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Technological challenges and R&D opportunities for the Mexican Oil Industry

Dr. Héber Cinco Ley

CEO Mexican Petroleum Institute

May 7th 2008

Contents

- Introduction
- Exploration and production in deep water
- Secondary and improved oil recovery
- Production and upgrading of heavy oil
- Other challenges
- Summary

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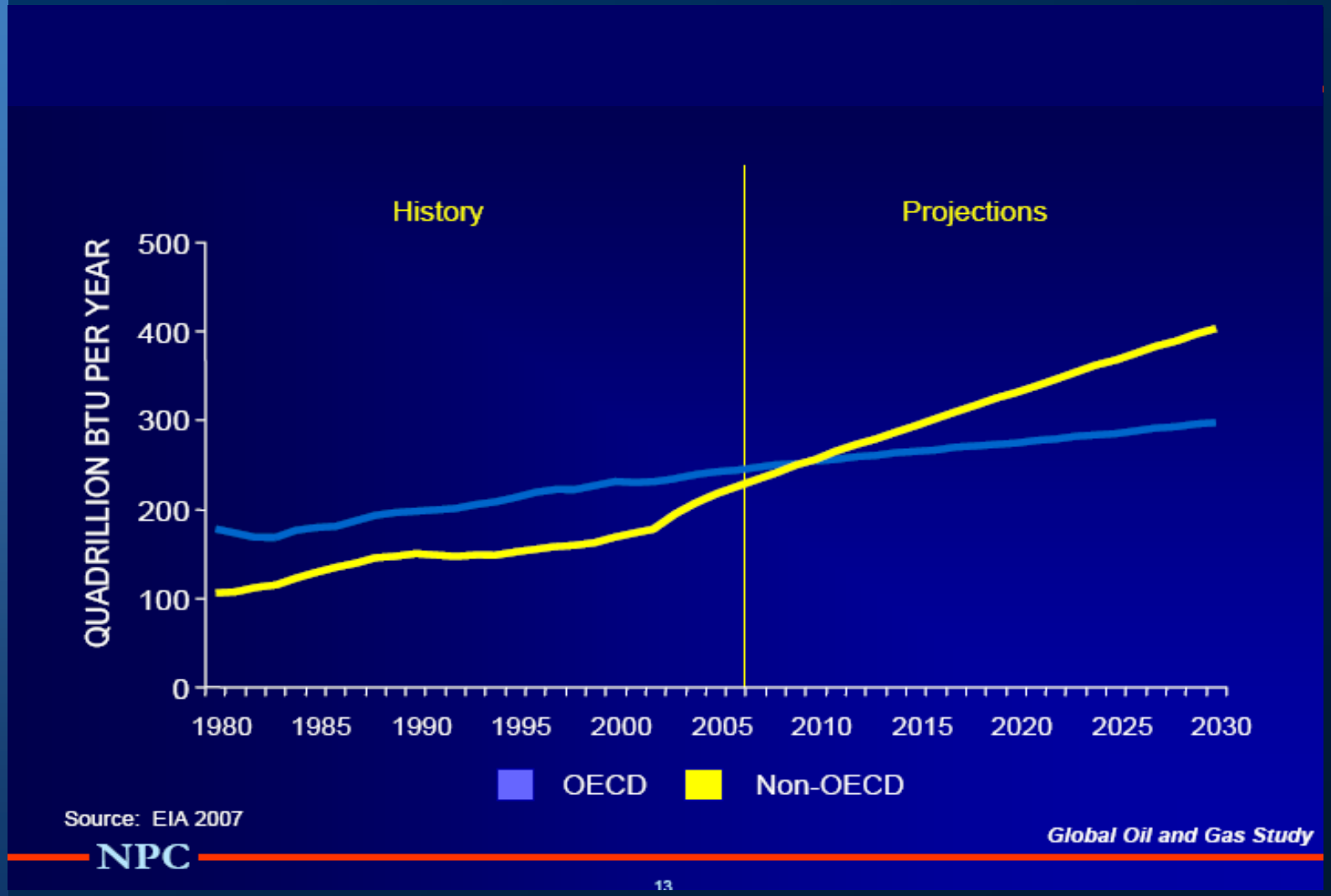
1. Introduction

Challenges in the petroleum industry

Hart's E & P Supplement, Research and Development.

Worldwide demand of fossil fuels

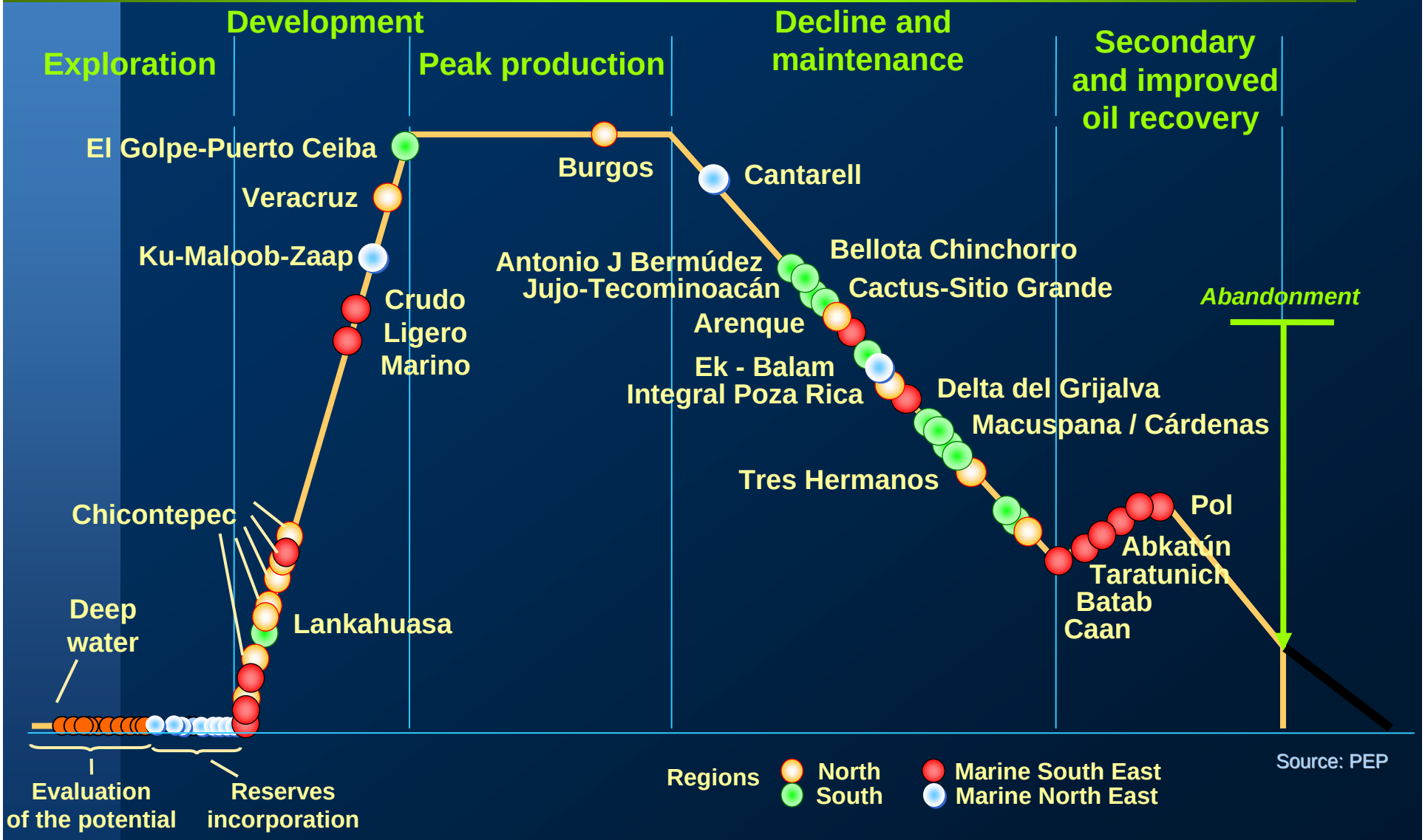


Fuente: OCDE, Global Oil and Gas Study, 2007

Elements to satisfy worldwide hydrocarbon demand

- Incorporation and development of reserves mainly from deep water
- Increase of recovery efficiency for existing fields:
  - Application of secondary and improved oil recovery
  - Use of innovative technologies to extend the productive life of reservoirs
- Cost reductions in oil field discoveries and oil production
- Development of processes to optimize the use of data, tools, technologies and personnel

Life cycle of exploration and production projects in Mexico



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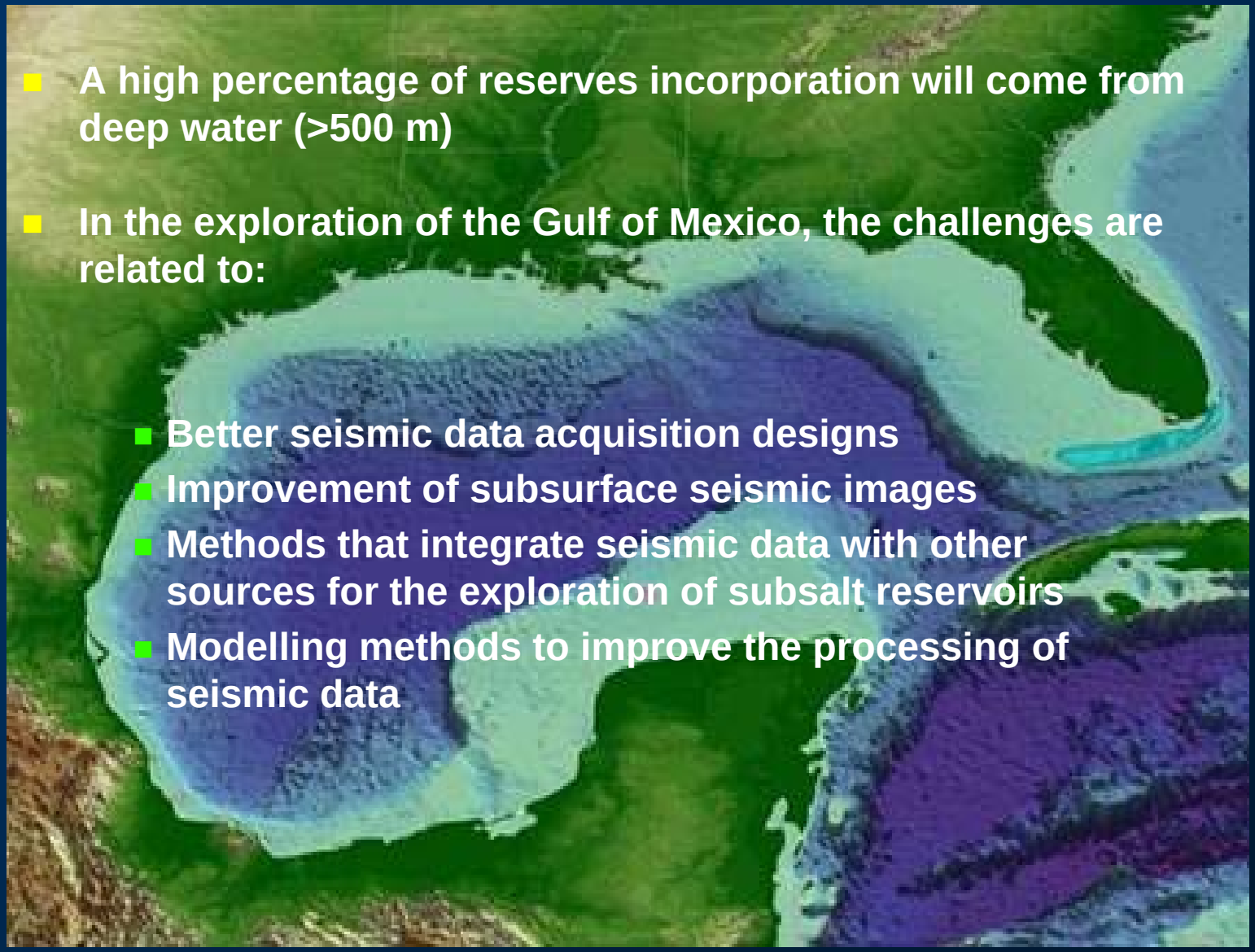
2. Exploration and production in deep water

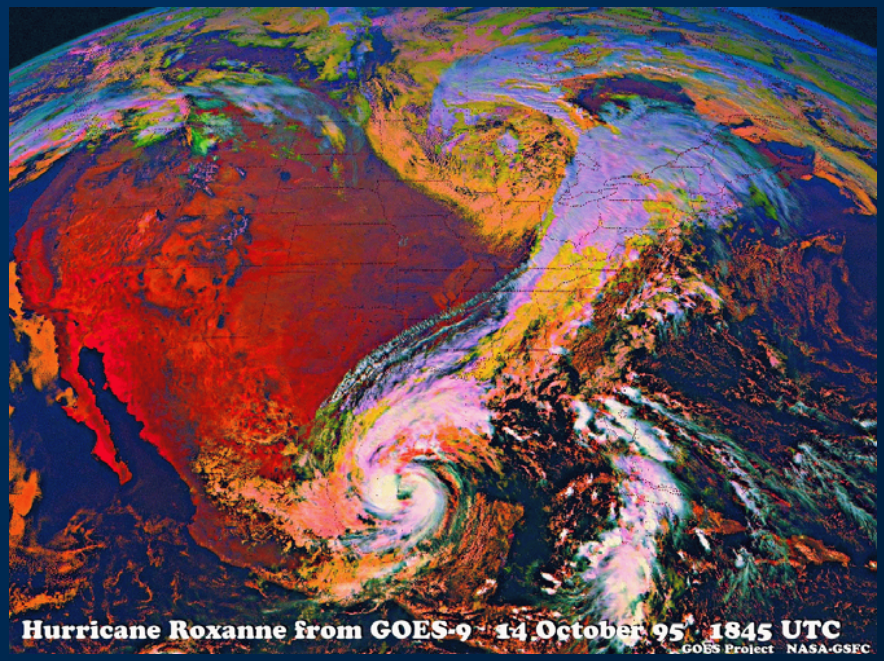
Exploration in deep water

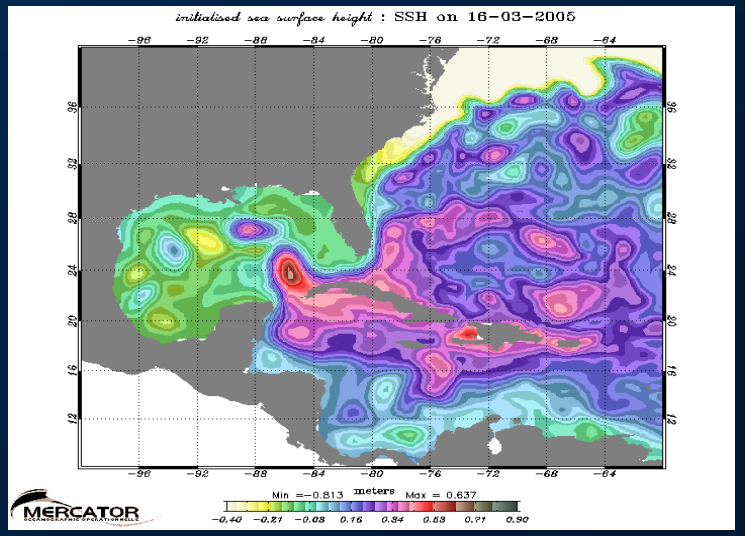


- A high percentage of reserves incorporation will come from deep water (>500 m)
- In the exploration of the Gulf of Mexico, the challenges are related to:
  - Better seismic data acquisition designs
  - Improvement of subsurface seismic images
  - Methods that integrate seismic data with other sources for the exploration of subsalt reservoirs
  - Modelling methods to improve the processing of seismic data

Production in deep water

- Oceanographic, meteorological and geotechnical characterization
- Development of reliability based codes for selection, design and assessment of production systems
- Complement the current project administration capacities





Numeric oceanographic model
GOM

Production in deep water

Deep water production systems

Deep water production Systems

- Floating systems, moorings and risers:
  - Behaviour of semisubmersibles under ultra deep water conditions
  - Composite materials for TLP tendons and risers
  - Analysis and testing of risers under Vibration Induced by Vortex (VIV) conditions
- Subsea processing
  - Multi-phase pumping
  - Wet compression
  - Separation
  - Extra heavy oil modelling

Production in deep water

- Flow assurance
  - Modelling of hydrate formation, asphalthenes and wax precipitation
  - Mechanical techniques for prevention
- Control, pipelines and subsea systems
  - Reliability assessment of subsea control systems
  - Real time monitoring
- High pressure and temperature conditions
  - Well drilling and completion
  - Subsea production systems

Methane hydrates blockages

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3. Secondary and improved recovery

Hydrocarbon recovery

Technologies

Water injection	Chemicals	Gas injection	Thermal
Gas injection	Polymers	Nitrogen injection	Steam injection
	Gels	CO_2 injection	Steam Additives
	Surfactants		Air injection
	Microbial	Acoustic stimulation	Catalyst injection
		Microwave stimulation	

Secondary recovery

Improved recovery

New processes

In Mexico, the main challenges are related to the exploitation of mature fractured reservoirs and those of the type of Chicontepec

Naturally fractured reservoirs

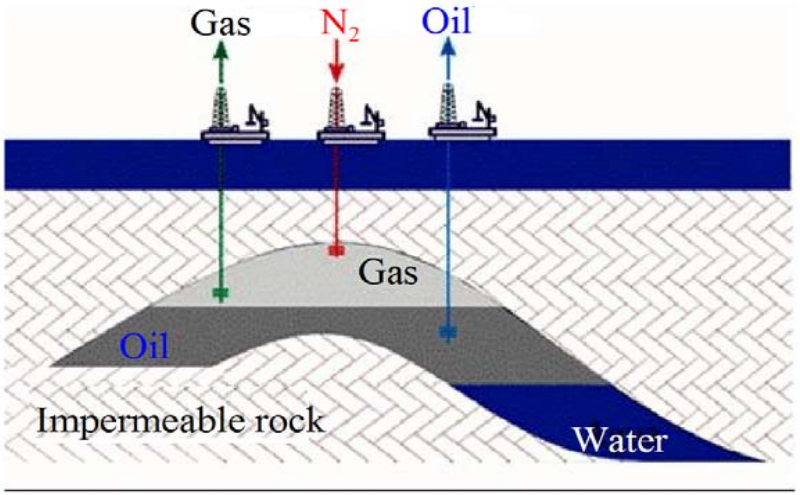
- Most production is associated with naturally fractured reservoirs
- Due to their features, they are difficult to characterize, model, and simulate
- There are no analogous examples to use in the documentation of recovery processes
- Emerging technologies
  - Characterization of fracture systems
  - Reservoir simulators that include matrix, vuggy and fracture porosity
  - New improved recovery processes

Fracture features of the Cantarell oil field

The development of technologies to understand fluid-rock interaction and proposals for specific recovery processes is necessary

Naturally fractured reservoirs

- Identification of recovery processes that allow the extraction of crude from the matrix
- Remaining oil recovery in zones with water invasion
- Remaining oil recovery in the gas cap in Cantarell
- Identification of zones with remaining oil



Remaining oil in the Cantarell gas cap after nitrogen injection: Approx. 16,000 MMB

Chicontepec oil field

- Main features
  - Represents the largest oil reservoir in Mexico
  - Heterogeneous reservoir, formed from alternating sandstones and shales with carbonate cementation
  - Irregular distributions of important formations
  - Low permeability reservoir with low productivity wells
  - Low initial reservoir pressure
  - Expected primary recovery for Chicontepec: 5-7%
- Emerging Technologies
  - Improved subsurface images
  - Unconventional wells
  - Improved recovery with new processes

- Optimized water injection
- CO_2 injection
- Chemical injection (ASP)

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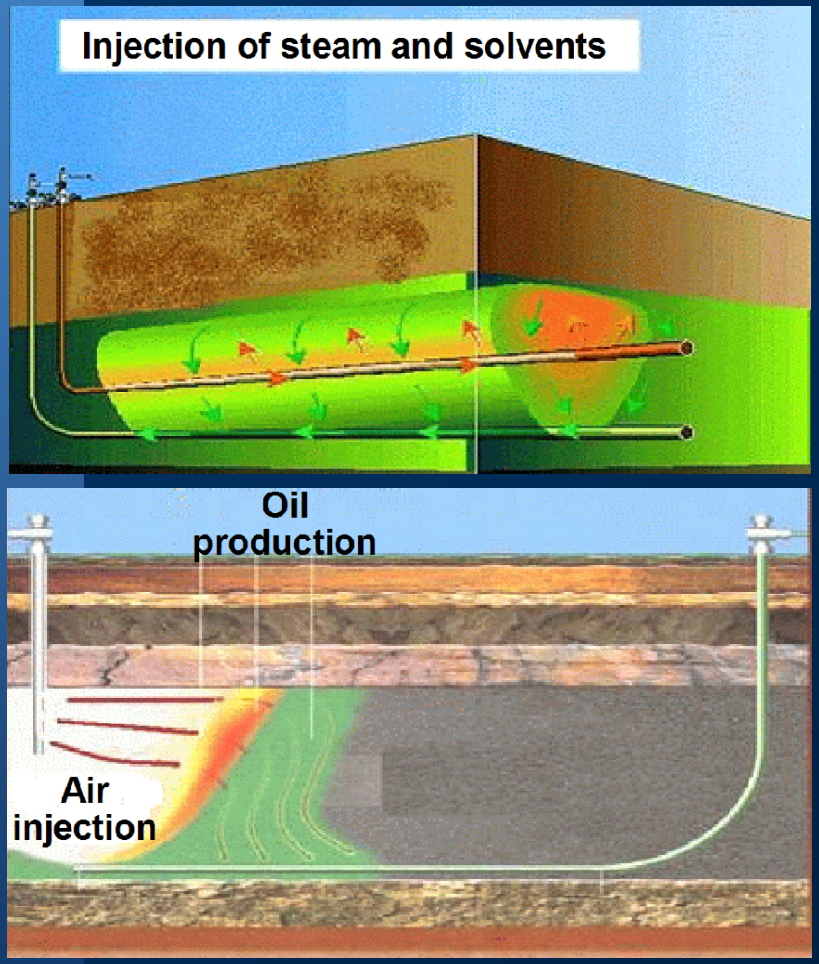
4. Production and improvement of heavy oil

Heavy oil accumulations

- Tertiary reservoirs
- Mesozoic reservoirs

Exploration opportunities
54 onshore
117 offshore

Heavy oil production technologies

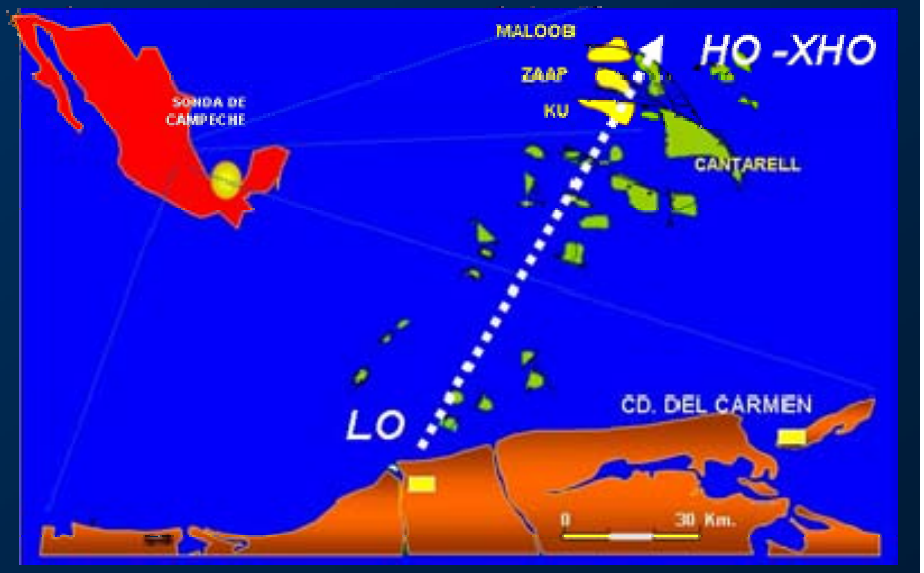


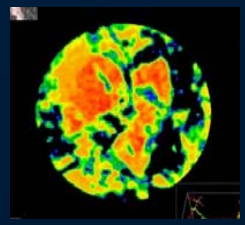
Application of improved recovery processes in heavy oil reservoirs: steam, VAPEX, SAGD, *in situ* combustion

- A large part of worldwide reserves are related to non-conventional accumulations where heavy and extra heavy oil predominates
  - Complex production, transport and handling
  - Needs additional treatment and processing for its exploitation and commercialization
  - High sulphur content, metals, and coke-precursors
- Emerging technologies
  - Non-conventional drilling
  - Gel-foam injection
  - Solvent-optimized steam injection
  - Subsurface upgrading
  - Upgrading at the surface
  - Heavy oil processing

Heavy oil offshore Mexico

- An important part of heavy oil reserves in Mexico are in offshore fields in the Gulf of Mexico
- These reservoirs are associated with fractured carbonates
- An important part of the production technologies has been developed for sandstone reservoirs and also for onshore environments
- The main technologies which can be adapted for the exploitation of these reservoirs are: gas injection, solvent injection and oil upgrading





Heavy oil offshore Mexico

- Commercially applied technologies for enhancing heavy oil can be classified as catalytic hydro-treatments at high pressure and thermal processes
- The main challenges for oil enhancement are:
  - To improve IMP hydro-treatment technology for enhancement of Mexican heavy oil, to achieve a higher profitability in comparison with H-Oil and delayed coking processes
  - To generate technology for viscosity reduction in extra heavy oil at marine installations, facilitating its transport onshore with a minimum requirement of supplies and sub-product handling

IMP new technology for heavy oil upgrading

- Hydrotreating technology operated under moderate conditions
- Increase of °API
- Reduce substantially sulphur, metals and sediments
- Increase distillates yield

Results of upscaling of the technology

	Ku-Maloob-Zaap Oil	Upgraded oil
°API	12.93	23.38
Sulphur (ppm)	5.19	1.15
Metals (ppm)	584	98
Sediments %wt	ND	0.01

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5. Other challenges

Control and management of produced water in reservoirs

- Worldwide, the production of water in oil wells is in the order of three barrels per barrel of oil produced
- In mature reservoirs, the challenge is to handle the produced water economically
- In deep water reservoirs, the challenge is to predict accurately the amount of water production, in order to develop an improved production plan for these fields
- Current situation in Mexico:
  - Many fields produce with a high water cut, affecting hydrocarbon production (e.g. Samaria, Jujo-Tecominoacán)

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6. Summary

Summary

The main challenges for the petroleum industry are:

- Increase the rate of reserves replacement
- Develop deep water fields
- Achieve better seismic images in sub-salt plays
- Improve subsurface interpretation and modelling
- Carry out efficient drilling at lower costs
- Develop processes for oil production in fractured reservoirs
- Develop heavy and extra heavy oil recovery technologies that are technically and economically advantageous
- Develop technology for viscosity reduction in heavy and extra heavy oil
- Develop effective diagnosis, control and management methods for water production in reservoirs

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Thank you