Case Study

FIBERLINE INTERVENTION

FLI DIAGNOSES AN OFFSHORE RESERVOIR CONTAINMENT BREACH USING A POST-INJECTION SURVEY.

THE CHALLENGE

A mature oil field in the central North Sea, which has been producing for around thirty years, is reliant on pressure support from several water injection wells. The operator of this shallow field was concerned that reservoir containment had been breached and a study was required to establish whether out of zone injection was occurring or if a permanent flow path existed.

Some of the wells were highly deviated or horizontal, adding to the complexity of the project, but if data could be acquired from above the water injection zone, this should be able to locate any out-of-zone movement.

An additional challenge was that the drilling rig was located above the target injector wells, so any intervention method required a low rig-up height and small footprint to avoid impacting concurrent rig-based operations.

THE SOLUTION

FiberLine Intervention (FLI), with its distributed real-time sensing, was selected for this complex injection profiling survey. FLI's bare fibre has the acute sensitivity to capture high -quality temperature, acoustic and micro-seismic data at significant distances through physical barriers, including sub-surface geological formations.

In this project, FLI would survey three wells using distributed temperature sensing (DTS) to detect the cooling and warm-back effect from the injection of cold water and distributed acoustic sensing (DAS) to detect any acoustic events resulting from residual flow through restrictions, or the activation of faults.

FLI's low rig-up height and lightweight, manoeuvrable equipment would allow survey operations to be performed in the restricted space of the wellhead bay beneath the active rig.

To perform the surveys FLI was rigged up in advance so it was ready to deploy, then a sustained period of high-rate, cold water injection was introduced to the reservoir to stimulate potential out of zone egress.

On cessation of injection, FLI was rapidly deployed into the deviated section of the injector well, across or above the injection zone. Survey data was immediately available and continued to be captured throughout the warm-back phase. This process was repeated on each of the three wells.

VALUE

- FLI can use temperature and acoustic data to give a detailed picture of fluid and solid interfaces in sub-surface geological formations.
- Monitoring injection performance can provide feedback on the location and connectivity of fluid flow paths, plus the integrity of the cap rock and reservoir formation.
- Compared to wireline or slickline deployed fibre, FLI has a tiny footprint and does not require the same surface equipment spread.
- Compared to wireline logging, FLI is able to show distributed data across the entire wellbore and beyond, plus the direction and velocity of acoustic events.
- Bare fibre has acute sensitivity and delivers high quality data.
- The FLI system is small and lightweight, with a tiny wellsite footprint and low rig-up height.
- Well-SENSE provides a streamlined and fully integrated service which includes project planning, mobilisation to site, well deployment, data processing, analysis and reporting.

THE RESULTS

DTS data indicated an out of zone flow path from one of the wells, evidenced by an overall drop in temperature above the intended injection depth. The DAS data indicated a complex and active flow path from this well through a fractured formation above the reservoir zone. No direct flow path was observed from the reservoir to the shallow formation or nearby well annuli. The combination of DAS and DTS results provides a powerful dataset with valuable insights into reservoir containment challenges.

The compact and lightweight rig-up of FLI enables multiple and simultaneous well surveys to be performed that enrich the understanding of the problem. Well-SENSE has experience in performing successful reservoir containment studies for water injection, water disposal and CO_2 storage.

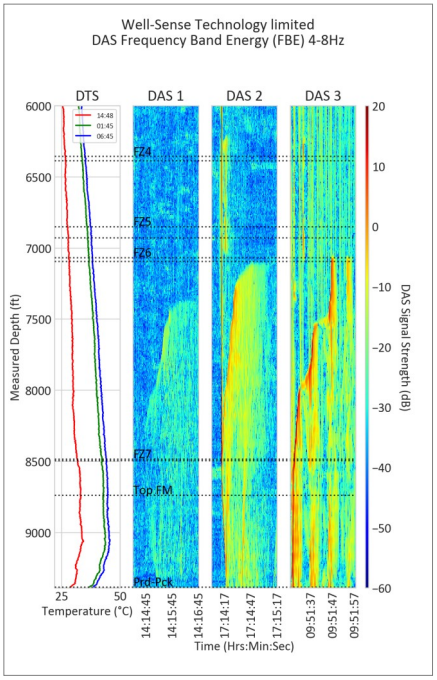

Figure 1 (L): Repeatable indications of flow in the DAS data, from a modelled fracture to a second modelled fracture and down into the reservoir. The high intensity acoustic energy is observed on the low frequency range 0 – 8 Hz. Distributed Fibre Optic Sensing data enables both the depth, direction and velocity of the fracture flow to be determined. Direct flow reversal is also observed during a period of low-rate injection – DAS 3 – with flow from the

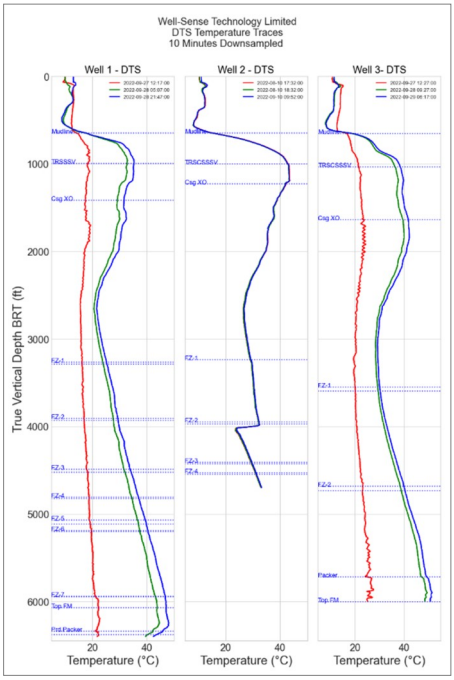

Figure 2 (C): The observations are support by a deviation in geothermal temperature at this depth.

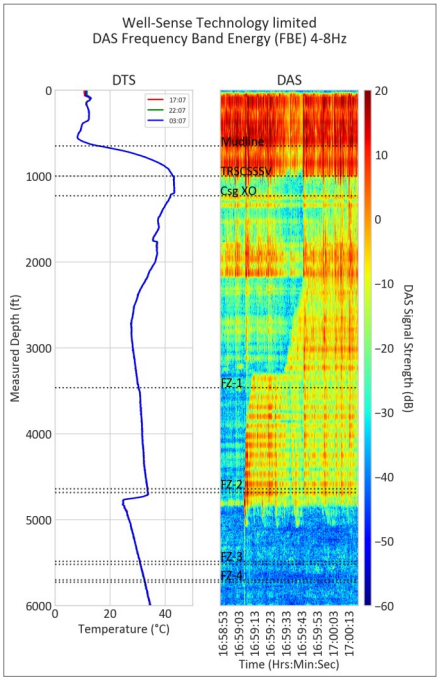

Figure 3 (R): Out of zone injection observed in one well as a large temperature reduction from the geothermal gradient which terminates at a known fracture. The top depth of the temperature deviation correlates with the origin of acoustic energy, indicating fracture activation and flow away from the well bore.