Tracerco
Insight through innovation

Optimization of a water and gas flood using interwell tracers

Using tracer flow insight to re-balance water and gas movement between wells.

The Challenge

An operator sought to improve the efficiency and maximize the productivity of their EOR program within the Salt Creek Field in Wyoming. Salt Creek is located in Natrona County on the south western margin of the Power River basin. The field is positioned within an asymmetric anticline that was formed on a west-verging back thrust fault, forming a gentle sloping eastern flank and a steep western flank. It is characterized by localized complexities and contains multiple producing horizons. After decades of production, these are now mature developments that require some sort of enhanced oil recovery (EOR) program to maintain economic viability.

Instead of a typical waterflood program, this operator sought to improve production using a water and gas (WAG) flood program. Multiple water injectors were placed along the exterior flanks of the field to provide a "water curtain" to contain any mobilized oil from moving outside of the unit. WAG injectors are positioned in five spot injection centred patterns throughout the interior of the field to flood the reservoir with reinjected produced gas and CO_2. Though this area had seen incomplete waterfloods in the past, the WAG program was a major improvement over more commonplace EOR programs. In an ideal scenario, injected CO_2 would re-pressurise oil layers and dissolve into residual oil, decreasing its viscosity and increasing its mobility.

However, the effectiveness of a CO_2 flood can easily be skewed through the presence of fault systems, fracture networks, and complications beyond the wellbore that divert the injected gas and decrease sweep efficiency. To help combat this the operator turned to chemical tracers to help quantify the improvements from the new WAG program, confirm hypotheses about reservoir behavior and fluid migration, and to support future project changes.

The Solution

To better understand the reservoir architecture of their asset, the operator worked with Tracerco to apply specialty gas chemical tracers to the injected produced gas and CO_2 as well as water chemical tracers to the injected water. Five water injectors on the eastern boundary were tagged with unique water tracers. An additional sixteen CO_2 injectors had their injected gas marked with tracers from the Tracerco gas suite. Distributed between these injector wells, fifteen producers were sampled to identify which tracers were being recovered alongside produced oil and the travel time those tracers needed to span the gap between wells. By testing samples from select production wells, Tracerco was able to establish where injected tracers, and by extension reservoir fluids, travelled within the reservoir. By measuring which production wells recovered the injected gas and water tracers, as well as breakthrough time, it was possible for the operator to:

- Evaluate specific injector-to-producer flow connections
- Identify thief zones
- Identify the existence of faults or barriers to flow

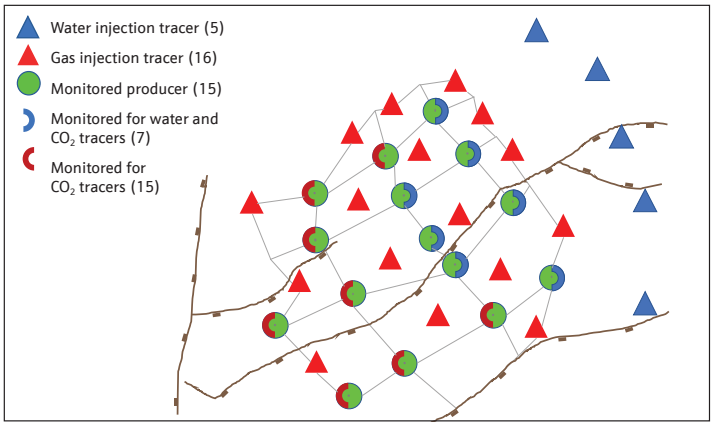


Figure 1 - Map showing position of water and gas injectors and producer wells.

Operator Value

Collected well samples quickly determined the flow paths of the injected gas and water across the network of the field. These results identified areas that required further investigation due to fast breakthrough as well as identifying water injectors that ineffectively added to the water curtain. Figure 2 graphically illustrates results by indicating the level of communication using small and large arrows as well as flow paths.

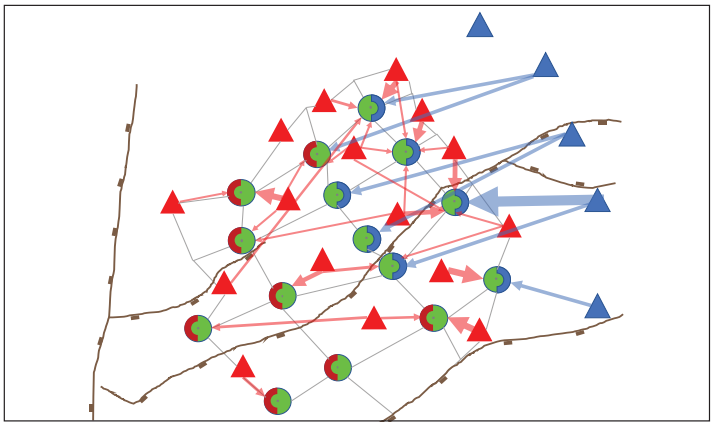


Figure 2 - Communication between injected water and gas and targeted producing wells.

This streamline data was invaluable in refining simulation models related to relative porosity and the extent of fracture systems within the field. Additionally, the quantitative data provided by the tracers offered insight in how to rebalance the water and gas flood to better optimize the EOR strategy. An example of this is shown in Figure 3 which illustrates the tracer recovery from one problematic water injector-producer pair whose interaction was adjusted based on tracer data.

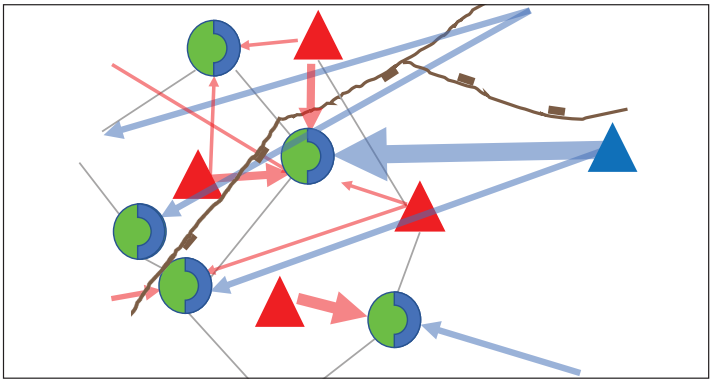


Figure 3 - Northern water injector showing dominant recycle to one producing well.

Here, the tracer data established that much of the water introduced into the injector was moving quickly and exclusively to one producer, resulting in a high produced water cut and undermining the effectiveness of the 'water curtain'. Based on these findings, this particular water injector was shut in, resulting in the surrounding production wells seeing far less water encroachment and more of a static pressure barrier from the injected water. Just this change resulted in a drop of 50% in produced water and doubling of hydrocarbon production from the offset production well and provided additional water capacity to be injected more effectively in other water injection wells across the field.

Looking at an example of gas flow through the reservoir, another lesson learned through the chemical tracer study was how a production well that had several gas injectors on all sides interacted with those injectors. The tracer data revealed one gas injector that disproportionately was communicating with the producer compared to its peers. High gas rates produced in this well suggested a channel

from one of the gas injectors and sparked an investigation into whether the offending gas injector could be choked or shut-in without reducing oil recovery.

Figure 4 presents communication from all the surrounding gas injectors (circled) that were communicating with the producer (circled).

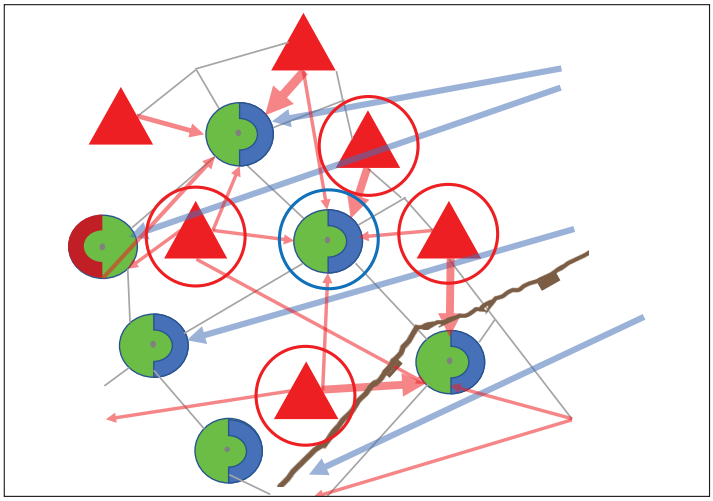


Figure 4 - Showing pressure support from all surrounding gas injectors to central producer.

The closest gas injector to the north east had the highest magnitude of communication among all the injectors. This injector circulated 50% of the injected gas to the producer while the remaining injectors circulated less than 20%. The tracer data confirmed near-ideal flooding through the reservoir matrix, hopefully reflective of a highly fractured reservoir network. Data from the other producers indicated that all the injectors also supported the remaining associated producers and making changes to the injection would cause negative production impacts to those producers.

Finally, a third significant finding related to gas support from the north western part of the field. The row of gas injectors along the outer flank were seen to be providing pressure support and ultimately incremental recovery to the producers located to the east. To gain the maximum benefit from the incremental recovery of the injected gas a degree of communication was needed from the injectors to producers.

Figure 5 presents the communication of the gas injectors in the northwestern portion of the field. Over the course of the sampling time, no communication was indicated from the sample analysis as presented by the circled gas injector. This lack of communication suggested little to no gain from the injector. The injector was switched to a water injector and the previously injected gas diverted to other areas to ultimately improve incremental recovery more effectively.

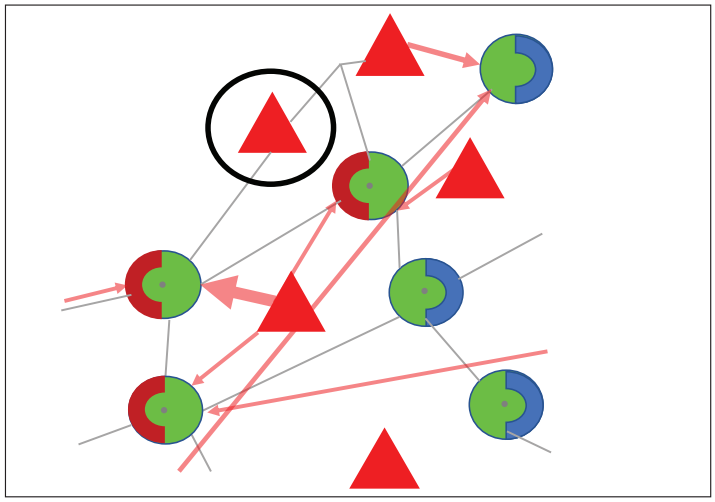


Figure 5 - Showing a lack of gas communication with offset producing wells.

The Conclusion

Using Tracerco to evaluate the effectiveness of a novel EOR strategy, the operator was able to improve and validate their reservoir models in a relatively short period of time. Furthermore, decisions to rebalance their injection strategy based on the tracer study allowed a substantial reduction in on-going costs by eliminating high water cuts, improving sweep efficiency and ultimately oil recovery. As the operator themselves summarized it, “the tracer study allowed us to optimize our flood and paid for itself many times over”, all without interrupting on-going operations or requiring any shut-in of existing wells.

Our innovative work gives customers the insights they need to help solve their problems. To learn more, read our case studies at **tracerco.com/downloads/case-studies**

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