CASE STUDY

LEAK DETECTION IN WELLS

ON THE USE OF DISTRIBUTED TEMPERATURE GRADIENT SENSING (DTGS) WITH DAS FEBUS A1

WHAT IS THE NEED?

The aim of well integrity interventions using DFOS (Distributed Fiber Optic Sensing) is

- **to significantly reduce the duration of these operations**
- **as well as their cost**
- **and to provide additional information**

in comparison to traditional logging tool.

FIELD DEPLOYMENT

We perform all measurements using a wireline deployment and monitor the well integrity in real-time with the FEBUS A1 placed in the control room of the PetroLS company wireline logging truck (Figure 1).

For well monitoring, combined with DTS temperature measurement, DAS is traditionnally used for its ability to access acoustic frequency range witnessing production events or leaks with high efficiency. We propose here to investigate the potential of the **DTGS (Distributed Temperature Gradient Sensing) with low frequency DAS (<1 Hz) to monitor leaks on the completion tubing of a well** by direct comparison with conventional DTS monitoring.

The main advantage of using DTGS with DAS is its sensitivity to small leaks, including the direction of propagation of the leak.

> Figure 1. Logging unit including a wireline cable composed of both SM and MM optical fibers. The DAS FEBUS A1 and the DTS FEBUS T1-R are located in the logging truck control room for real-time data interpretations.

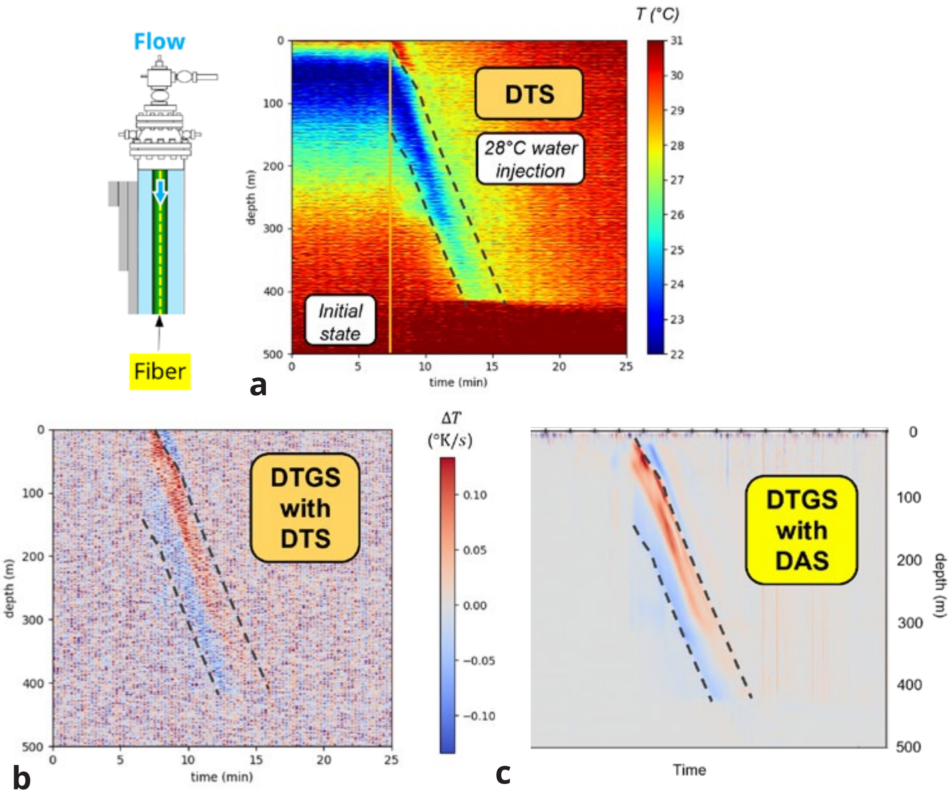
> DAS ACCURACY FOR DTGS MONITORING

We estimate the accuracy of our DAS FEBUS A1 for DTGS monitoring in the context of field operations.

In this aim, we induce temperature variations in a well by injecting water in the production tubing at wellhead localization (Figure 2).

With the DTS FEBUS T1-R we monitor the absolute temperature (Figure 2a) and the temperature gradient (DTGS) of the injection phase (Figure 2b), while we also monitor DTGS using the DAS FEBUS A1 at low frequencies (Figure 2c).
As the color bar is valid for both Figure 2b and Figure 2c, we observe that the temperature gradient measured using the DAS FEBUS A1 is the same than the one measured using the DTS FEBUS T1-R.
However, the SNR using the DAS FEBUS A1 is much better. The DTGS is monitored in the range of 10^{-3} K/s with DAS while DTS offers a maximum resolution of 10^{-2} K/s.

We also note that we do not record the strain of the cable when it is entirely deployed.



> Figure 2. Monitoring of the absolute temperature (a) and the temperature gradient (b) using the DTS FEBUS T1-R during the injection of water in a production tubing. The temperature gradient is measured at the same time using the DAS FEBUS A1 (c).

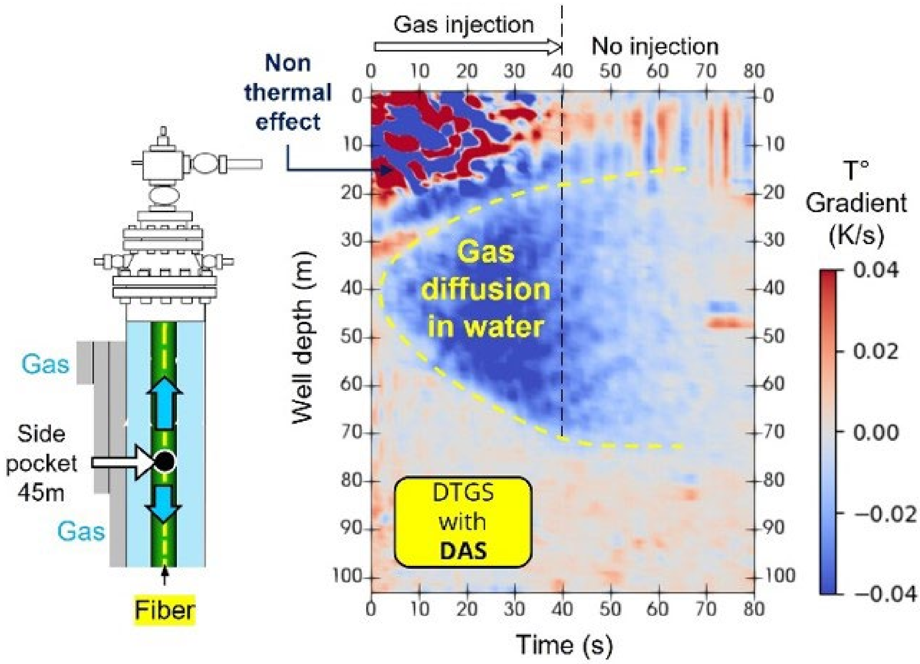
OPERATION

As we monitor DTGS with a good accuracy using the DAS FEBUS A1, we proceed to field operations to detect both gas (Figure 3) and liquid (Figure 4) leaks.

GAS LEAK

Regarding gas leak detection, a leak is simulated at 45 m depth at a side pocket level (Figure 3). We mainly observe two phenomena as

- **non-thermal effects**
- **temperature effects coming from the side pocket area.** In this case, we attribute the cooling effect observed to the diffusion of gas in water.



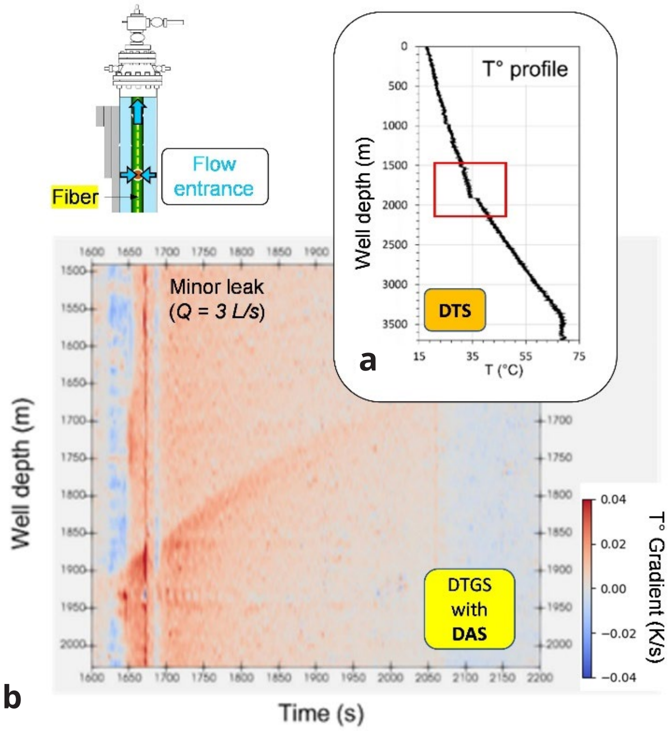
> **Figure 3. Monitoring of a gas leak on a well production tubing using DTGS data from the DAS FEBUS A1.**

WATER LEAK

In the same way, **we are able to detect minor liquid leaks** on the production tubing, that can be induced by several environmental factors.
In the Figure 4, the leak is not detected using traditionnally non-distributed logging tools. We are able to detect it using both

- the DTS FEBUS T1-R (Figure 4a), by observing the break in the temperature profile slope when pumps are off
- and the the DAS FEBUS A1 (Figure 4b).

The flow is induced by a rebalancing of the pressure between the annulus and the production tubing.
The leak detection using DTGS with the DAS FEBUS A1 allows to detect the leak in real-time too, but also to estimate the speed (from the temperature front) and the direction of the leak-induced flow.



> Figure 4. Monitoring of the absolute temperature profile in a well production tubing using the DTS FEBUS T1-R (a) and of the DTGS with the DAS FEBUS A1 to monitor a minor leak located on the tubing (b). The flowrate of the leak is around 3 L/s.

CONCLUSION

To conclude, we obtain consistent DTGS data using the DAS FEBUS A1 technology at low frequencies in comparison to the DTS technology in the context of field operations.

The main advantage of DTGS using the DAS FEBUS A1 is due to the good SNR which allows to detect temperature events in the range of 10^{-3} K/s, enabling to detect gas or liquid leaks in well using a wireline deployment.

The combination of DTGS with the DAS FEBUS A1 and high frequency DAS (flow, tube vibrations) allows simultaneous and real-time qualification and quantification of leaks in wells.