N508: Optimizing Development of Unconventional Reservoirs: Well Spacing, Stacking and Sequencing of Wells

Format and Duration

Classroom - 3 Days

Instructor(s): Robert Hull and Mike Zuber

Summary

The course will address field development optimization, landing horizontal wells and their sequencing at a high level. Discussions on reservoir engineering, geomechanics, completions and the technologies to evaluate the stimulations are key parts of this course. Besides the basics of field development related to well spacing, the training focuses on specific technologies to better understand the stimulation and its effectiveness. Integrated data sets are used to highlight key understandings of what controls EUR for unconventional wells. A data set working through well landing zone selection will also be utilized. Beyond understanding key aspects of the reservoir and where to land wells, we will discuss the dynamics of offsetting completions affecting reservoir pressures and stress shadows. Participants will learn how to interpret key reservoir engineering and geoscience data to help control stimulation effectiveness.

Business Impact: This multidiscipline course provides engineers and geoscientists with a set of principles and processes that will enable them to plan, evaluate and subsequently optimize the spacing, stacking and sequencing for wells in multi-well pads in unconventional and tight resource plays. This optimization of wells in participant's areas of responsibility will enhance value and reduce costs even when criteria set by management and external constraints by land-owners or regulatory bodies are included.

Learning Outcomes

Participants will learn to:

1. List and enumerate key variables characterizing an unconventional play.
2. Assemble and rank key geoscience and engineering data needed prior to and during unconventional field development.
3. Explain basic economics controlling an optimized field development program, including consideration for "cube" development scenarios.
4. Identify and plan reservoir target (landing zone) selection as well as basics for an appropriate completion design for a single well.
5. Explain key variables that affect a completion's zone of influence.
6. Select key factors that affect a multiwell development program and how to avoid negative interactions between wells.
7. Gauge multiple workflows on how to optimize well spacing between multiple wells.
8. Employ, illustrate and interpret key datasets to better understand the interaction of the completion with the reservoir as well as with offsetting wells.
9. Describe and evaluate techniques to both understand and minimize the impact of adjacent well parent child interactions.

Training Method

This classroom course includes lectures with discussions of case studies, worked examples, hands-on exercises, pre- and post-training self-assessment, and a group exercise.

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Who Should Attend

This course is designed for:

- Integrated project teams that need to understand what affects well production, after an initial well has been drilled on the lease.
- Junior- to mid-level engineers, geoscientists, petrophysicists and data scientists who are responsible for shale fields development and production.
- Multidiscipline development teams.
- Reservoir, completion, drilling, and facilities engineers working on shale development.
- Field and asset supervisors and managers interested in improving the performance of their unconventional assets.

Course Content

Daily Agenda

Day 1:

- Course introduction
  - Course objectives and agenda.
  - Participant introductions and learning goals.
- Brief introduction on issues with examples of too tight a well spacing
  - Well Spacing Drivers - Economics and Spacing: capturing the maximum recovery factor for the lease, maximizing EUR for the well while minimizing costs for a program with varying commodity prices and costs occurring during the project.
  - Understanding the issue of too tight a well spacing - Type curves – for single vs. pad completions at various spacings.
  - Economics – optimization of the correct well spacing.
- Reservoir characterization overview – Introduction to Unconventional Reservoir Characteristics
  - Description of typical shale reservoir.
  - Geology – typically deeper marine slow-rate sedimentation, low-energy environment, limited oxidation; horizontally variable over tens of miles. Sediment flux at basin margins etc. (Eagle Ford and Wolfcamp examples).
  - Porosity and permeability.
    - Components of matrix and of porosity.
    - Air permeability vs. effective hydrocarbon permeability at in situ stress.
    - Pore volume compressibility and stress sensitivity of permeability.
  - Excess resistivity.
  - Variations in reservoir pressure, oil quality and gas-oil ratio with depth.
  - Rock strength: Young’s modulus, Poisson’s ratio, yield strength, toughness, cohesion and friction coefficient, matrix properties vs. bulk properties.
  - Vertical heterogeneity and bedding surfaces.

    - Presence and roles of natural fractures.
    - Fracture orientations, lengths, heights and frequency.
    - Degree of cementation.
    - Impacts on inter-well connectivity: "planes of weakness".
- Reservoir characterization case studies
  - Barnett: multi-county, laterally extensive single target interval, dry gas grading to oily, moderate overpressure.
  - Eagle Ford: multi-county, structurally involved single target interval, dry gas grading to oil, high overpressure.
  - Midland Basin: multi-county, multiple target intervals, oil, variable overpressure.
  - Other unconventionals, depending on customer needs, would require access to customer data.
- Where do you want to land your well? Landing zone selection – Team problem set to work.

Day 2:

- Project Engineering overview
  - Reservoir target selection.
  - Well planning considerations.
  - Completion planning considerations.
  - Facility planning considerations.
  - Production data and analysis.
  - Economic evaluations.
  - Project planning.
- Reservoir target selection and well planning – spacing and stacking
- Completions planning
  - Definitions - Sigma 1, 2, and 3, Max Horizontal stress direction,
  - Fractures open in min horizontal stress direction, stress magnitude and variation may vary by depth.
  - Hydraulic fracture basics, fluids, rate, proppant, pumping, gel, isolation, types (PNP, sliding sleeves) etc.
  - What does a HF look like? (Strain mapping examples).
  - PKN fracture and design – basic introduction to models. Appropriate designs (stage spacing, state to stage interaction). Poroelastic effects.
  - Pad – volumetrics vs distance.
  - Establishing an understanding of the distance of the frac perm zone. Effective pressure definition.
  - How far out does the pressure disturbance extend beyond the HF?
  - Factors affecting variability in the completion along the wellbore: friction, landing zone variations, build up of altered rock during the stimulation with stress shadows, timing of completion between stages, etc. All affect effective fracture network.
- Facility planning considerations
  - Benefits of pad development.
    - Safety, security, capacity sharing.

        - Provision of utility services --> reduced costs.
    - Facility design relative to development sequencing.
        - Facility utilization vs value of acceleration.
- Production data and analysis
    - Decline curves and type curves.
    - Parent wells vs child wells.
    - Spacing impacts vs completion designs.
- Project planning case study to work as a team.

Day 3:

- Project evaluation and optimization: Ways forward and advanced topics
- Data needs prior to full field development
    - Cost of data vs. not having it. Value of information.
    - In-house “science”: rocks and fluids, pressure gauges, etc.
    - Analogs, offset operators & data trades.
    - Society participation and conferences.
- Quantifying frac hits and inter-well communication
    - What is a frac hit? What causes it? Are frac hits necessarily bad?
    - Frac Hits in offset wells with downhole pressure gauges and fiber optics.
- Integrating data between the Engineer and Geoscientist
    - Oil and RA Tracers.
    - Geochem fluid typing to a zone.
    - Seismic inversion to understand rock properties.
    - Microseismic application and evaluation.
        - Mapping the drainage zone using MS.
        - Depletion zone mapping during a recharge injection into a parent well. Strain mapping from offset well using fiber optics.
    - Tiltmeters.
    - Production diagnostics (RTA; Chow group).
        - Characterization of the Chow Group.
        - Hydraulic Fracture Test Site data case study.
- Enhanced oil recovery from shales
    - What we know now:
        - Reservoir models suggest recovery factor is limited to near hydraulic fracture zone – 10s of cm about conductive pathways.
        - Data of COP for Eagle Ford (Raterman et al).
    - What we hope for…
- Development planning issues
    - What you don’t control (geology, pressure, leak off rate, etc.).
    - What you can control (Spacing, Stacking, Sequencing, Completion design).
    - Cube development challenges and opportunities (Concho,QEP and other examples).
    - Mitigating frac hits.

    - Shut-in of offset wells - required timing for some pressure recharge.
    - Protection fracs and refracs - recharging offset parent well with fuild/gas.
  - Final summary and pulling it all together: reservoir, pressure, spacing, stacking, and sequencing. Re-looking economics again.