An Overview of Heavy Oil Carbonate Reservoirs in the Middle East*

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Abstract

Global heavy oil resources in carbonate rocks have been estimated to be on the order of 1.6 trillion barrels, of which about one-third may occur in the Middle East. Owing to its vast light oil reserves, documentation in the public domain on Middle Eastern heavy oil accumulations is not complete, but enough information is available to assemble a reasonable picture of the geological setting, reservoir and oil quality issues and the status of cold and EOR production in the region.

Productive heavy oil carbonate fields can be grouped into two categories: 1) low matrix permeability, fracture dependent, and 2) matrix permeability dependent production. Fracture enhanced, low matrix permeability production is dominant and occurs in Oman, Iran, Iraq, Syria, Turkey and Egypt and includes producing fields such as Qarn Alam in Oman and Issaran and Bakr-Amer in Egypt. In Iran, several fractured carbonate fields have successfully cold tested oil qualities on the order of 10 degree API. Wafra, located in the Partitioned Neutral Zone (PNZ) of Kuwait and Saudi Arabia, is the most notable example of an accumulation that has ample matrix permeability to allow economic cold production without significant fracture enhancement. Ultimate recovery from these fields is heavily dependent on oil viscosity and the ability to lower it. EOR implemented in the region include a CO_2 flood at Bati-Raman in Turkey, a full-field crestal steam injection project that is underway at Qarn Alam, and an ongoing pilot steam flood at Wafra that commenced in February 2006. These three fields, along with Issaran, where a CSS project began in 2006, constitute the bulk of carbonate heavy oil activity in the Middle East. Current carbonate heavy oil production is on the order of 100-150 TBD (0.5% of Middle East production) and will likely stay at that level until Wafra production is increased or fields with large potential, such as Ferdows in Iran, are brought onstream.

References

Meyer, R.F., E.D. Attanasi, and P.A. Freeman, 2007, Heavy oil and natural bitumen resources in geological basins of the world: U.S. Geological Survey Open-File Report 2007-1084, Web accessed October 15, 2010, http://pubs.usgs.gov/of/2007/1084/

Penney, R., R. Moosa, G. Shahin, F. Hadhrami, A. Kok, G. Egnen, O. van Ravestejin, K. Rawnsley, and B. Kharusi, 2005, Steam Injection in Fractured Carbonate Reservoirs: Starting a New Trend in Enhanced Oil Recovery (EOR): International Petroleum Technology Conference 21-23 November 2005, Doha, Qatar, SPE Paper No. 10727, Web accessed 9 November 2010, http://www.onepetro.org/mslib/servlet/onepetropreview?id=IPTC-10727-MS&soc=IPTC

An Overview of Heavy and Extra Heavy Oil Carbonate Reservoirs in the Middle East

April 2010

John W. Buza

Middle East HO Carbonate Reservoirs Summary

- Difficult to obtain uniformly reliable data but can get “picture”

  Published STOOIP of 500-971 BBO vs. 130 BBO in published fields

  STOOIP estimates include all rock types but ME dominated by carbonates

  - No demonstrated supergiants in inventory, Ferdows (Iran) and Wafra (PZ) possible

- Production of 125-200 TBD for foreseeable future (0.5% ME)

  Dominated by Wafra with small future increases in Oman & Egypt

- Rock Fabric is a key element for cold production

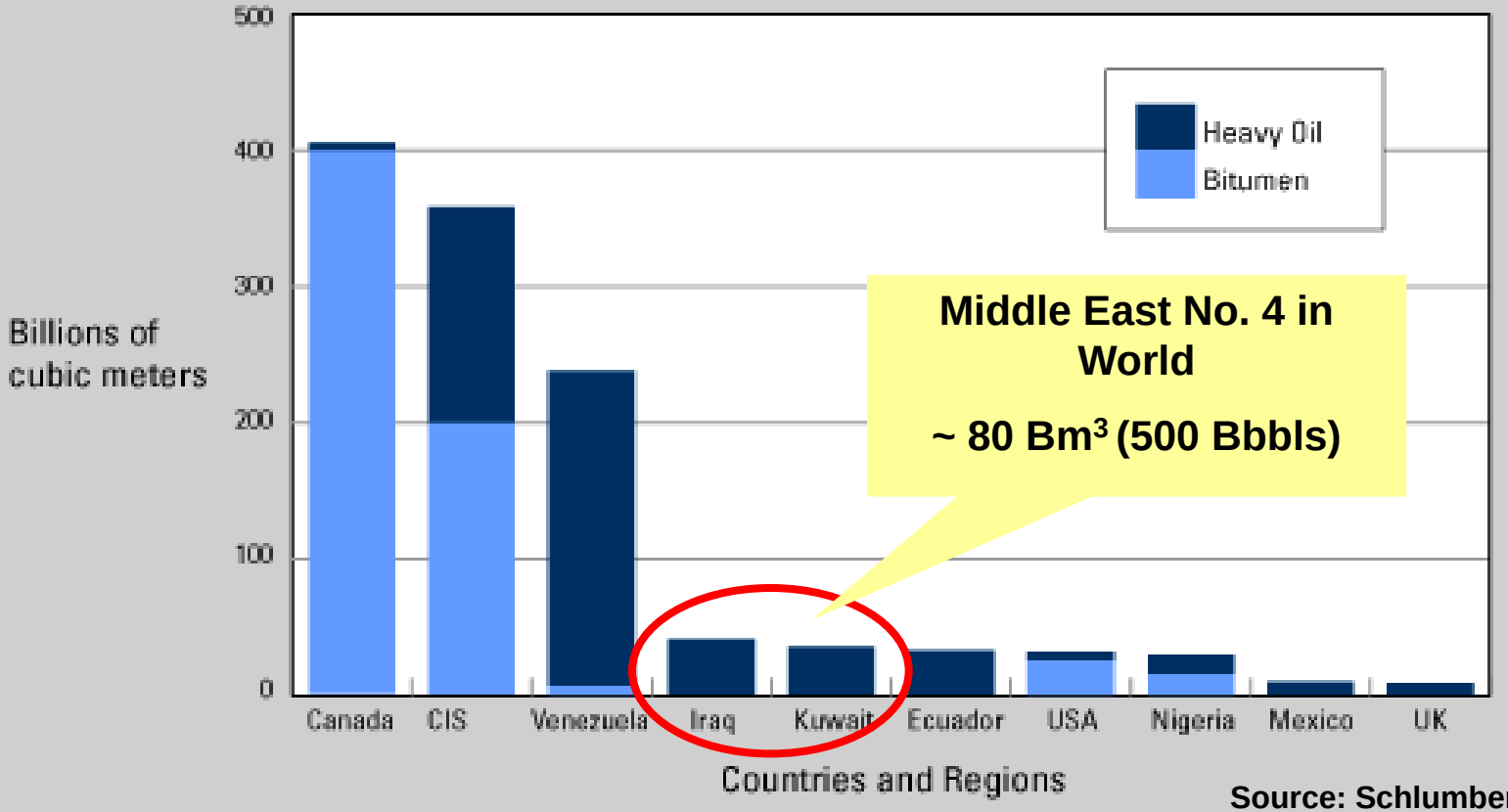
  Fractures required in low matrix perm, extra heavy oil reservoirs

  Good poro-perm overcomes need for fracture network (Wafra)

- Recovery factor most dependent on oil viscosity

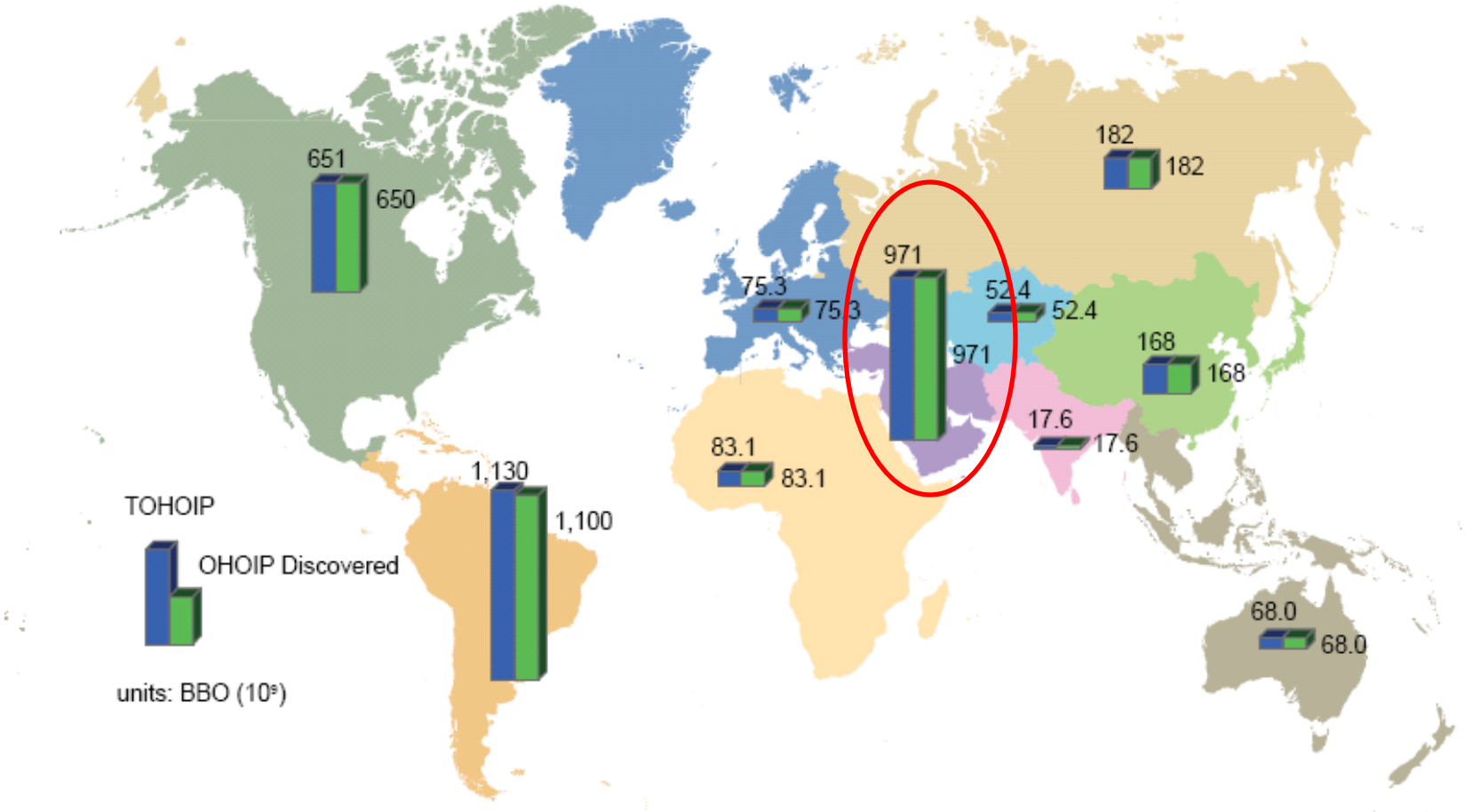
- EOR underway includes CSS, Steamflood, TAGOGD & CO_2

World Heavy Oil & Bitumen Resources



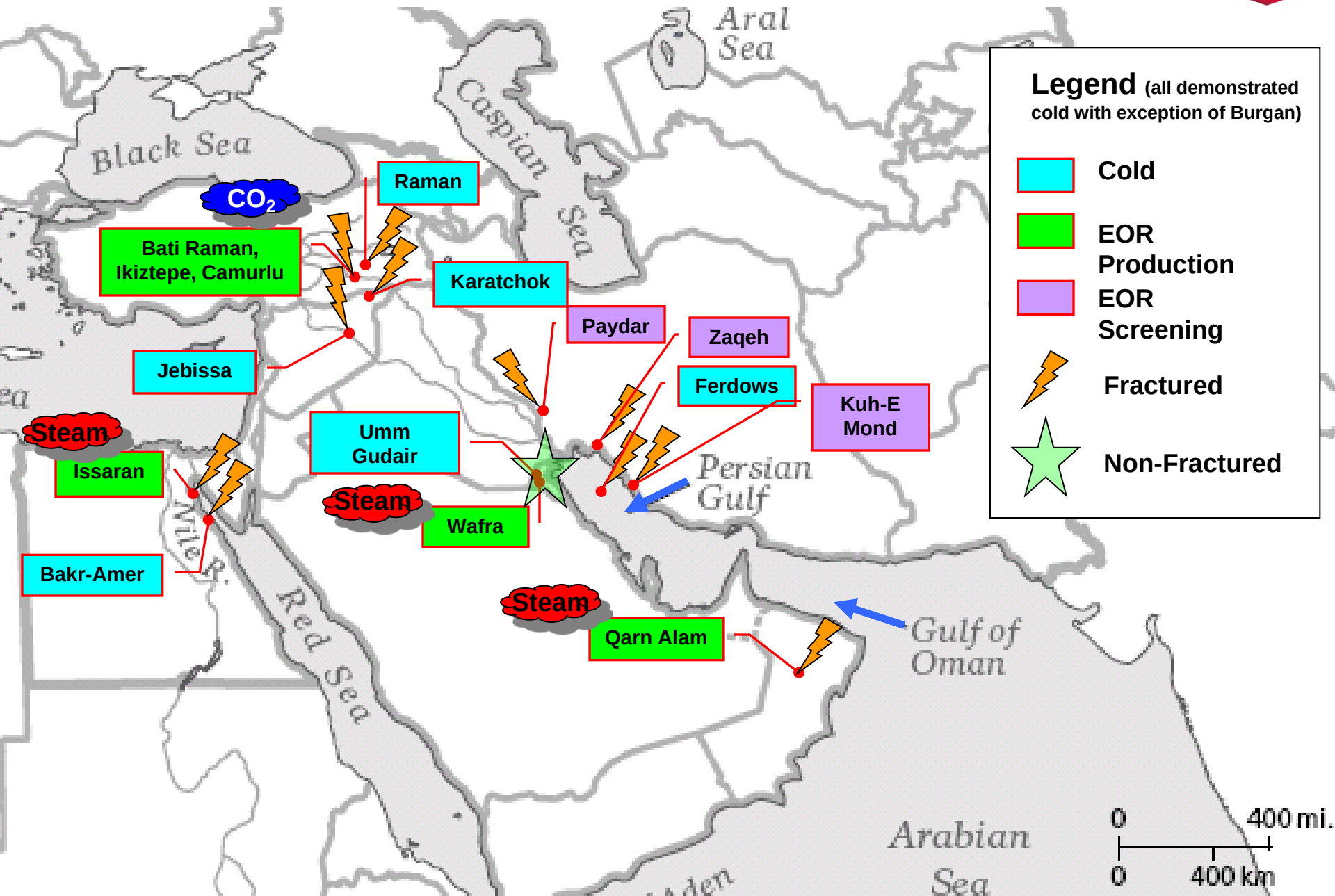
Source: Schlumberger

U.S. Geological Survey
Heavy Oil Distribution



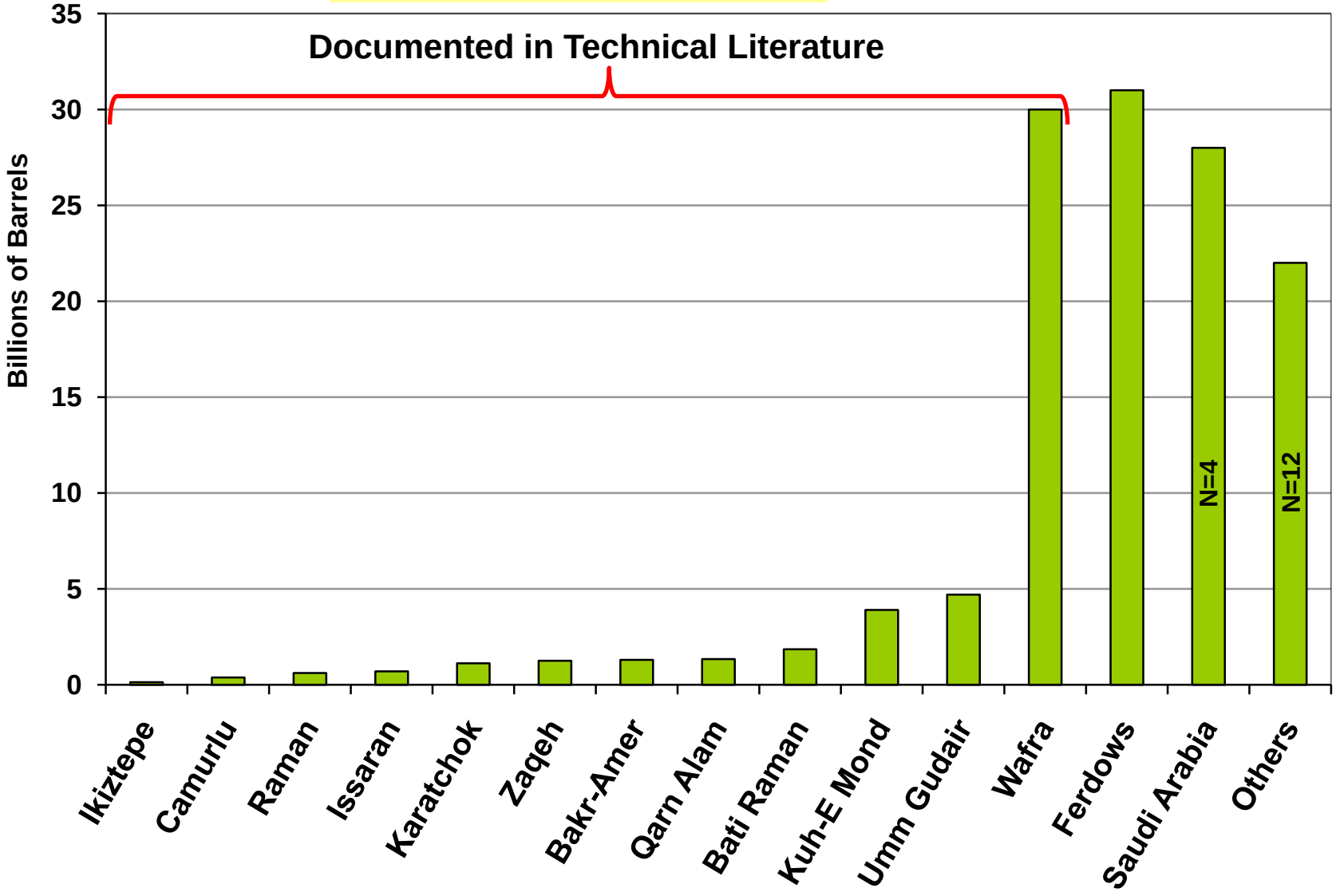
Meyer, R.F., Attanasi, E.D., and Freeman, P.A., 2007, Heavy oil and natural bitumen resources in geological basins of the world: U.S. Geological Survey Open-File Report 2007-1084, available online at http://pubs.usgs.gov/of/2007/1084/.

Middle East - Heavy Oil Carbonate Reservoirs

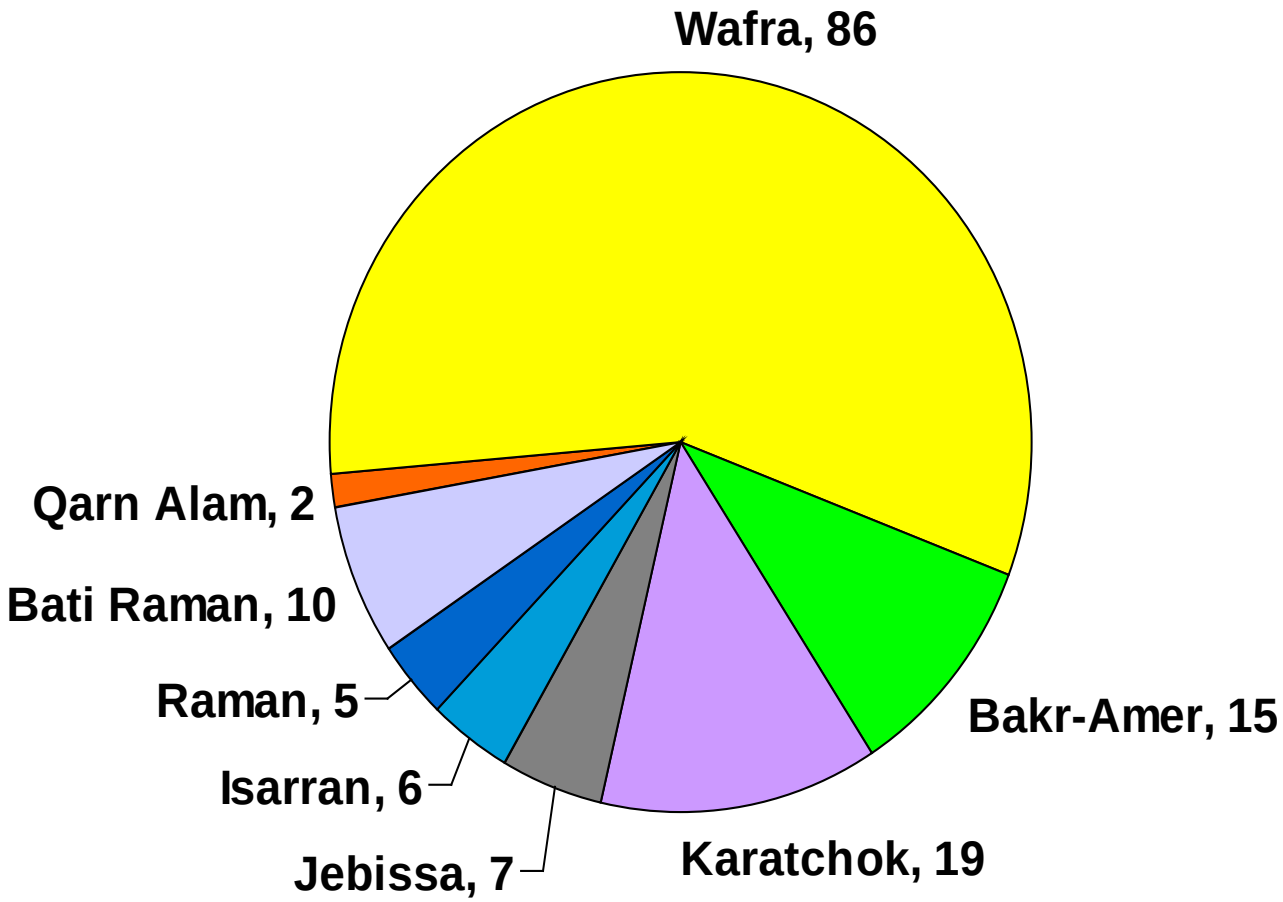


Middle East Heavy Oil Carbonate STOOIP

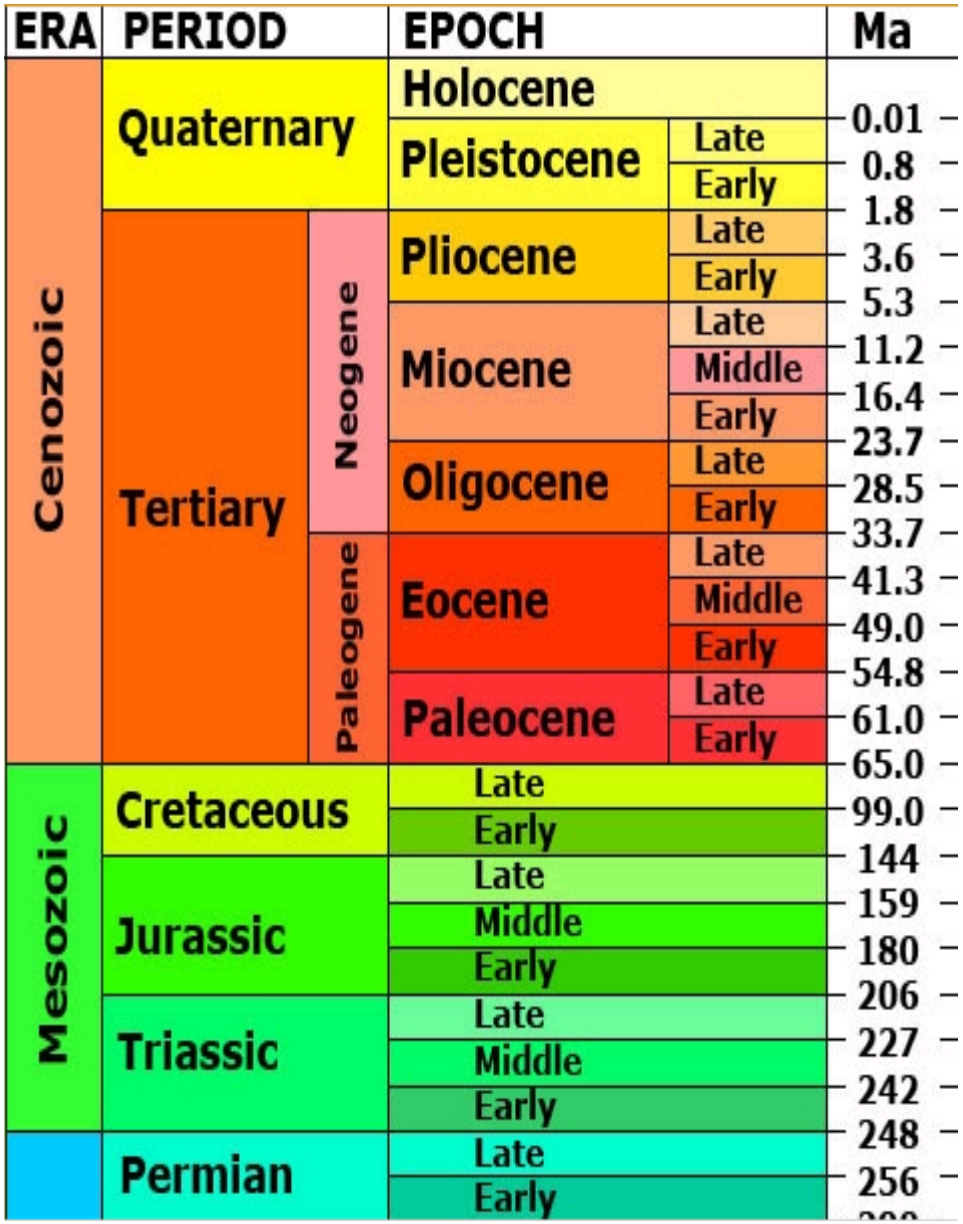
Total STOOIP = 130 BBO



Middle East Daily Carbonate HO Production
125-150 TBD

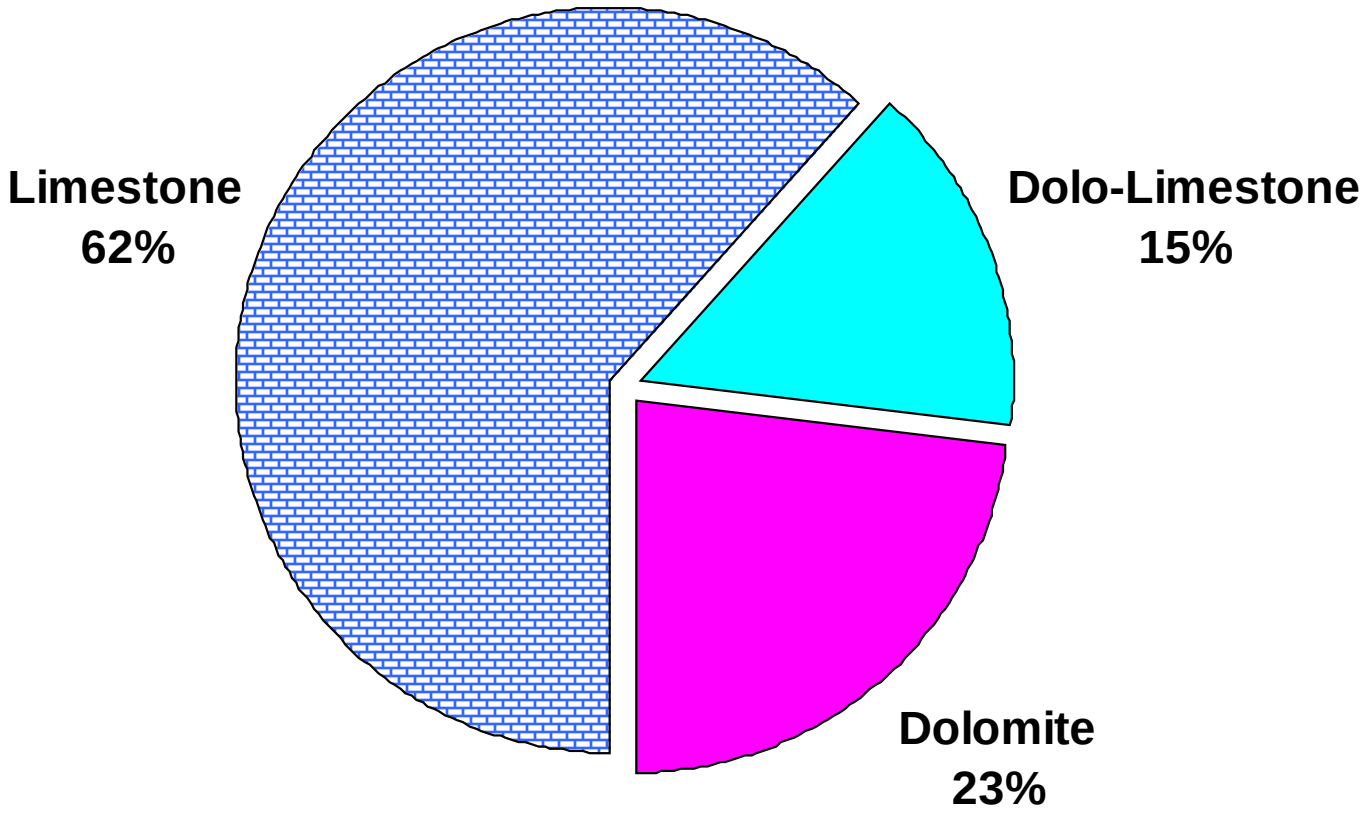


Age of Middle East HO Carbonate Reservoirs

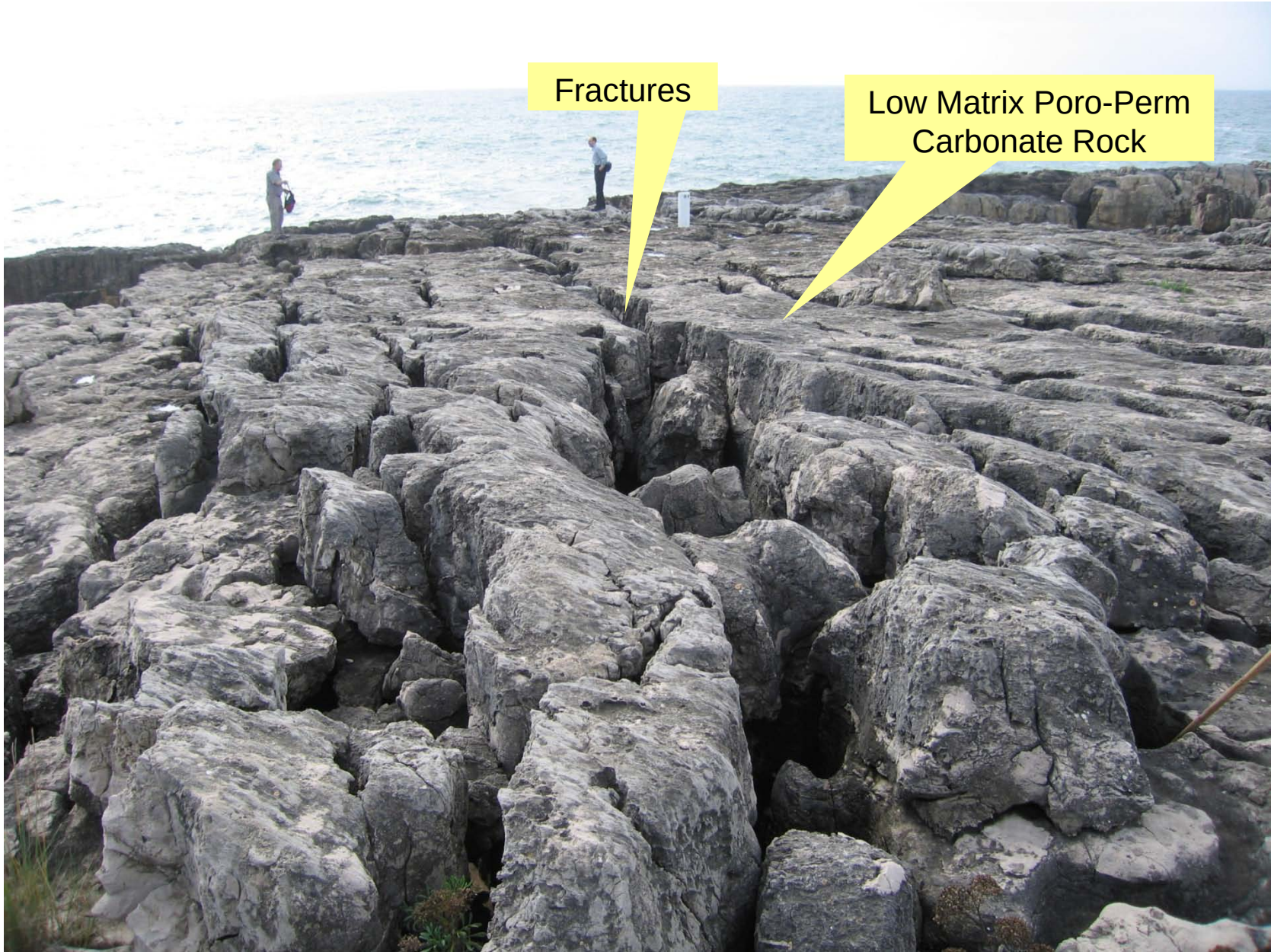


Aptian-Miocene

Middle East HO Carbonate Rock Types



Outcrop Analog

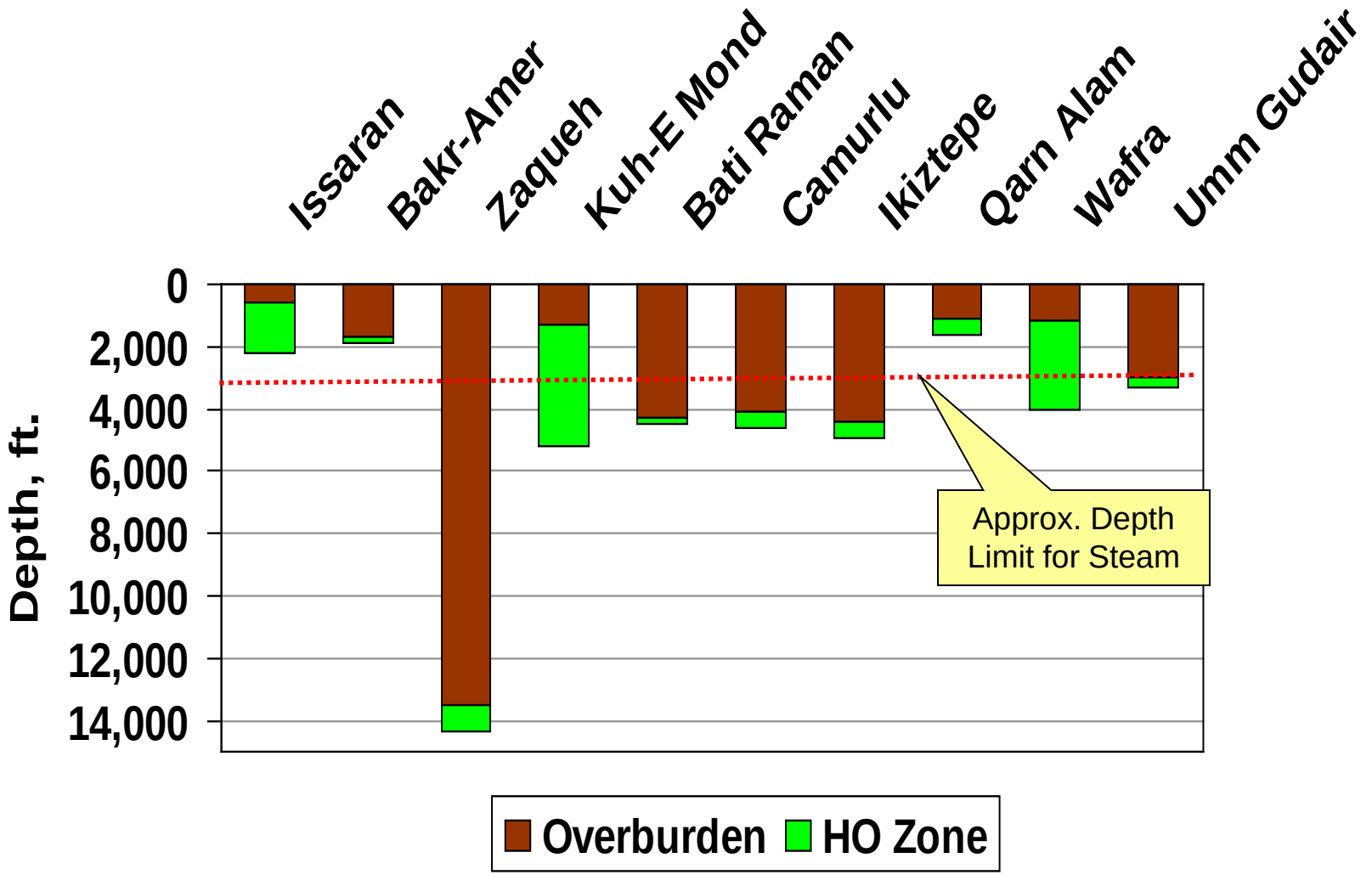


Oil-Filled Fractures vs. Cement-Filled Fractures

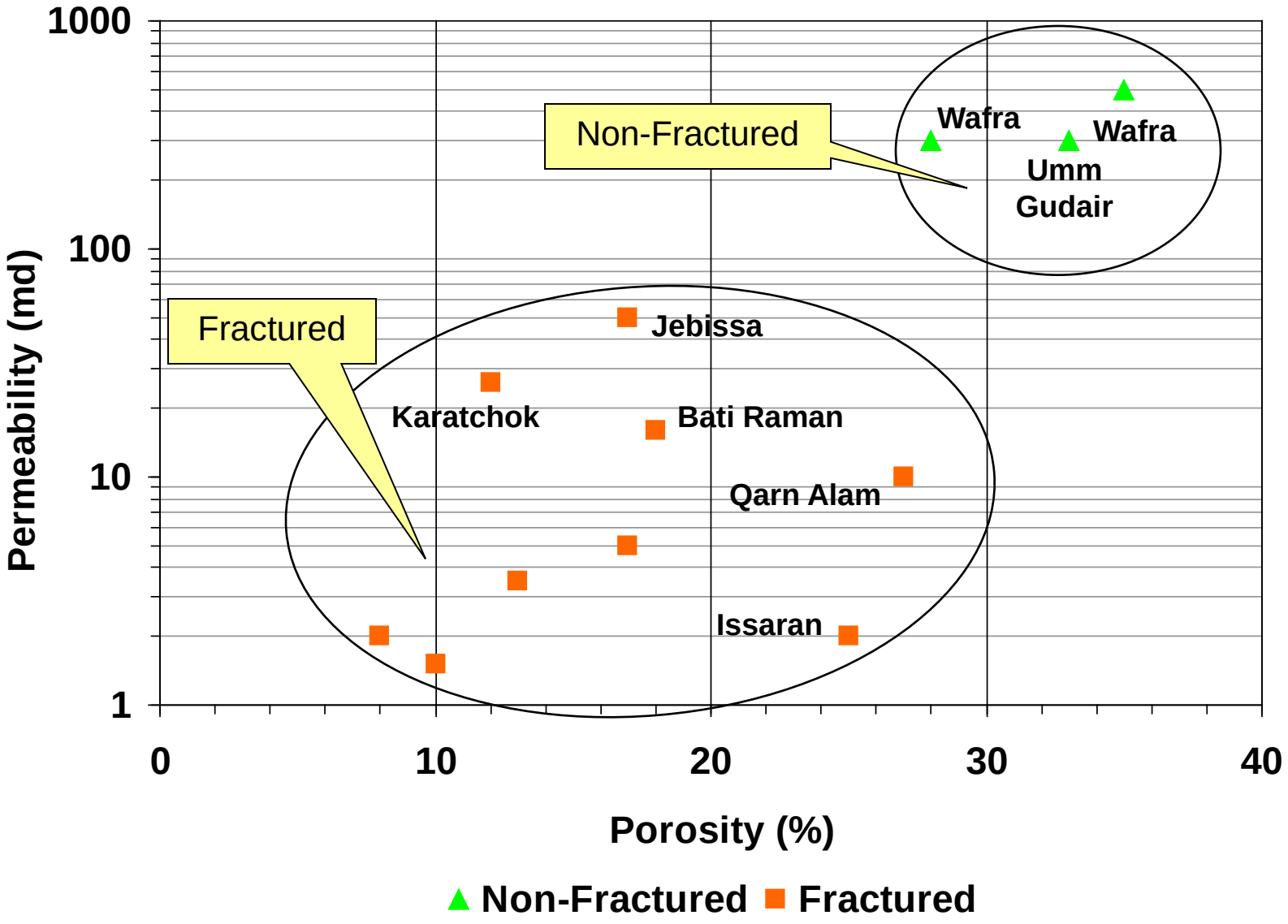
Oil-filled fractures

Cement-filled fractures

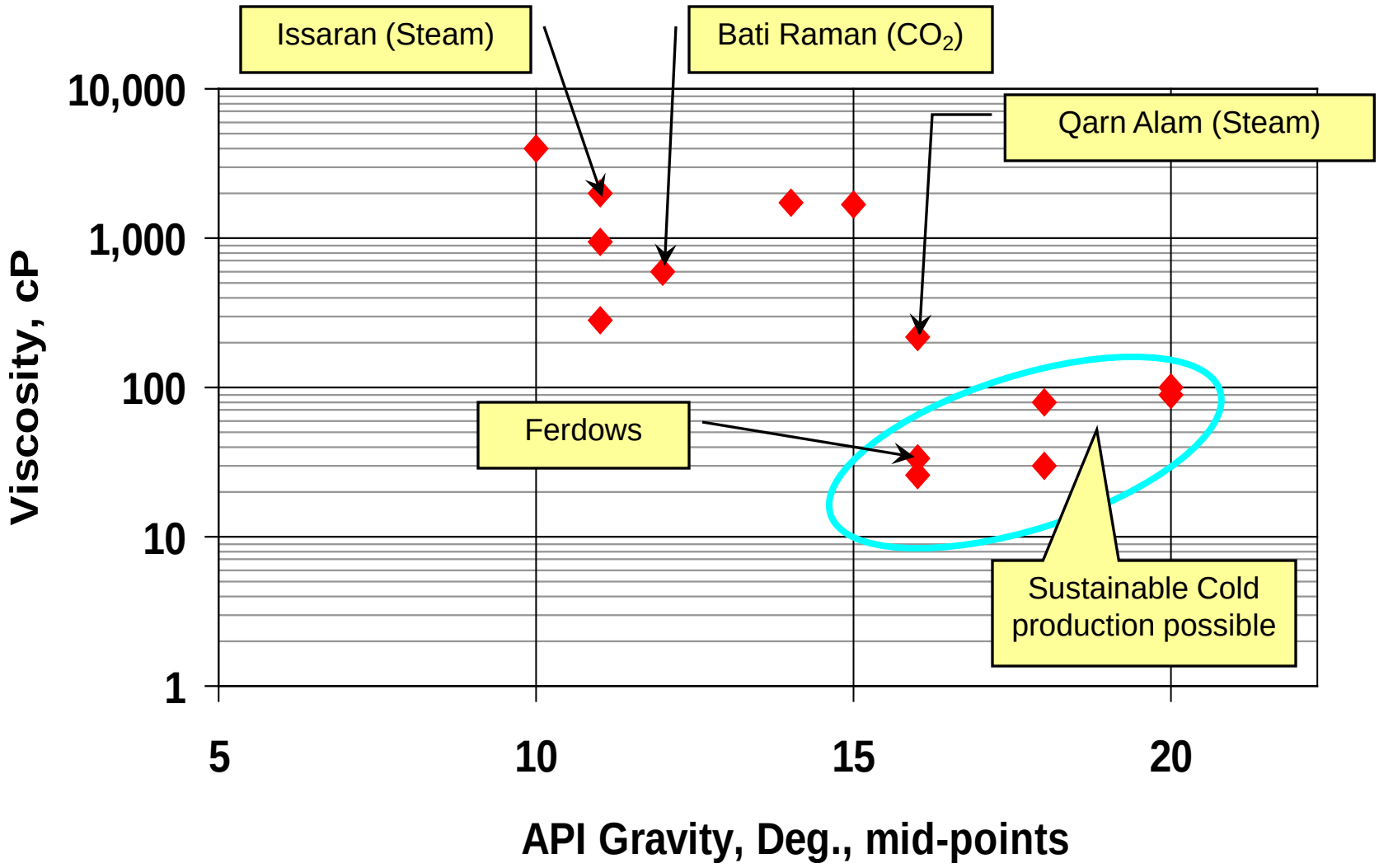
Middle East HO Pay Depths



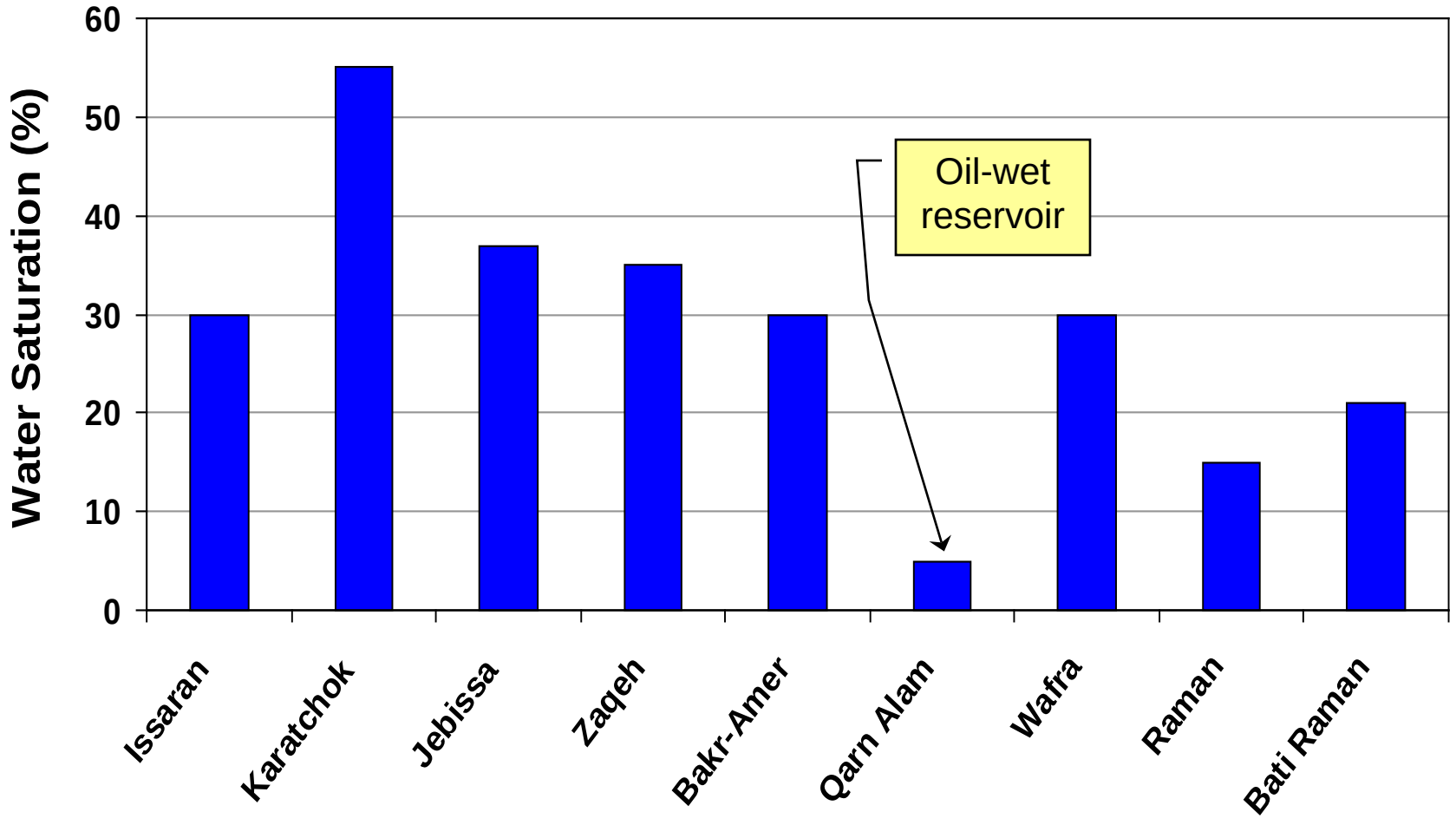
Middle East HO Carbonates
Matrix Porosity vs. Permeability



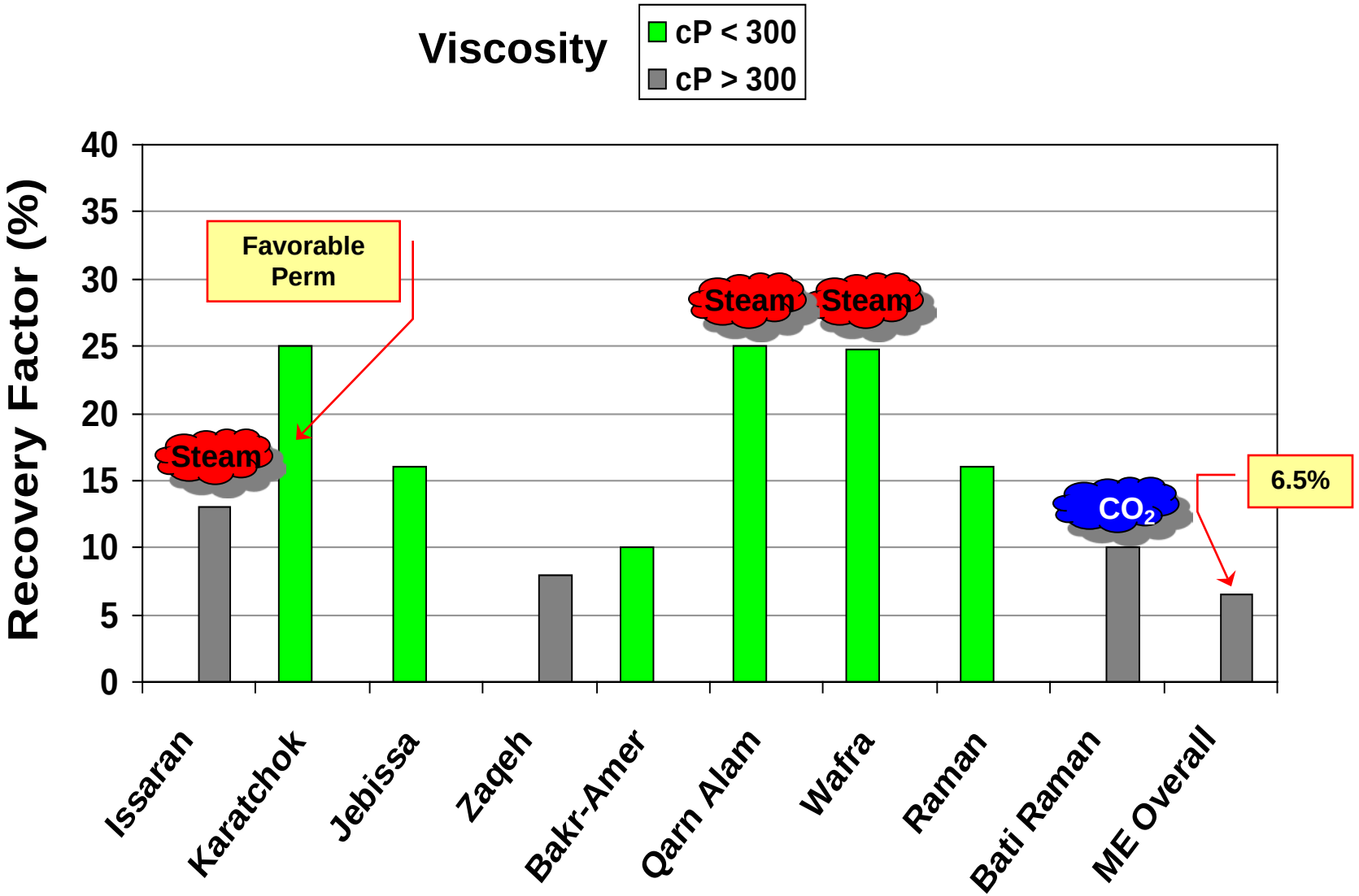
Middle East HO Gravity & Viscosity



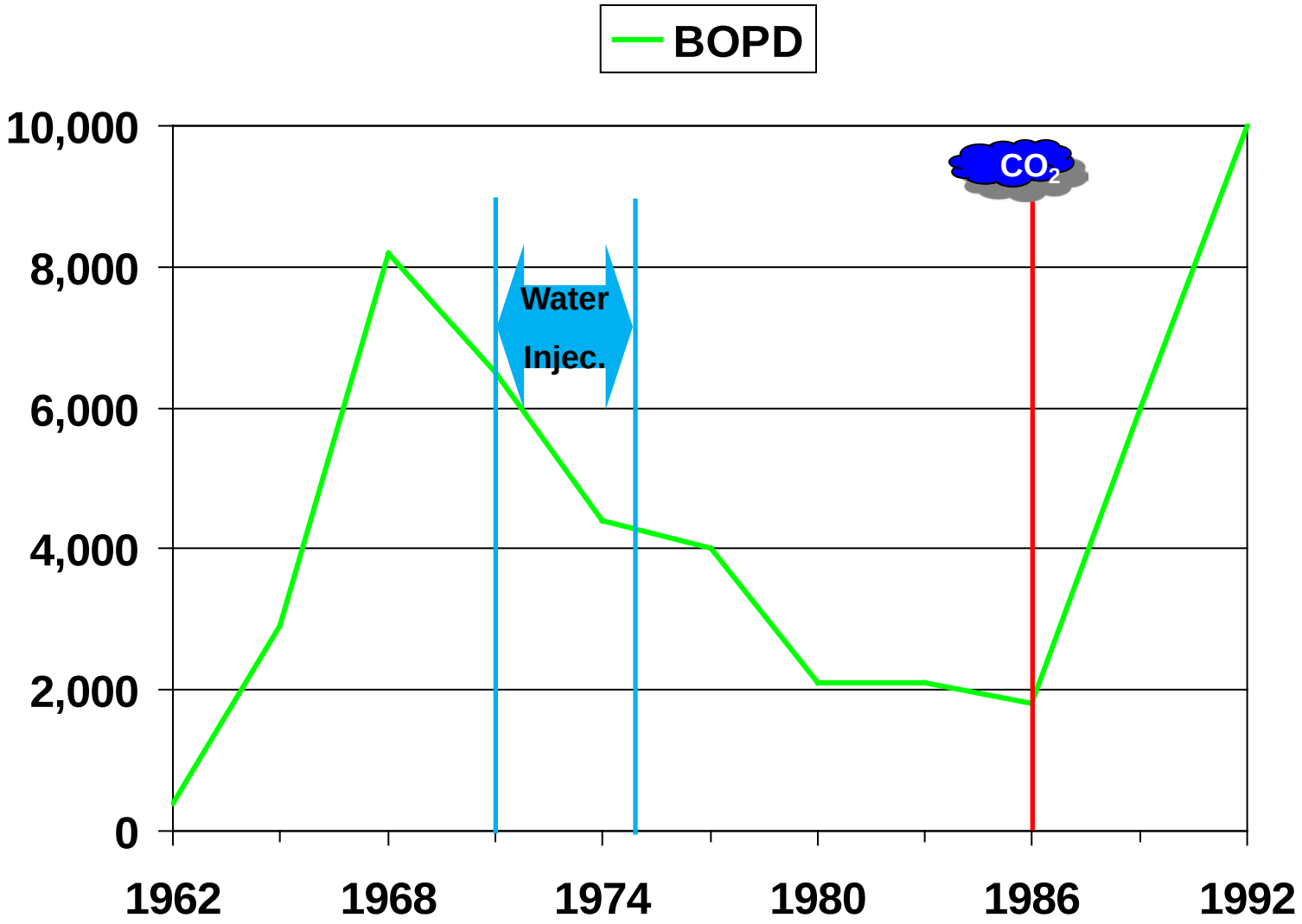
Middle East HO Water Saturation



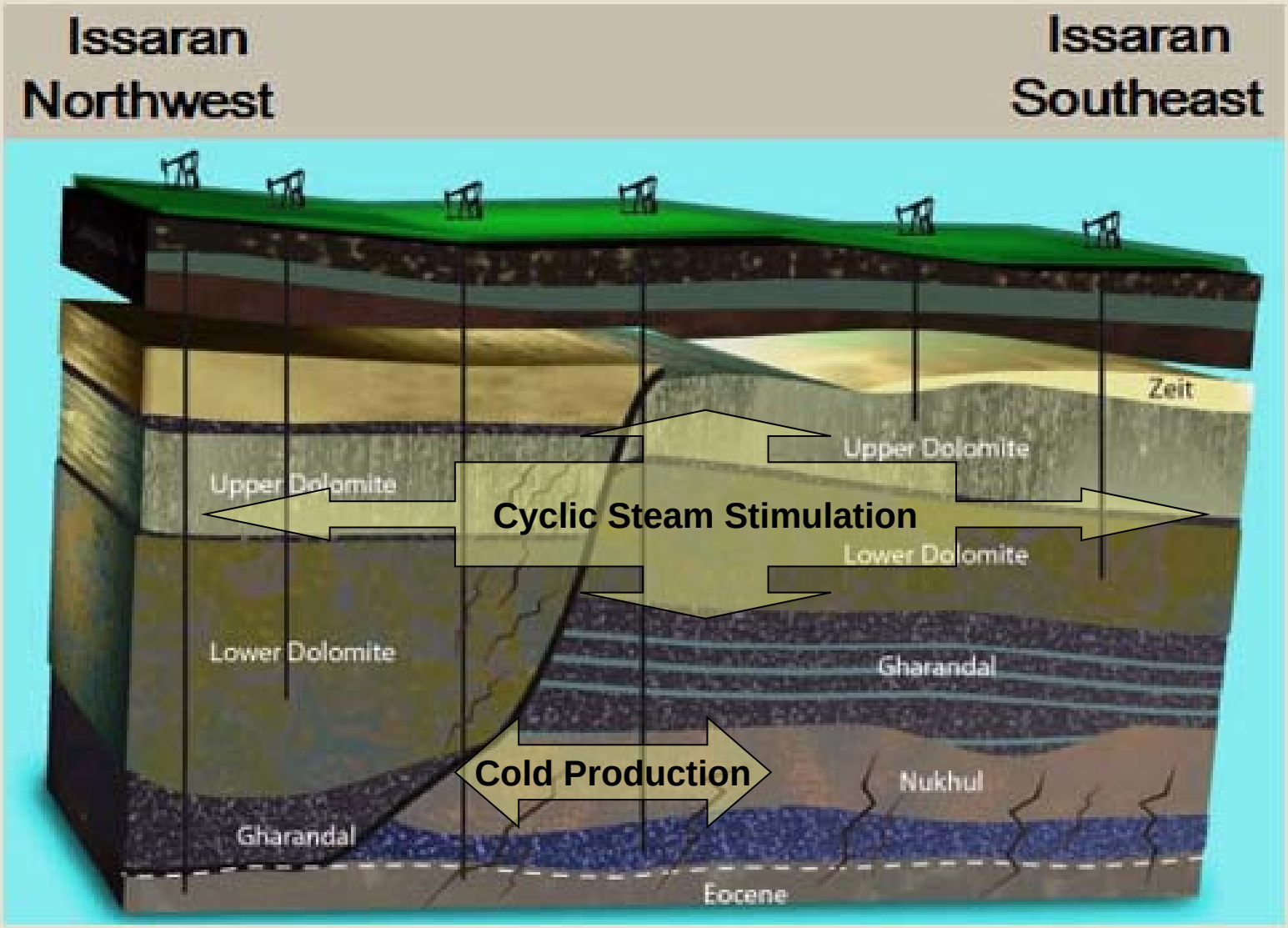
Middle East HO Recovery Factor



Bati Raman Production



Issaran Field, Gulf of Suez, Egypt

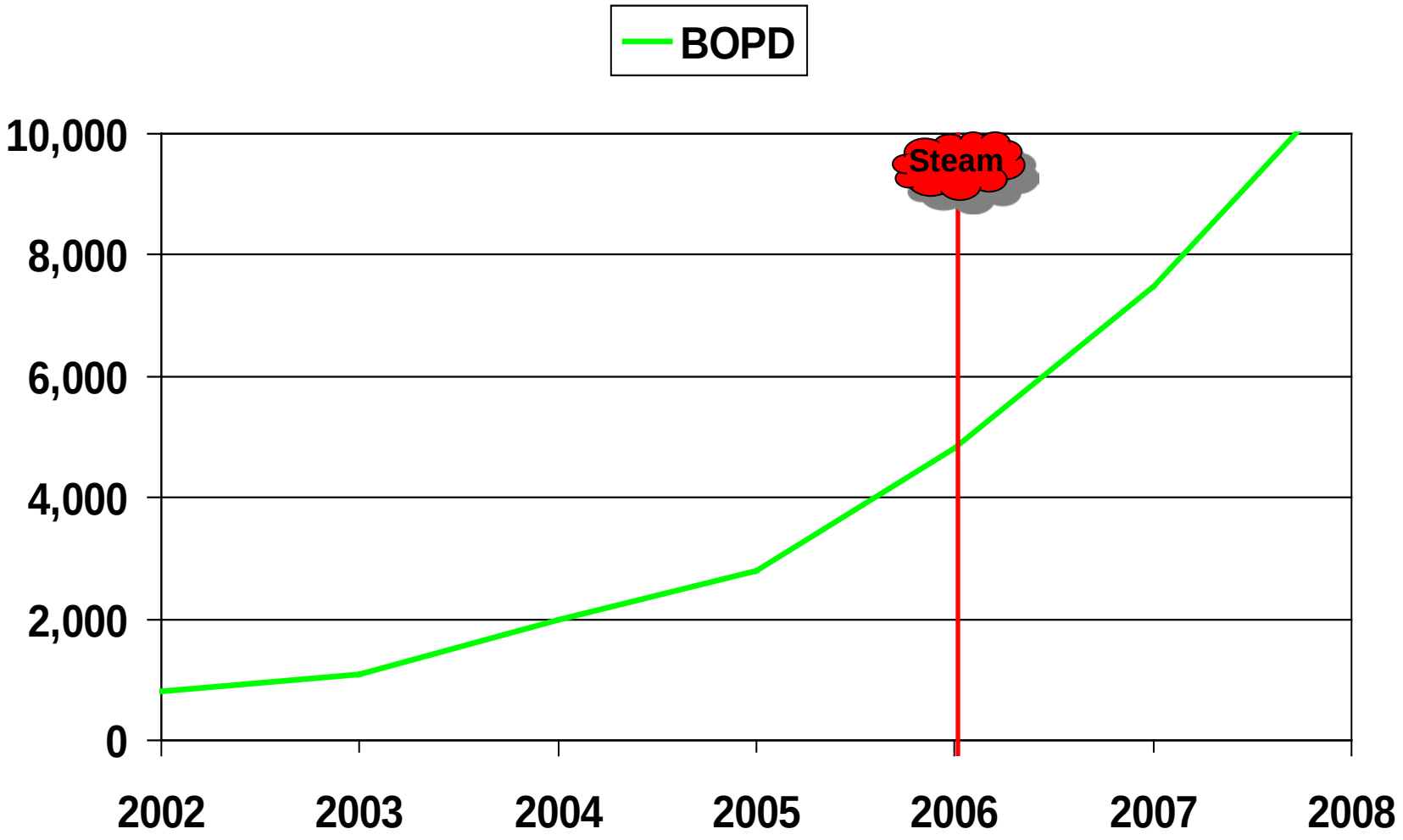


Source: Rally Energy website

Issaran Field, Egypt
50 Mmbtu/hr Steamer

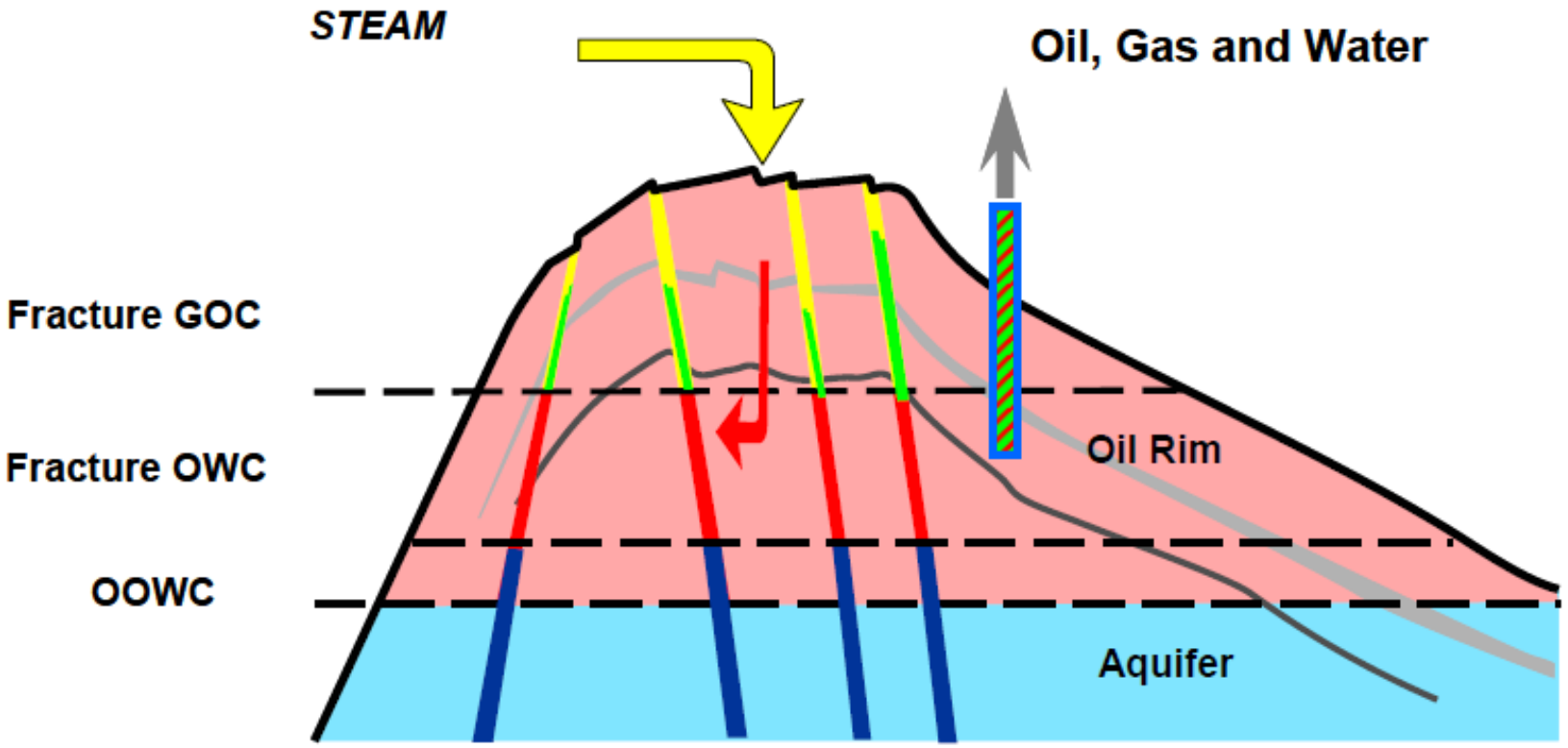
Source: Rally Energy website

Issaran Production



Source: Rally Energy website

Qarn Alam, Oman, TAGOGD Process
(thermally assisted gas-oil-gravity drainage)

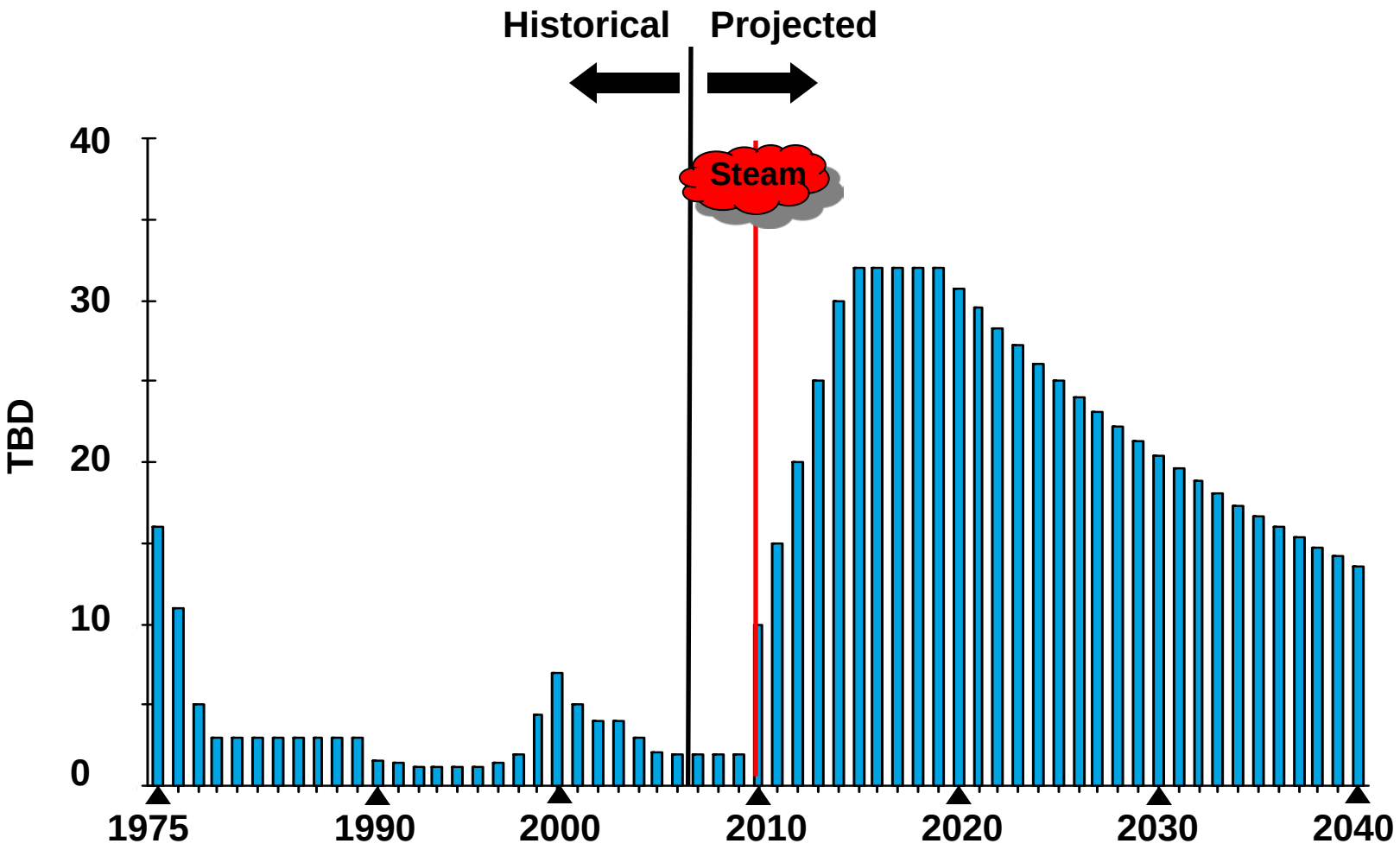


from Penney, R.; Moosa, R.; et al, 2005

Pilot confirmed:

- **No significant dissolution of matrix or caprock**
- **Matrix heated adequately to liberate oil to fractures**

Qarn Alam Oil Production Profile

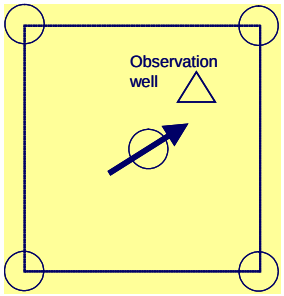


Source: Wood Mackenzie

Wafra Radhuma

Objectives and Scope Steam Flood Pilots

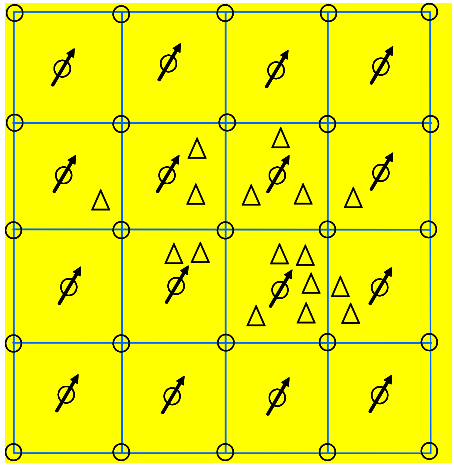
Small Scale Test (1.25 ac, 2006)



Objectives

- Generation of steam from produced water
- Injectivity of steam in carbonate reservoir over long duration

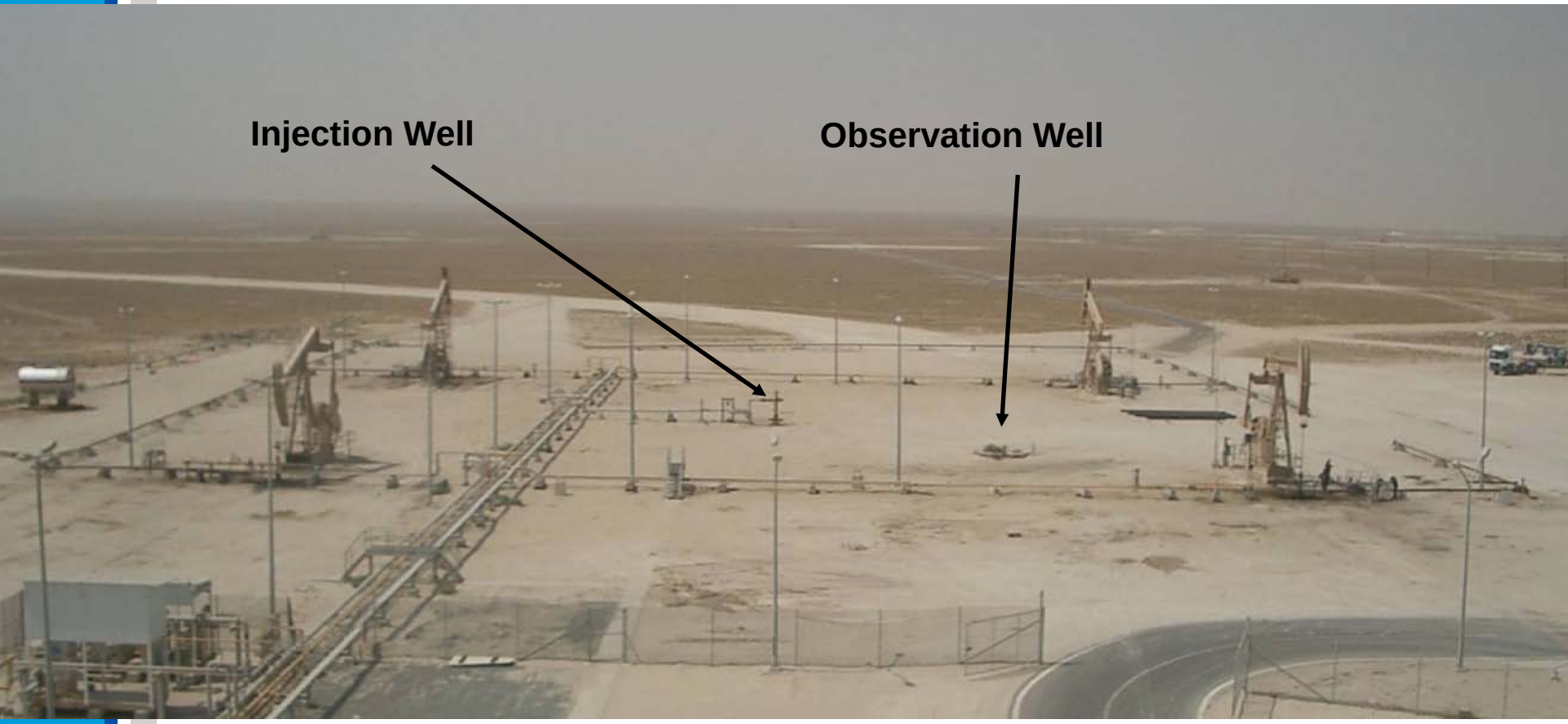
Large Scale Pilot (40 ac, 2009, 16-2.5 ac inverted 5 spots)



Objectives

- Determine Field Wide EOR expansion potential
  - Production response
  - Recovery
  - Overall efficiency

Small Scale Test



Large Scale Pilot Steamflood Project

Middle East HO Carbonate Reservoirs
Production Processes and EOR Evaluations

Production Process			Bati Raman	Camurlu	Ikiztepe	Qarn Alam	Issaran	Bakr-Amer	Zaqeh	Kuh-E Mond	Wafra	Umm Gudair	Karatchok	Jebissa
			Turkey			Oman	Egypt		Iran		Saudi + Kuwait		Syria	
Primary (Cold)			X	X	X	X	X	X	X	X	X	X	X	X
Thermal	Steam	CSS			X		X							
		Flood			X						Pilot			
		SAGD								X				
		TA GOGD				2008 X								
	Combustion Fire Flooding								X					
Non-Thermal	Water flooding		X			X HOT								
	CO2 Injection		X	X										
	Chemical Injection													
	VAPEX													

Legend

- X — Screen Result
- X — Demonstrated
- ○ — Operational Now
- ○ — Tested, Suspended

Middle East HO Carbonate Reservoirs Conclusions

Resource base estimates appear overly optimistic

- ✓ 130 BBO documented vs. 500-971 BBO estimated STOOIP
- ✓ No *demonstrated* supergiants in inventory
  - Wafra and Ferdows have supergiant potential

Production of 125-200 TBD for foreseeable future (0.5%)

- Could reach ~1MMBO if Wafra and Ferdows successful (3%)

Rock Fabric is a key element - 2 types dominate

- ✓ Fractures needed in low matrix perm, extra heavy oil reservoirs
- ✓ Good poro-perm overcomes need for fracture network (Wafra)

Viscosity is major control on ultimate recovery

Thermal and CO_2 methods successful and in use today