Planning a well through a Zechstein Stringer - Best practices used in NAM

With acknowledgements to Martin de Keijzer, Piet van den Heuvel, and Ide van der Molen
OUR STEPS IN PLANNING A WELL

- Interpretation & Stringer Identification
- Well trajectory planning
- Pore pressure prediction
- Risk assessment
STRINGER IDENTIFICATION

- Scanning for high amplitude events with expected polarity.
- Beware of poor imaging:
  - Stringer edges
  - Stacked stringers
  - Vertical sections
  - Small stringers
- (subtle) pull-ups at ZEZ2A level can be indications for poorly or non-imaged stringers.
- Consider all available seismic datasets and seismic vintages.
INTERPRETATION – REGIONAL MAPPING

- ZEZ3AC geological model of deposition and deformation taken into account.

- Regional mapping can be used to identify gaps and chance for “invisible” sections
STRINGER INTERPRETATION

- If available we use different seismic datasets, e.g.,
- 2 Vintages of processing
- Inversion
POSITIONING UNCERTAINTY

- We include both VERTICAL and LATERAL uncertainty
- Different seismic datasets may help to assess positioning uncertainty as well
TRAJEKTORY & WELL DESIGN

- We try to avoid stringers if possible
  - Use targets and anti-targets to guide trajectory
- Include distance uncertainty (lateral and vertical)
- Reduce risk for intersecting fractures:
  - Avoid high curvature areas
  - Stay away from edge
  - Perpendicular intersection

- Casing scheme
- Mud weight

Simplified 2D showing wellbore “B” higher chance of intersecting fractures or faults
PORE PRESSURE PREDICTION

- Rafts are fully surrounded by salt
- Hence pressures are assumed close to lithostatic
- In line with observed kick data
"CHANCE FOR FLOW"

- We use "Chance for flow" as the key indicator for risk for a kick
- In our understanding only flow from carbonates, not anhydrite
- Parameters used to assess "Chance for flow":
  - Intersection angle
  - Seismic amplitude (dimming indicates fractures)
  - Vicinity of edge
  - Curvature
Bottom line: A kick can never be 100% excluded

G&G rules-of-thumb that help (de-)risk ZEZ3C kicks:
- Stringer positioning uncertainty and imaging resolution
  - Likelihood of hitting the stringer
- Stringer geometry in combination with planned well trajectory,
  - Risk of fractures or fault intersection
- Stringer position in the salt,
  - Risk of overpressure
- Offset well data, both geographically close-by and structurally analogous
- Regional knowledge (deposition & deformation understanding)
STRINGER GEOMETRIES

- Stringer geometry affects the risk assessment
  - Higher deformation (fragmented) increases change for encountering fractures
  - Folded coherent sections also have higher risk for encountering fractures
  - Floater gaps provide an opportunity to avoid the floater, but also can be deceptive (poorly imaged edges or sections)
  - ‘Simple’ thick zones are not considered an increased risk (thicker anhydrite)
RISKING DEPENDENT ON GEOLOGICAL SETTING

Regional lines – On purpose no scale
ZECHESTEIN RISKING SUMMARY – Worked example

3C probability hit: 100%
- The well will drill through ZEZ3C in a syndinal position

3C probability kick (5%)
- No kick experienced in nearby wells including OW-1
- The well orientation is orthogonal to the stringer
- Not many analogue wells shown, but the closest analogue well (OW1) did not have problem

2C probability hit (100%)
- All surrounding wells drilled through ZEC 2C

2C probability kick (0%)
- No Kick reported in surrounding wells, but high gas reading reported
- Connection gas ~500,000 ppm
- Trajectory hits the 2C in a benign area avoiding identified lineaments

Other including intra-salt BRINE INFLOW
- Squeezing Salts is expected at the top of ZEZ4H
- Brine kick risk is low in this area
NON TECHNICAL ASPECTS

- People competency
- Drilling hazard workshop (mandatory 2 year refresher)
- Pore pressure prediction course
- Salt knowledge database ("salt wiki")
GOLDEN RULE

- Zechstein is always unpredictable

Hence

- Hope for uneventfull drilling
- But be prepared and plan for anything

- Studies and understanding of the drilling hazards helps in preparation and planning, and communication of the risks
Q&A