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Mature Fields: Keep Revisiting the Fundamentals

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Introduction

This is the story of a field most people thought was in terminal decline:-

- Drilling had ceased
- Rapid production decline
- Some partners had sold out
- Shut in looking not far off

In 2001 things were looking grim!

Reservoir History Plot - Kutubu

Forecast
History

It looked like the field would be shut in around 2008!
Greater Kutubu Area – Toro A

Discovered 1986
First oil 1992
72 wells to 2001
Iagifu Hedinia – Toro A Structure

Seismic is very poor quality in New Guinea foldbelt and so not many lines have been shot
Crestal Cross Section
Kutubu Vital Statistics

- **Papua New Guinea’s largest oil field**
- Main formations: Toro A,B,C sands
- STOOIP: about 600 MMstb
- EUR: about 350 MMstb
- Peak oil rate: 130,000 stb/d
- Gascap: about 1.2 TCF OGIP
- Permeability: 400 md
- Porosity: 13%
- Viscosity: 0.3 cP
Gas Drive or Water Drive?

- Large gascap
- Gascap expansion throughout field life
- Wells gas out, rather than water out
- The highest wells, those nearest the gascap, *should* gas out first……..
- Hence placed wells downdip near OOWC
- Very little water production

Melbourne SPE Conference 1994:-

- 3 papers on Papua New Guinea development
- 1 paper on aquifer hydrodynamics
- Emphatic conclusion that region dominated by powerful aquifer flows
Evidence for the Strong Aquifer

- Strong aquifer should cause a tilted contact
- Some variation in OWC depth across field
- Some pressure anomalies
- Some water found in a well nearest the centre of the field
- It looked like all the oil had been swept to the east and SE side of the field

Conclusion

- A large part of the field, the centre, was considered to have been water swept and was therefore not a drilling target !!
The Feared Central Water Channel

Top

Gas in Centre

Base

Water in Centre
The Beginning of the Rethink

- A full petrophysical review
- A full facies study
- All the above fed into simulation
- New simulation built
- A seismic review
Rethink - continued

– A full RFT review:-
  • All the original data was on the one straight line
  • All the post production data was not
  • Huge amount of detail in the post production RFT data revealing subdivisions within sands
  • This data had major implications :-
    – changed our completion philosophy, leading to more zone splitting
    – needed more layering in the simulation
Well Performance Review

- This is a gas drive system
- However the highest well on the structure had not gassed out
- Instead it was the best well in the field
Alternative Theories to the Dynamic Aquifer Model

- Compartmentalisation
- Measurement uncertainties
- Permeability variations

Unlikely in this case
Compartmentalisation ??

• Compartment behaviour had been observed in the other New Guinea Highlands oil fields

• This applies to Moran and Gobe fields – no dynamic aquifer needed to explain their performance

• Did we really want a different theory for Kutubu? Was it a special case?
Competing Theories

Compartmentalised System

Strong aquifer with tilted contact
Reasons against Tilted Contact

• Compartment behaviour obvious in nearby fields Moran and Gobe
• Worried about having a different theory for Kutubu
• Some parts of Kutubu obviously compartmentalised so why not all?
• Seismic data and well performance suggested potential compartmentalising faults exist
• Intriguing anomalous performance of well IDT5
  – Highest well on structure
  – Would be expected to gas out first
  – Instead it’s best well in field!!
  – Second best well was nearby
• No water production in centre of field near where dynamic aquifer might be
• Simulation suggested oil in the centre of the field
A review of available seismic data pointed to the fact that significant, potentially compartmentalising, faults exist that had not been previously recognised.

- It soon became apparent that the North Iagifu region was unappraised and may contain significant volumes of unaccessed oil.
• Drilled IDT-9ST2 in North Iagifu region
  – Found water in the Toro!
  – BUT..................
  – Unusually high water confirmed compartment theory!
  – However also discovered a deeper reservoir
Action

- It was decided to drill *updip of the highest well* in a mature gascap drive field !!!

- Drilled 4 updip deviated wells into the central “water-prone” region :-
  - Drilled IDT-4ST1
    - Found oil in Toro A, B, C and no water
  - Drilled IDT-22
    - Found more oil and no water
  - Drilled IDT-23
    - Gas swept, no water
  - Drilled IDT-23ST2
    - Found more oil, some trapped or “perched” water
• All 4 central wells were found to be in separate compartments !!!
• The central oil pool extension had been supporting the structurally high wells which had not gassed out as early as expected
In 2001 things were looking grim....

Reservoir History Plot - Kutubu

It looked like the field would be shut in around 2008!
By 2006 things were looking good

Reservoir History Plot - Kutubu

field shut in now expected around 2020 to 2025
Other Actions

- Resurrection of old wells shut in and forgotten
  - Do not forget “watered out wells”
- Workovers
  - Often a low cost, high return activity
- Wireline
  - Keep checking all zones
  - Imbalance of reinjection can create opportunities
- Development of undeveloped zones
  - You need to break the ice.....
Highlights

• At the end of the round of drilling discussed above, Kutubu production levels had recovered to 24,000 bopd, the highest capacity since late 2001 / early 2002
• Have added over 10,000 bopd of capacity
• Have added 10 to 20 MMstb reserves

Lowlights

• The severe tectonic stresses which create the compartments also cause occasional collapsed casing
• Need to keep doing things else field goes back onto decline
Conclusions

• Beware of “dynamic aquifers” and tilted contacts
• Step back from the detail and look at the regional issues occasionally
• Performance of “outlier” wells is often an omen
• Keep going back to basics:-
  – Are all zones perforated?
  – Wells change, even “dead” wells
  – Keep testing old wells
• Simulation
  – If it tells you there has to be more oil there, that’s good
  – If it can’t see more oil maybe there’s a new compartment, which is even better
• Keep revisiting the fundamentals !!
A Final Note

• Interesting to note that IDT 23ST2, our newest well, *the highest well on structure*, is the only well still producing at solution GOR...

• Many appraisal opportunities remain in Kutubu
This presentation was based on

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by

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