Mature Fields: Key Factors for Successful EOR Projects*

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Abstract

Notwithstanding the recent advances in geological, reservoir, and production technologies as well as the significant ramp up in oil prices over the last decade, the Ultimate Recovery in producing reservoirs around the world averages between 30-40%. In our opinion, reasons for the low recovery factor are the relatively low number of EOR projects worldwide where such technologies are applied. It is estimated that total worldwide production coming from EOR projects is around 1 million barrels of oil per day, which represents less than 1% of total world production.

This paper reviews various EOR methods but it focuses largely on CO_2 injection and steam flooding as these are the most successful methods from the production point of view.

It is the authorôs opinion that some of the key factors, both technical and economical which contribute the most to the success of EOR projects are the following:

1. Proper reservoir suitability, primarily volumetric sweep efficiency.
2. The need of an upgraded or in some cases a new reservoir geological model.
3. Plentiful and inexpensive injection fluids.
4. Optimum monitoring of pilot and field wide expansion project.
5. Strategic technology approach.
6. Continuous profitability management.

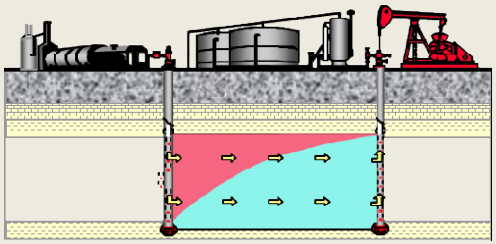
Reference Cited

Greaser, G., and R. Ortiz, 2001, New thermal recovery technology and technology transfer for successful heavy oil development: SPE International Thermal Operations and Heavy Oil Symposium, March 12-14, 2001, Porlamar, Margarita Island, Venezuela, SPE 69731-MS, 7 p. doi:10.2118/69731-MS.

ENHANCED OIL RECOVERY

Growing Production and Reserves

Key Factors for Success



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Agenda

- Today's Message and Value of EOR
- Ultimate Recovery Factors
- Main EOR Methods
- Steamflooding
  - Principles
  - Success Story
  - SAGD
  - Keys to Success
- CO2 Flooding
  - Principles
  - Success History
  - Keys to Success
- Summary

Today's Message

One of the best places to find new oil reserves is in your own field!

You know the geology, you have the wells, and you have the data

Once you have produced on primary by gas expansion or water drive, and after secondary recovery by waterflooding, what's left . . .

Most of the OOIP in known and understood reservoirs

Improving the average recovery factor by 1% globally = 50 Billion barrels of Oil!

Global Ultimate Oil Recovery Factors

Method	% Recovery	Process
Primary	5-25	Natural Decline
Secondary	25-45	Pressure maintenance
EOR (Tertiary)	45-80	Rock and fluid modifications

Global Average Recovery Factor = 35%

MAIN EOR METHODS

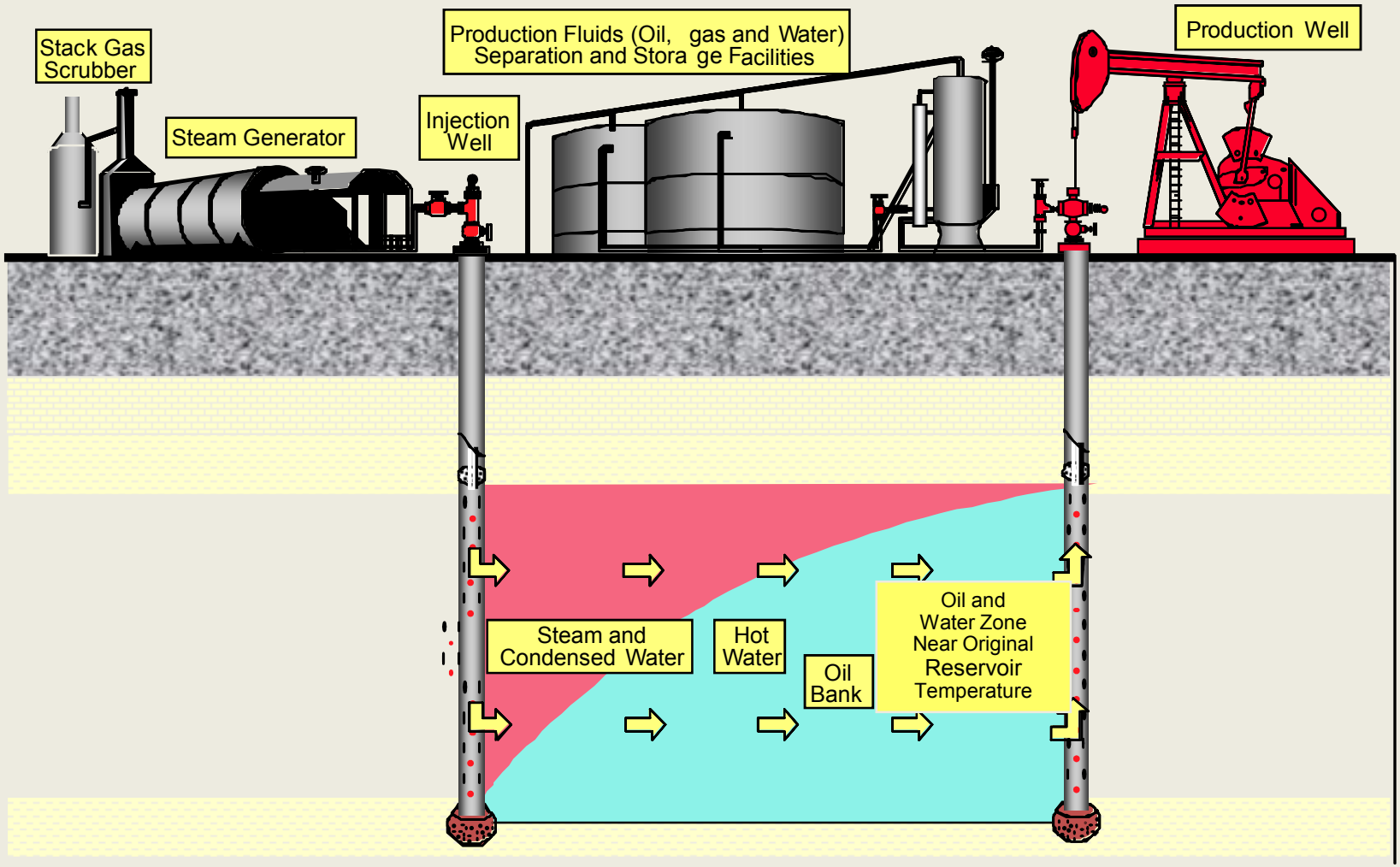
Method	No. of Projects	No. of Projects	MBO/day	Locations
Steam Flooding (Continuous & Cyclic)	Vertical Wells	50	500	California, Indonesia
	SAGD	9	460	Canada
In Situ Combustion (including THAI)		11	18	Rockies, Colorado
CO2 Injection (Miscible pressure)		120	300	Permian, Rockies
Chemical Flooding		3	20	Permian Basin
Hydrocarbon Miscible		10	200	Alaska, Venezuela
TOTAL		**203**	**1,498**	

Note:
Projects in China and India are excluded
Low-salinity waterfloods, microbial and other minor or high cost methods are excluded.

Why so Low EOR Production?

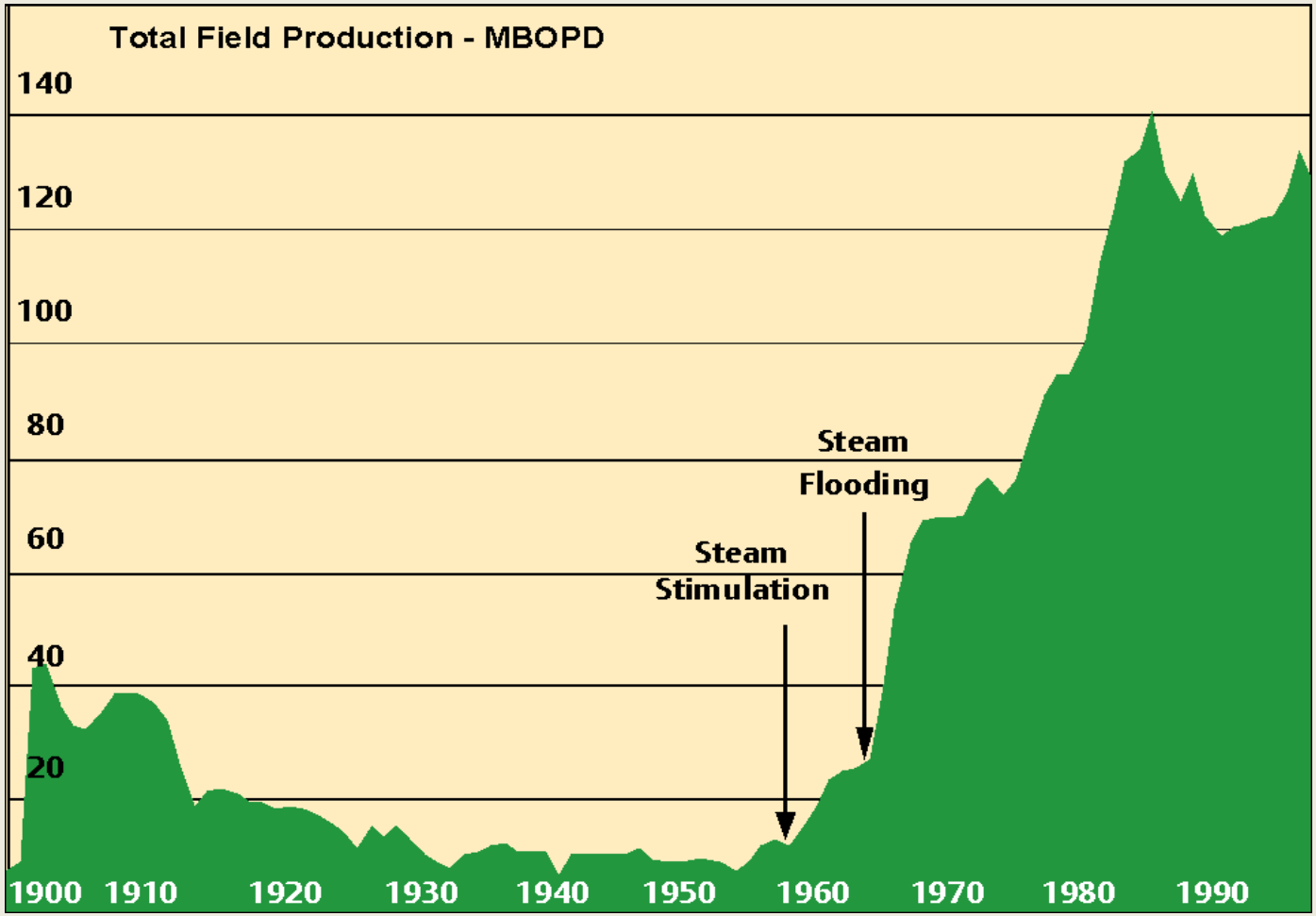
- Very Complex (need to know more details)
- Poor Pilot Design (need to gain investor confidence)
- Poor Surveillance (work is very detailed and time-consuming)
- Availability of Injection Fluid (e.g. steam, CO2)
- Conventional Contract Terms (need long-term reliability)
- Critical Skills Shortage (EOR requires specialised skills)
- Lack of “Romance” (explorationists are the golden ones)

STEAM FLOODING



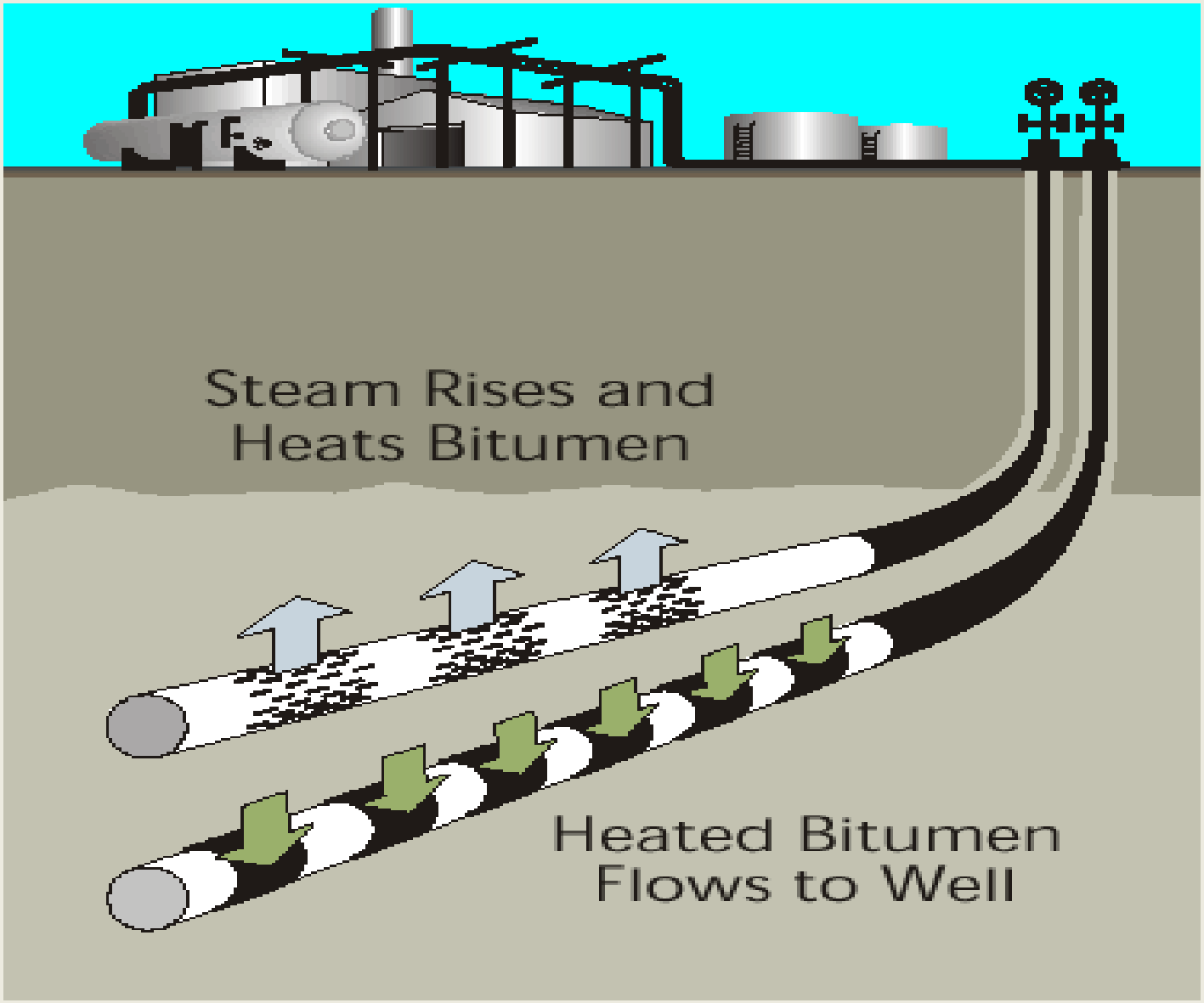
Steam Flooding: a Major Success Story

Chevron's Kern River Field in California



From SPE 69731: R. Ortiz & G. Greaser, Texaco Inc.

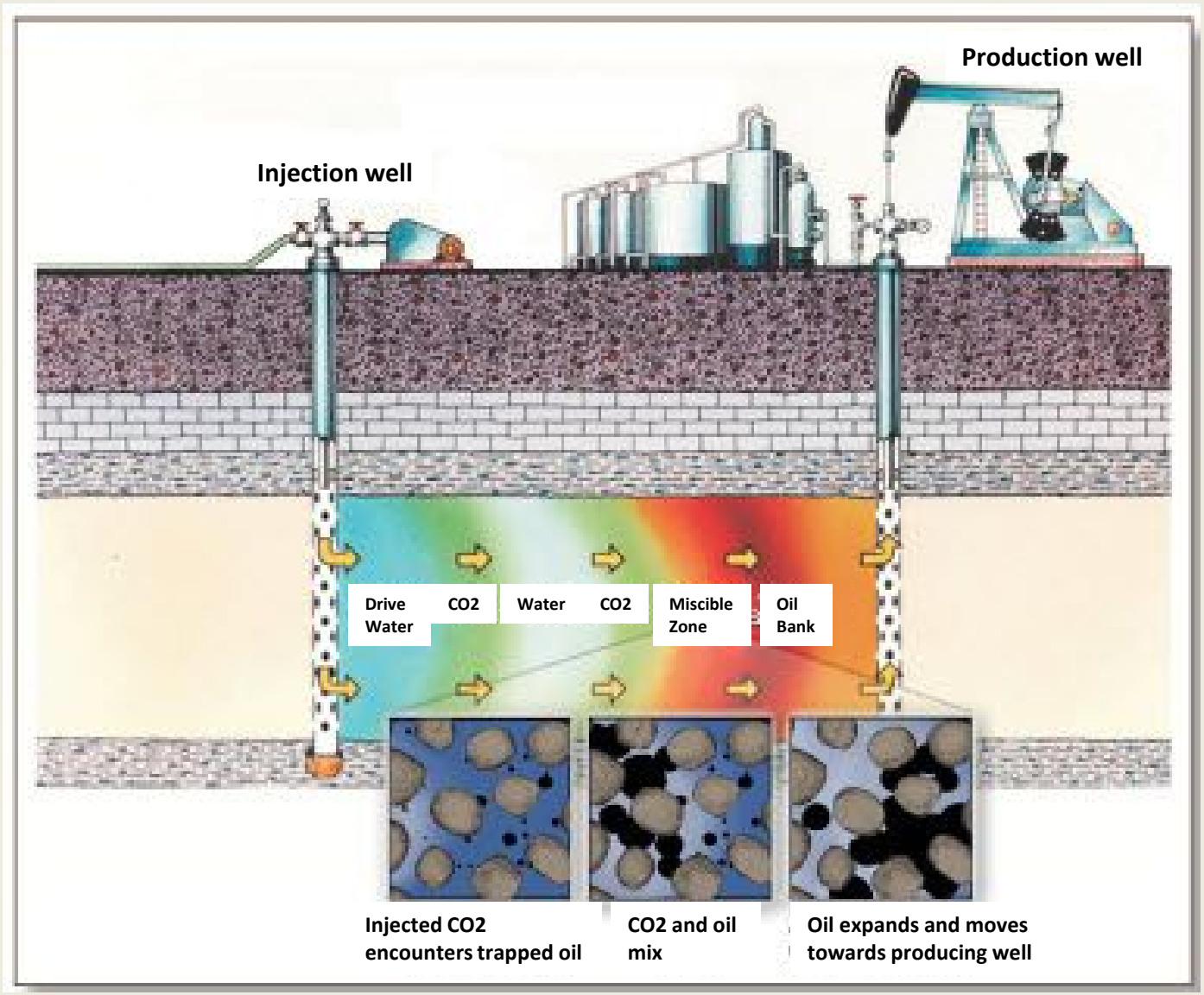
STEAM-ASSISTED GRAVITY DRAINAGE (SAGD)



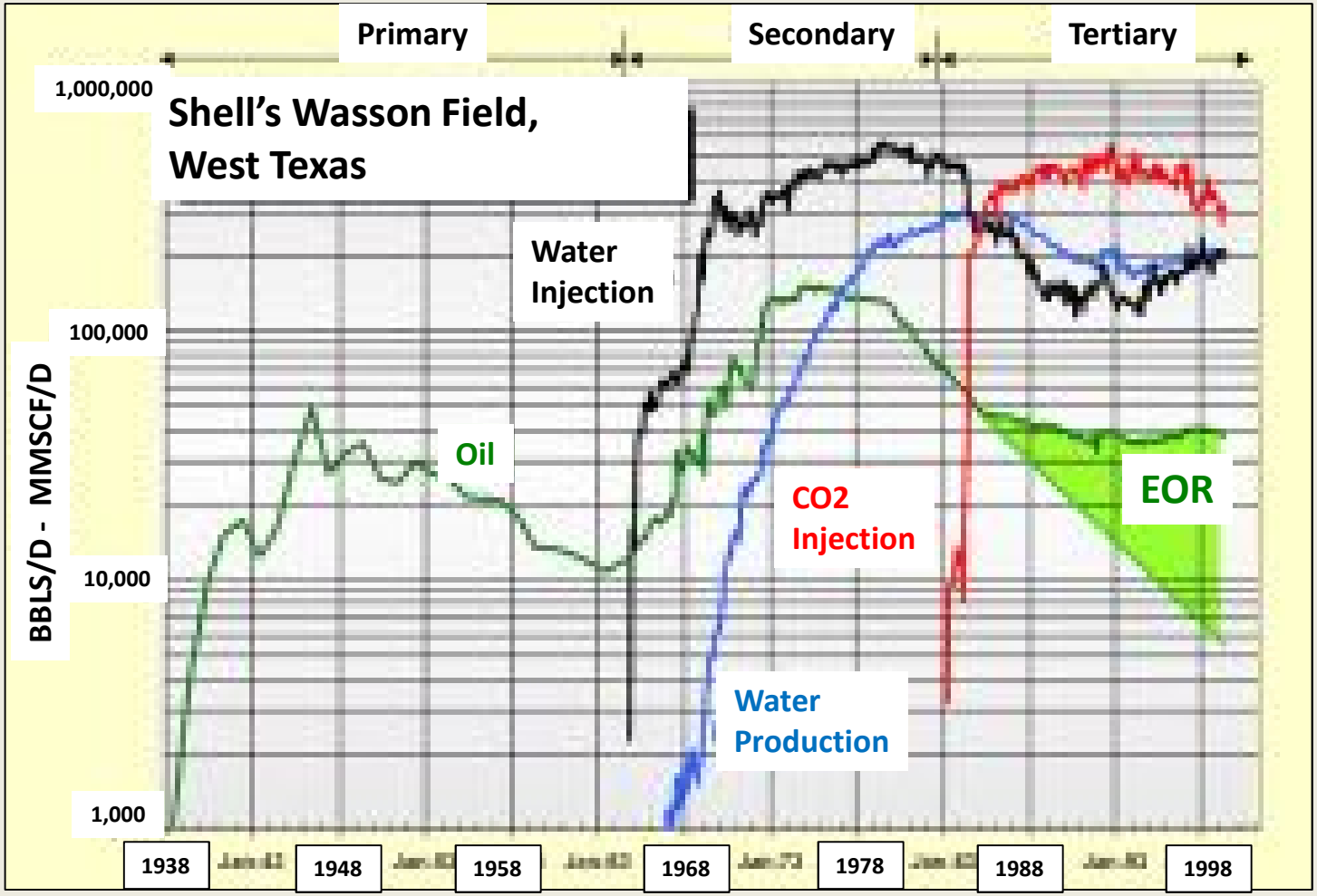
Steam Flooding: Keys to Success

- Right reservoir and shallow depths
- Very detailed geological/reservoir characterization
- Low cost steam / high steam quality
- Rigorous heat management (surface & subsurface)
- In-house technology
- Critical skills / experience: Essential
- Full Integration: Key to Economic Success

CO2 FLOODING



CO2 Flooding: Success History



From: Carbon Dioxide EOR; USDOE Publication

CO2 Flooding Pilot, High Resolution Reservoir Imaging

From ZSeis, Crosswell Image, EOR Applications

CO2 Flooding, Keys to Success

- Right Reservoir/Miscibility Pressure
- Low Cost/Abundant CO2
- Very Detailed Geological/Reservoir Characterization
- Volumetric Sweep Efficiency
- Thorough Pilot/Expansion Surveillance
- Minimize CO2 for Maximum Recovery
- Critical Skills/Experience: Essential

Enhanced Oil Recovery, SUMMARY

- Great source of new reserves
- Very few projects worldwide are not suitable
- Detailed geological-reservoir characterization
- Inexpensive injecting fluid
- In depth reservoir surveillance & management
- In-house technology
- Critical skills / experience: Essential
- Full integration: top quartile profits

Thank you,
Any Questions?

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Colombian examples:

- Cyclic steaming in heavy oil fields of Middle Magdalena
- Cyclic CO2 in Galán and Llanito fields
- Chemical (polymer flooding) in Casabe field
- In situ combustion in Quifa field, eastern Llanos