Exploration Well Failures from the Moray Firth & Central North Sea (UK)

21st Century Exploration Road Map Project
Christian Mathieu
1. Project Objectives, Time-Line and Status
2. A few statistics…
3. Reasons for failure
4. Selected interpretation pitfalls
5. Conclusions
2003 – 2013 Wells (E&A) to be looked at:

- 150 Exploration main bores + Exploration Side-tracks have been drilled over this 10 years period by 42 Operating Companies.
- Project tried and understood the reasons for failure of the dry wells and a few “technical” successes.
- 98 such wells (currently owned by 24 companies) have been reviewed >>> 104 segments successfully analysed.
Project Objectives

• Part of the 21st Century Exploration Road Map recommended by ETF (“Exploration Task Force”) and aligned with Sir Ian Wood Review

• Project entirely sponsored by DECC / OGA.

• Project focused on Dry Holes and a few Technical Successes drilled 2003-2013 in Moray Firth (MF) and Central North Sea (CNS)

• 150 Exploration main bores + Exploration Side-tracks with overall Technical Success rate = 40%

• Rigorous well failure analysis conducted by DECC / OGA together with Industry

• Objectives:

  ➢ To fully understand the reasons why a prospect was drilled (i.e. Geological and Petroleum settings)
  ➢ To better understand the reasons for success and failure in Exploring MF and CNS during the last 10 years
  ➢ To share the main findings with the Industry
  ➢ To test the “Collaborative Model”.

4 21CXRM Project_Exploration Well Failures from MF-CNS _UKCS_Ch.Mathieu_23rd October 2015
22 Companies (over 24) opened their “books” during “1 to 1” workshops

Summary results for each well / each explored segment gathered into a Post Well Analysis Sheet

Number of Post Well Analysis Sheets completed = 104 belonging to 97 wells (compared to 98 wells initially targeted)

Preliminary findings have been presented at the O&GUK 2nd Pitfalls in Exploration Conference (London, 05th February 2015). Overall findings presented at O&G Industry Conference (Aberdeen, 17th June 2015) and PGC VIII (London, 29th September 2015)

Multi-companies workshops gathering companies having drilled in the same Geological Basin / Entity held (London & Aberdeen video link: 16th and 29th June – 09th July 2015).

Final report + Final presentations to be delivered September - November 2015.
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Setting the scene (1/2)

- 104 segments have been analysed, corresponding to 97 wells: 9 lacking overall Chance of Success (CoS) and/or detailed risking assessment.

- **93% Exploration wells** – 7% Appraisal wells. **33% were firm Commitment wells.**

- 62.5% of these segments belong to post 20th Round licenses; 28.8% were drilled on licenses awarded during the Rounds 1st to 7th.

- **90.4% were dry holes; 8.6% Technical successes; 1% Commercial success**

- **Objectives:**
  - 38 % above BCU
  - 56 % Jurassic
  - 2 % Triassic
  - 4 % below Zechstein Salt

- **33 % of the 104 analysed segments have been drilled because of some sort of “DHI”: AVO, amplitude, gas cloud, “impedance indicator”...etc...**

- **Chance of Success**
  - 34% of the 98 segments with available pre-drill risking fall within the 21 to 30% CoS (i.e. what you would expect in such mature Basins).
  - But 40% of these segments have CoS > 31%: this highlights a trend towards over-confidence in the risking assessment.

- **Number of causes for failure: 3 main reasons = 38.8%; 2 reasons = 48.6%; 1 reason = 12.6%**

- **The main risk was not adequately predicted in 36%**
Objectives

- 38% above BCU
- 56% Jurassic
- 2% Triassic
- 4% below Zechstein Salt

Trap types

- 55% Stratigraphic traps
- 45% Structural traps

NB: Sum (>104 as several traps are Combined 4 way dip closure / stratigraphic upside)
1. Project Objectives, Time-Line and Status
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Main Reason for Failure (1/4)

Overall Main Reason for Failure

- Target Reservoir absent = 22.7%
- Reservoir Quality / Connectivity = 5.4%
- Lateral Seal = 27.3%
- Lack of Trap = 17.3%
- Lack of Charge (Migration Shadow....) = 5.4%
- Bottom Seal = 5.4%

- Seal ~ 38%
- Reservoir ~ 28%
- Trap ~ 17%
- Charge ~ 14%

Absence of Target Reservoir and Top Seal Failure are acting effectively as “killing parameters”

Top seal efficiency is well assessed even when it fails
Source Rock maturity too… except on Basin margins

DHI (mispicking of Top Reservoir) ~ 1%
Main Reason for Failure (2/4)
Tertiary Plays (Eocene-Palaeocene)

Lack of Trap = 34.6%
Lack of Bottom Seal = 15.4%
Lateral Seal = 19.2%
Migration issue = 7.7%
“DHI” issue = 7.7%
Reservoir Quality = 3.8%
Target Reservoir absent = 7.7%
Top Seal = 3.8%
Sample size = 24 segments

However, 20 (i.e. 77%) have been drilled because of some sort of DHI (AVO, amplitude, gas cloud, “impedance indicator”…etc…)
Another 2 were drilled despite AVO indicated the sands would be wet.

“When looking at prospects that are solely dependent on AVO it is necessary to examine the pre-conditioned gathers.

Match amplitude response to shear log recorded in near by wells.

Produce and risk the geological model unsupported by AVO. Does the play make sense without AVO support?

AVO responses are modelled outcomes, not unique solutions. They do not eliminate risk.”
Main Reason for Failure (3/4)
Upper Jurassic: Fulmar Fm. in an interpod setting

- **Lateral Seal** = 28.5%
- **Target Reservoir absent** ~ 43%
- **Lack of Charge (Migration Pathways)** = 28.5%

- Limited sample = 7 segments
- However all 3 reasons for failure highlight pretty well what is requested to find such a trap being hydrocarbon bearing.
- Migration effectiveness is the 2nd reason for failure in 5 over 7 cases >> detailed pre-drill Basin modelling should be carried out
Main Reason for Failure (4/4)
Upper Jurassic Deep water turbidites
(Buzzard, Ettrick, Peterhead...all kind of traps)

- Target Reservoir absent = 29%
- Lateral Seal = 38.7%
- Top Seal = 12.9%
- Bottom Seal = 3.2%
- Reservoir Quality = 6.4%
- SR immature = 3.2%
- Lack of Charge = 3.2%
- Lack of Trap = 3.2%

- Sample size = 27 segments
- The search for Buzzard look alike in adjacent Grabens failed; it was mostly driven by conceptual analogy and on “notional” prospects.
- 76.7% were interpreted as Stratigraphic Traps
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1) Map cut short
>> does not allow optimal understanding of the trap (1/2)

No way to understand the prospect weak point!!

Potential leakage zone

Top Fulmar Depth Map (m TVDss)
TCM 31\textsuperscript{st} March 2006
i.e. @ technical decision point
2) Seismic picking questionable

>> need for other advice (Peer review?)

>> need to improve QC (1/5)

> Keep using analogues, but beware of respecting the data
3) Efficient seal and / or efficient sourcing pathway?

Thickness map of the Source Rock >

Fulmar prospect outline

Source Rock = Kimmeridge Clay Fm
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Conclusions – 1/2

• **Underestimation of the physical content of the seismic response:**
  - Well to seismic ties must be properly done >> impact on choice of the relevant horizon to be picked and / or on reservoir polarity
  - DHI type and robustness must be double checked
  - When looking at prospects that are solely dependent on AVO:
    • seismic data must be properly processed prior to any AVO study
    • Produce and risk the geological model unsupported by AVO. Does the play makes sense without AVO support?
  - Seismic picking must not cut through valid seismic reflectors. Dual polarity displays should help more rigorous picking particularly in Tertiary or relatively shallow Plays.
  - Prognosis of sand presence cannot only rely on “rules of thumb”, particularly when seismic data are poor /fair quality. Re-processing, acquiring new fit for purpose 3D data and rock physics modelling should be undertaken before locating wildcats on poor quality data

• **Cognitive bias:** Since the “X” discovery was just made, was there some kind of “cognitive bias” which led to a too fast move to drill what was deemed to be an analogue amplitude feature / an analogue stratigraphic trap?

• **Drilling quality prospects should prevail against drilling as many wells as possible** >> food for thought for the OGA?

• **In some instances, the operator was the sole licensee:** being not far enough away to assess the prospect this resulted in over-confidence. >> food for thought for the OGA?

• **Access to information:** In some instance the lack of access to a well recently drilled up dip of the prospect lead to the drilling of another dry well >> food for thought for the OGA?
Conclusions – 2/2
What shall we do to become more successful?

- **Geology**
  - Better regional understanding using Play Fairway maps
  - Improve quality and expand scope of well data in CDA (biostratigraphic & geochemical...etc...)
  - Understanding trap integrity / fault and top seal key issues; prospects being under-risked.

- **Geophysics**
  - Data quality of seismic for prospect generation must be up to the task
  - Reprocessing together with data scaling and conditioning
  - More accurate depth conversion required, more sophisticated velocity modelling
  - Potential seismic anomalies e.g. bright and flat spots, need to be carefully analysed

- **Interpretation skills**
  - Prospects evaluation needs integrated technical input from geophysicists, geologists and reservoir engineers
  - Prospect evaluation teams need to ensure there is good linkage with field teams
  - Post-Well Analysis is key element of Exploration Quality Insurance process
  - Staff movement and turnover can lead to disconnects in prospect generation, post well analysis and regional knowledge
Thank you for your attention!

Thank you to all those who have been sharing with me on these post well assessments:

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21 21CXRM Project_Exploration Well Failures from MF-CNS_UKCS_Ch.Mathieu_23rd October 2015