

INTER-WELL OIL SATURATION MEASUREMENT FROM TRACERS

RESTRACK CAN OFFER MEASUREMENT OF OIL SATURATION IN PETROLEUM RESERVOIR INTER-WELL REGIONS. THE METHOD WORKS BY INJECTING ONE OF OUR SIX PROPRIETARY PARTITIONING TRACERS TOGETHER WITH A STANDARD WATER TRACER AND COMPARING THE TWO TRACER PRODUCTION CURVES . OIL SATURATION IS DIRECTLY RELATED TO THE TIME DELAY OF THE PARTITIONING VS. THE WATER TRACER AT THE PRODUCERS.

The partitioning inter-well tracer test (PITT) is a non-intrusive low-cost test that can provide measurement of oil saturation in the region between injectors and producers in an oilfield. Lack of stable partitioning tracers has previously limited the application of PITTs in petroleum reservoirs. A recent field test in the Total operated Lagrave oil field proved the stability and reliability of six new partitioning tracers at reservoir conditions.

In PITTs remaining oil saturation is given by

$$S_o = \frac{T_p - T_w}{T_p + T_w(K - 1)} \quad (1)$$

where T_p and T_w are retention times for the partitioning and water tracers, respectively, and $K = C_o/C_w$ is the oil/water partition coefficient. Based on retention times the six new tracers yielded $\bar{S}_o = 24 \pm 1\%$. This result was later verified and corresponds very well to saturation measurements on core samples

With the new tracers PITTs could become a standard method to identify EOR targets and to evaluate the performance of EOR operations. (See SPE 164059 for full paper).

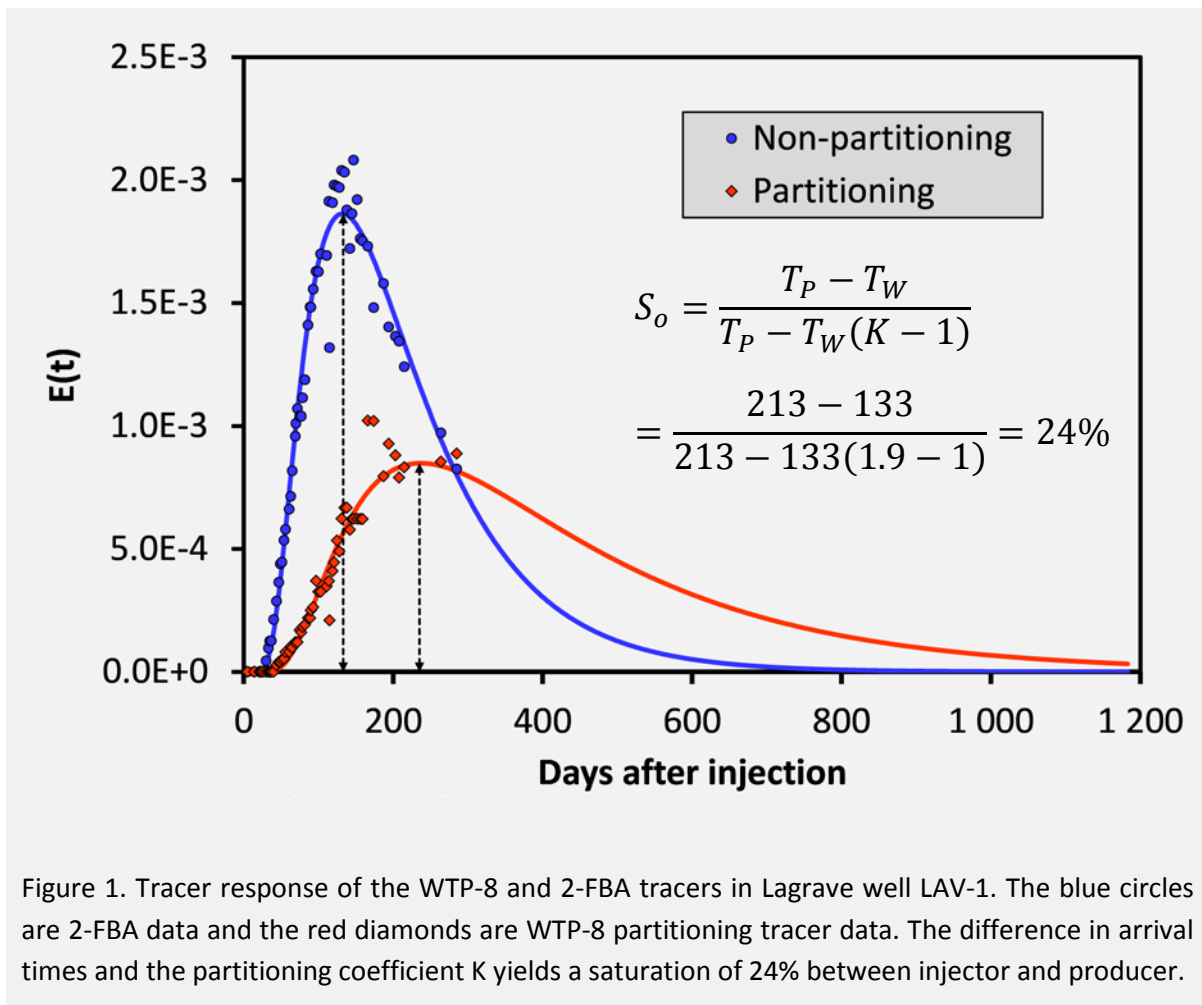


Figure 1. Tracer response of the WTP-8 and 2-FBA tracers in Lagrave well LAV-1. The blue circles are 2-FBA data and the red diamonds are WTP-8 partitioning tracer data. The difference in arrival times and the partitioning coefficient K yields a saturation of 24% between injector and producer.

Table 1. Results from Lagrave PITT. The amount of tracer produced in LAV-1 is summarized, as well as average and peak arrival times and inter-well oil saturation between injector LAV-7 and producer LAV-1.

Tracer	Injected amount [kg]	Produced amount [kg]	Average time \bar{T} [days]	Peak time T_p [days]	S_o from T_p [%]	S_o from \bar{T} [%]
WTP-1	5	2.3	249	133	25	23
WTP-2	5	1.4	314	226	25	27
WPT-3	5	1.8	352	200	25	27
WPT-4	5	2.1	395	200	22	21
WTP-7	5	1.4	353	239	24	22
WTP-8	5	2.0	420	233	24	25
2-FBA	5	2.2	423	213	-	-

PITT OPERATION IN THE LAGRAVE FIELD

The Lagrave field (operated onshore in the South-West of France by Total E&P France during the test) is an Upper Cretaceous limestone reservoir and can be divided into four zones (A, A/B, B and C) with an excellent lateral facies continuity. Core measurements yield residual oil saturations of 25% (Zone A), 28% (Zone B top) and 23% (Zone B base). The oil is light (42° API) and under-saturated.

The reservoir was very well swept by water prior to the pilot and all the producers have a water-cut higher than 97%. During the test all produced water was re-injected and no external water source was used. Six partitioning tracers were injected together with the passive tracer 2-FBA in LAV-7 in February 2011 and sampled at producers LAV-1, LAV-2 and LAV-6 (cf. Figure 2).

To remove contribution due to water re-injection and for further interpretation, the data were recast as residence time distributions $E(t) = C(t) \cdot Q_p(t) / M$, defined from produced tracer concentrations, $C(t)$, production rate, $Q_p(t)$, and injected tracer amount, M . De-convolution was used to remove background and a type function was then fitted to the data (cf. red and blue curves in Figure 1) and used to find produced amounts and retention time by $M_p = M \int_{-\infty}^{\infty} E(t) dt$ and $\bar{T} = \int_{-\infty}^{\infty} t \cdot E(t) dt$. Saturations estimated from the peak and the

average retention times, using Eq. (1) are summarized in Table 1.

Saturations obtained from six tracers correspond well with the core measurements and are also mutually consistent.

This confirms the PITT technology and verifies that the six tracers are well suited to measure inter-well oil saturations at reservoir conditions.

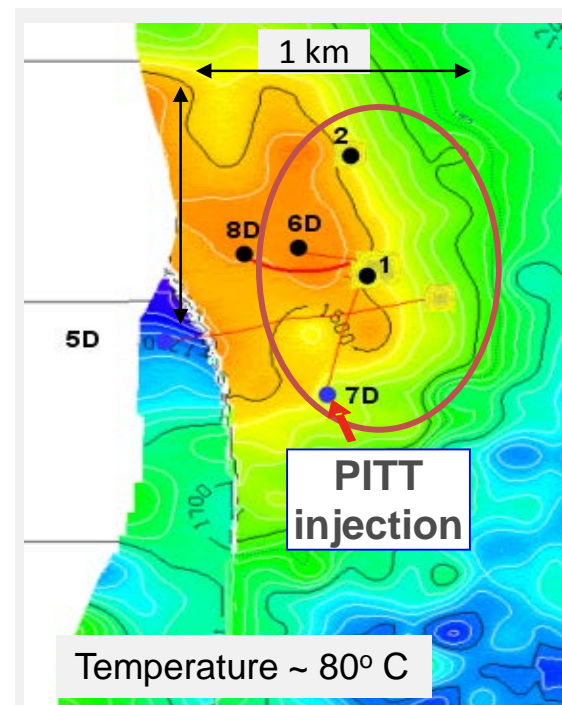


Figure 2. Map of the top reservoir and pilot area in the Lagrave field.