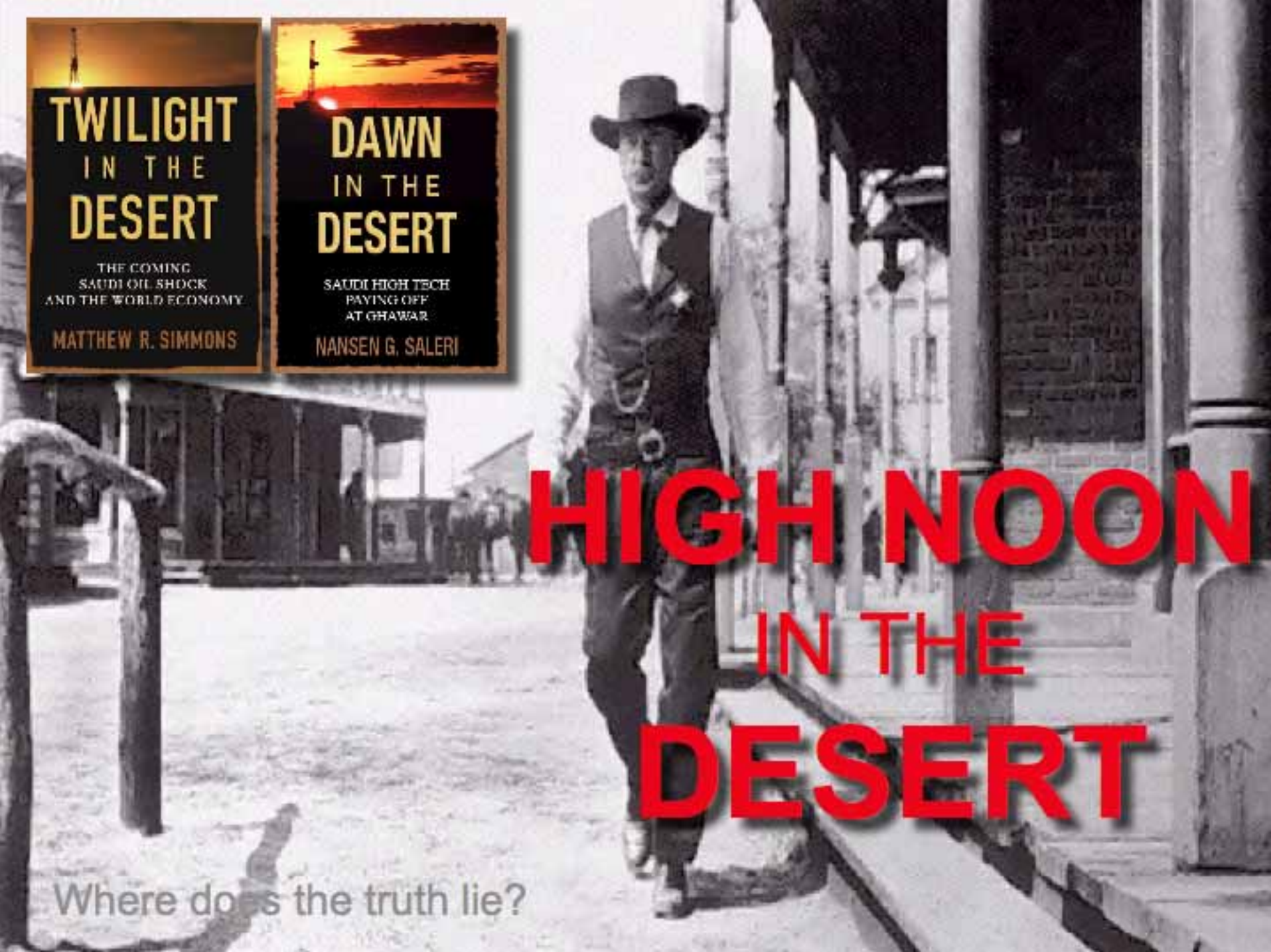
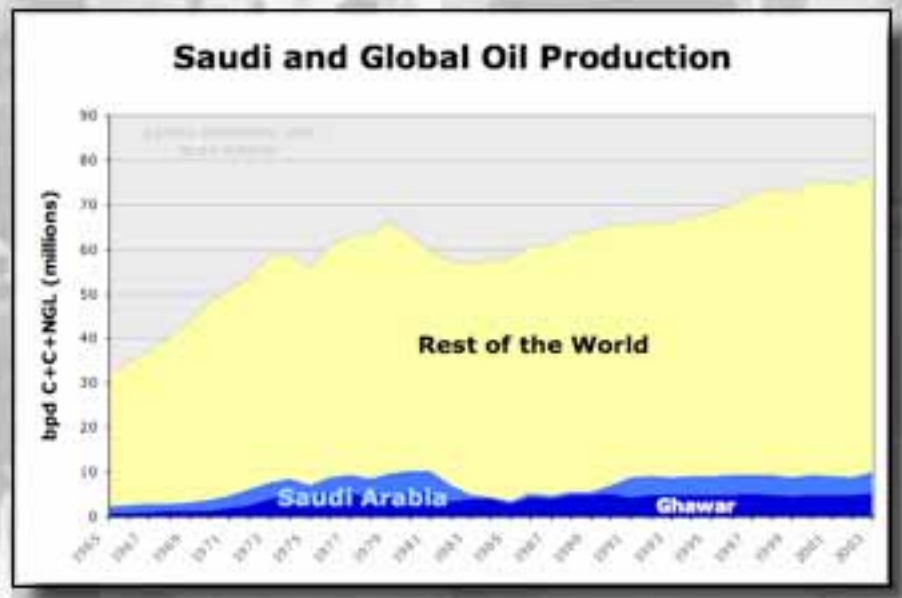

TWILIGHT
IN THE
DESERT
THE COMING
SAUDI OIL SHOCK
AND THE WORLD ECONOMY
MATTHEW R. SIMMONS
DAWN
IN THE
DESERT
SAUDI HIGH TECH
PAYING OFF
AT GHAWAR
NANSEN G. SALERI
HIGH NOON
IN THE
DESERT
Where does the truth lie?

High Noon in The Desert

- Setting the scene
  - Opinions of others
  - Saudi oil fields
  - Data sources
- Reserves estimates, different approaches
  - Pre-nationalisation
  - Top down - Hubbert
  - Bottom up analysis
- Unknowns



In 2003, Saudi Arabia accounted for 13% and Ghawar 6.7% of Global oil production

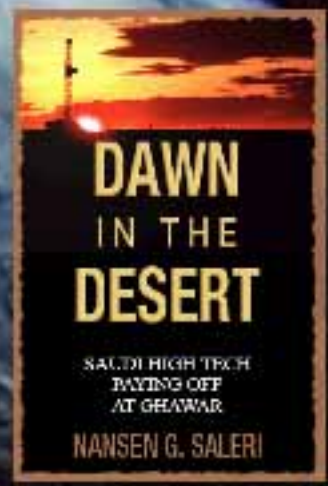
Synopsis

Baqi and Saleri

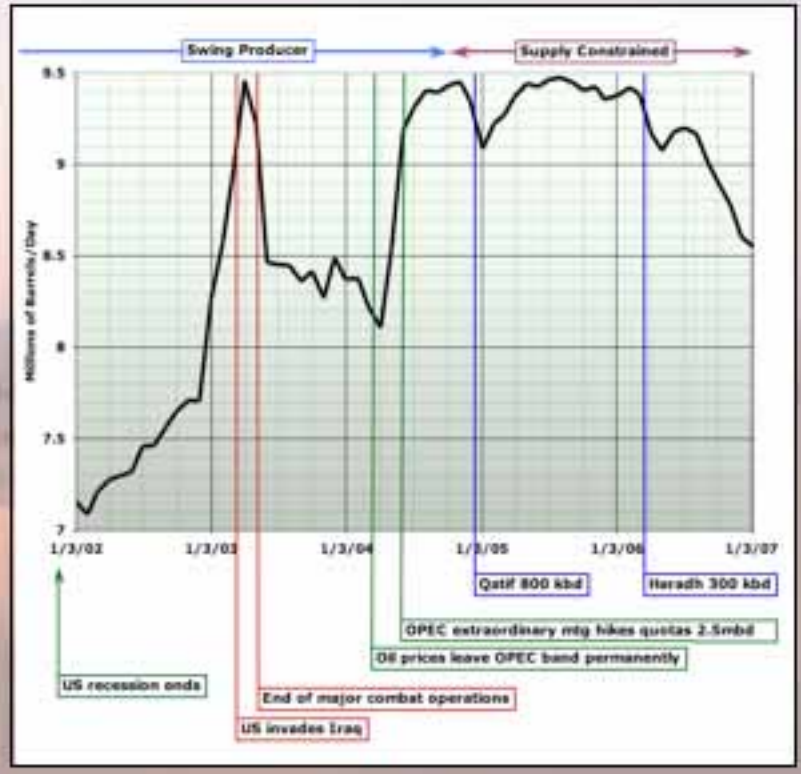
bright future

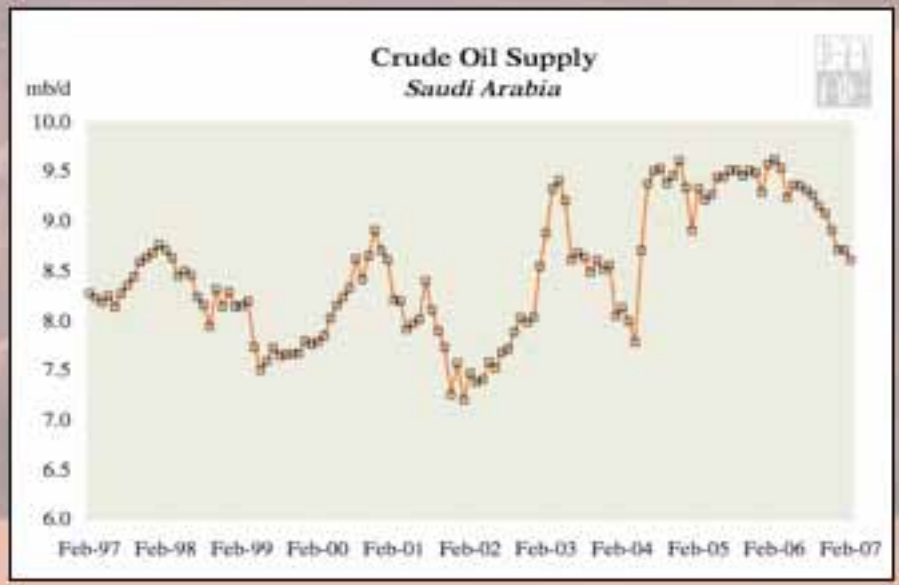
- **Conservative Reserves with Significant Upward Potential**
- **Capacity and Commitment to Continue as a Reliable and Cost-Effective Global Oil Supplier**
- **Sustained Production Levels at 10, 12 and 15 Million Barrels per Day, Well Beyond 2054**

15 million bpd for 48 years = 263 Gbs



A nose dive toward the desert

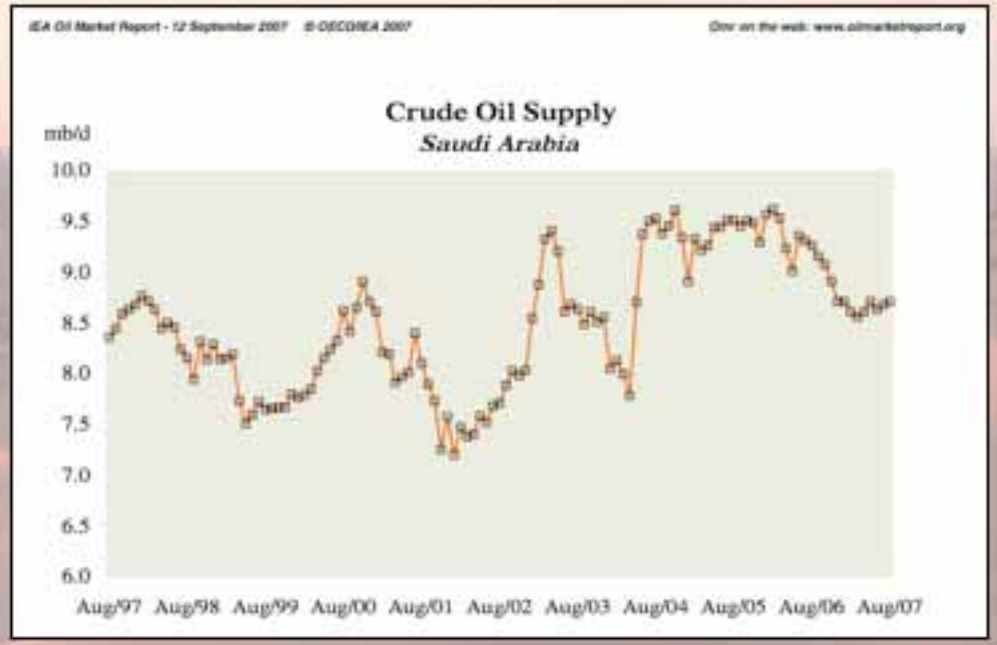




The Oil Drum
DISCUSSIONS ABOUT ENERGY AND OUR FUTURE

February 07

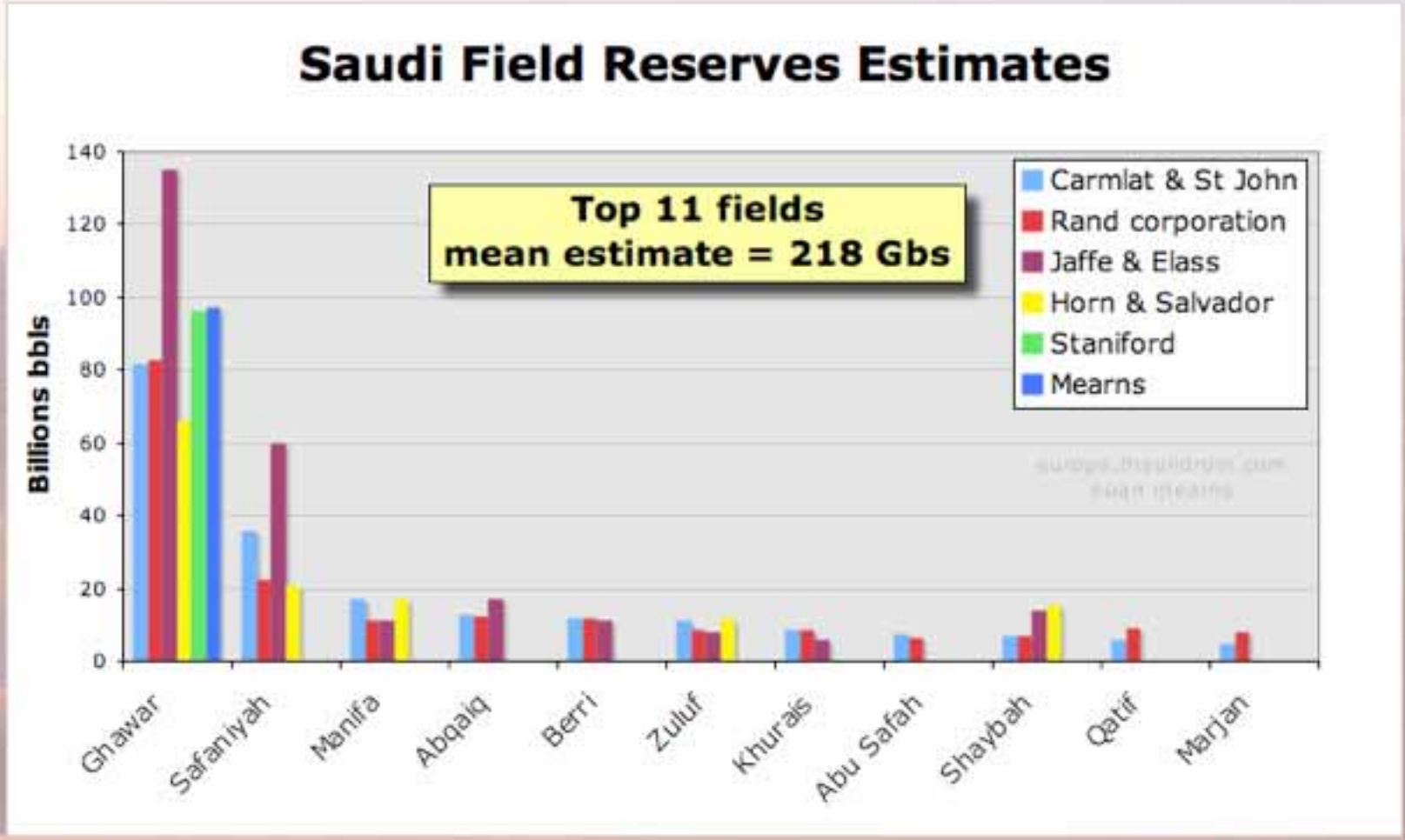
A bounce off the desert?



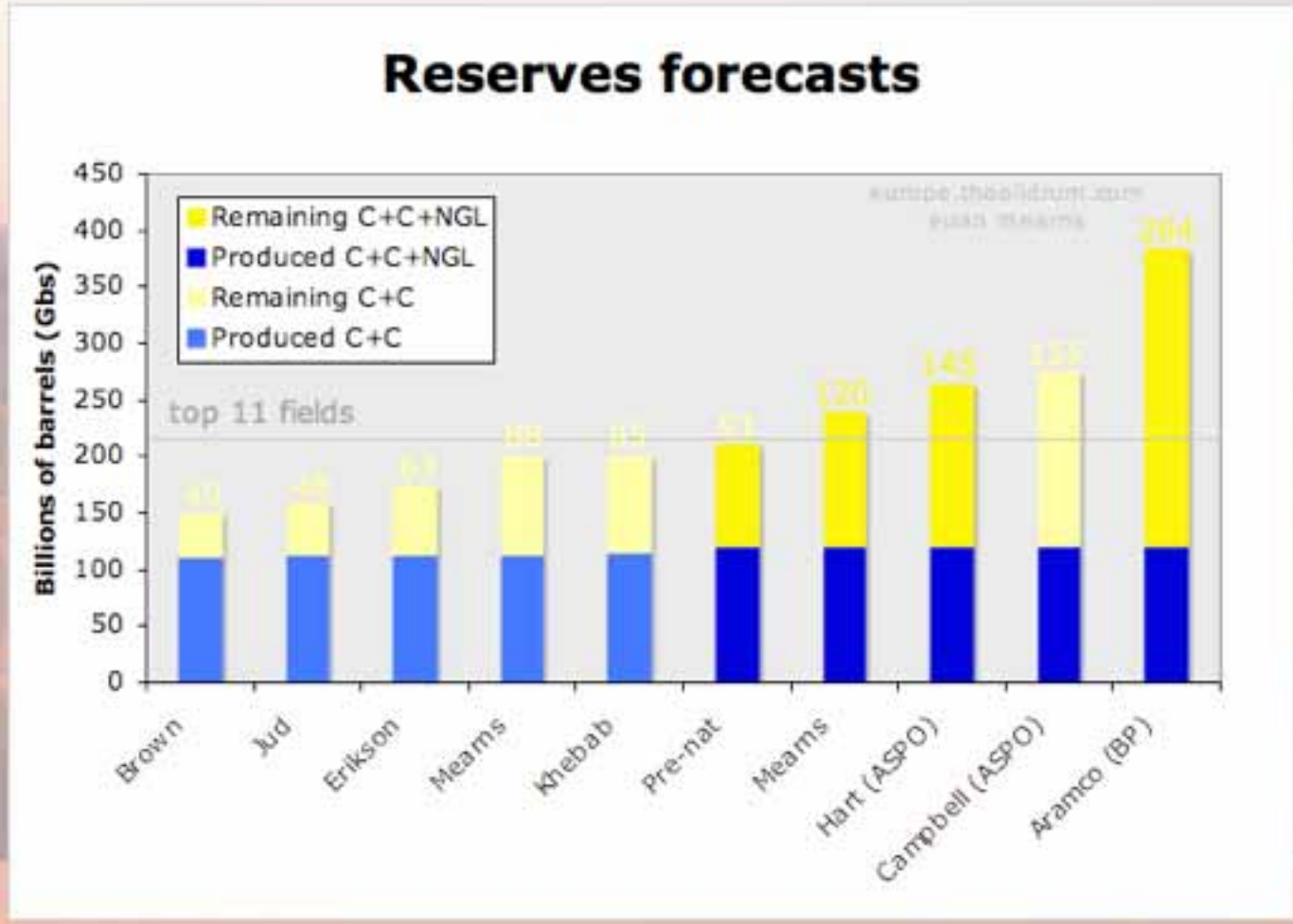
August 07

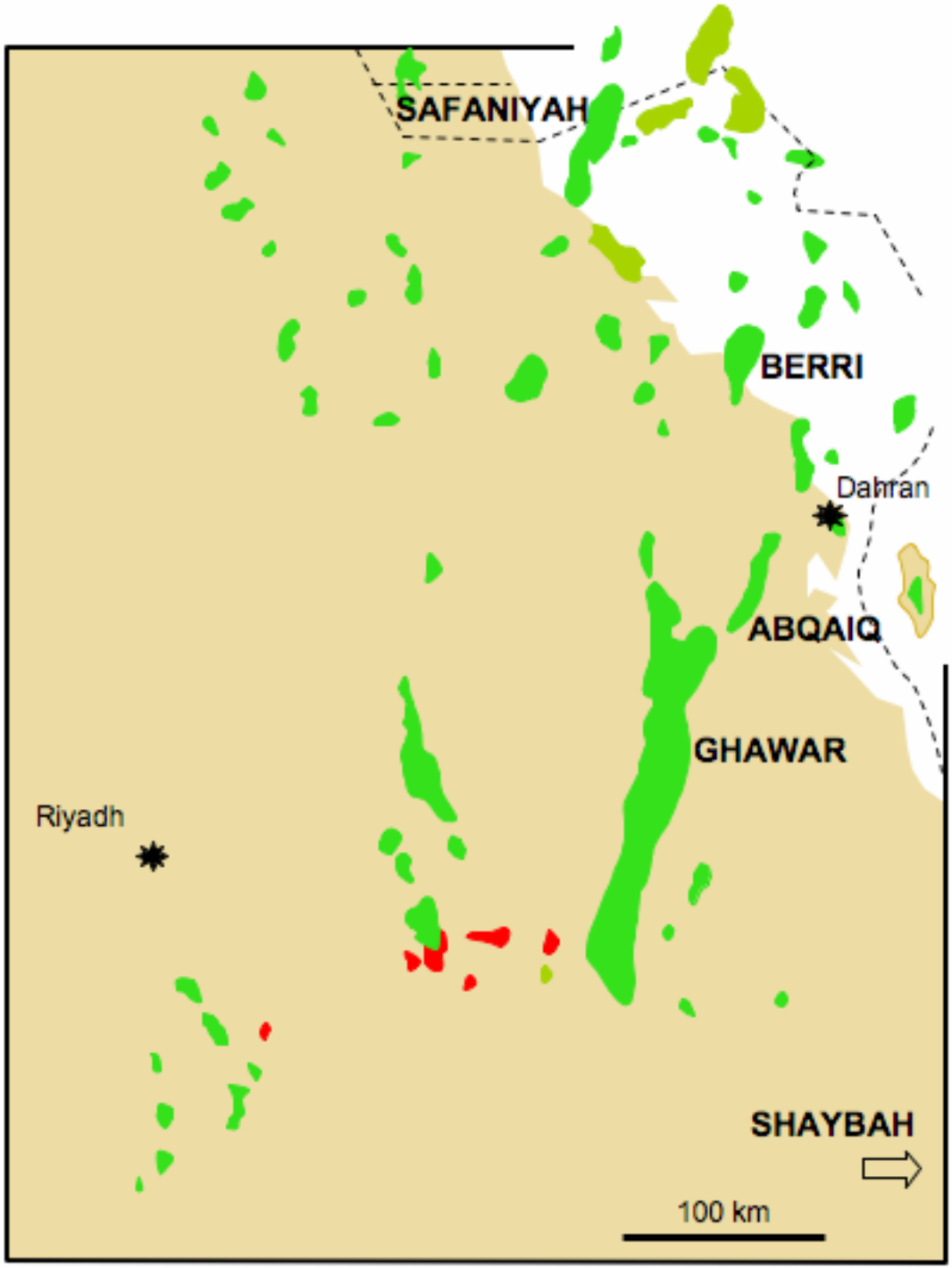
- Past production falls all voluntary
- Saudi is swing producer
- The undeveloped reserves cupboard is not yet bare

Field reserves

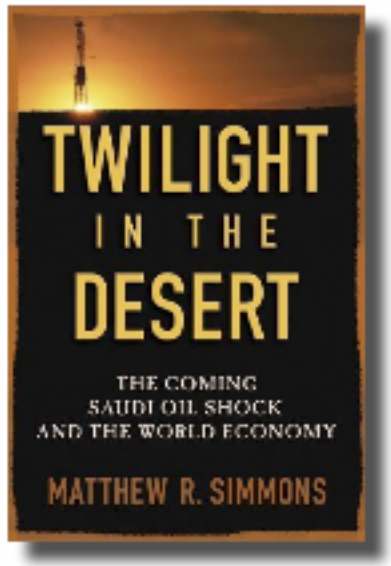


Saudi Arabia URR Estimates

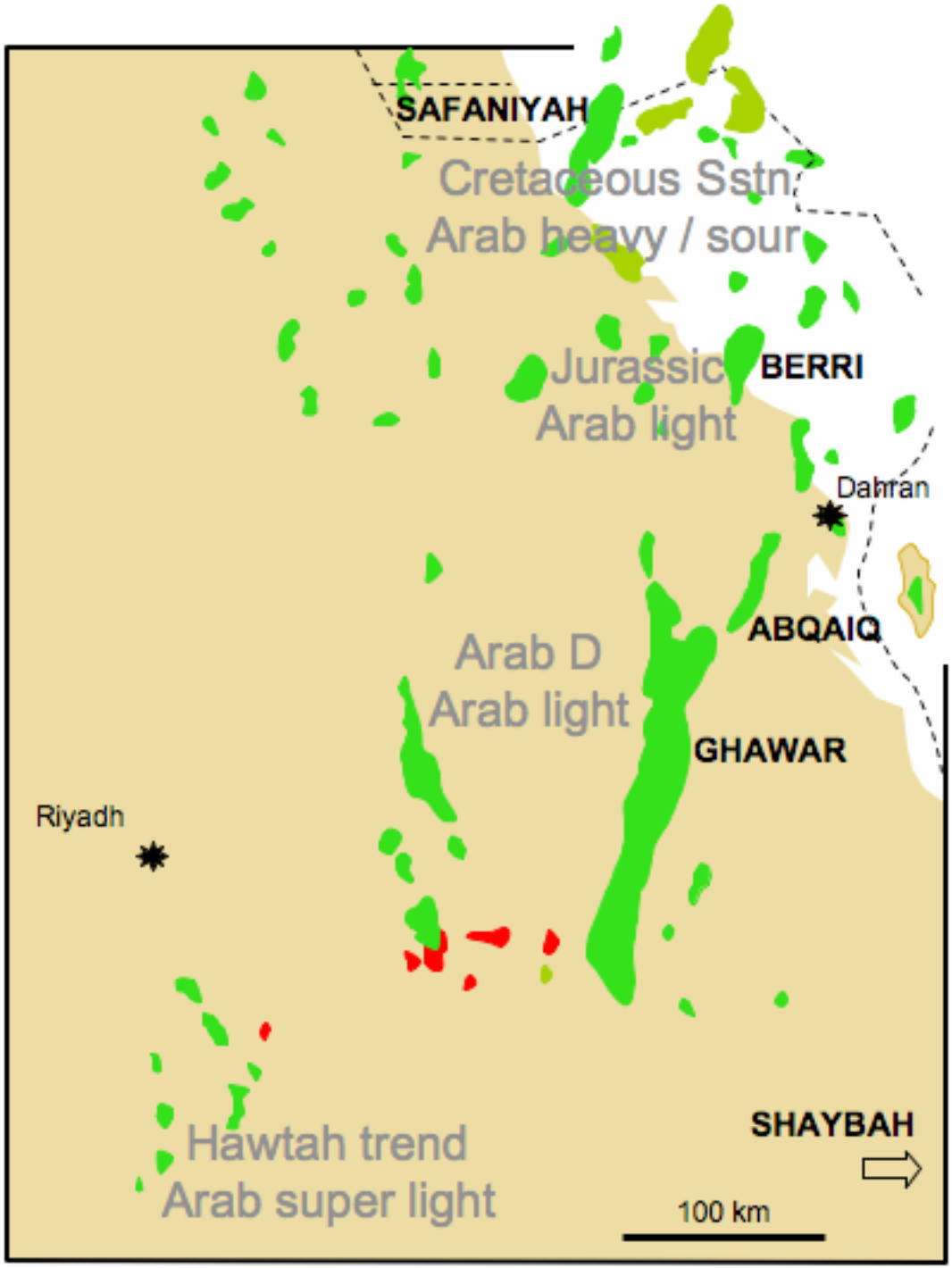




Sketch Map of Saudi Oil and Gas Fields



Based on Simmons. Twilight in the Desert p 33



5 Main plays in Saudi Arabia

How to estimate reserves and future production when this is a state secret?

Data sources

- Pre-nationalisation reserves data
- Production data - BP, iea, etc
- API Facts and Figures Centennial edition 1959
- Large number of SPE papers
- Twilight in The Desert
- Jaffe and Elass
- Rand Corporation
- Voelker PhD thesis
- Greg Croft's web site
- Saudi Aramco, Oil Reservoirs, Table of Basic Data, Year-End 1980
- Other internet sources
- Saudi presentations - Saleri and others
- Aramco releases - projects timeline
- OPEC official data

Different approaches

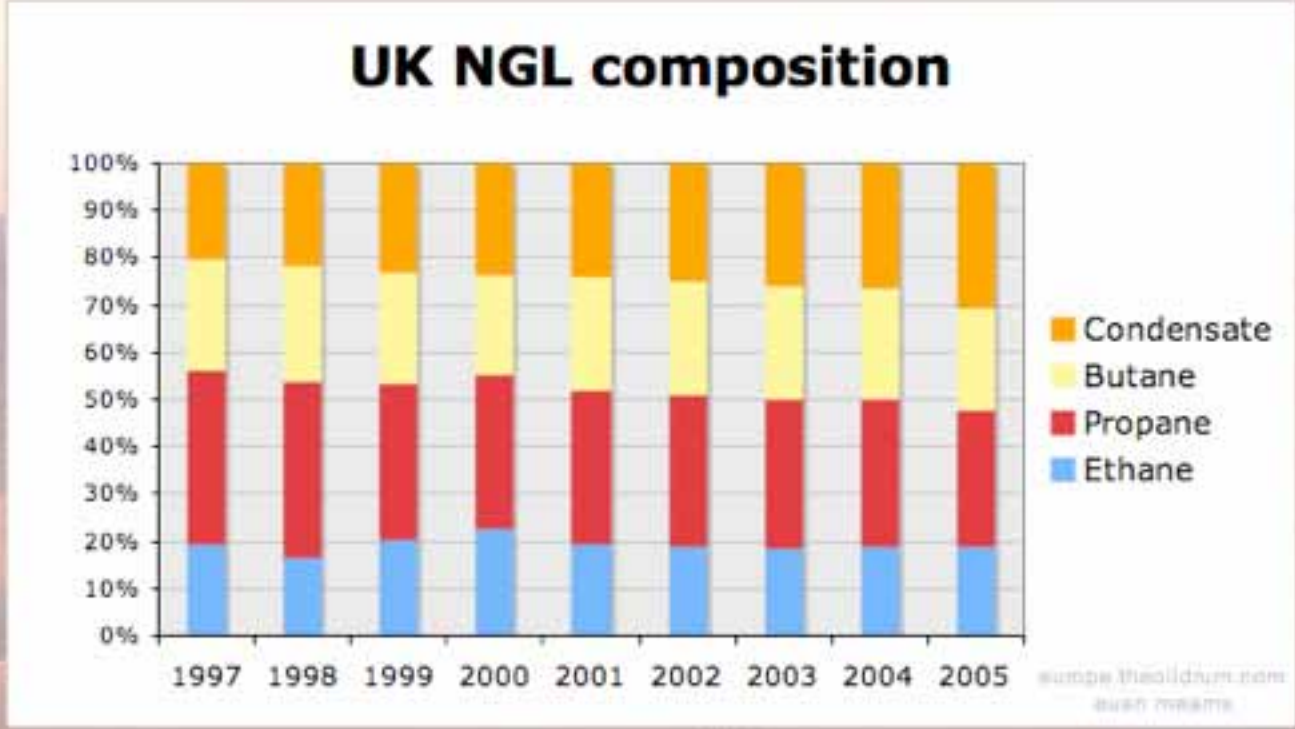
- Pre-nationalisation estimates
- Top down - Hubbert Linearisation / decline
- Bottom up - field by field evaluation
- Combined

Hydrocarbon definitions

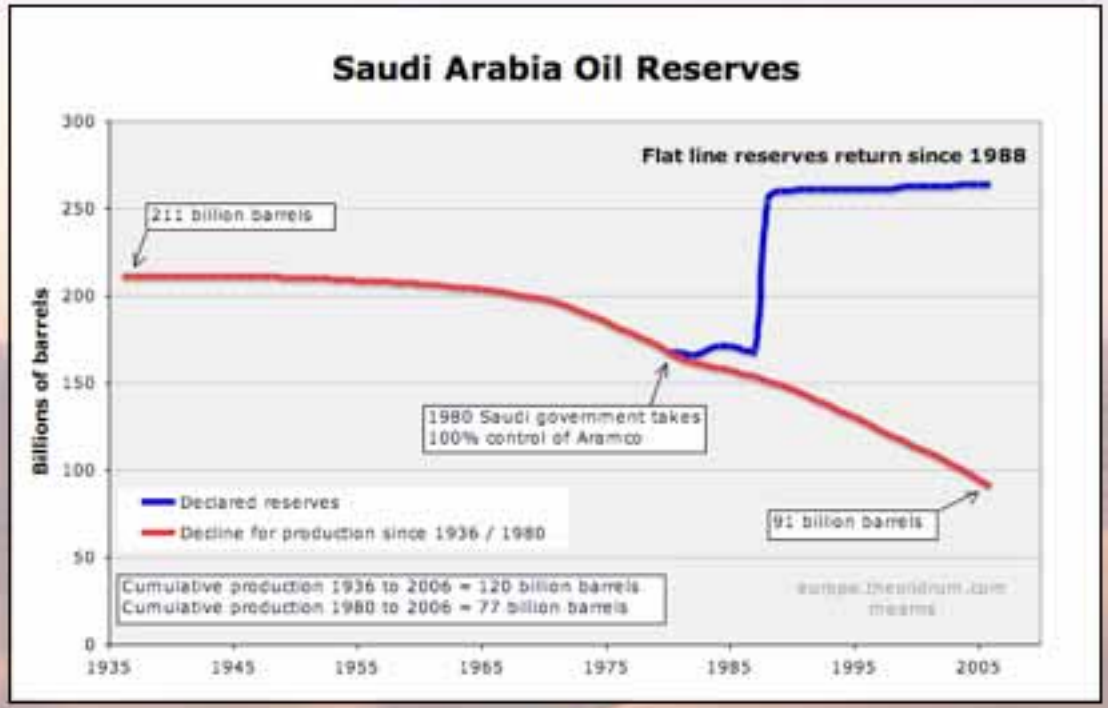
- C = crude oil
- C = condensate
- NGL = natural gas liquid

- C+C = crude + condensate
- C+C+NGL = crude + condensate + natural gas liquid

What is NGL?



Pre-nationalisation C+C+NGL



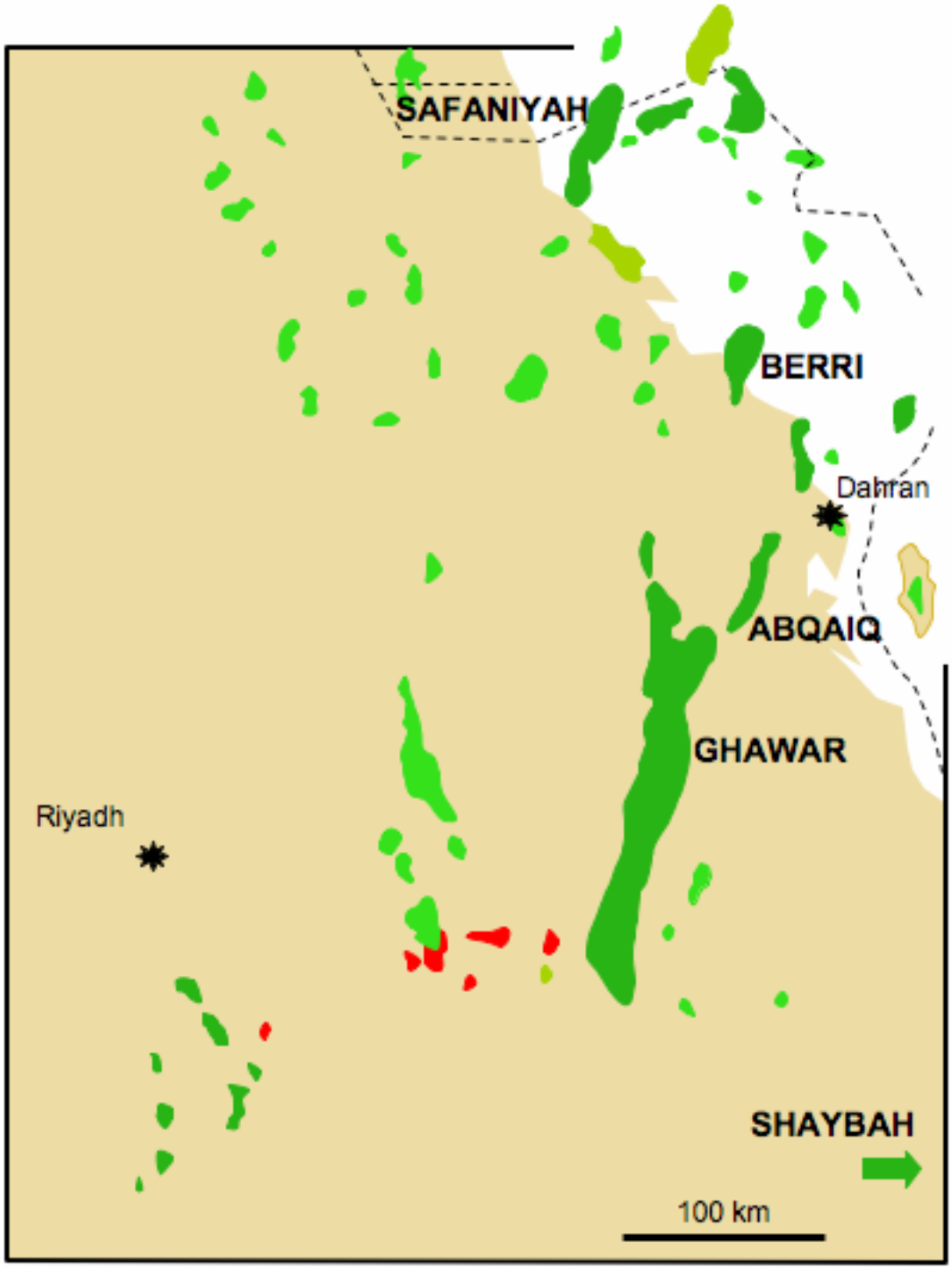
- Step rise in 1980s due to increased estimate for recovery?
- SEC reporting too strict - leads to reserves growth
- SPE reporting more liberal = actual estimate?
- Using SPE leaves little room for reserves growth
- Flat line return since 1988 = false accounting

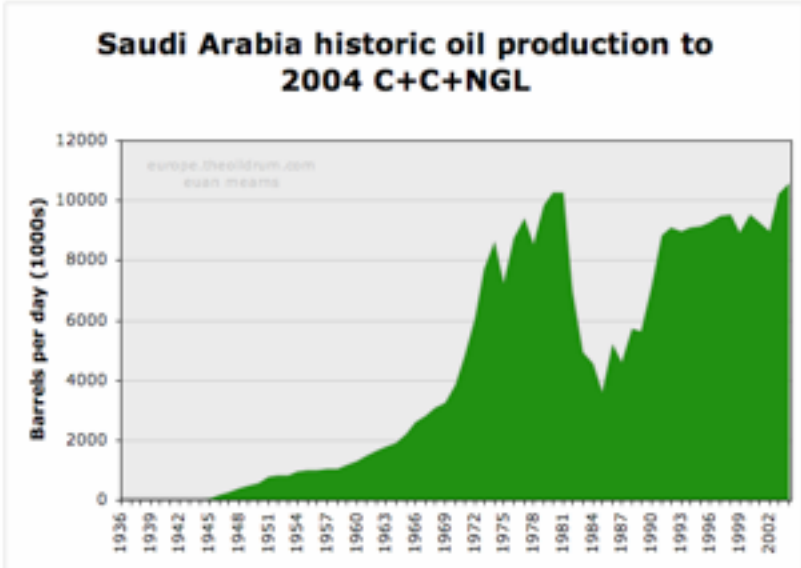
The 1980, pre-nationalisation reserves estimate adjusted for production gives 211 Gbs initial / URR with 91 Gbs remaining.

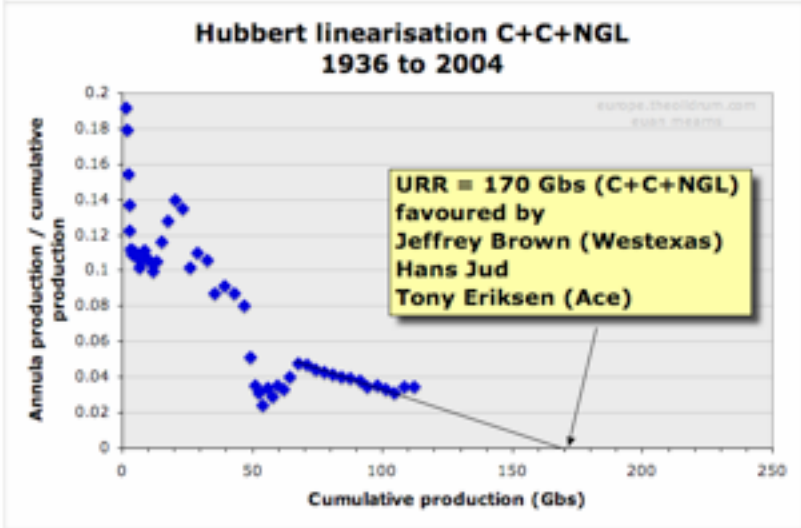
57% depleted.

Production Data

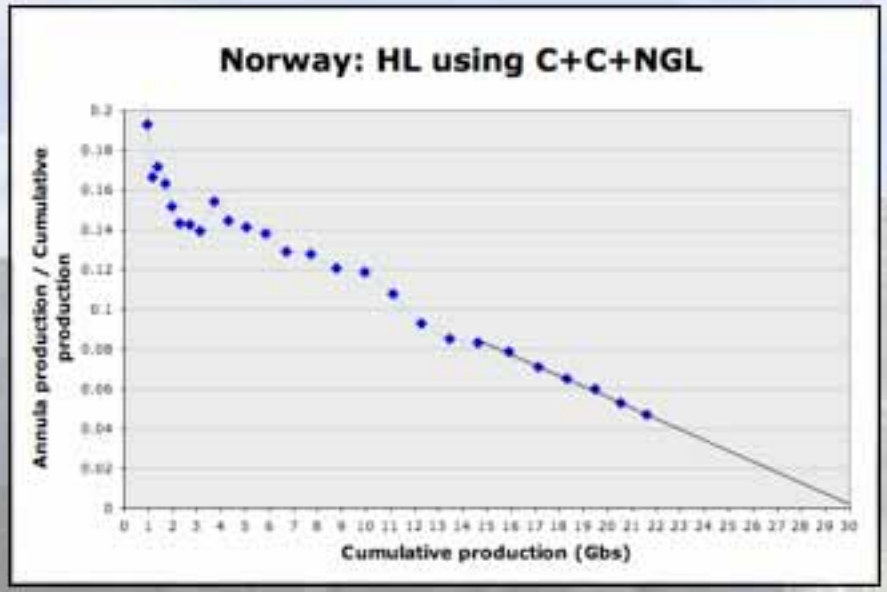
C+C+NGL, 1936 to 2004



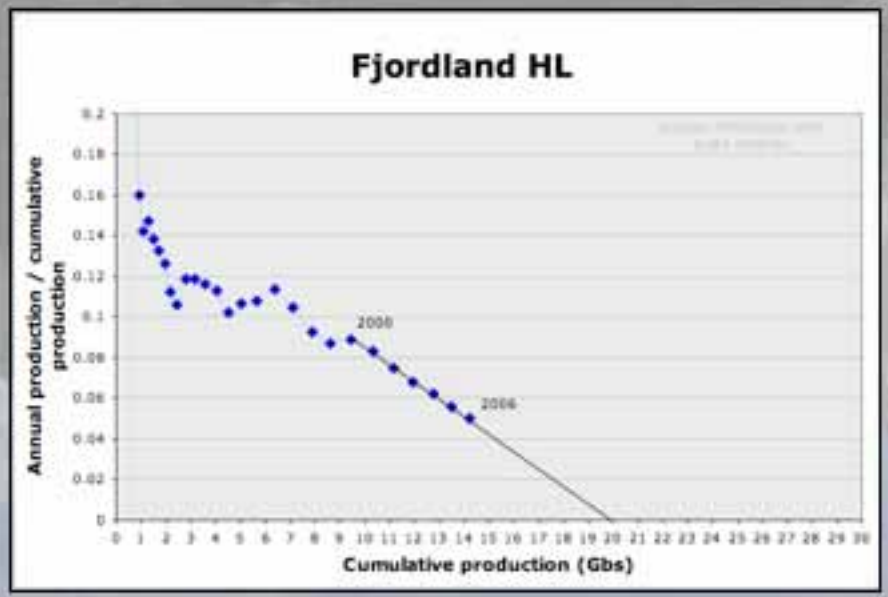




Synthetic HL experiment



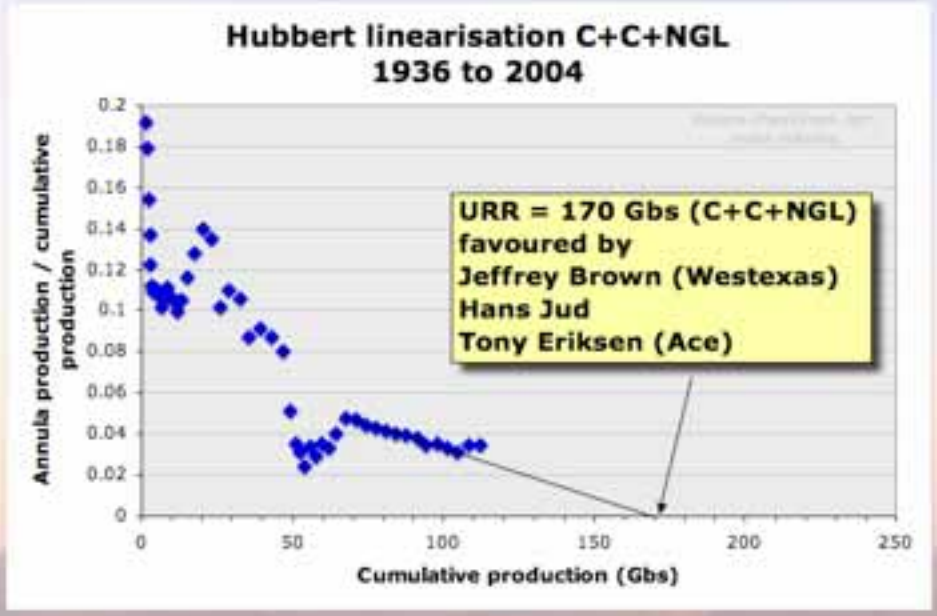
Norway HL - URR for C+C+NGL = 30 Gbs

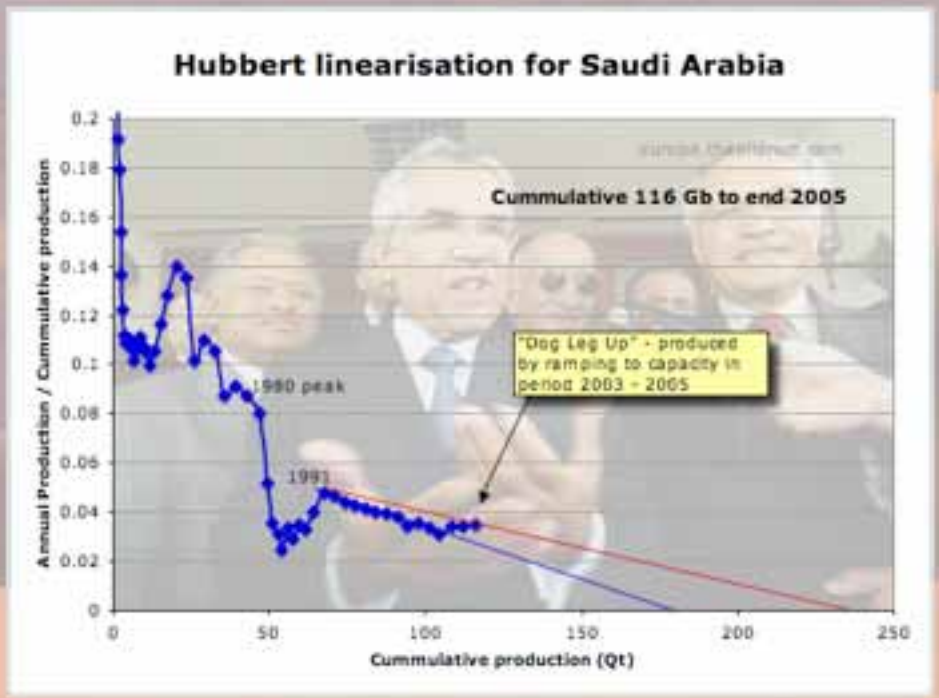


Fjordland - based on real Norwegian data. But 4 fields left fallow, and production pinned to 80% of capacity.

Apparent URR = 20 Gbs

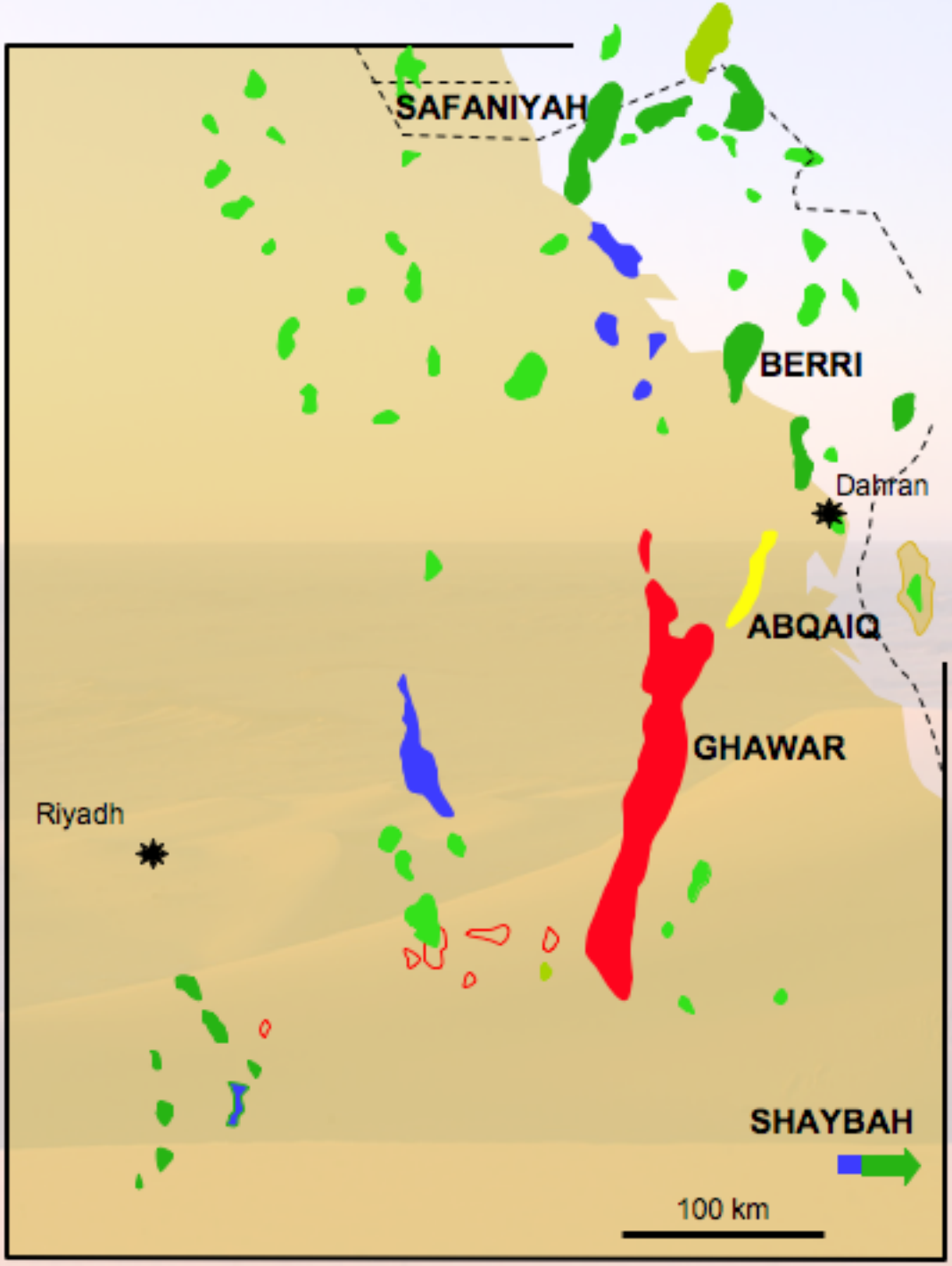
HL - apparent and stretch





1991 to 2002 - Saudi had many fallow fields and was not producing at capacity from fields in production - we know for sure the apparent HL will give a false low result.

Stretch HL - drawn through 1991 and 2005, two years we suspect Saudi was producing at capacity - 240 Gb indication?



Saudi Fields

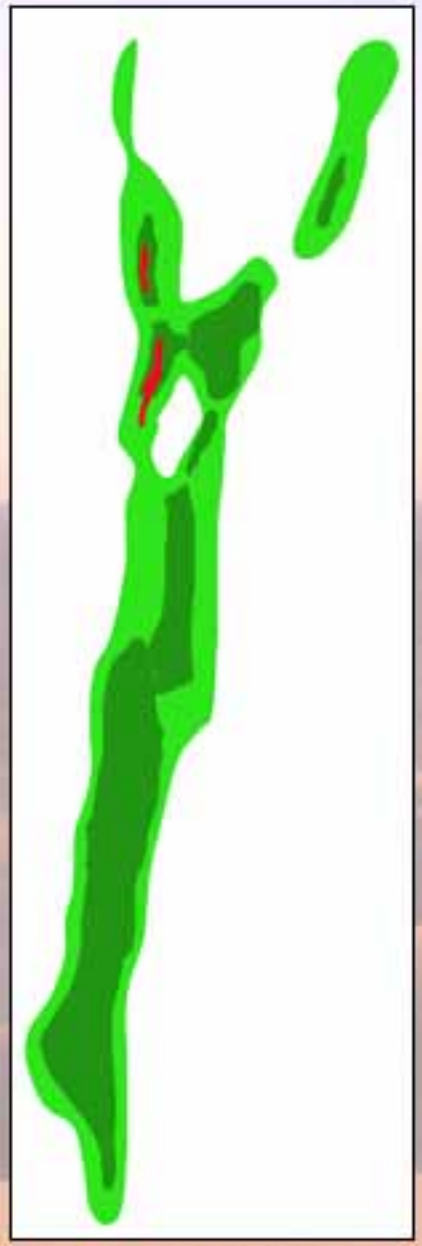
Discovered undeveloped

New developments to 2011

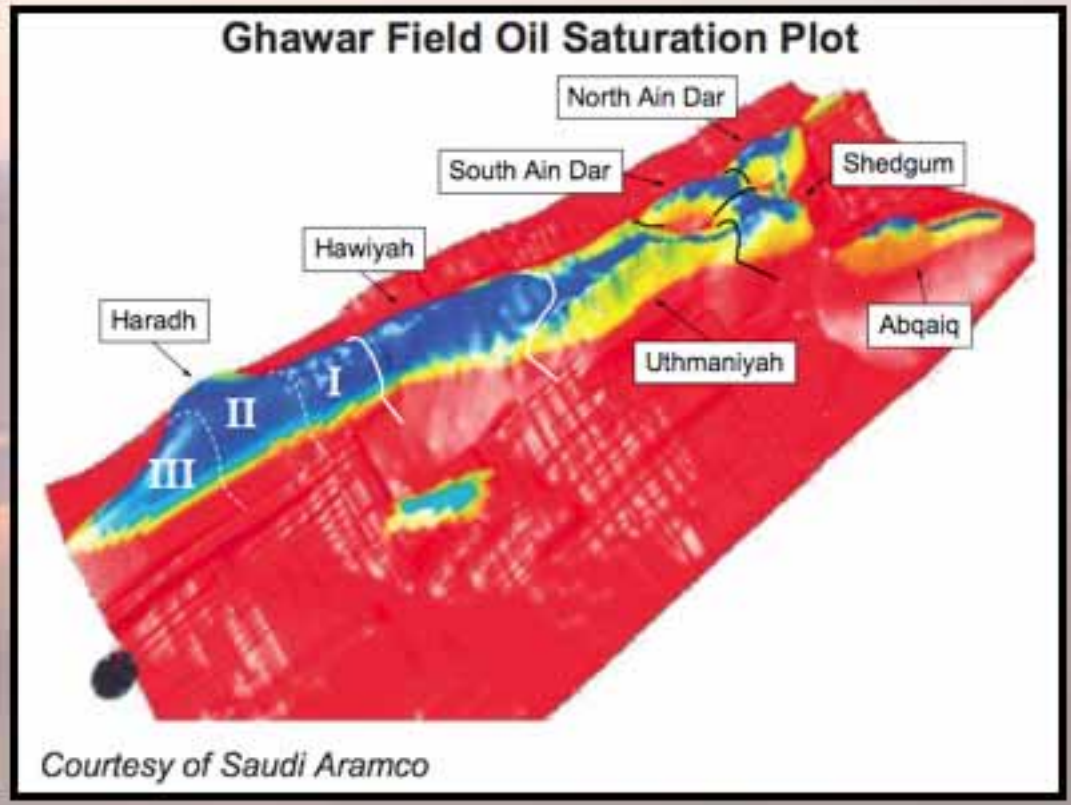
Heritage supergiants

Ghawar + Abqaiq

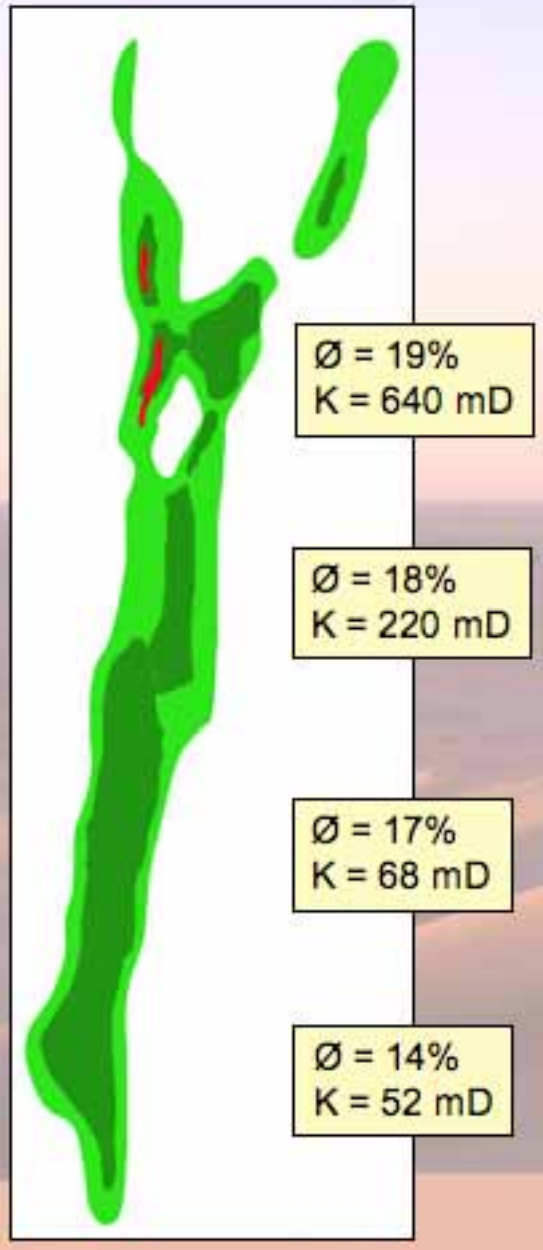
Ghawar

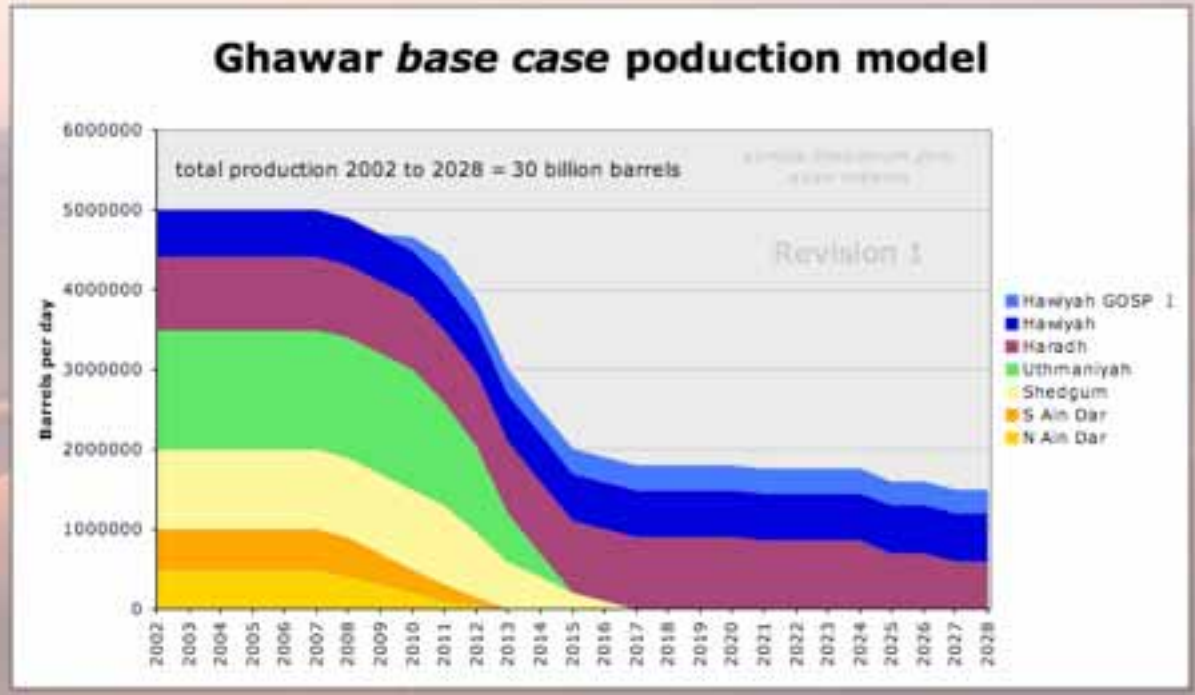


Map based on Greg Croft

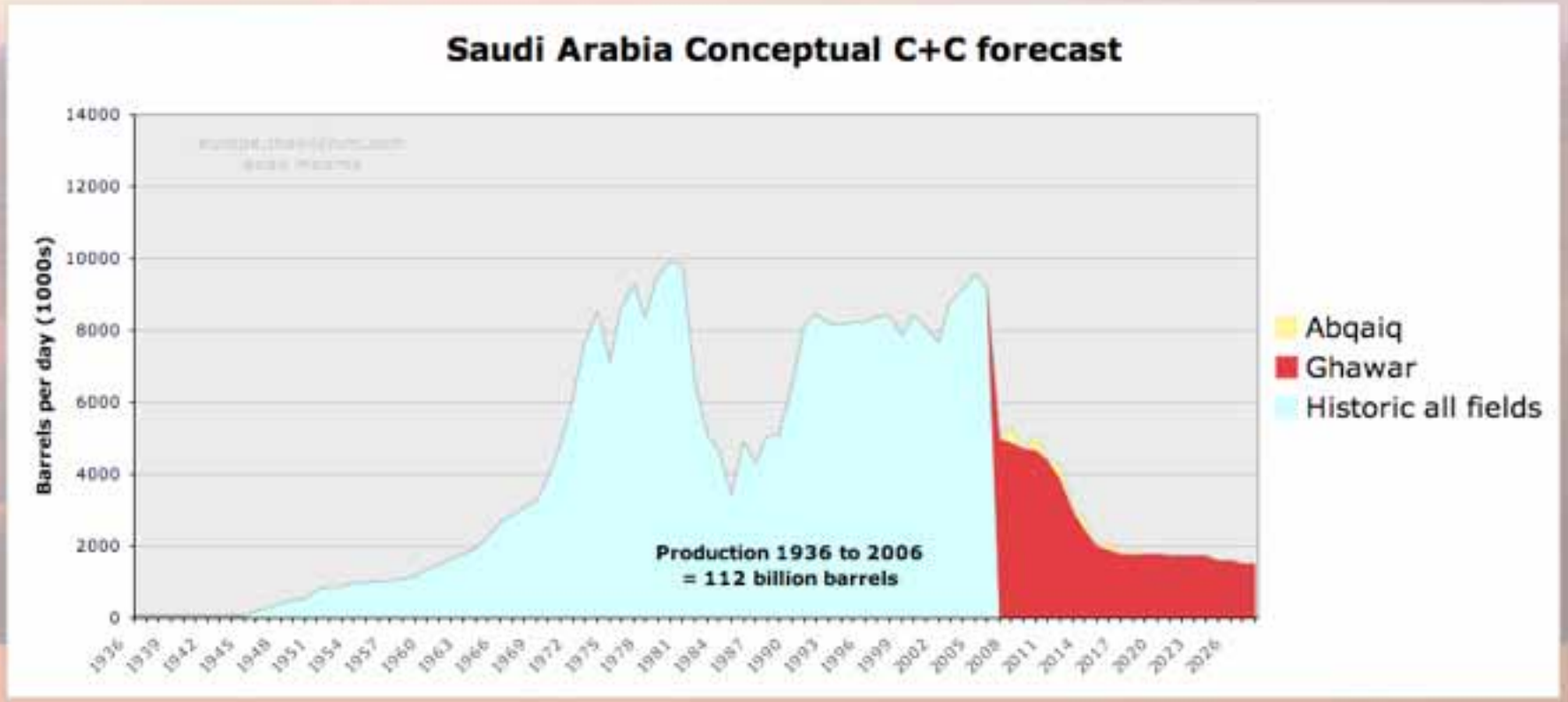


Ghawar


Ø = 19%
K = 640 mD
Ø = 18%
K = 220 mD
Ø = 17%
K = 68 mD
Ø = 14%
K = 52 mD


Ghawar base case poduction model
total production 2002 to 2028 = 30 billion barrels
Revision 1
Barrels per day
6000000
5000000
4000000
3000000
2000000
1000000
0
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
Hawiyah GOSP 1
Hawiyah
Haradh
Uthmaniyah
Shedgum
S Ain Dar
N Ain Dar

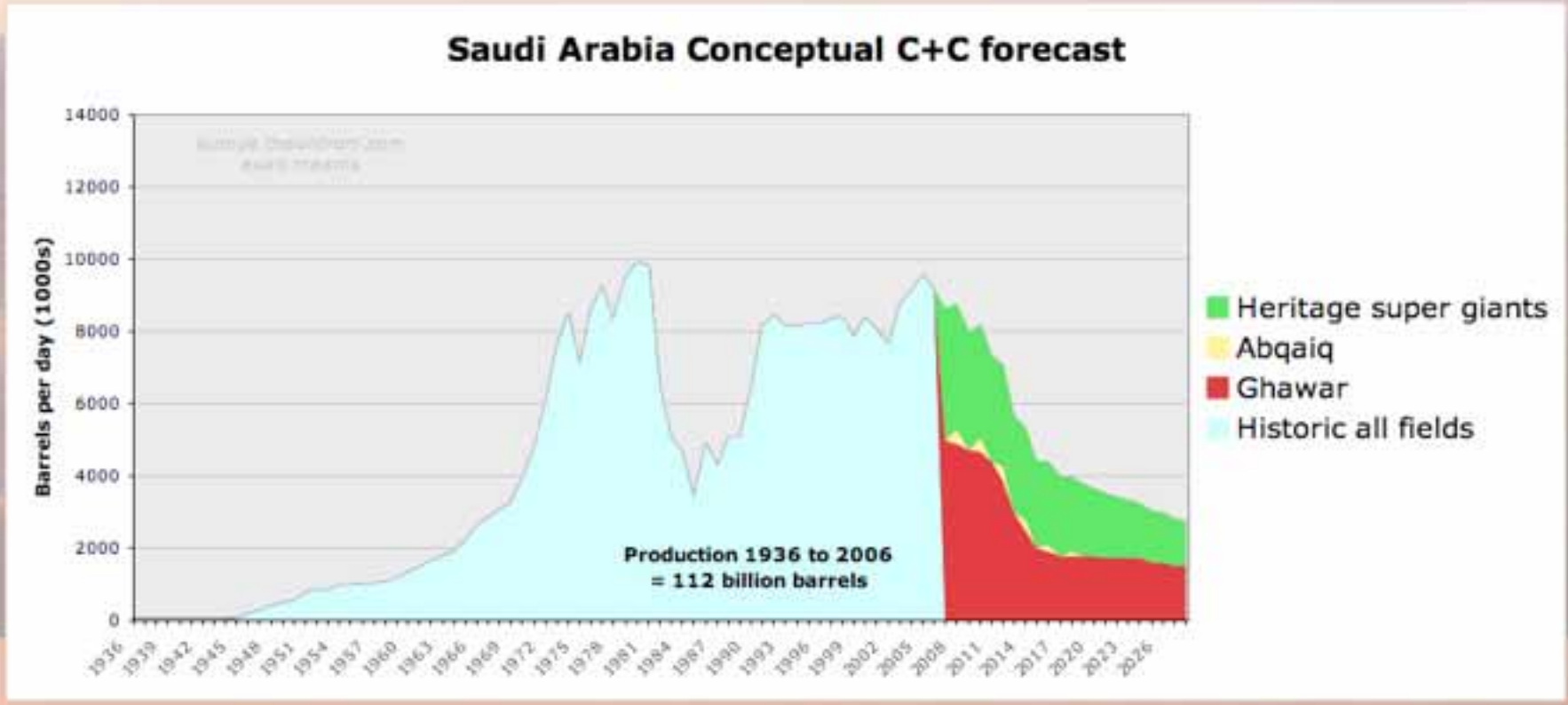
C+C Ghawar and Abqaiq



+ Heritage Supergiants

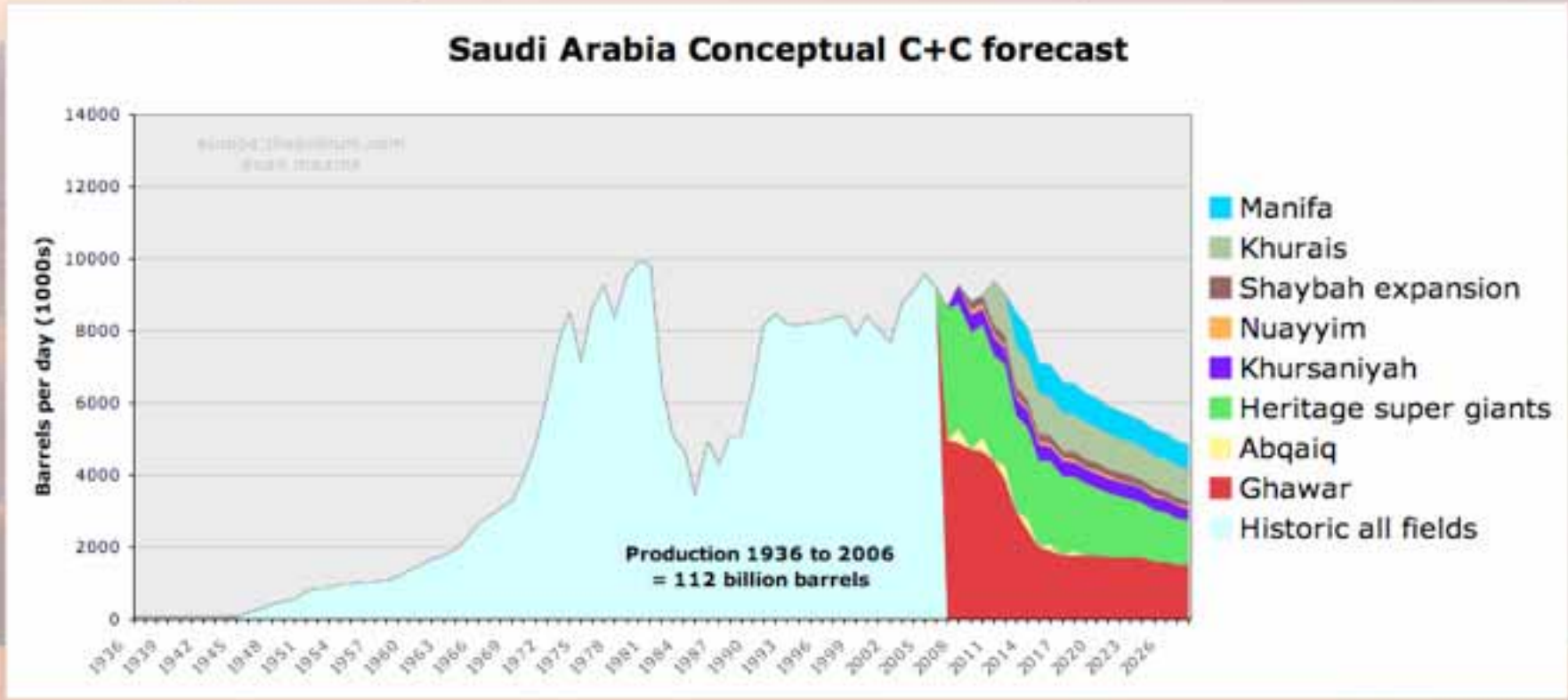
Heritage fields are declined
at 5% per annum

?



+ New Fields to 2011

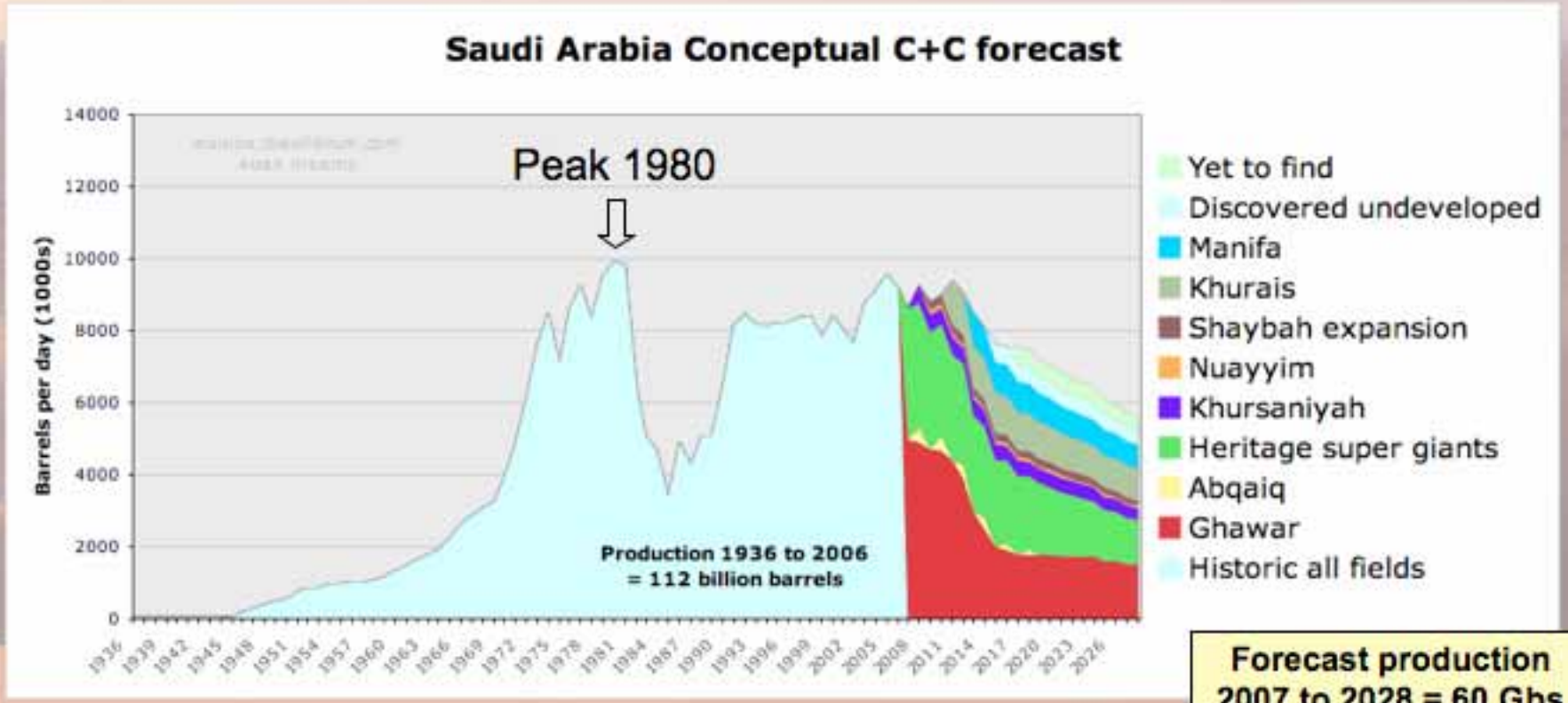
New fields from Aramco time line at name plate capacity.
1 to 2 year delays built in, declined at 2% per annum



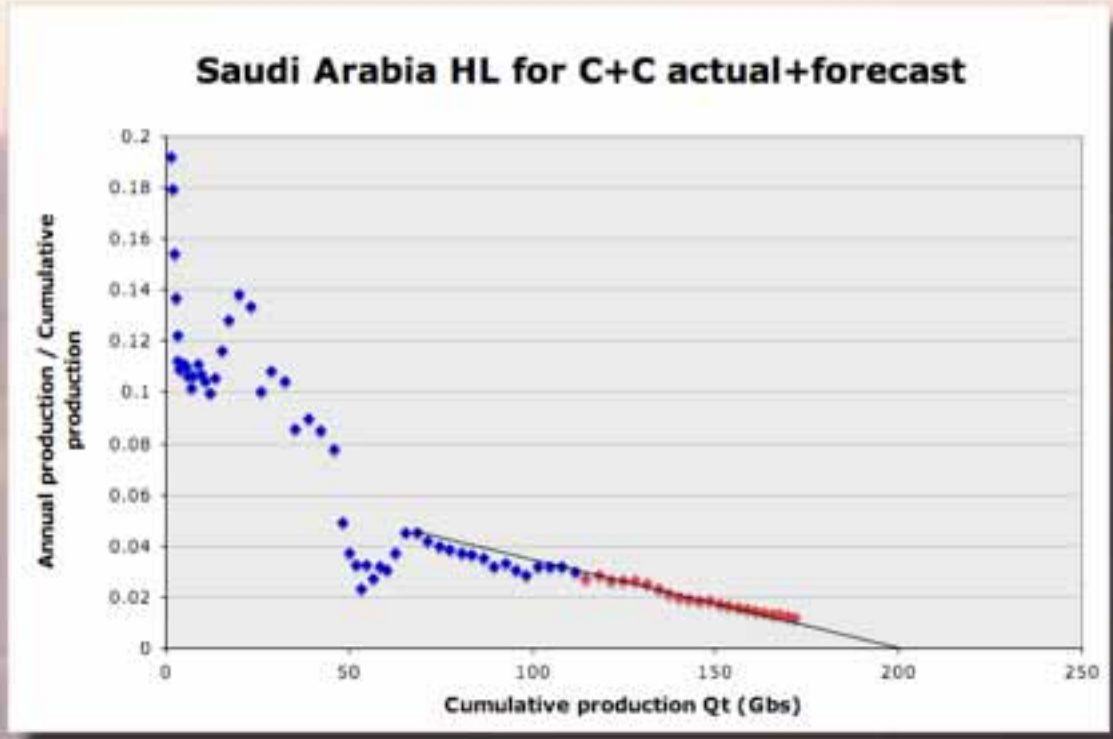
+ Speculative

Discovered undeveloped, 500 Kbpd from 2015, 2% per annum decline

Yet to find, 500 Kbpd from 2017, 2% per annum decline



C+C summary

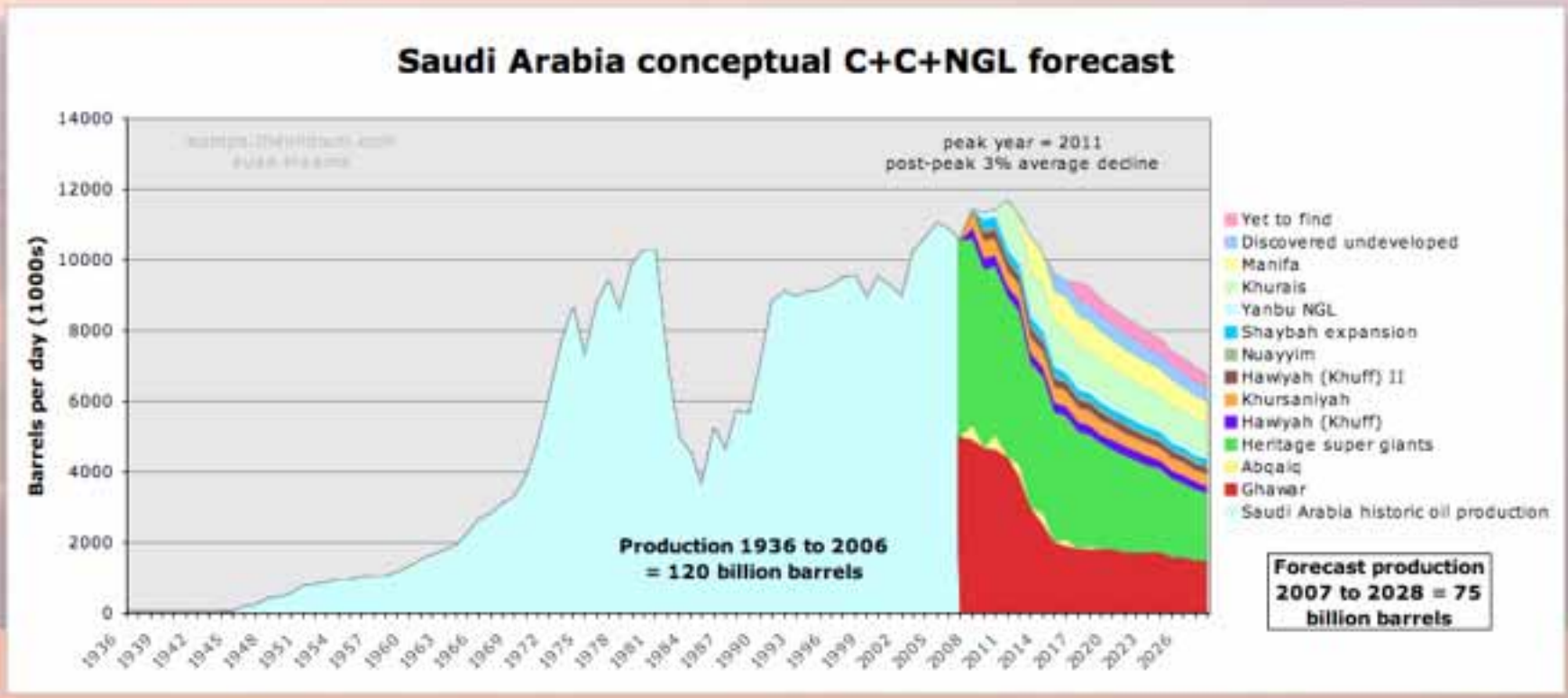


- Produced = 112 Gbs
- Production model 2007 - 2028 = 60 Gbs
- HL points to a URR of 200 Gbs
- 88 Gbs remaining at end 2006?
- 56% depleted at end of 2006

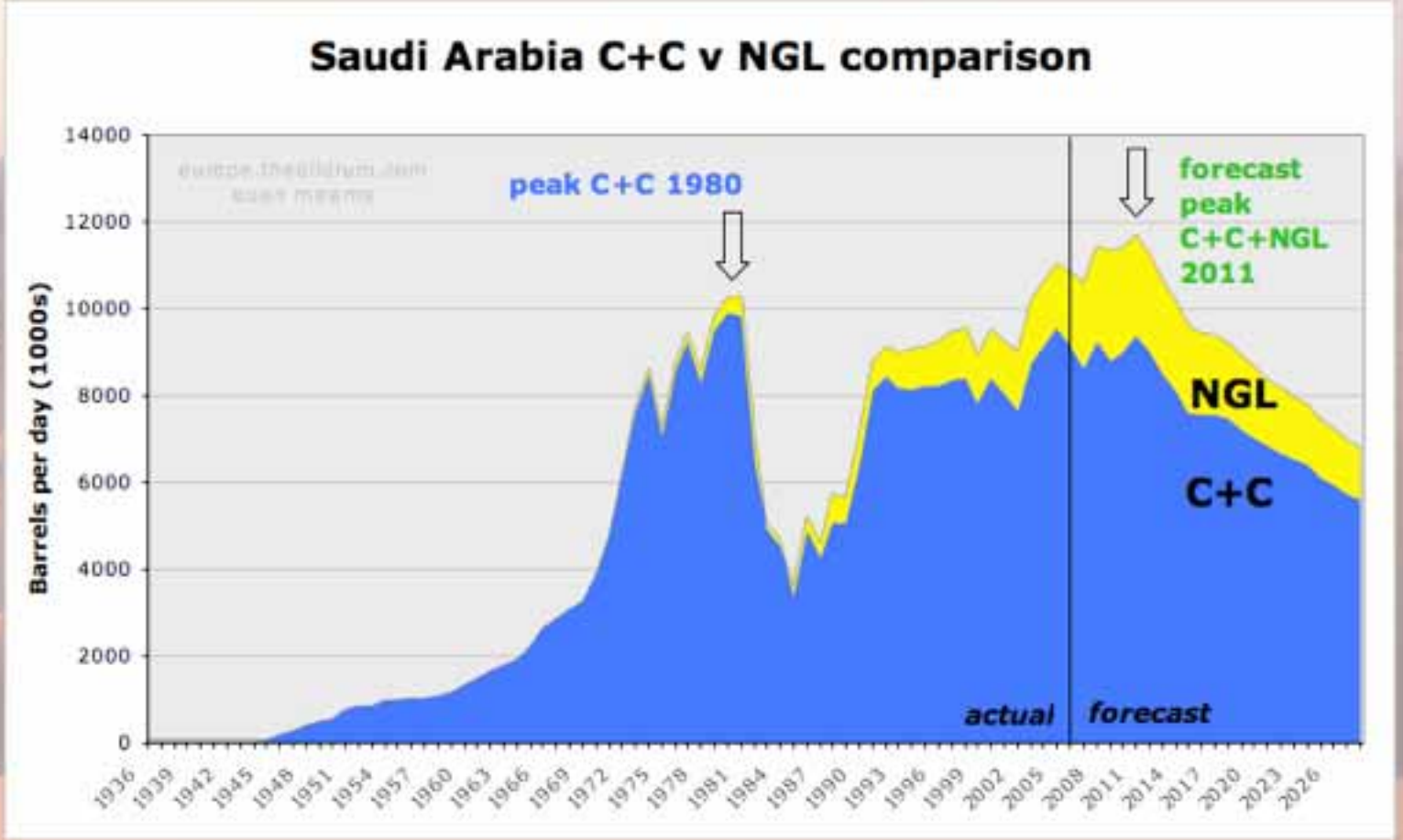
So what about NGL?

C+C+NGL forecast

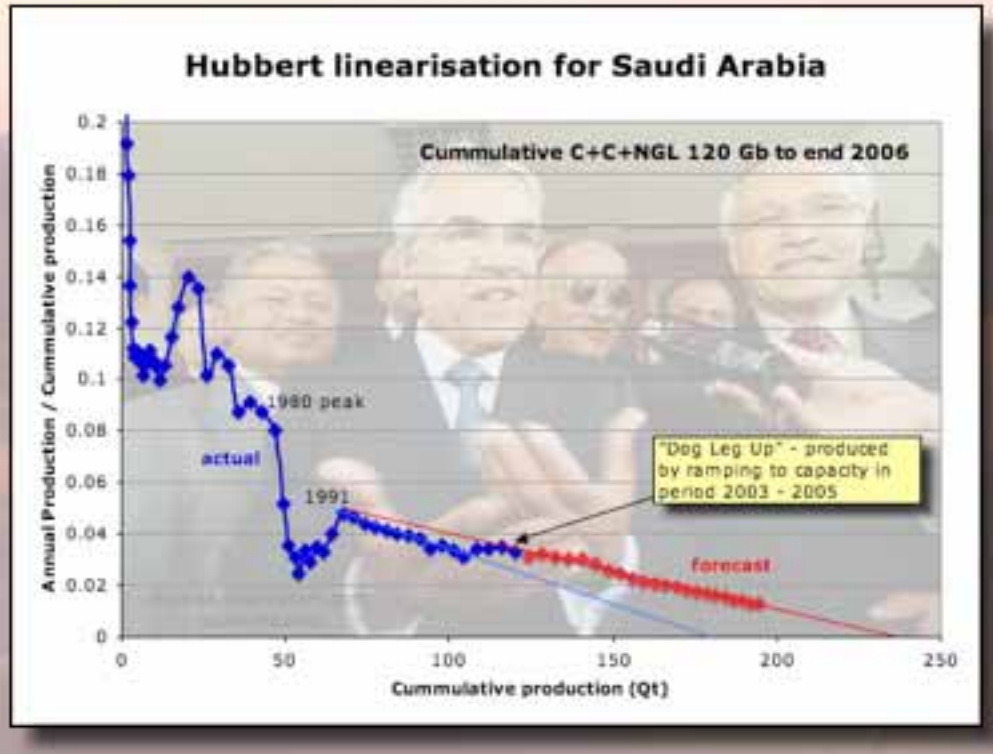
Future peak of 11.7 million bpd in 2011



Ethane is not oil



C+C+NGL Summary



- Produced = 120 Gbs
- Production model 2007 - 2028 = 75 Gbs
- HL points to a URR of 240 Gbs
- 120 Gbs remaining at end 2006?
- 50% depleted at end of 2006

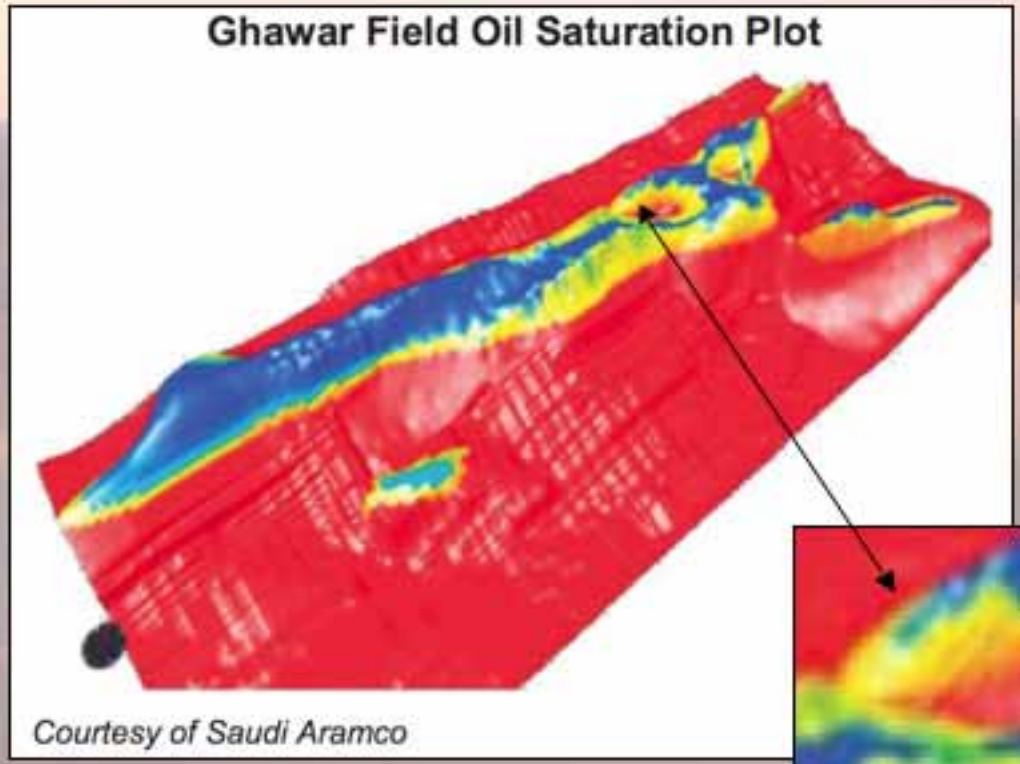
Unknowns

- Reservoir parameters and reservoir volumes in Ghawar are not known in detail
- Timing of decline in N Ghawar (±4 years?)
- Impact of new technology
- Segregation of oil from water behind flood fronts
- Saudi desire to expand water handling facilities
- The reserves status of Safaniyah, Berri etc

J. K. Galbraith

"One of the greatest pieces of economic wisdom is to know what you do not know"

Secondary Segregation of oil from water?

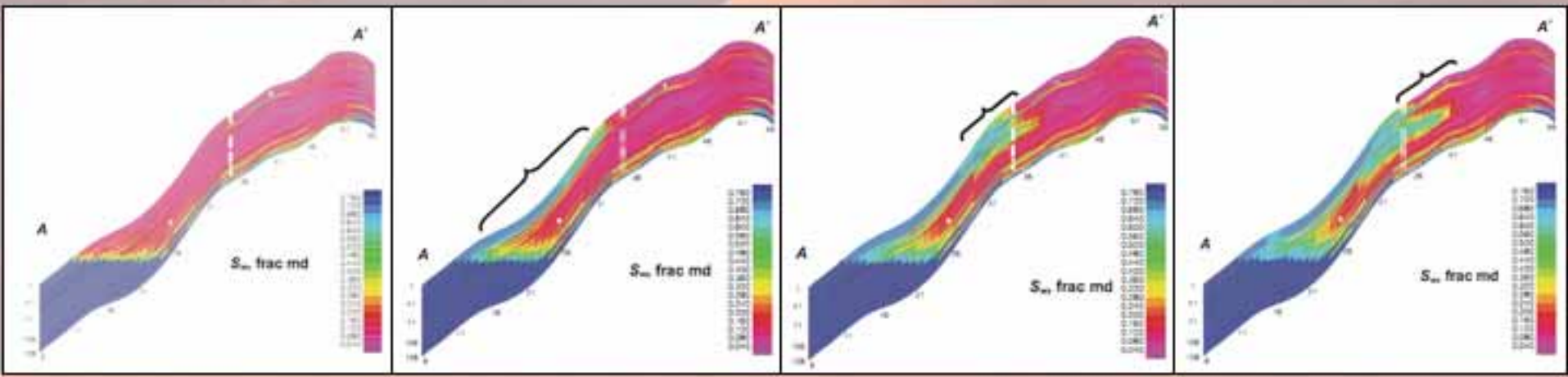


- Decadal time scale for production from super giants
- Oil in ridges of Ghawar and Abqaiq
- Secondary segregation in water flooded zones?
- Would lead to higher recovery.

Berri 1984 to 2000

Water saturation profiles showing progressive water flooding.

SPE 79718. E. J. Pavlas



original 1984 1994 2000

Summary

- Pre-nationalisation C+C+NGL = 211 Gbs (minimum)
- Mean of top 11 fields compilation = 218 Gbs (minimum)
- Mearns C+C = 200 Gbs (minimum)
- Mearns C+C+NGL = 240 Gbs (minimum)

Colin Campbell, geologist,
former IHS Energy

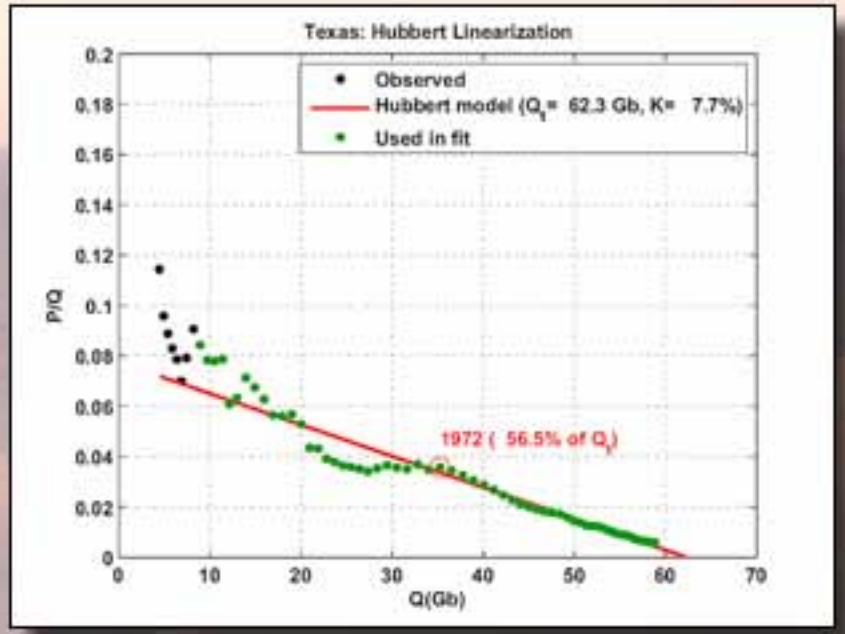
"all numbers are wrong"

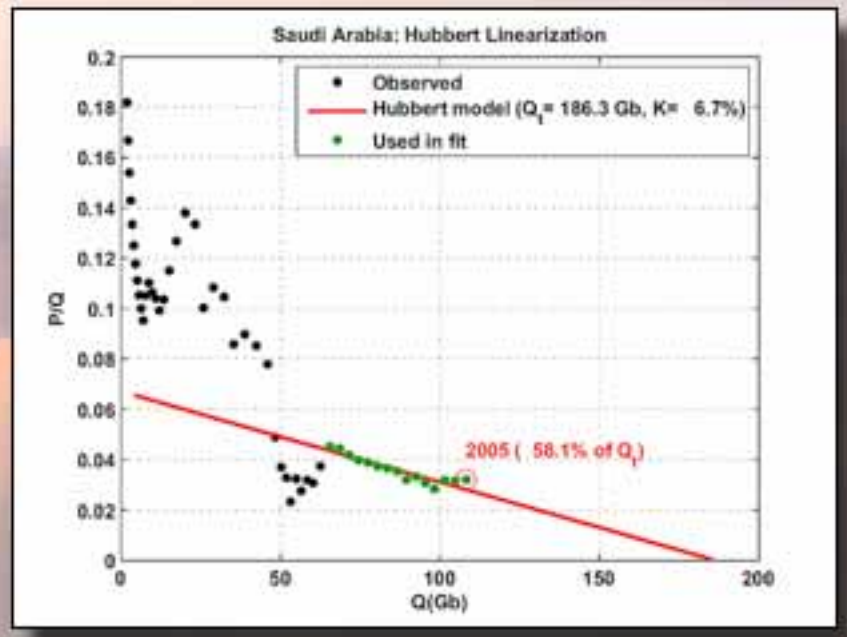
His estimate 275 Gbs

I wouldn't bet against it.


High noon
240 Gbs reserves
120 Gbs produced

HL for Texas and Saudi





2007 Houston World Oil Conference

Proceedings

- Conference Program
- Conference DVD
- Video Highlights
- Peak Oil Review
- ASPO-USA