

PTTC Technology Workshop
Technical Report to PTTC

Drilling and Completion Technology Updates

May 31st, 2006 at Salt Fork Resort, Cambridge, Ohio

Hosted by: The Society of Petroleum Engineers (Ohio Petroleum Section)

Purpose of workshop

The Society of Petroleum Engineers, in conjunction with the PTTC, hosted a Technology Workshop in Cambridge, Ohio on May 31, 2006. The focus of this workshop was to provide the oil and gas community with the latest in technological advances in the microhole technology program with an additional focus on new completion technologies which could open up unconventional reservoirs for exploitation. Specifically, the focus was on technology that could or should be applied in the special circumstance and economics of the Appalachian Basin.

Problem addressed

The Appalachian Basin is historically a stripper well basin driven by economics. Many areas of the basin have been drilled to the brink of depletion with vertical wells in currently produced reservoirs. Current market forces are allowing review of new and previously unavailable prospects within a producers' inventory. Moreover, there has been a rapid boom in the addition of new drilling rigs to the area. The exposure to microhole technology is one that could have a great advantage to the Appalachian Basin as the technology comes online. The additional focus was on completion technologies as they could be applied to open up previously ignored reservoirs to economic development.

Coordinator's Assessment of the Workshop

The focus of this workshop was to have professionals with first-hand knowledgeable of the current state of available technology present as much information as possible to the oil and gas community. The first half of the workshop was presented by industry professionals who have intimate knowledge of the current state of development of microhole technology. Additionally, the coordinators sought out speakers with knowledge of the newest, brightest technologies available along with operators who have had experience with the drilling, completing and production of unconventional reservoirs. Speakers were encouraged to share field experience and present technologies which could, or should, be applicable to the particular economics of the Appalachian Basin.

Attendance at the workshop was lower than expected. This was partly due to the holiday week and partly due to the current market state with high activity and a low personnel count. 43 total participants were in attendance; 31 attendees, 10 speakers, and 2 coordinators. Attendees were largely from the Appalachian Basin region. The location was central to the region, and the facilities were more than adequate. The one not-so-insignificant issue with the venue was it's short term lack of air conditioning. With the air conditioning out and the temperature somewhere north of 90 degrees, it was warm inside. The staff did everything they could to accommodate the workshop including bringing in a workable, if loud, portable air conditioner to the meeting room.

Information on the workshop agenda and speakers is included in the handbook. The workshop began with at 8:30am with Dwight Rychel speaking on the development of coiled tubing drilling. Dwight gave us a review of coiled tubing components and walked us through the major contractors and last years rig

counts. He showed us the historical and current uses of coiled tubing both as a service (cleanouts, etc.) and as a front end drilling operation. From there he developed a brief history of coiled tubing drilling and developed the pros and cons of using coiled tubing as a drilling tool. He developed some ideas on where improvements could or are being made in the current state of technology. Lastly, he showed the status of coiled tubing drilling in Alaska and Canada expounding on the successes and failures of the current technologic development.

Kent Perry of the Gas Technology Institute gave a presentation on Microhole Coiled Tubing Drilling. His presentation was largely a case study of a Niobrara Chalk field in western Kansas and eastern Colorado which was infill drilled using a "built for purpose" coiled tubing drilling rig. The rig handles 1" to 2 5/8" coiled tubing and has a depth range of up to 5000'. It can run 7 5/8" R3 casing. The entire operation is mobile via 4 loads and the rig drilled 220 wells in 2005. It can drill 3000' wells in one day. Multiple economic enhancements were demonstrated during the 20 + well case study in the Niobrara Chalk field. These included: decreased environmental impact; drilling rates up to 500' per hour using a 4 3/4" PDC bit; reduced location costs; reduced mobilization and demobilization times; increased safety. Kent then went through some market forecasts for this technology including the addition to the Appalachian Basin of more than 400,000 shallow (<5000') wells which would add a resource base of more than 47,000 Bcf.

John Pursell of Integrated Production Services presented a case history of a ten well, coiled tubing re-entry project that was conducted in the Texas panhandle in the fall of 2005. The intent was to drill single laterals in each of the wells using 2 3/8" electric line coiled tubing. Further, to use only locally available equipment and to then evaluate long term feasibility, production performance, and ways to improve operations. This was a good case study in that the multiple problems encountered were presented for review. From rig mobilization, to mud system problems and component integration, this was an expensive project. As there was no built for purpose rig, a service rig had to be brought in after the fact to run casing. Of the ten wells attempted, only three were successful, yet these three paid for the entire project. Valuable lessons were learned regarding equipment configurations and a new project is in the planning stages.

Don McClatchie of BJ Services gave a presentation on expanding the envelope of coiled tubing drilling from a global perspective. He used examples from Prudhoe Bay Alaska, Alberta Canada, the North Sea and Australia. He cited the current limitations of coiled tubing at 14,000' and 285 degrees. His focus was to develop ideas for expanded use in the lower 48 of the USA. These included gas storage wells, drilling of laterals in deep gas wells to hunt for fractured reservoirs and to deepen existing wells.

Virginia Weyland of the National Energy Technology Laboratory gave a presentation on Microhole Technology from the viewpoint of government development initiatives. She described the important ideas behind microhole development as being significantly lower reservoir access cost, cost effective vertical seismic profiling for complex reservoirs and a smaller drilling rig footprint with associated reduced environmental impact. The entire project has a single goal of increasing domestic oil recovery. She took us through some of the DOE awards to individual companies in the development of the technology and some of the successes. These include the hybrid CT rig used in the Niobrara Chalk.

Steve Sadoskas of Pinnacle Technologies gave a presentation entitled Hydraulic Fracture Diagnostics and Applications. He presented the difficulties of determining fracture behavior within any given reservoir, and what properties would be important to determine in order to maximize economic return (orientation, length, well spacing and pattern). He presented three categories of fracture diagnostics as being indirect, direct near wellbore and indirect far field. He then developed the physics of using tiltmeters to measure deformation in order to determine fracture behavior. He also developed the concept of using microseismic event recorders to determine fracture behavior. He used an example Barnett shale real time frac and developed a model for field development using a two well model. He also introduced the idea of a stress shadow in horizontal well fracturing whereby a fracture is inhibited by adjacent fracture growth.

Jim Fontaine of Universal Well Services next presented a case study using Pinnacle Technology innovations as applied in the Appalachian Basin. His company became interested in this approach because in this basin it is well known that the performance of thousands of wells does not meet expectations, and we do not have an easy method to measure the geometry of a fracture to determine where it grows and what it looks like. His goal, therefore, was to develop an optimum completion strategy that would increase production, effectively drain the area, calibrate frac models and identify by-passed zones. Examples were presented from a 3-well multi-frac program on the Linden Hall lease in Pennsylvania. Up to six sandstones (Upper Fifth, Lower Fifth, Upper Bayard, Lower Bayard, Speechley, First Bradford) in the Upper Devonian section are productive in the area, and are usually stimulated using a balanced baffle staging system. On average, all stages mapped grew along a NE-SW azimuth. However, in cross section, fracture growth was more complex. For example, if fractures from the first stage grew preferentially to the southwest, stage two fractures grew to the northeast due to a change in stress direction following the initial fracture growth. Also, fractures were not confined to the individual sandstones in which they were initiated. Instead, they grew both upward and downward, such that the fourth and fifth stages appear to overlap each other. One conclusion reached was that the upper three zones could be perforated and stimulated in one stage rather than in three stages. The speaker concluded with a suggestion that perhaps we should look at the Devonian sandstone plays as thick shale plays with interbedded sandstone fingers and stimulate them accordingly.

Holly McDaniel (Halliburton) gave a brief overview of Halliburton's shale log that provides a tool to identify and quantify the potential of unconventional reservoirs. The technology integrates raw log data with core analyses to locate organic shale zones and provide values for gas content, total organic carbon, thermal maturity, kerogen types, shale mineralogy, brittleness, Young's modulus, Poisson's ratio, fracture barriers, and shale reservoir type. Actually, the method can be applied with or without core data. If digital files are available for four key logs, a shale log analysis can be run using generic core data from other cores in the region.

Former PAG Chairman Kevin Smith (Oxford Oil Company) revealed Oxford's strategy to revitalize old fields, using as examples four Clinton sandstone wells in Noble County, Ohio that were identified as performing below economic limits. These four wells are located between two existing Berea Sandstone fields, so Oxford studied the Berea through Gordon interval to identify potential plug-back candidates. However, a search through their log library revealed very little in the way of data on the reservoir properties and characteristics of these sandstones. Therefore, Oxford turned to the south, where they had established production in these units in Crooked Tree field, and used those wells as models for a completion strategy in the four Clinton wells slated for recompletion. In each case, the lower portion of the hole was plugged and abandoned according to state law, and the recoverable 4.5" casing was pulled, inspected and rerun. The wells were completed in two stages, first the lower Gordon-Thirty foot interval, and then the upper Berea-Gantz interval in stage two. After stimulation and cleanup, the first well produced 5.4 MMcf in the first four months on line. An economic analysis of the project concluded that 240 MMcf of new reserves had been added for the four wells. Following this successful, recompletion, Oxford has begun to use this same strategy in other wells slated for abandonment.

Martin Miller (Alliance Petroleum Corp) continued the theme of successful Upper Devonian multiple zone completions in Southeast Ohio. Step one was to examine all available logs and use the data to upgrade maps of all Upper Devonian sandstones and to identify faults that were present through the entire interval of interest. The observation had been made that high reservoir pressure was associated with these faults, so wells were spaced 1200-1500 feet apart to avoid steep declines. In older Berea wells, a pressure decline had been noticed in the Upper Devonian sandstones as the overlying Berea Sandstone was produced. New wells were drilled on air to total depth and a full suite of logs, including sonic and temperature, were run to identify reservoirs and gas shows. Four sandstones were completed in three stages; the "best" sandstone always was isolated, whereas two of the "poorest" sandstones were completed in one stage. The operator attempted to keep the number of perforations to 20 or less per interval, and injection rates to 20 bbl/min to stay in the zone of interest. Typically, 600 bbl/stage was pumped, but up to 900 bbl were pumped in the best zone, or in a two-sandstone stage completion. Production ranged from 7-10 Mcf/d, leading to the conclusion that good sandstone was not enough; faults

and fractures are necessary to make good wells. Therefore, a seismic program was initiated to pick deep faults with a NE-SW azimuth that extend upward through these shallow zones of interest.

The workshop was very well received by those in attendance. There were no logistical complications other than the HVAC complications, and the last minute arrival of the last speaker. The speakers were intelligent, informative and presenting a technology that was exciting to most of those in attendance. We feel that the knowledge gained by the attendees will effect the direction of their future oil and gas reserve development.

Summary of attendee evaluation forms

Of the 43 individuals in attendance at the workshop, 32 returned evaluation forms to the coordinators. Of the forms returned, 21 were operators, 7 were service company employees, 3 were consultants and 1 was a state/federal employee. Overall high marks were received for the three evaluation questions. The evaluations took a hit on question #2 (The speakers/facilities were acceptable) I suspect due to the air conditioning situation. Overall, the evaluations were very favorable and comments to the coordinators indicate that the attendees were most appreciative of the workshop. There were several topics suggested for future workshops. The evaluation forms are enclosed.