DYNAMIC UNDERBALANCE PERFORATIONS BRING HIGHER PRODUCTIVITIES THAN CONVENTIONAL PERFORATIONS

A large scale comparative review from the Tunu Gas Field (Indonesia)

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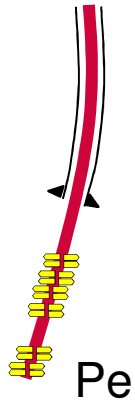
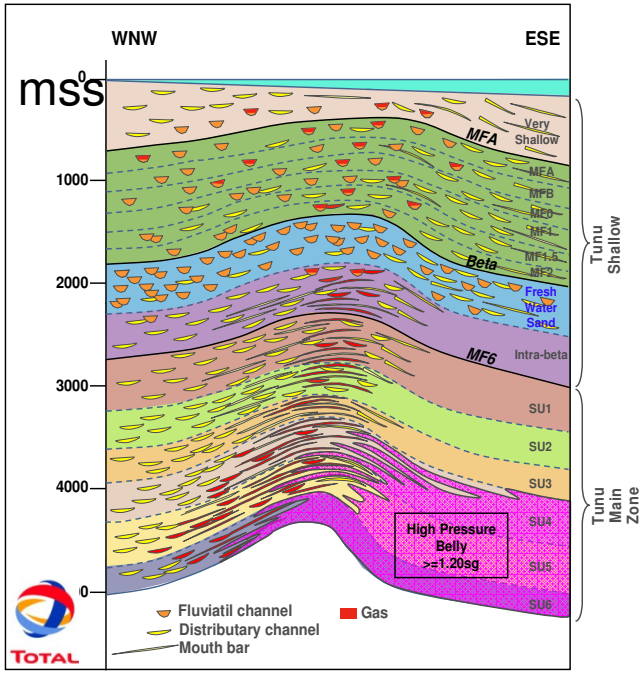
- What is the TUNU field (Indonesia, PSC Mahakam)?

Tubingless completions



Perforations are added by light intervention barges (electric lines)

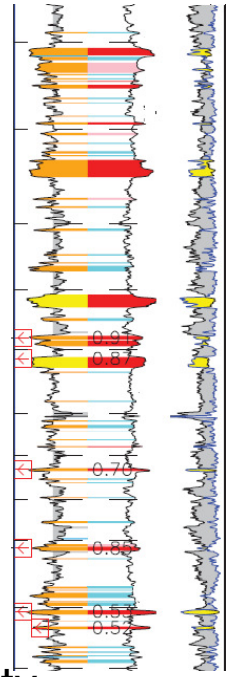


Multilayer thin sandstone Reservoirs

Gas + condensate

Deltaic channels and mouth bars

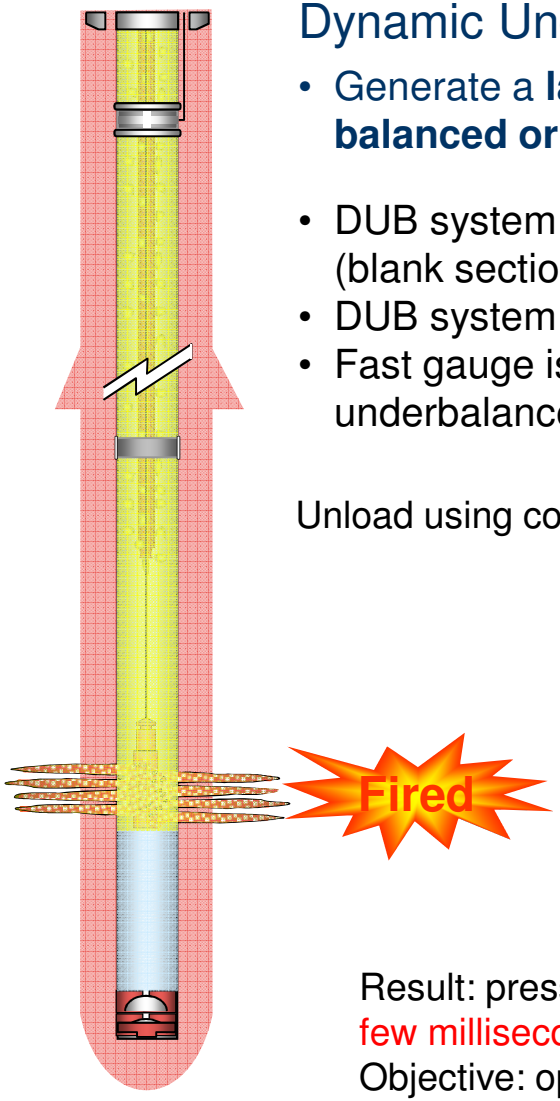
10-20% Porosity
1-500md Permeability



- Annually: more than 2500 ms of perforations, 600 intervals

- **Large activities and workload continue to increase as field become mature**
- **Sufficient data for developing comprehensive perforation analysis**

WHAT IS “DYNAMIC UNDERBALANCE” (DUB)?

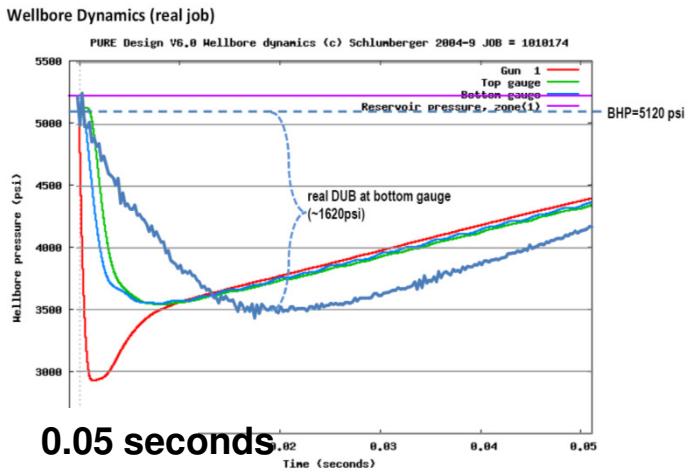


Dynamic Underbalance (DUB) Technology

- Generate a **large dynamic under balance** from **modest static under balanced or over balanced pressure**.

- DUB system needs set of charges and additional **void space inside the gun** (blank section, implosive chamber).
- DUB system required **liquid** (water / oil / mud) around the gun when shot.
- Fast gauge is run in tandem with the gun to measure actual dynamic underbalance (optional, record up to 100,000 samples/second)

Unload using coi



0.05 seconds

Result: pressure drop within perforation intervals by 1500 to 2500 psi during a few milliseconds

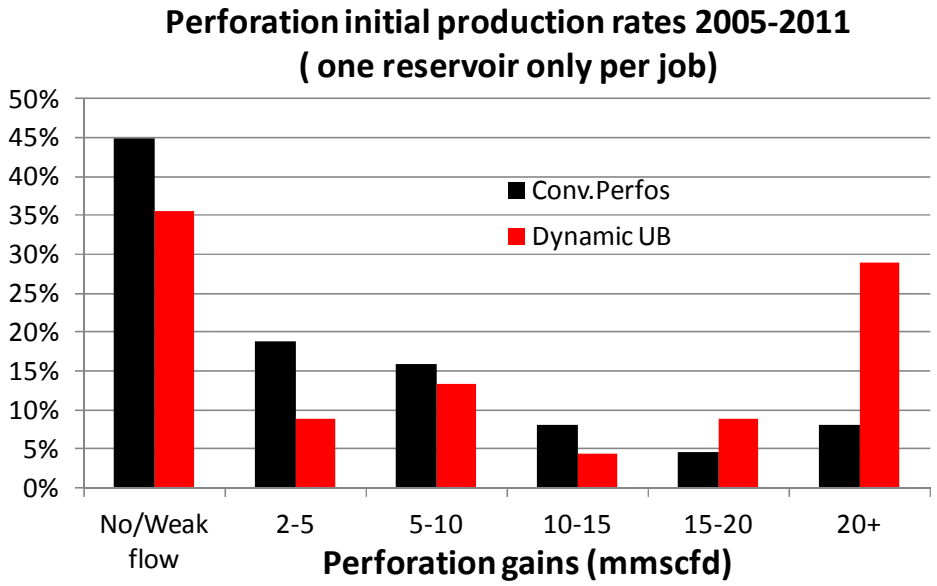
Objective: optimized clean up of the perforation cavity

DOES IT WORK?

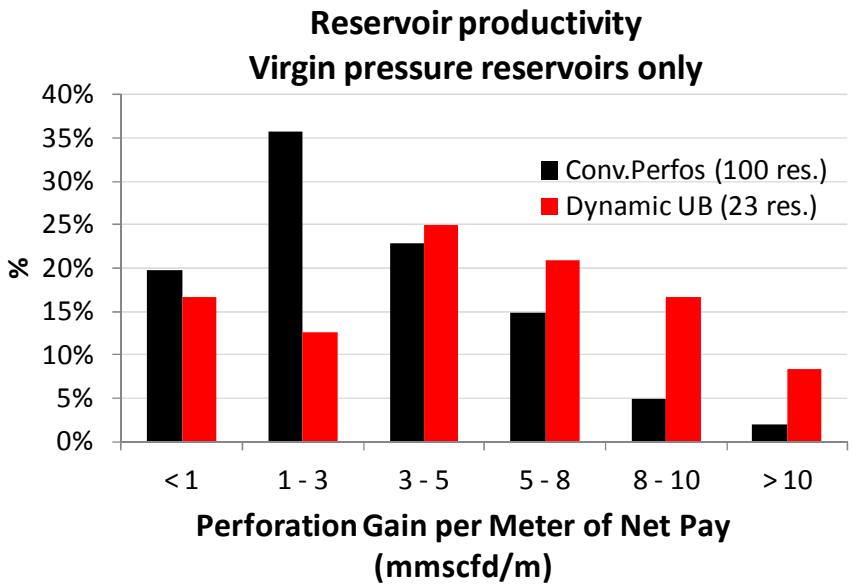
Legend in this presentation:
Conventional perforations, without DUB
Perforations with Dynamic UnderBalance

Data from TUNU gas field (2005-2011), operated by TOTAL EP INDONESIE

Perforation results, by classes of gain (mmscfd per job)



Productivity by meter of perforation (mmscfd / m)

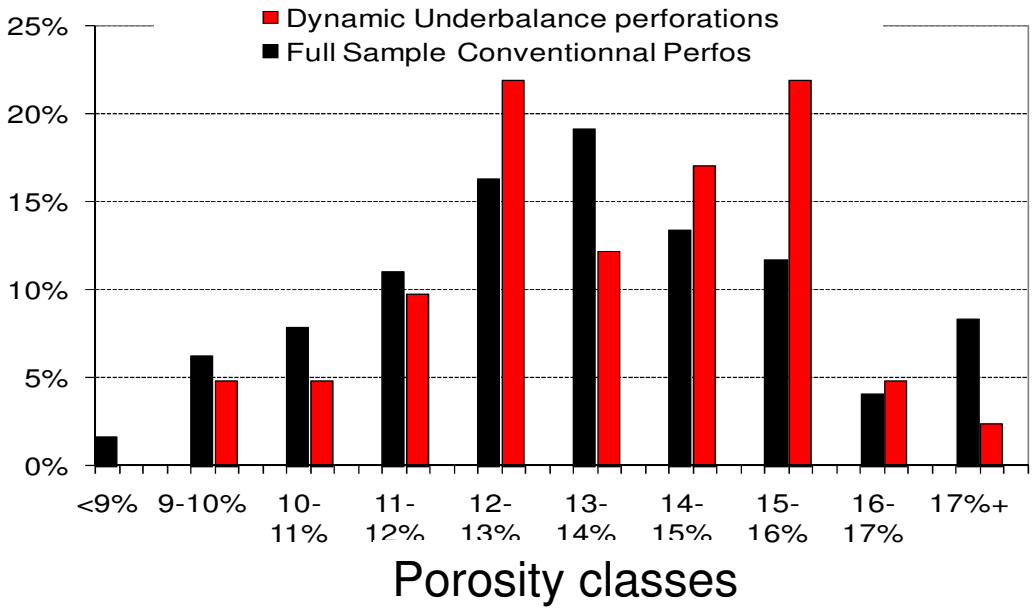


ARE WE SURE THERE IS NO BIAS?

There are always some classical bias

- Choice/selection of best reservoirs for application of DUB? “Quality bias”?
- ~30 DUB perforations only: “luck” effect ?

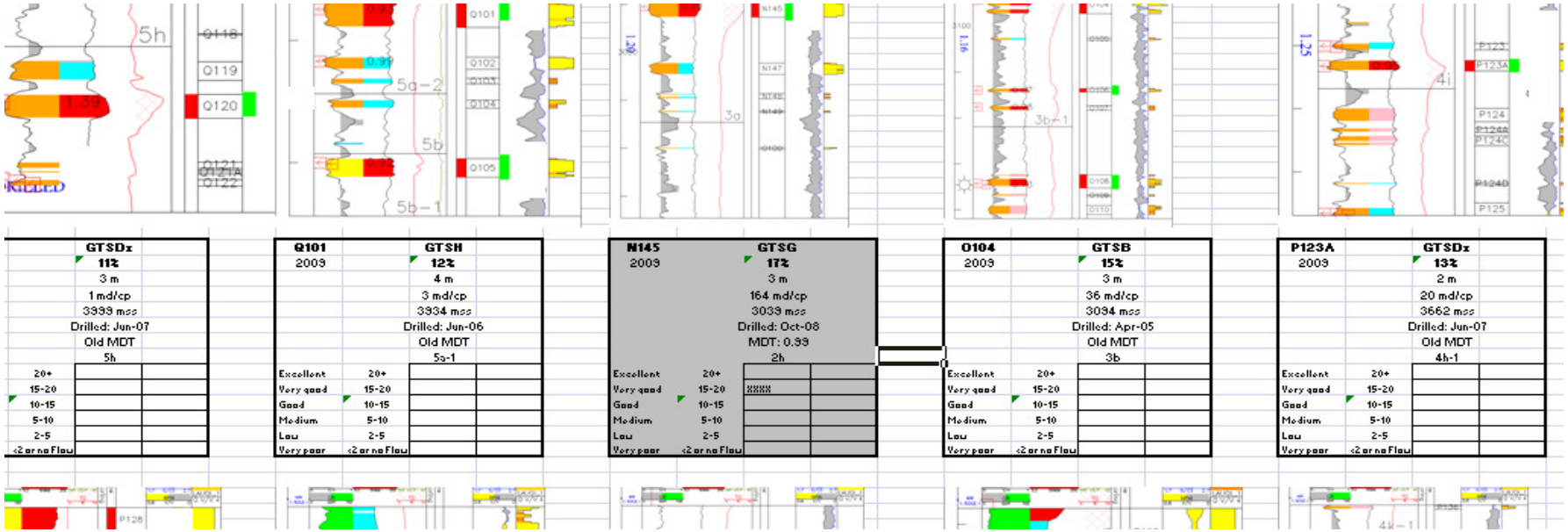
Example of petrophysical indicator : Porosity



It is a fact that reservoirs perforated with DUB in Tunu tend to have better petrophysical properties on average

The question becomes:
“once we remove quality bias and adjust for the sample size, will DUB still make a difference?”

FIRST METHOD: A POLL (13 INNOCENT PAIRS OF EYES)!



1 question: "for each reservoir, which perfo. gain (in mmscfd) do you expect?"

Gain	<2	2-5	5-10	10-15	15-20	>20	(MMscfd)
Mark	1	2	3	4	5	6	

	Participants' guess (average)	Real result
Conv. perfos	2,0 / 6	
Dynamic UB		

Experts of their field

In "blind " test, DUB Good Results not predicted

A reservoir quality bias is perceived

SECOND METHOD: USING EPIDEMIOLOGICAL METHODS

Epidemiological methods = classically used to test new drugs or health issues

1.Which steps?

- Validation of data quality is essential
- Perforations without a clear outcome are not considered

  → No perforation job with multi reservoirs

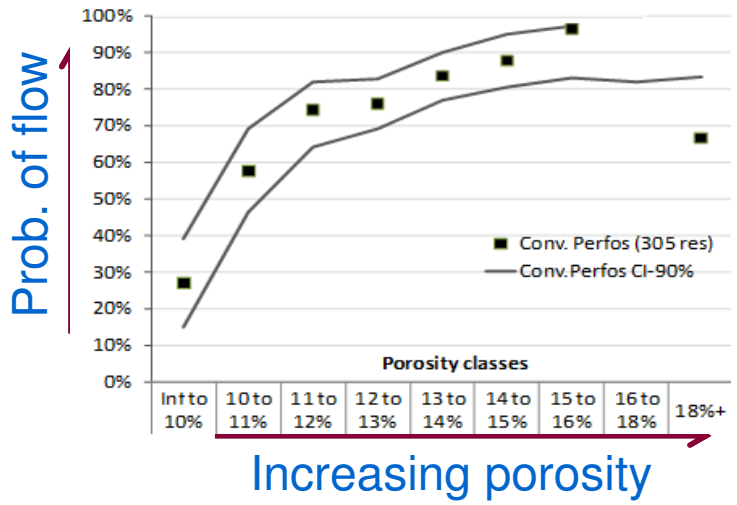
  →Reservoirs diagnosed with technical problems or water problems are excluded

  →Need to have reliable pressure data (cf infill wells)

- The statistical influence of each parameter on differences between results using the same perforation technique must be understood before any comparison

  – Degree of dependence between parameters
  – Influence of **porosity, res. pressure, etc…**
  – **gun size, static underbalance, brand, etc…**

  (cf. SPE paper 158083 for extensive details)



SECOND METHOD: USING EPIDEMIOLOGICAL METHODS

Epidemiological methods = classically used to test new drugs or health issues

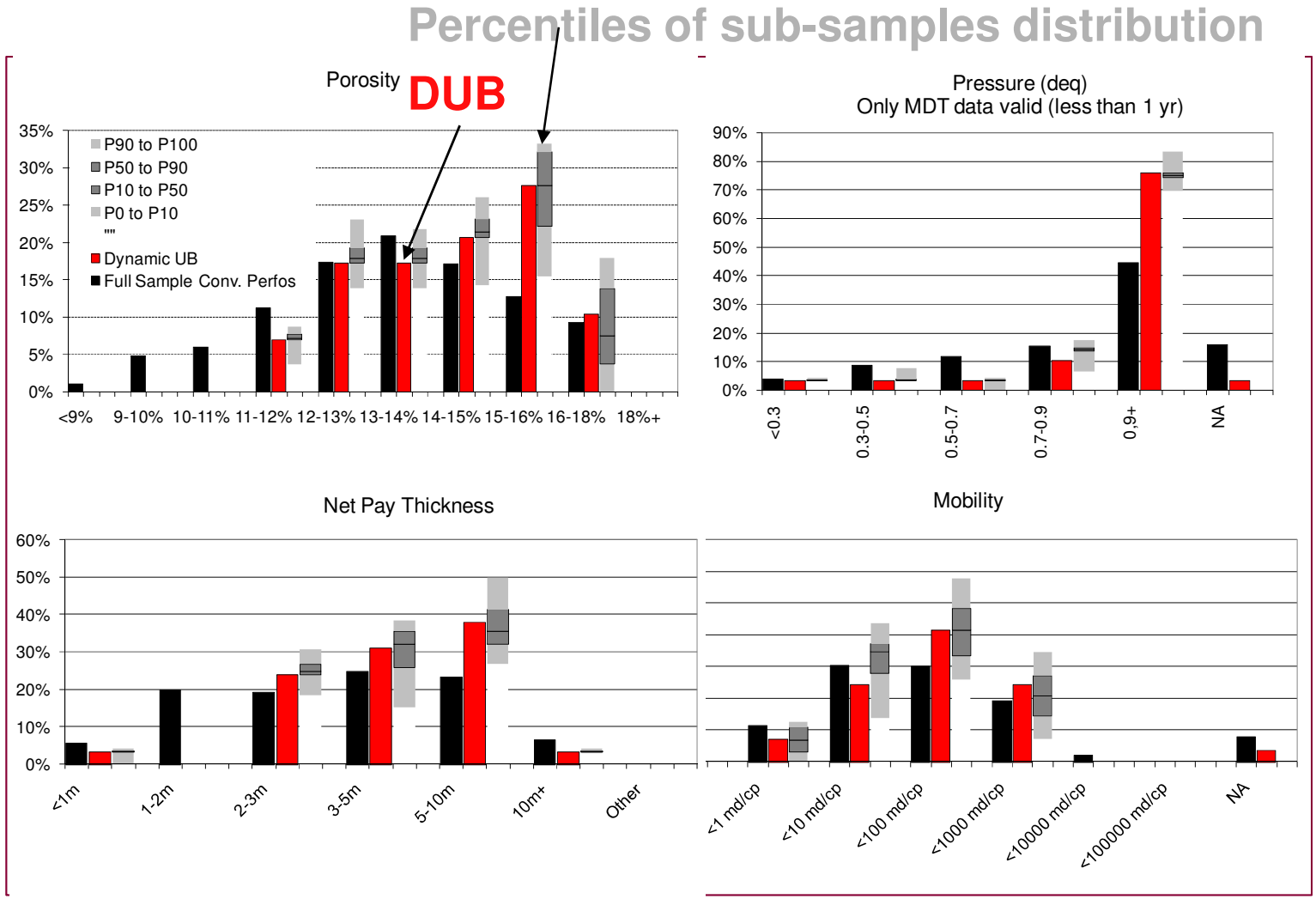
- The challenge: Build “comparable samples”, free of size and quality bias
- More than 200 eligible conventional perforations
- 29 flowing DUB perforations

- Two possible approachs:
- Our original approach →

– Our group of 29 DUB perfo is the reference sample
– Let’s downscale the 200 conv. perforations into random draws of 29 representatives, respecting same res. characteristics as DUB samples

To get an apple to apple comparison, let’ s try a comparison between
“Basket filled with 29 apples” and “baskets with 29 apples ”!

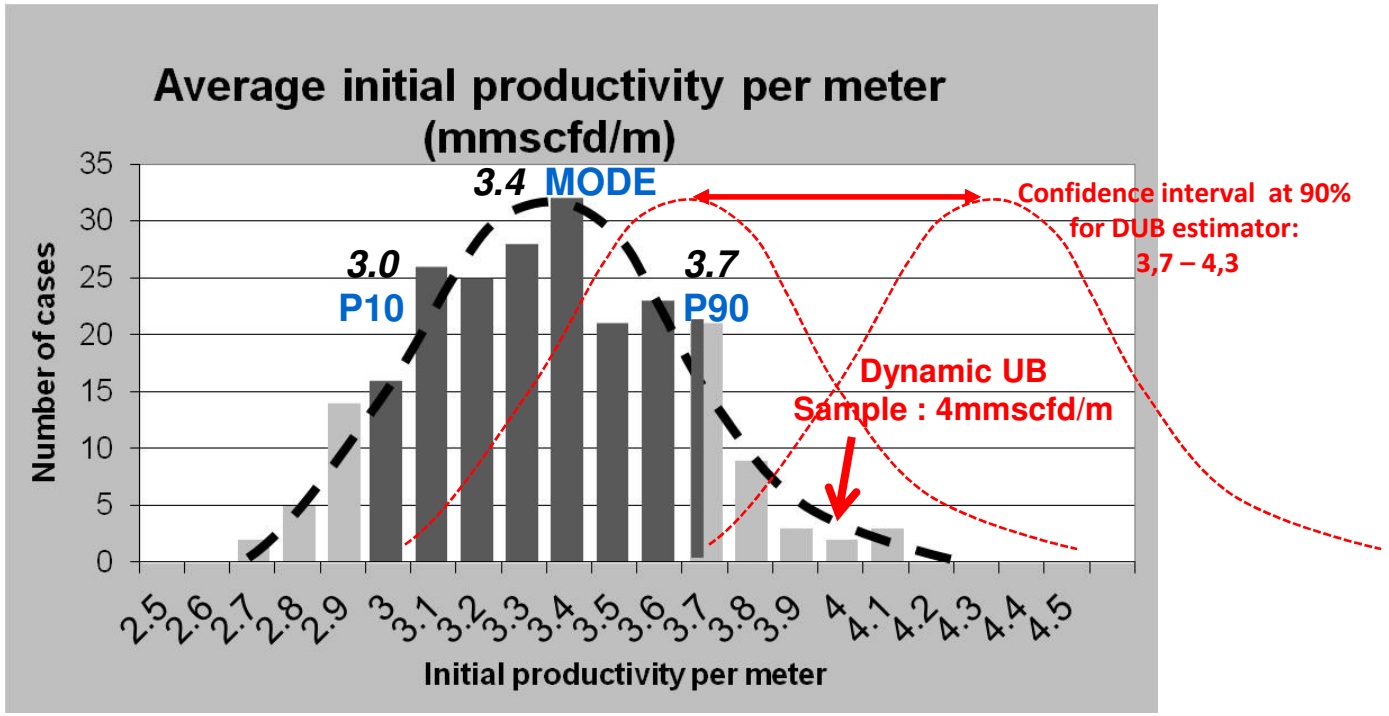
RANDOM GENERATION OF 150 COMBINATIONS OF 27-30 CONV.PERFOS, WITH SAME RESERVOIR PROPERTIES AS DUB SAMPLE



Sub-samples randomly created, but "matching" DUB sample distributions of porosity, pressure, mobility, and thickness

RESULT: AN EXPLICIT INSIGHT IN THE PERFORATION RESULTS

Distribution of Results (in mmscfd/m) of the 150 randomly created sub-samples of conventional perforations



At 90% confidence level:
Dynamic UB does bring better productivity results than conv. perfos

Explicit evaluation of benefit = +10 to +25% initial productivity (3.7-4.3 vs 3.4)

CONCLUSIONS

In Tunu gas sandstones, **Dynamic UnderBalance makes a difference**

→+10 to +25% initial productivity per meter of perforation

→after removing all possible statistical bias (reservoir quality & sample sizes)

10 additionnal jobs performed post-study reinforce the quantitative results
They still give 4.0mmscfd/d, with similar quality

Applicability?

- In gas wells, DUB is limited to wells with a liquid column *(provider)*
- Unlikely adapted for tighest reservoirs *(operator's observation)*

- Why not having worked with evaluations of "skin" ?
  - Too little data to be analysed (see paper)
  - Skin data validity and quality are a major variable, with little control, as associated to well testing procedures

- Independent analysis, and more in SPE158083

Acknowledgements

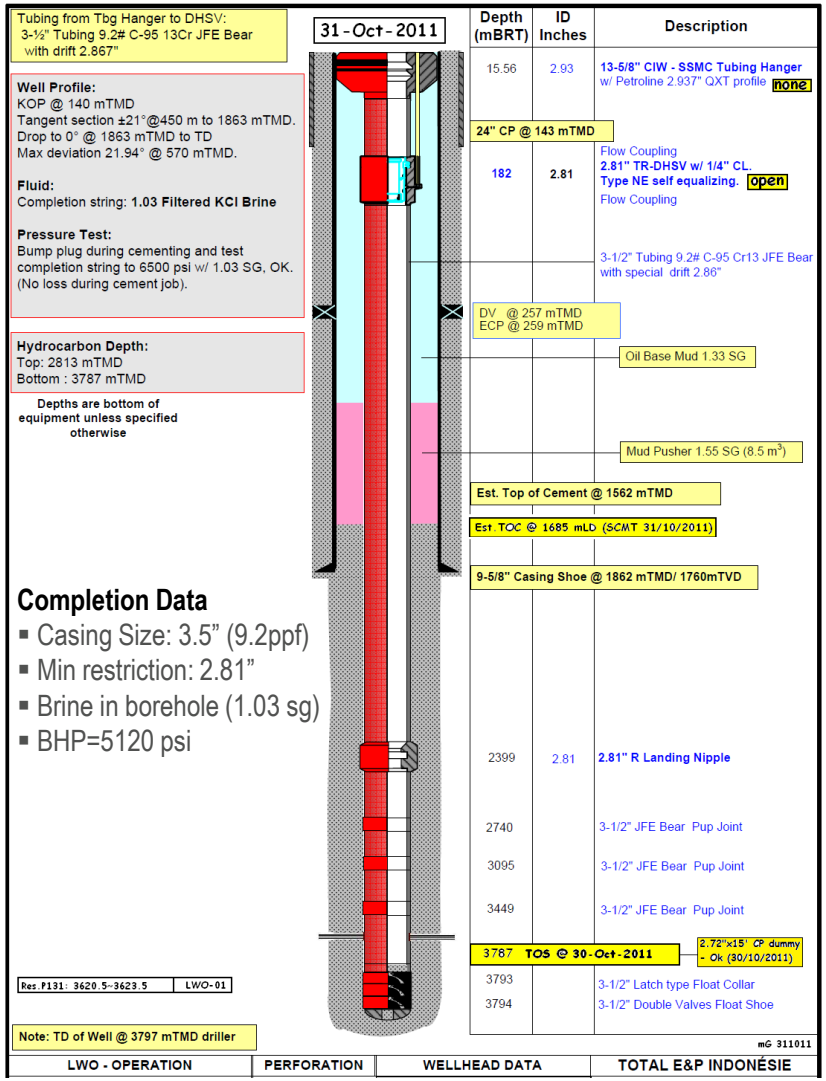
Total E&P Indonesie

INPEX

BPMigas - MIGAS

Thank You / Questions

DYNAMIC UNDERBALANCE SUCCESS



Completion Data

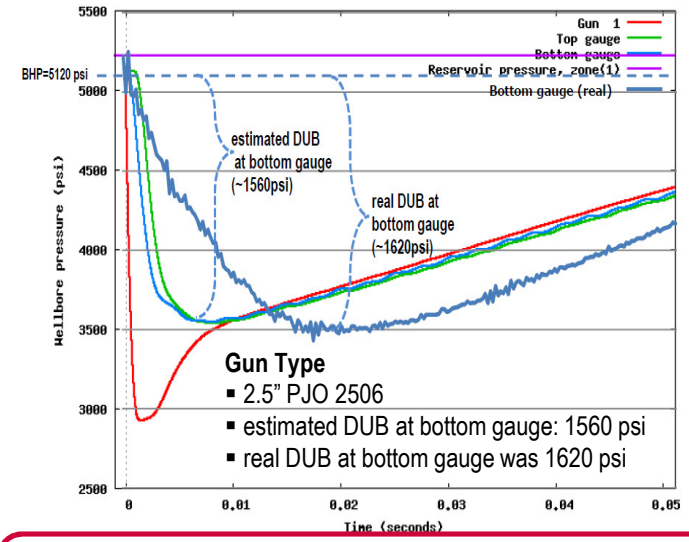
- Casing Size: 3.5" (9.2ppf)
- Min restriction: 2.81"
- Brine in borehole (1.03 sg)
- BHP=5120 psi

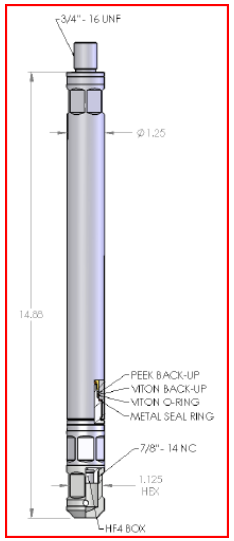
Reservoir Data

- Porosity: 12.95%
- Pore Pressure: 5211 psi
- Mobility: 31.6
- Interval 3620.5-3623.5m (3m reservoir P131)

Technique

- Design gun to get optimum dynamic underbalance
- Design 100psi static UB and estimate the reservoir pressure is enough to lift up the fluid column
- Clean up the well right after perforation, CT ready to start up in case well unable to flow
- RIH **fast gauge** tandem with gun to measure the dynamic underbalance





Result

- **Real DUB at bottom gauge: 1620psi (fast gauge data)**
- **Well flow 15.9 MMscfd without unloading job**