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Measuring Stage Water, Gas and Oil Production Using Tracerco Chemical Tracer Technology

Saving costs on unconventional extraction

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The expansion of unconventional oil and gas development has placed a new emphasis on better understanding well performance. The cost of horizontal and stimulated wells is higher than of conventional wells and requires reservoir professionals to look to new technologies to ensure optimal return on drilling, completion and stimulation. Using tracers allows the user to pinpoint stages of the well that are successfully producing, thereby saving costs by eliminating unproductive areas. Tracerco provides unique technologies for this purpose; this article explains how the tracers are applied and presents a case study illustrating their use.

Introduction

Historically the analysis of hydraulic stimulation (1) effectiveness has been based on modelling to evaluate the outcomes of completion along with petrophysical analysis to assess reservoir characteristics such as porosity, permeability, mineralogy and total organic carbon (TOC). Radioactive-based proppant and water tracers have been used in many wells, evolving more recently into water-based chemical tracers to determine spent fluid (water) relative flowback (clean out) and radioactive or neutron absorbing proppant tags to verify the position of its placement. It is imperative to address criteria such as:

- the nature of the geology
- whether the well spacing is appropriate
- the productivity of each stage
- correct interval spacing.

In 2014 Tracerco patented a new technology which provides information on stimulation water, native oil and gas that is produced from distinct sections or ‘stages’ of the wellbore (2). This technology utilises a range of specialist chemicals to the wellbore. The hydrocarbon phase tracer chemistry includes a variety of light aromatics dissolved in solvent. 17 tracers are available to tag the gas phase, 37 to tag the oil phase and 42 to tag the water phase. The tracers are added to the hydraulic fracturing fluid at the point of injection into the well.

Tracer Production Log™ (TPL)

Specialised tracers are orientated for the aqueous or hydrocarbon phases. At the onset of well production, water, gas and oil migration to the surface will transport the specific tracer placed in each stage of the wellbore. Samples of the produced water, gas and oil are collected from the wellhead and analysed for the presence and concentration of each tracer over time. A comparative analysis of the amount of tracer from each stage in a particular sample can then be related to the amount of

water and hydrocarbon produced, with more water and hydrocarbon production resulting in increased tracer displacement.

As the concentration of each tracer is directly proportional to the volume of gas and fluids flowing from the stage, each sample collected acts like a 'production log' finding the production of each stage at the time of the sample. Reviewing the analysis of sequential samples provides a continuous measure of each stage production.

The Tracer Production Log™ (TPL) (**Figure 1**) is used to study the production of each stage over the sampling period and to compare between stages, for example whether production from one stage began sooner or lasted longer than another stage. This provides an indication of how the operation of the well affects the production from certain stages and identifies how the well comes on stream, with diverse and changing individual stage productions as reservoir pressures stabilise.

Value from Output

Value from using chemical tracer tagging comes from its ability to gauge the success of drilling and completion activities to optimise future well design. Analysis of reservoir characteristics such as stress, TOC, Poisson's ratio, Young's modulus or permeability can show areas along the lateral with similar properties, and thereby locate potential areas where lateral coverage and completion efficiency can be maximised. Once such areas have been found, Tracerco's chemical tracer diagnostics measure the success of these efforts.

The TPL of the well in **Figure 2** is compared to the wellbore location and petro-data collected during completion. This data, combined with knowledge of natural faults present within the strata, allows a boost in effective production according to the known rock properties and flow dynamics of the petroleum in the area.

Case Study: Eagle Ford Shale

An Eagle Ford Shale, USA, customer had two wells with the same geophysical formation properties. The customer wanted to compare two stimulation strategies to determine their effectiveness for future well development and ensure that results were not skewed by an anomaly giving isolated dominant flow in one or more stages. In challenging market conditions, decreasing lift costs is paramount. Stimulation optimisation was identified as the key to reducing costs and yielding maximum production.

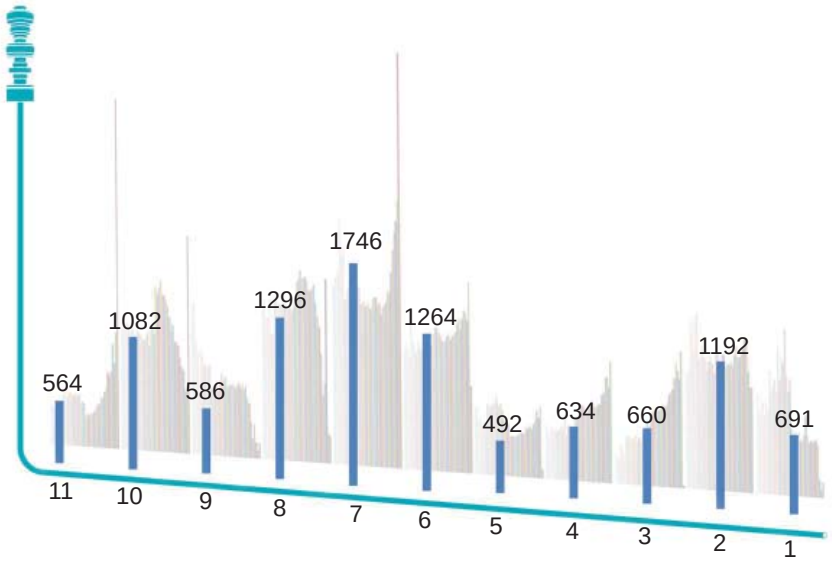

Fig. 1.Tracer Production Log™ (TPL) of stage contribution. The bar chart is a representation of the individual stage comparable production, using arbitrary axes. The dark blue bar is to represent the total stage output over the time frame indicated by the multiple faded bars. The multiple faded bars represent individual sample comparisons of production per stage

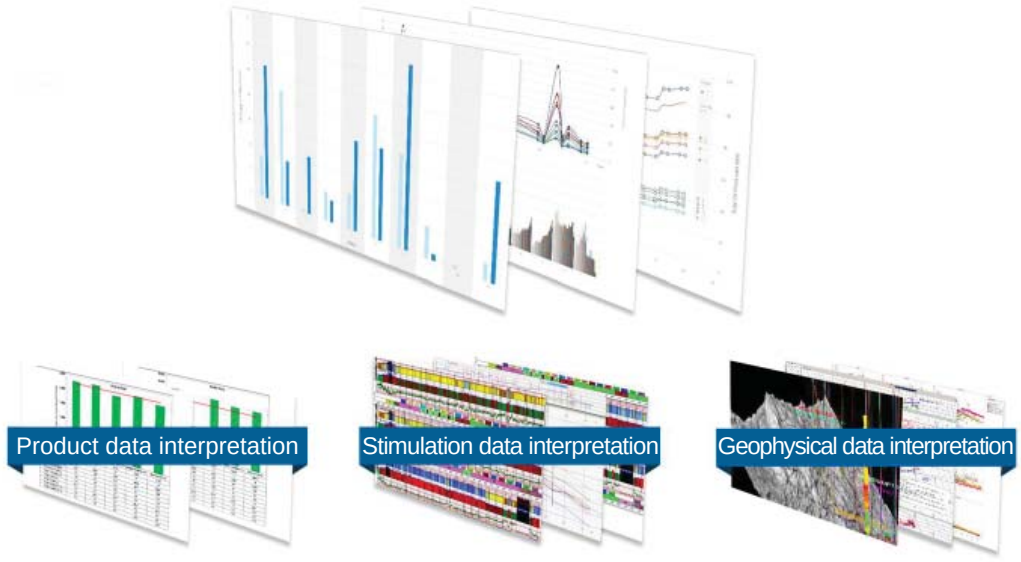

Fig. 2. Evaluation incorporating TPL, bore location and petro-data

With tracer the customer would be able to spot the exact stages that were affected by the stimulation. Tracers provided a detailed profile of what was happening day by day in each stage of the well so it was possible to see where each of the strategies was performing best. Unique tracers were used to tag the native oil reached in each stage in the two wells, obtaining accurate stage flow data to decide the most effective stimulation conditions.

The results were as follows:

- stimulation strategy 1 yielded 18,000 barrels per month
- stimulation strategy 2 yielded 30% more products at 26,000 barrels per month
- no anomaly showed majority flow from one stage due to unforeseen geological properties.

Further analysis showed that in both strategies the stimulation was ineffective in Stages 8 and 9 of each well (see **Figure 3**). Diminishing the stimulation of these two stages in either strategy would yield a 20% cut in costs with only a 4% depletion in production, which is effectively offset by the saving.

Design Strategy

These tracer results have been used to assist in the future design of landing zone strategy, number of perforations, cluster or stage spacing and number of clusters or

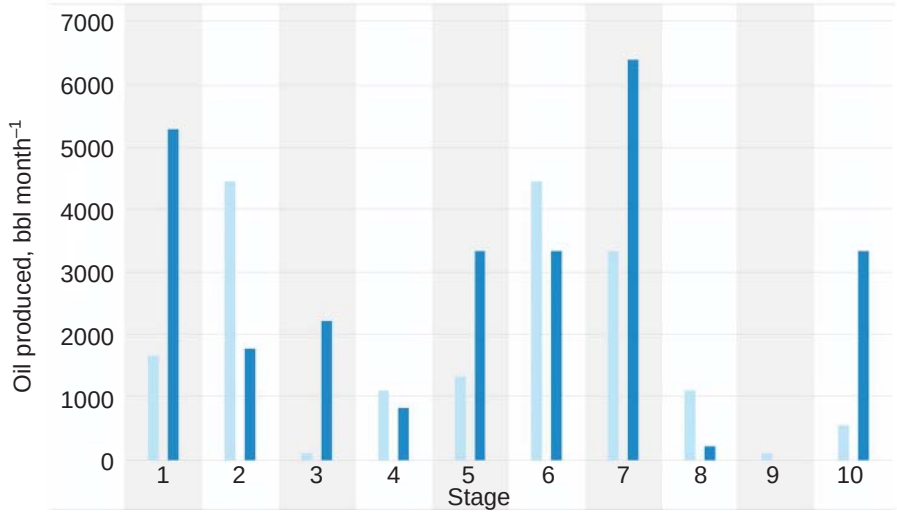

Fig. 3. Comparison of two stimulation strategies in side by side wells over one month

stages in future wells. All these parameters can have huge impact on creating the transverse fractures along the lateral and resulting hydrocarbon productivity.

Looking forward at informational requirements of the oil and gas community, ongoing research and development in hydrocarbon tracer tagging will see an ever increasing number of unique tracers developed to service increased multi stage stimulations beyond those currently available. Industry should also anticipate improvement in the TPL expectancy, with data contribution moving from several months to several years after well start up.

Acknowledgements

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Glossary Terms

Completion	Making the well ready to begin production of oil or gas
Flowback water	Water that flows back to the surface during hydraulic fracturing operations
Hydraulic stimulation or hydraulic fracturing	The process of injecting water-based fracturing fluid into a reservoir to stimulate production of oil or gas
Proppant	Particles, such as sand or ceramic which prop open the fractures
Stages	Sections of a well
Tracers	Chemicals added to the fracturing fluid to follow the flow of hydrocarbons from the reservoir
Well or wellbore	The hole or shaft drilled to obtain oil or gas from underground

The Author

Jon Spencer is currently working as the Technical Advisor for Reservoir and Completion Tracer Technologies for Tracerco, a division of Johnson Matthey. Tracerco is a world leading industrial technology company, providing unique and specialised detection, diagnostic and measurement solutions to the oil and gas industry. Mr Spencer has been with Tracerco since 1993, collaborated on three papers for the Society of Petroleum Engineers and is co-sponsor of the patent on oil tracer technology for hydraulic stimulation production measurements, a member of the Society of Petroleum Engineers, and an officer of the Society of Petroleum Engineers – Gulf Coast Section Northside Study Group. He has been in the oil industry since 1976. After obtaining an engineering degree he spent 15 years with Halliburton Logging Services performing open hole, cased hole and production logging services in Texas, South America, the Middle East and Far East before joining Tracerco where he worked in various technical and managerial roles in Texas, Alberta and Brazil leading the reservoir tracer technology group.