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The "Other" Big Bang Theory

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Something just went seriously wrong with the subsurface position of my well

How much trouble am I in?

A lot more than you know!!!!

Let us review the issues

- Experiences
- Well life cycle consequences
- Graphics and Correlations fool the user
- Why don’t we do the right thing?
- Time to correct the errors affecting your company

Companies in experiences

- Company AAA
  - Global independent
  - 6th gen Deepwater drill ship, SE Asia, Appraisal well
- Company BBB
  - Global independent
  - Modern land rigs, onshore Europe deep exploration well in uncertain geological environment & development drilling

Wellbore survey programs inadequate

- Position uncertainty too large for relief well interception requirements
  - Company Relief Well Plan
  - Industry practices
- Position uncertainty too large for
  - Target interception
  - Fault tracking with managed risk
- Position uncertainty has negative impact on subsurface correlation

Relief Well Drilling AAA

- Company BOCP
  - Borehole lateral uncertainty on the XXXX well should be approximately +/- 2 to 3 m / 1000m and will provide an adequate zone for ranging.
  - Required error at 4,500 m = + / - 9 m lateral
- Directional plan MWD shows at 4,500m
  - + / - 28.5 m major axis
  - + / - 14 m minor axis
  - + / - 9.3 m TVD
- No high accuracy gyro planned

Uncertainty for Sub Surface - TVD

- Desire + / - 2.5 m for correlation
- Directional plan
  - 4,500 m = + / - 9.3 m
  - 5,800 m = + / - 12 m
- Surveys tabulated to 2 decimal places
  - Subsurface thought this was accuracy
  - It is not the accuracy!

Company Global Standard focusses on anti collision – not total needs

- Survey uncertainty requirement is driven by:
  A. Intercepting target
  B. Relief Well Drilling
  C. Data accuracy for sub surface modelling
  D. Anti collision (the fault)

High accuracy gyro was needed BUT not planned

Borehole surveying practice BBB

- Company has NO Borehole Survey Manual
  - Fundamental requirement
- BOCP requirement – 10 m between wells?
- Error model in planned surveys show:
  - Exploration - 6000m vertical well + / - 20 m lateral
  - Development - 4000 m 50 deg incl +/- 57 m by +/- 14m & + / - 8 m TVD
- Survey program inadequate for relief well drilling
  - Need to run high accuracy Gyro
- Survey also does not meet requirements for:
  - driller's target – an issue for effectiveness
  - Geological modelling (lat, long, TVD (+/- 2 m))
  - Collision avoidance - fault avoidance

Consequences from these bad practices

- Relief well interception would be highly challenging - if not impossible
  - Loss of company (Europe land & S E Asia offshore)
- Vertical correlation between wells totally inadequate
  - Massive correlation errors in TVD
  - Big impact on asset development economics
    - **Saved a gyro run cost – what a hero!!!!**

Conclusion from Experiences

- Lack of knowledge
  - Who trained these drilling engineers?
- Lack of understanding
  - Who educated these subsurface engineers?
- Failed systems
  - Why don’t you use the borehole survey manual free from industry professionals at ISCWSA?
- Managers do not ask the right questions
  - Focused upward not downward!

Well life cycle borehole surveys

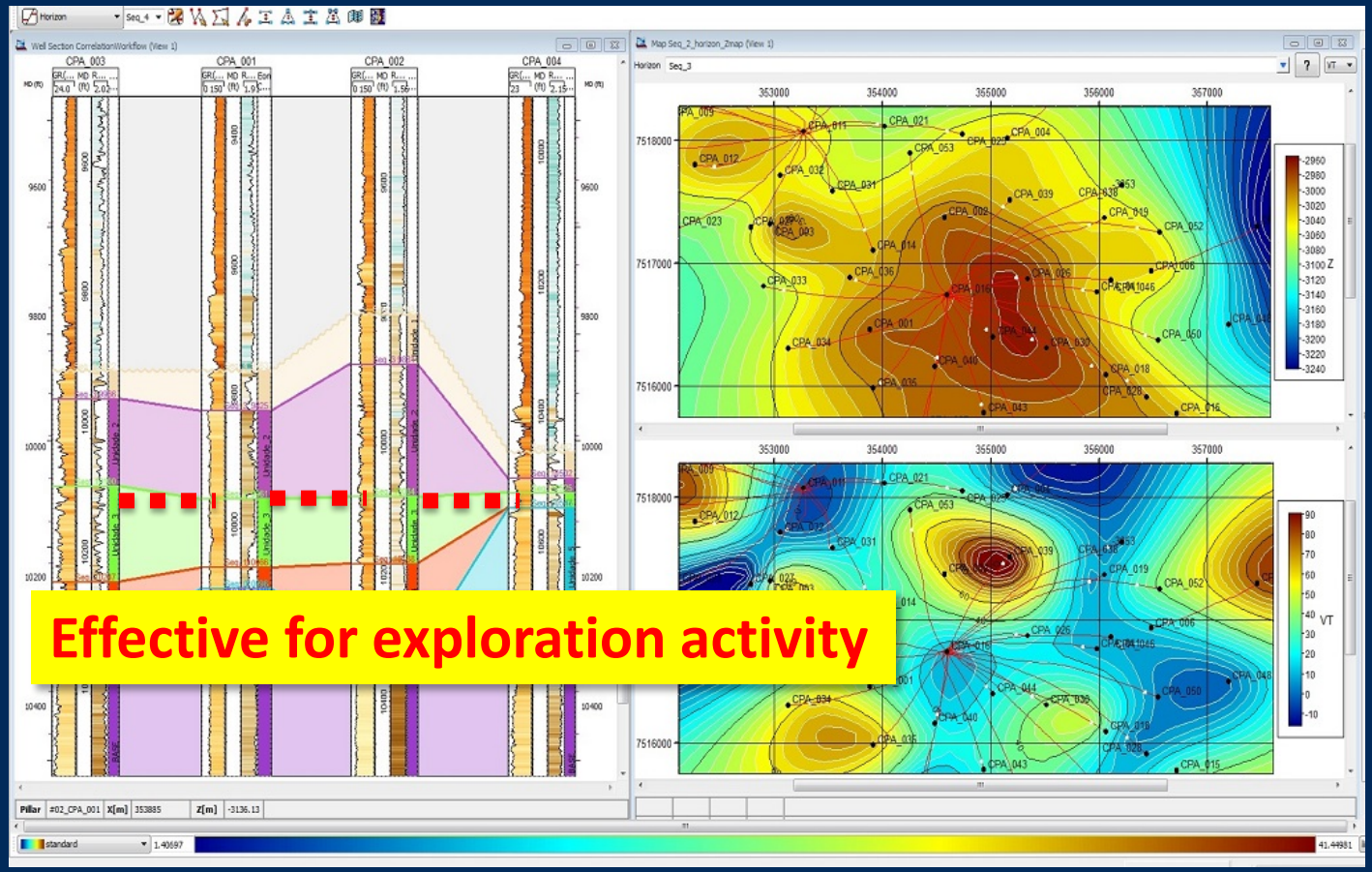
1. Collision avoidance
   - Loss of asset / loss of production
2. Target interception
   - Achieve objective – drillers target
3. Subsurface correlations
   - Correlations while drilling / correlations post drilling / correlations during production cycle
   - Size of reservoir / fault interpretation / OWC
4. Tortuosity (not just DLS)
   - OPEX from tubing & rod wear / OPEX from workovers to replace pumps

- Relief well potential – continuous
  - **Loss of company**

Subsurface correlations from wellbore data

- a journey of illusion -

Exploration can correlate on well logs tied to seismic



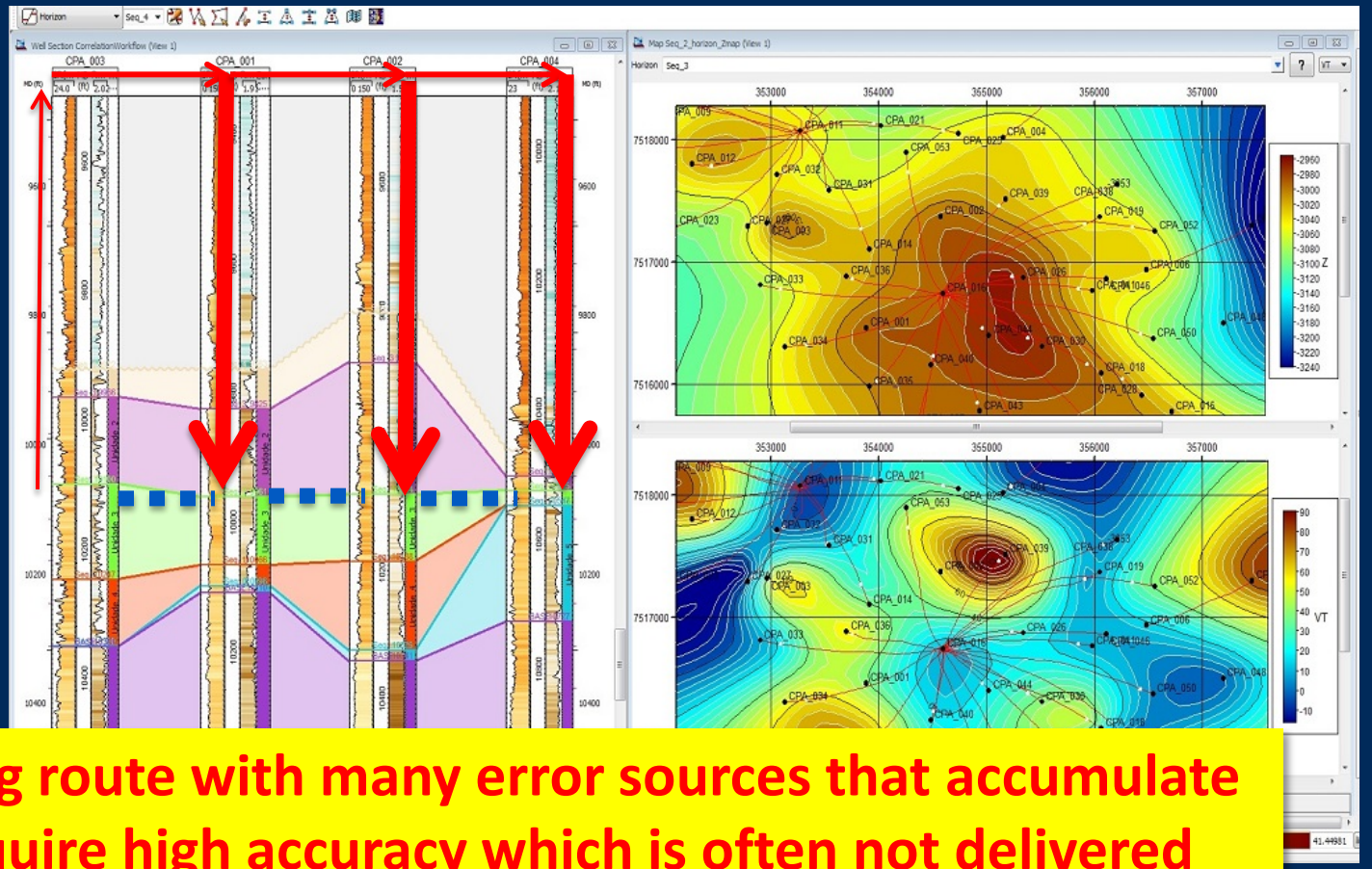
Source: Paridigm

Subsurface correlations from wellbore data

- a journey of illusion -

Exploration can correlate on well logs tied to seismic

Assets must correlate on well logs tied to True Vertical Depth



This is a long route with many error sources that accumulate
Assets require high accuracy which is often not delivered

Source: Paridigm

Presentation fools the end user

- Borehole survey tabulations show results of lateral and vertical positions to 2 decimal places
  - 0.00
  - Accurate – of course!
- Survey error models shown previously are
  - 9 to 57 m uncertainty ranges
  - The uncertainty is orders of magnitude larger than the data tabulation suggests
    - Subsurface users are being deceived

Adopt knowledgeable practices

- Borehole survey manual
- Connect drilling engineers to subsurface users
- Carry errors from data acquisition through to subsurface modelling
- Ask – don’t make up rubbish

Value is routinely available

- Accuracy that delivers value in subsurface correlation through well lifecycle is the same as accuracy required for blow out contingency planning
- Borehole surveys from two different physics is a critical means to manage errors
- Costs are small compared to value with new high speed technologies

Value is routinely available

- Accurac
  subsurf
  lifecycl
  for blo
- Boreho
  physics is a critical
  errors
- Costs are small compared to value with new high speed technologies

Borehole surveying big bangs

- Well collisions are serious events
  - Good practices becoming more prevalent
- Ability to intercept blowout well
  - Spectrum of good practice through to ignorance
- Well position uncertainty for subsurface modelling
  - Major disconnect between drilling engineers and geo modelers / reservoir engineers
  - Disconnect between drilling engineers and production

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Thank you

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Educate to stay out of trouble

Mitigate your reservoir uncertainty