RESTRACK™

Fluid Dynamics in the Snorre Field from Tracers & 4D Seismics

In the Statoil operated North Sea Snorre field, production data, 4D seismic and tracer monitoring were used in an integrated process to map reservoir flow (SPE 105288). Tracer data confirmed interpretations of water fronts indicated by 4D seismic dimming, thus giving unambiguous interpretation of drainage patterns.

Case description

The Snorre field is located in the Tampen Spur area on the Norwegian Continental Shelf and is a system of rotated fault blocks with beds dipping 4-10° towards North-West. The reservoir sections consist of fluvial deposits and reservoir units contain thin sand layers with alternating shale in a complex fault pattern. The average reservoir pressure in the Central Fault Block (CFB) is 300 bar and the reservoir temperature is 90°C.

To understand sand layer communication and to what degree the faults act as barriers or not, a significant tracer program (with more than 50 individual injections) has been executed at Snorre. The tracer program started early in 1993, about ½ year after production start, and still continues today.

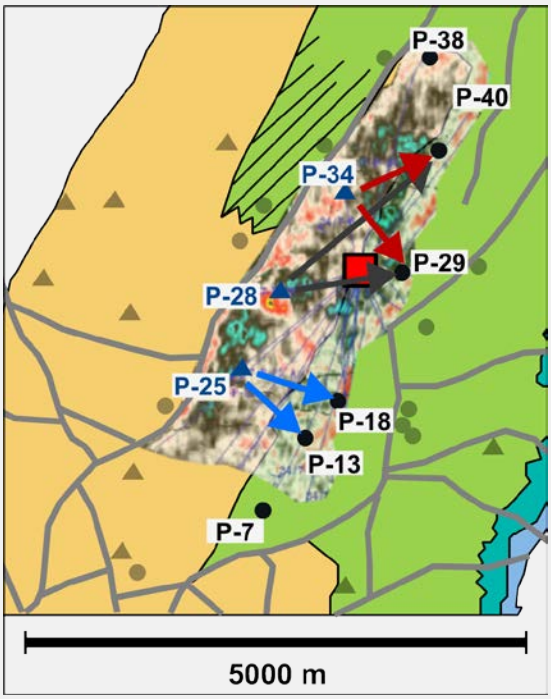

Figure 1. Map of Snorre with CFB. The seismic image shows dimming effects interpreted from the difference between the two first seismic surveys at Snorre. The black represents strong dimming and indicate the water front. Tracer breakthrough (as indicated by arrows) at the second seismic survey data correspond well with the front from the dimming.

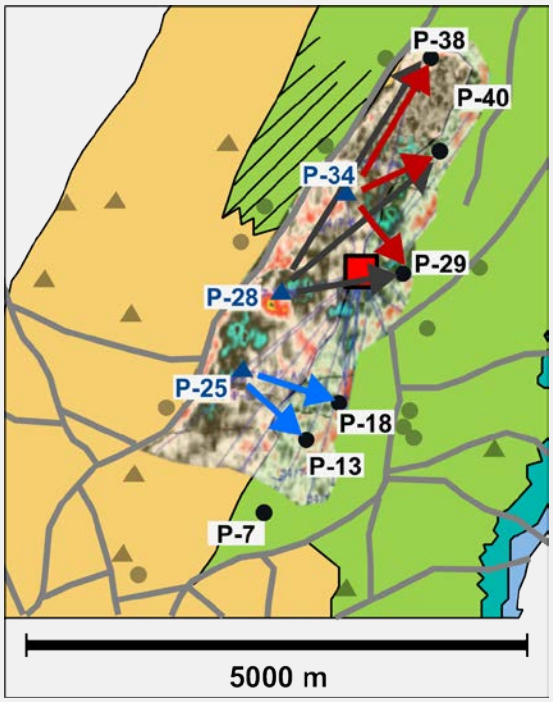

Figure 2. Map of Snorre with dimming effects interpreted from the difference between the second and third seismic surveys at Snorre. The black dimming indicate that the water front has reached further north, which correspond well with tracer data that show breakthrough in P-38 from P-28 and P-34 at the time of the third seismic survey.

During execution water-alternating-gas (WAG) programs, tracers have been injected both in the water phase and the gas phase, here we focus on two water tracer injections in the Central Fault Block.

WATER FRONTS FROM SEISMIC DATA

In the Snorre field, 4-D seismic surveys and corresponding interpretation show clear dimming (seismic amplitude decrease) as oil is substituted by water (cf. Figure 1 & 2). These surveys were performed after five years of production (Figure 1) and after an additional four years of production (Figure 2). The dark color of Figures 1 & 2 corresponds to reservoir areas where oil has been substituted by water. In Figure 1 it can be noted that the water front has reached a front located about halfway between the producers P-40 and P-38.

TRACER INFORMATION CONFIRMS 4D SEISMIC DATA

As part of the extensive tracer program in the Snorre field, three distinct tracers were injected in P-25, P-28 and P-34 in the same month at an early stage of the water injection in the CFB. By monitoring these tracers in the producers it is possible to track the water front moving North and East in the CFB in Snorre (cf. Figure 3 for a typical tracer curve).

The results from this tracer survey are summarized in Table 1 and Figures 1 & 2.

Table 1. Summary of tracer observation in producers in the CFB in the Snorre field. None of the tracers are observed in P-38 during the first 4D survey.

Injection well	Prod. well	Time [days]	Seen during 1st 4D survey	Seen during 2nd 4D survey
P-25	P-18	937	yes	yes
	P-13	330	yes	yes
P-28	P-29	721	yes	yes
	P-40	931	yes	yes
	P-38	2257	no	yes
P-34	P-29	349	yes	yes
	P-40	674	yes	yes
	P-38	1216	no	yes

Comparing with the 4-D seismic data the tracer data are in excellent agreement with the water front inferred from the seismic study. In addition, the tracers add significant information, revealing that the water in the P-38/P-40 area originates from *two* sources, namely P-34 *and* P-28.

In conclusion we note that tracer data can be used to confirm 4-D seismic interpretations. Moreover, the 4-D seismic data confirms that tracer data provides an excellent tool to track water fronts in petroleum reservoirs.

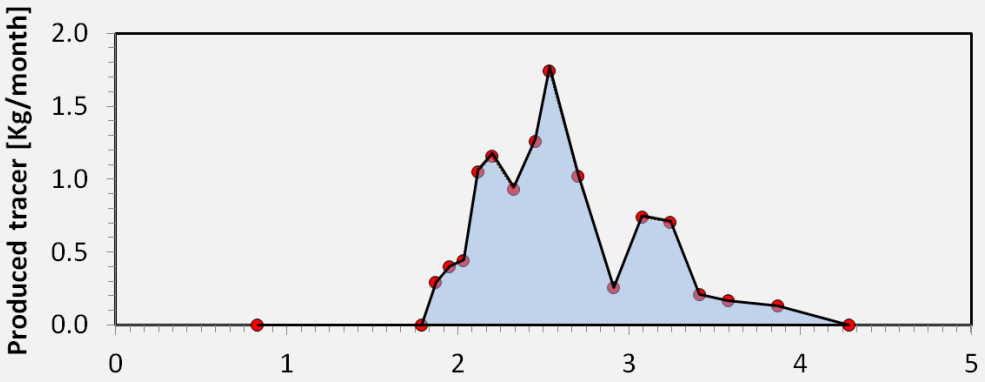

Figure 3. Monthly produced tracer amount in P-29 vs. time after injection for the tracer injected in P-28. The area under the curve corresponds to total produced amount of tracer in P-29.