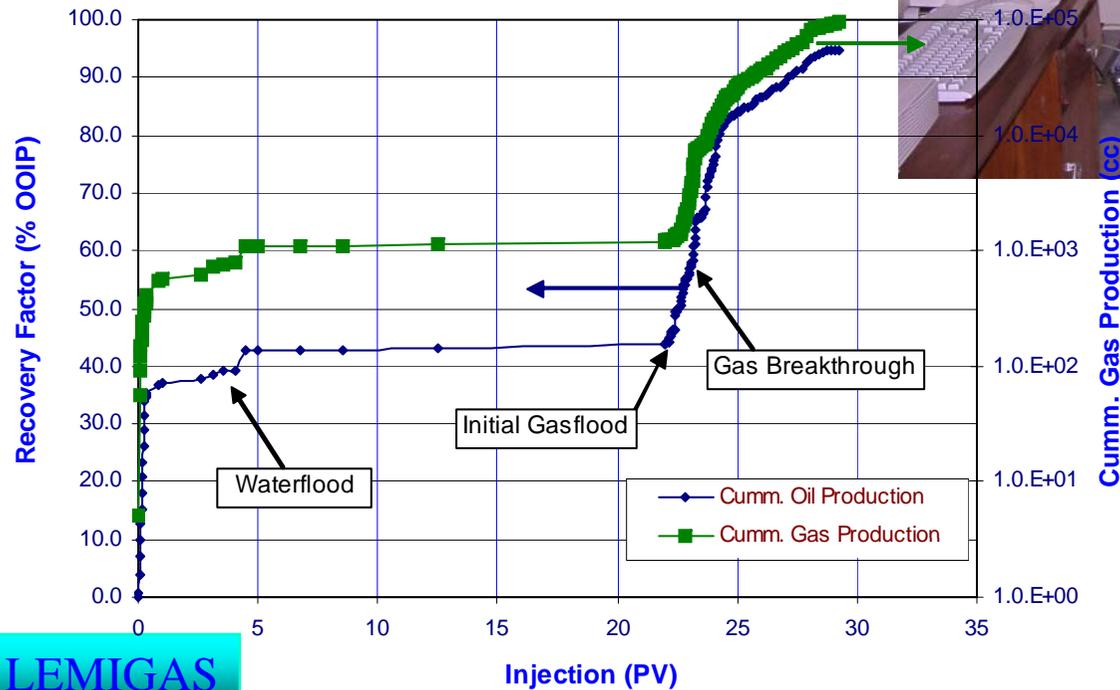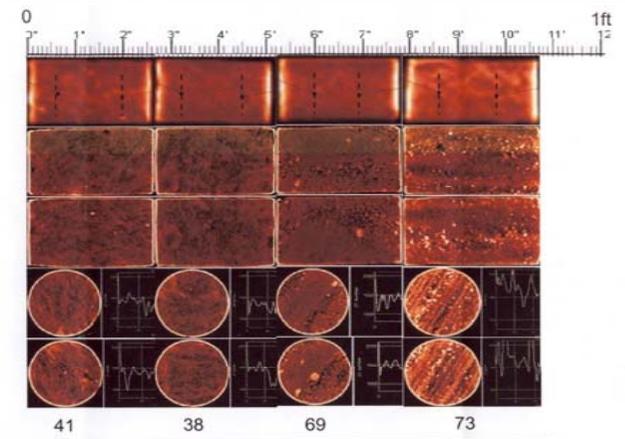
Well	8D-67E	8D-67E	8D-67E	8D-67E
Plug No	41	38	69	73
Perm (mD)	3210	4450	5060	4730
Por (%)	30.5	31.0	29.8	29.7

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Field Selection for Simulation Study

FIELD	WELL	MMP PSIG	COREFLOOD RF (% Sor)	LOCATION
ATTAKA	B-19	2150	90.00	EAST KALIMANTAN
	UB-1	3150	No. CF	
SANGATTA	**ST-77**	**2800**	**93.26**	**EAST KALIMANTAN**
JATIBARANG	JTB-137	2575	96.37	WEST JAWA
TUGU BARAT	TGB-06	3000	52.67	
KAJI SEMOGA	KS-100	2420	70.00	SOUTH SUMATERA
JENE	**Jene-12**	**3200**	**91.33**	

- ❖ Sangatta : LEMIGAS
- ❖ Jene : LEMIGAS
- ❖ Jati Barang : PERTAMINA

Selected For Simulation Study

Sangata Field Simulation

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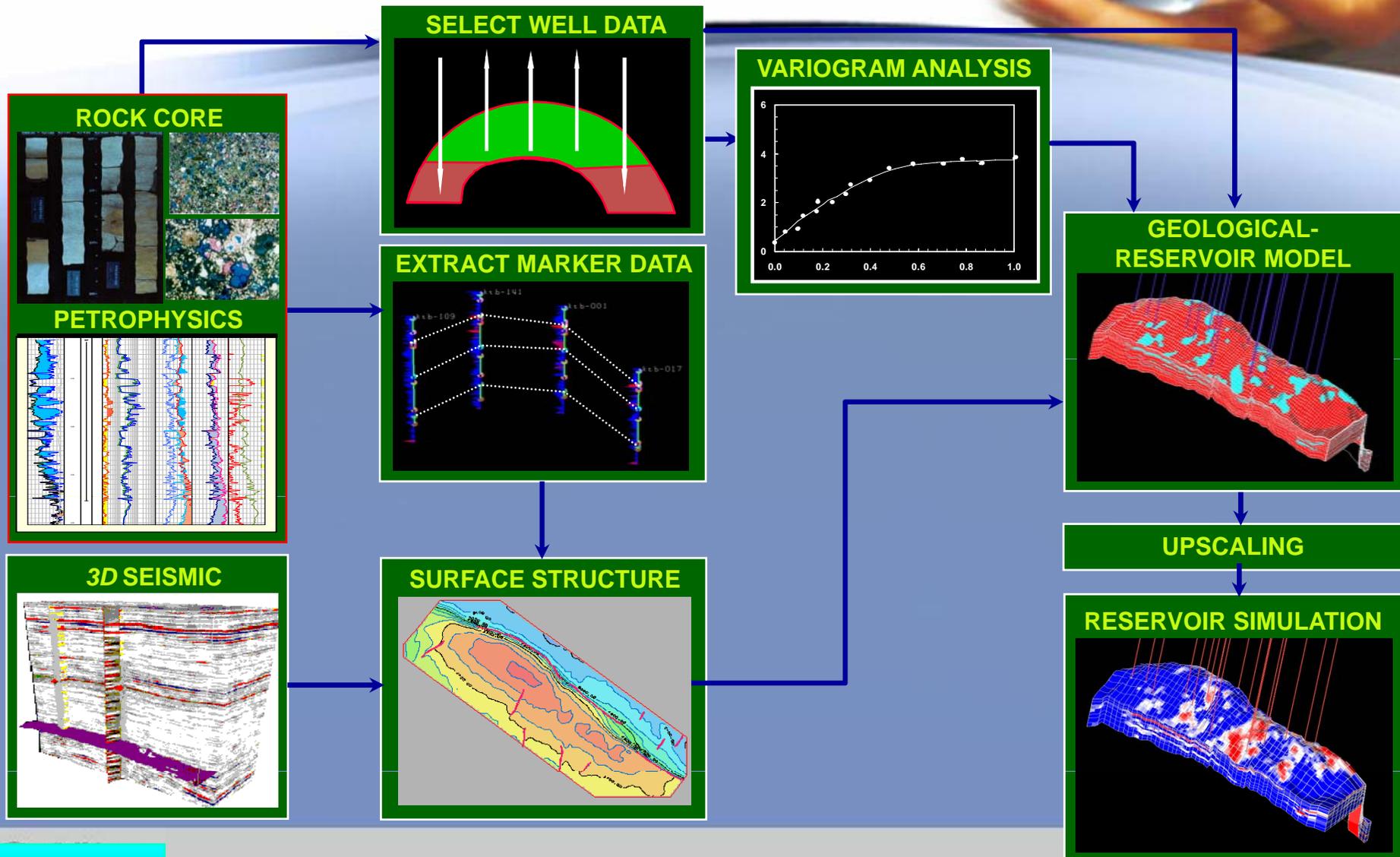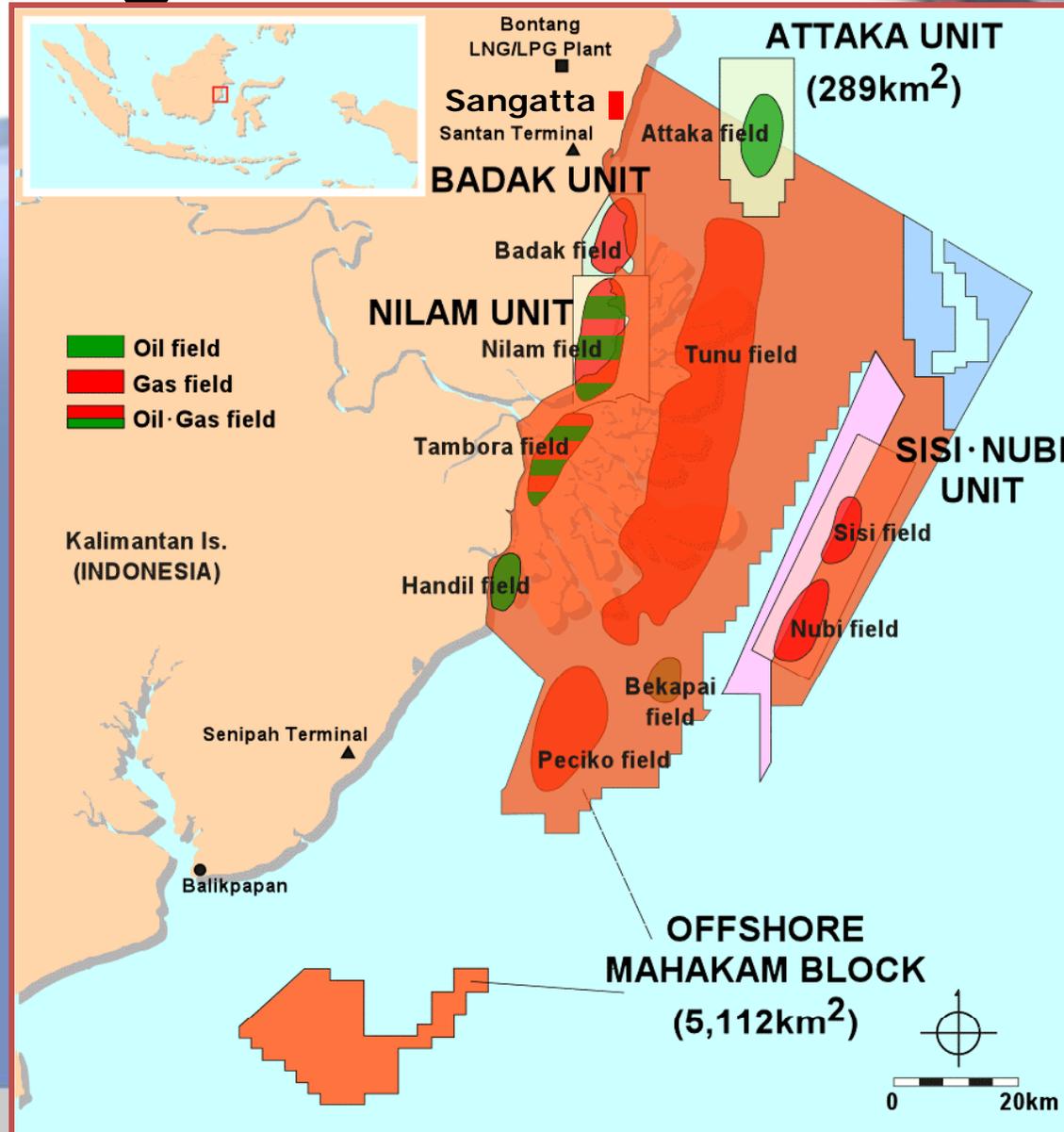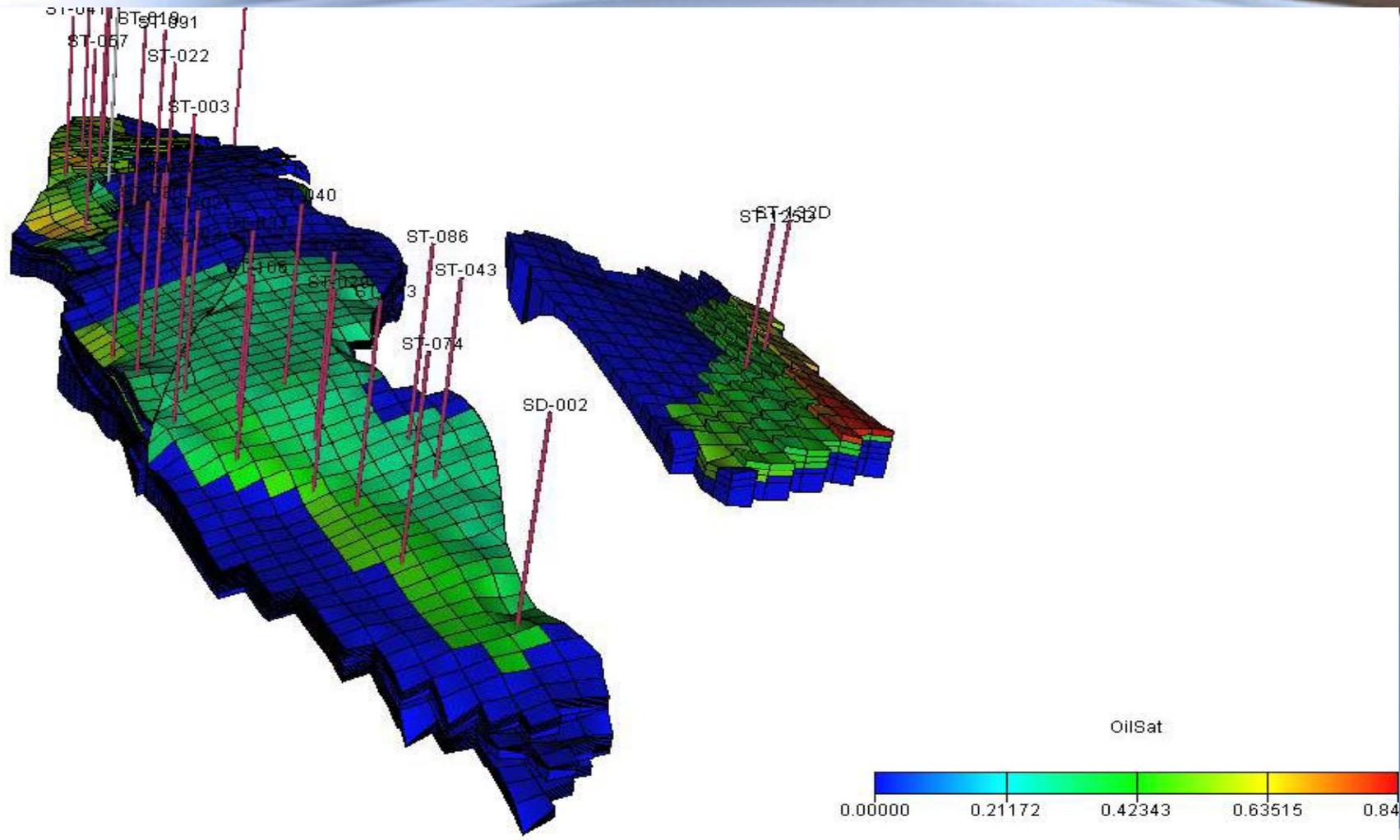
Sangata Field Simulation

Jene Field Simulation

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Jene Field Simulation

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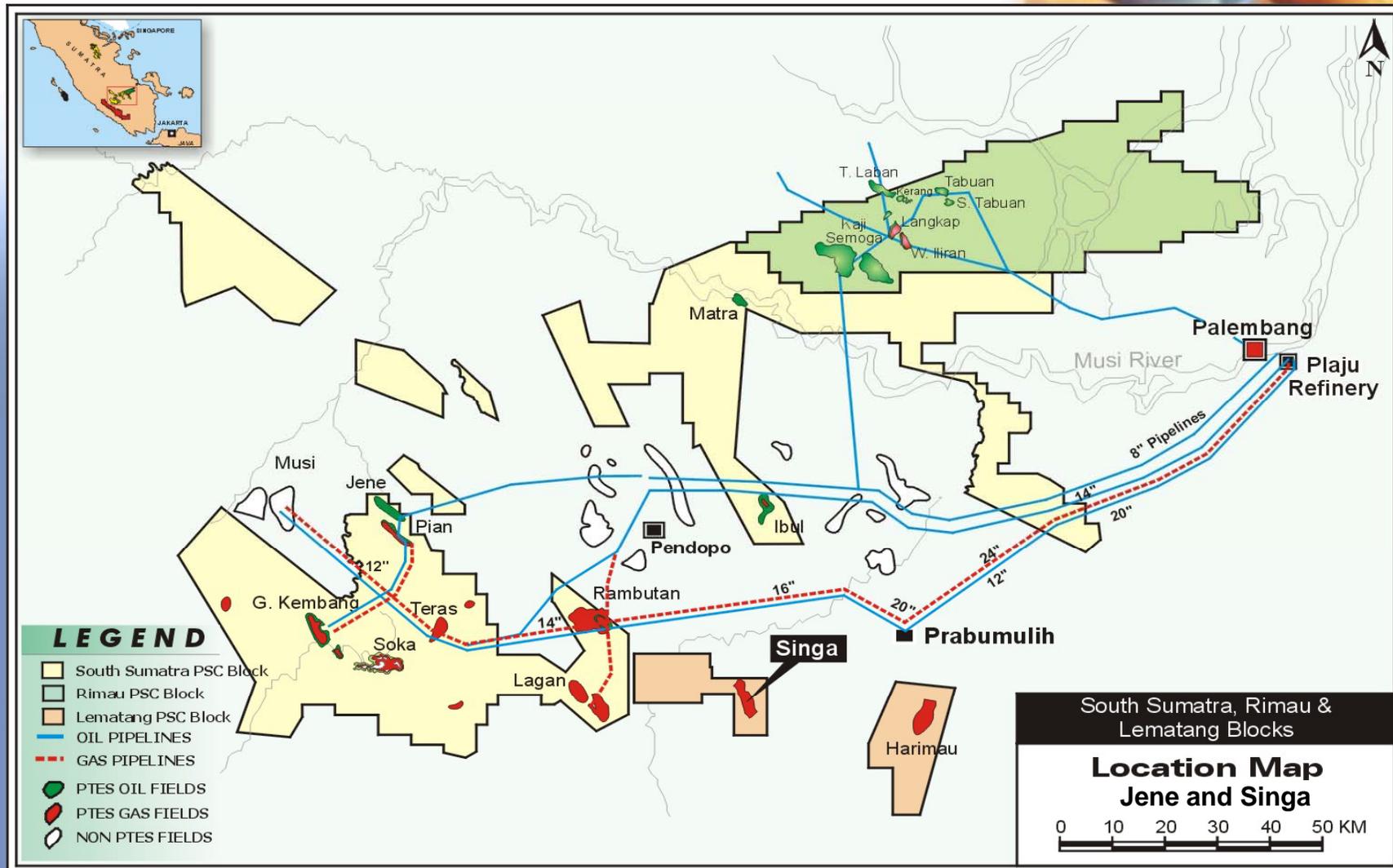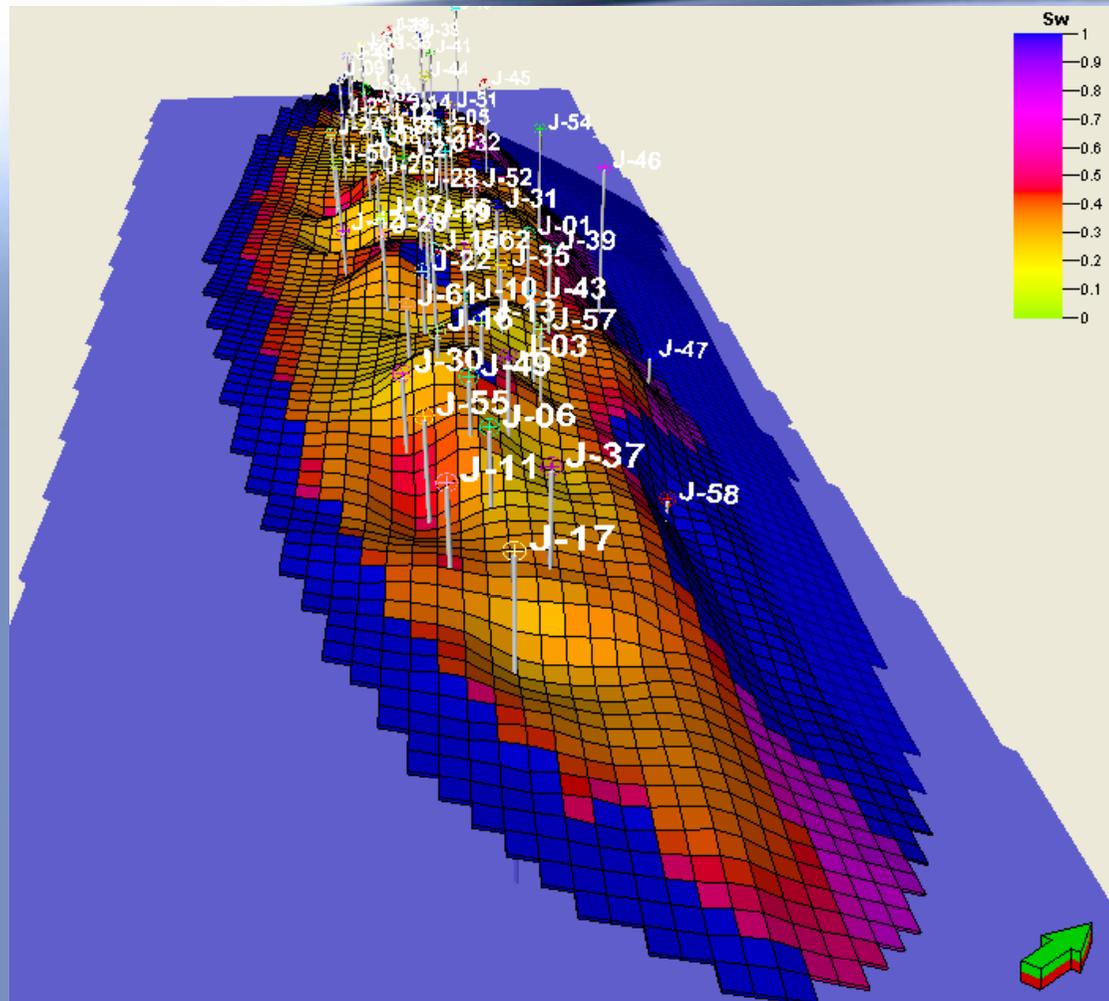
CO_2 Storage – EOR Potential

Rule-of-Thumb Approach (historical experience)

- **Incremental Oil Recovery (% OOIP)**

    - **8-16 %**

- **Gross CO_2 Utilization (Mcf/Bbl)**

    - **5-10 Mcf/Bbl**

- **Net/Gross Utilization Ratio (fraction)**

    - **0.5**

Plan of Implementation (cont'd)

Preparation of Implementation

◆ Estimating Enhanced Oil Production by Laboratory Tests & Studies

◆ Estimating CO_2 Delivery Cost

◆ Studying Total Project Economics

◆ Studying the Merit of CDM Scheme

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Plan of Implementation (cont'd)

Concept of
CO_2 Emission Reduction and Utilization
In Bontang Area

Existing Facilities → CO_2 (Off Gas) → CO_2 Compression & Dehydration → 4,300 T/D

CO_2 (Off Gas) → CO_2 Compression & Dehydration → 9,500 T/D

Bontang LNG Plant → Flue Gas → CO_2 Recovery → CO_2 → CO_2 Compression & Dehydration → 16,000 T/D

2,000 psig

CO_2 Pipeline

CO_2 Pipeline (8~20")

Neighbor Oil Fields

ATTAKA HANDIL BEKAPAI SANGATTA Etc.

Oil Production Incremental
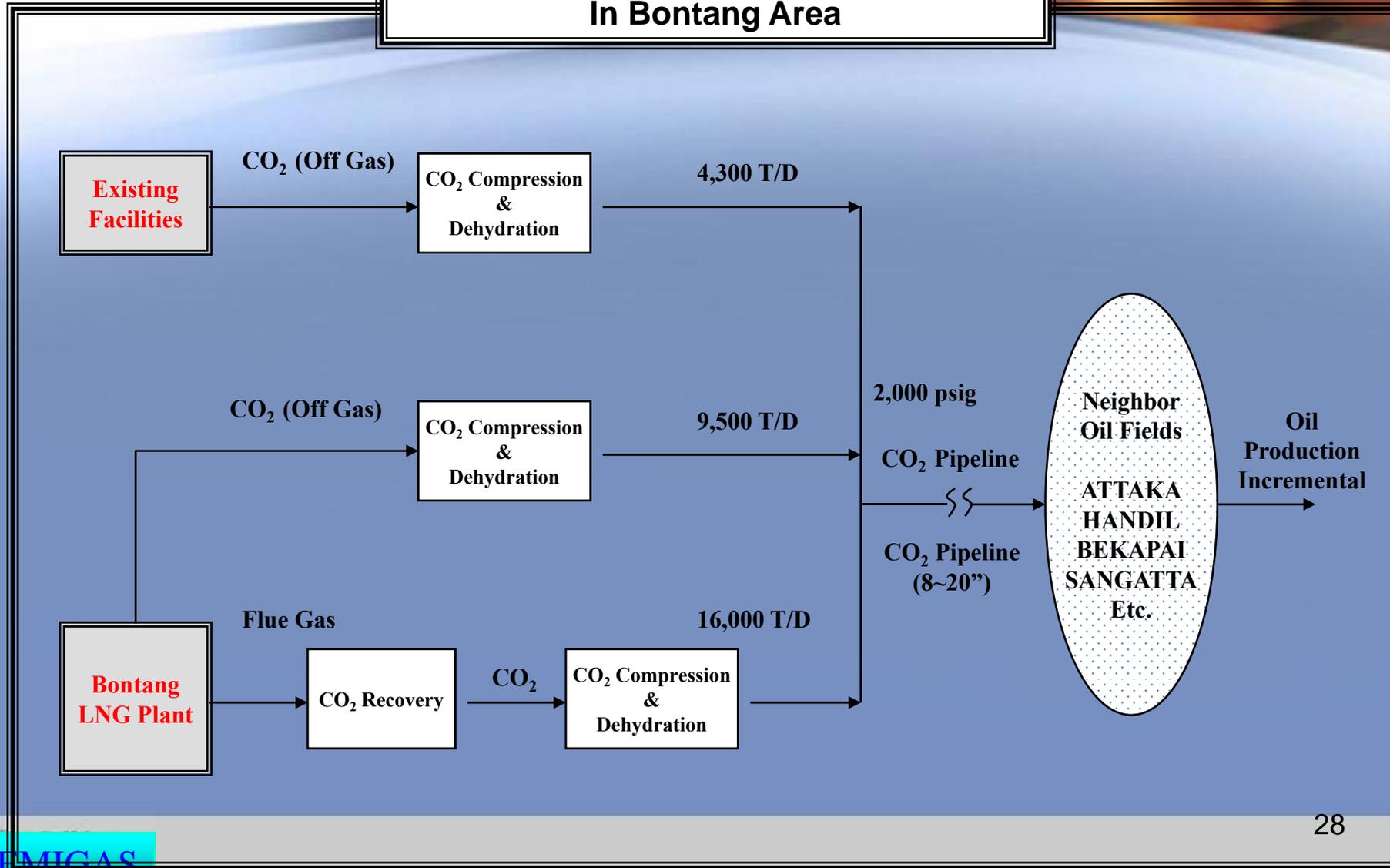
Conclusions

- CO_2 emission especially from Petroleum Industries must be re-injected to follow CDM Scheme

- EOR is the only method to increase oil recovery and offset of cost only project for emission reduction

- Indonesia may build up work cooperation with other countries to implement CO_2-EOR project at Indonesian oil field

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THANK YOU