First year of Distributed Strain Sensing in the Groningen field

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Introduction

The Groningen field in the Netherlands, discovered in 1959, is one of the largest producing gas fields in the world. Since production started in 1963, pressure depletion has led to reservoir compaction and subsequent surface subsidence. Although the compaction rates from the sandstone reservoir are small compared to chalk fields or unconsolidated reservoirs, the impact of the subsidence is very significant due to the proximity of the Netherlands' surface to the sea level. Additionally, recent observations show a relation between compaction and production-induced seismicity (Bourne et al., 2014), highlighting the importance for understanding the compaction behaviour of the field.

To improve the understanding of the reservoir compaction, dedicated observation wells have been drilled as early as the 1960s, where compaction is monitored using the gamma-ray marker technique (e.g. Mobach et al., 1994 and Doornhof et al., 2006). Although the marker technique has provided valuable data over a large range of reservoir pressures and at various locations, its resolution does not allow for monitoring on a scale similar to core or log data. To achieve a more detailed understanding of the reservoir compaction, a fibre optical Distributed Strain Sensing (DSS) system (Soller et al., 2005) was installed in a newly drilled well in 2015 as part of a wider data acquisition plan (NAM, 2016).

Fibre optics system for measuring reservoir strain

The DSS system installed in the Groningen well is a DSS SureVIEW WIRE system (Baker Hughes, 2016), developed jointly by Baker Hughes and Shell for the purposes of monitoring casing deformation, reservoir compaction, and cap-rock integrity, among other applications. The fibre contains Fibre Bragg Gratings (FBG) along its length, which reflect a very narrow band of wavelengths. Upon stretching or compressing the grating, the wavelength of the reflected light will shift accordingly. By monitoring the change of the reflected wavelength over time, the strain development can be traced, at a resolution and accuracy per grating which is better than 5 $\mu\varepsilon$.

First results from the Groningen DSS

DSS data has been recorded since October 2015. Initially, strain signals are observed that reveal the generic wellbore settling period following disturbances in near-wellbore pressure and temperature due to drilling activities. These disturbances slowly decay away over a six-month period. Strain measurements acquired shortly after the well was completed are affected by strains induced by the cement curing process. The presence of these signals at the order of tens of microstrains demonstrates the extreme sensitivity of the system to strain.

The DSS derived reservoir compaction rate resembles the compaction rate as determined by the gamma ray marker data, as well as surface levelling and GPS. Also, the strain profile developed in different parts of the well exhibits correlations with other well data, like for example the wireline density (Figure 1). These highly detailed correlations of in-situ strain, made on a centimetre scale, have not been possible with the gamma-ray marker data, nor has it been possible to obtain compaction rates in Groningen in less than a year time.

Since Groningen experiences relatively low compaction rates, more insights into the compacting behaviour are expected to develop in the coming years as correlations between the incoming data and compaction profiles and trends become more apparent.

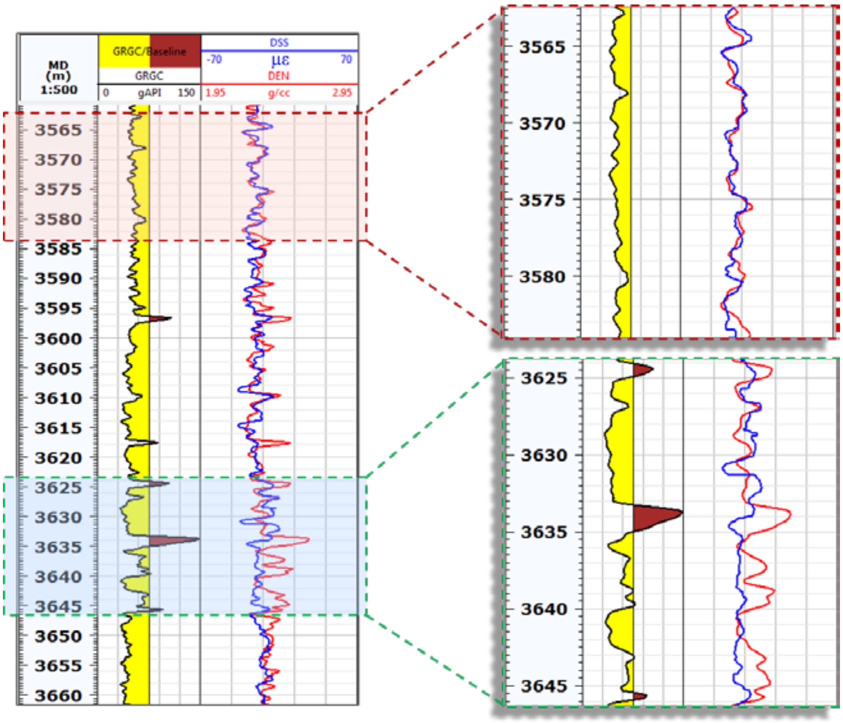

Figure 1: Correlation between in-situ strain as measured by DSS, and the formation density measured by wireline in uniform sands (upper inset) and more shaly sands (lower inset).

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