Operations Geology and application to Energy Transition and Renewables (March 2022)

Abstract

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Operations Geologists are primarily concerned with trajectory and well planning and supervision of geological operations during the drilling phase but often there is considerable overlap with development geology. The role is primarily using the planned trajectory to estimate Pore pressure, fracture pressure and geohazards using offset data and seismic.

For well planning geohazards begin at the seabed and extend all the way through the reservoir to TD. Well planning begins with the trajectory and finding the optimum way of reaching the reservoir targets with minimal encountering of geohazards and to identifying pore pressure ramps in order to plan casing.

Using a geological model and integrating with various disciplines it is the responsibility of the well planning or operations geologist to identify the optimum well position in the reservoir to maximize production in the case of a development well. Targets for the exploration well will have been selected by the exploration geologist. These however may need to be modified depending on the results of a geological risk assessment.

The next piece is around defining a data acquisition program which meets the well objectives then selecting an appropriate third party contractor to carry out the acquisition whether it be LWD, wireline, coring or mud logging.

Windfarms. The techniques used in well planning and geological operations are not unique to the oil and gas industry. The operations geologist is often responsible for interpreting sea bottom surveys from site survey investigations used in placing Jack up rigs. This is to de risk the chance of a punch through with one or more of the jackup drilling rigs legs. This methodology can be applied to locating optimal position for windfarms offshore where high resolution 2D seismic is used to estimate the depth of key layers and Cone penetration tests for the maximum depth a windmill can be placed before punch through is likely to occur similar to jack up legs (Figure 1)

Figure 1 Location of windfarms depends on seabed morphology and geology so site surveys are necessary.

Other hazards in the shallow overburden are shallow channels which can have a complex morphology. Mud filled channels can be as hazardous as sand filled channels. These can be interpreted from shallow 2D seismic. The channel shown in figure 2 is a bit deeper but nevertheless these need to be flagged before spudding the well so that severe mud losses or stuck pipe in the channel lags can be avoided.

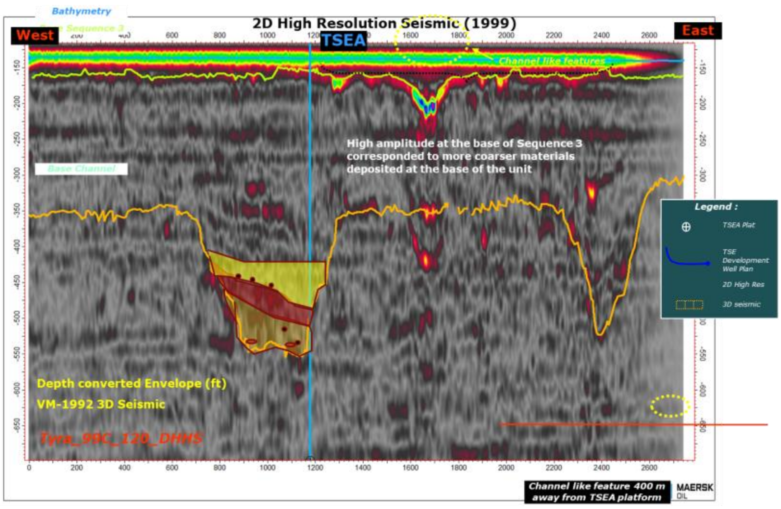

Figure 2 Shallow channels definitely to be avoided.

In Geothermal exploration the distance between boreholes is used for heat flow investigation. The heat source intensity depends on proximity to a local geological area that might contain magma such granite or gabbro. Heat flow is a product of thermal gradient and thermal conductivity of the formation. This information is acquired from core material. Drilling Geothermal wells is not too different to drilling oil and gas wells. Completion is in open hole with a slotted liner but often over 1000 to 2000m in length and the wider the hole diameter the better. Temperature and pressure logs are the most important for data acquisition. Temperature is acquired during drilling, after a few months when it reaches equilibrium and after injection. As with oil and gas wells trajectories need to be planned to target the optim feeder zones in the reservoir (Figure 3). The temperature plots are then analysed and maps are made to identify or predict likely sweet spots (Figure 3). . Cuttings descriptions and logging are necessary to identify rock properties as is coring. The only real difference may be identification of Igneus and metamorphic rocks in drilled cuttings as the geothermal reservoirs or feeder zones as they are called are most likely to be from volcanic or metamorphic rock. The core analysis focusses on mineral alteration as that is likely to be the result of hydrothermal alteration which signals a potential feeder zone (Figure 4).). Fractured zones and permeable feeder zones are the equivalent of oil reservoirs. Core material is required for a more accurate assessment. Geohazards are still likely to cause issues in the overburden and it is important to use methods that may detect discontinuities and likely fault occurrences as seen in figure 2 above and in figure 5 below. As with oil and gas wells pore pressure still needs to be estimated and casing planned to case off the overburden and seal (Figure 6). Several methods are used to assess geothermal gradient while drilling as this is the most difficult parameter to read in real time.

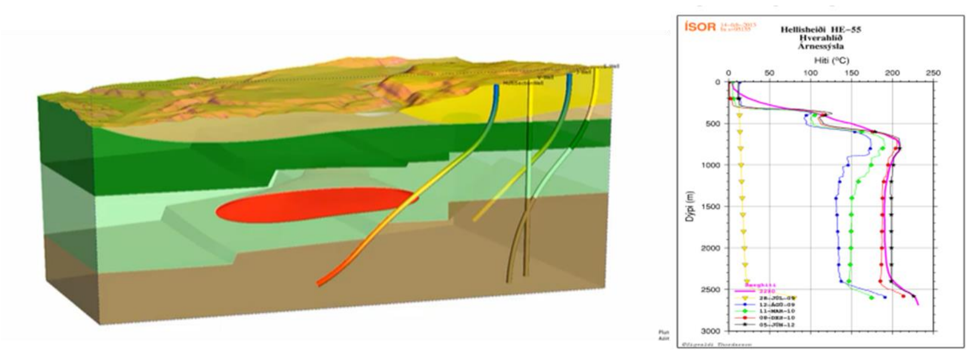

Figure 3 Well planning in Geothermal field and temperature gradient

Figure 4 Typical Core from Geothermal well in this case Andesite. The objective to detect areas of hydrothermal alteration

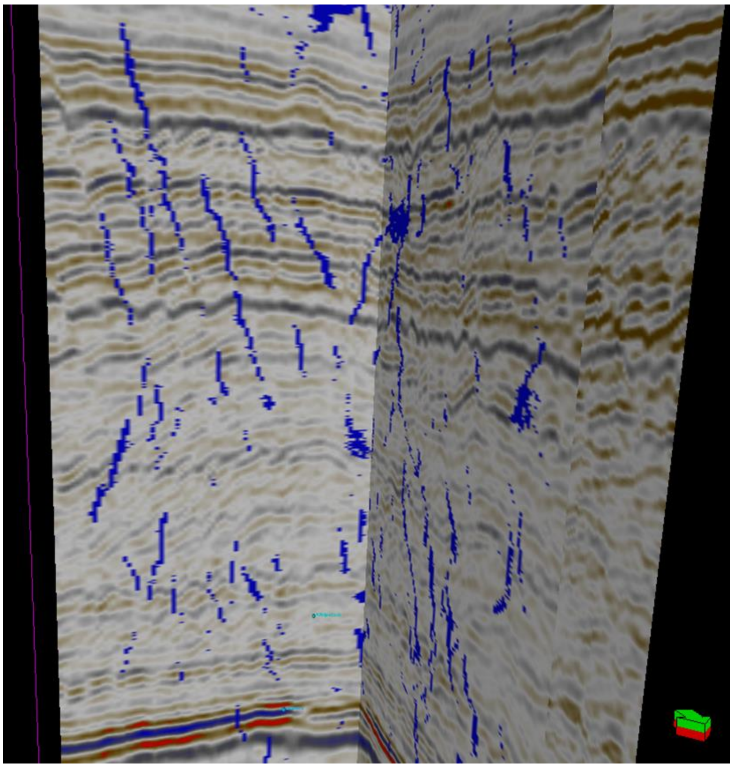

Figure 5 Using geophysical attributes such as AntTracking to evaluate faulting in the overburden. Important when trajectory planning ensuring the well path does not follow a fault plain.

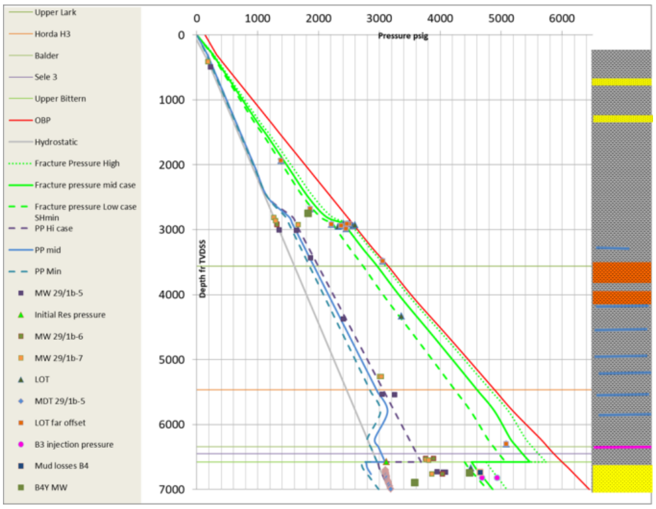

Figure 6 Example PPFG plot. It is still very important to assess pore pressure and fracture pressure in Geothermal wells as casing still needs to be planned.

Carbon Capture and Storage (CCS) is increasingly being planned by operators in the North Sea sectors in Norway, Denmark the UK and the Netherlands. The Process involves first identifying a suitable reservoir with a high storage capacity that is close to its COP date so that CO2 can be stored over a long period of time. Then identifying a strong reservoir seal to prevent leakage but also to investigate well penetrations to see if they have been suitably abandoned in order to prevent a leak path for CO2. (Figure 7).The reaction of CO2 to fluids and metals is investigated and impact on marine life in the oceans should leakage occur. A geological model is very important in order to simulate rates of CO2 injection and its impact of reservoir pressure. The operations geologist can use the skill in identifying permeable zones that may still require sealing and to evaluate cement bonding and presence of abandonment plugs(Figure 8). This requires knowledge of log interpretation especially when it comes to identifying key lithologies that may be potential leak or permeable zones. Cement bond logs and cementing operations reports are key in understanding whether the wells are properly sealed from the storage reservoir within the chosen cap rock. This will in most cases require digging back through very old drilling reports and logs.

Fault identification and examining if there is a leak through the cap rock using seismic.

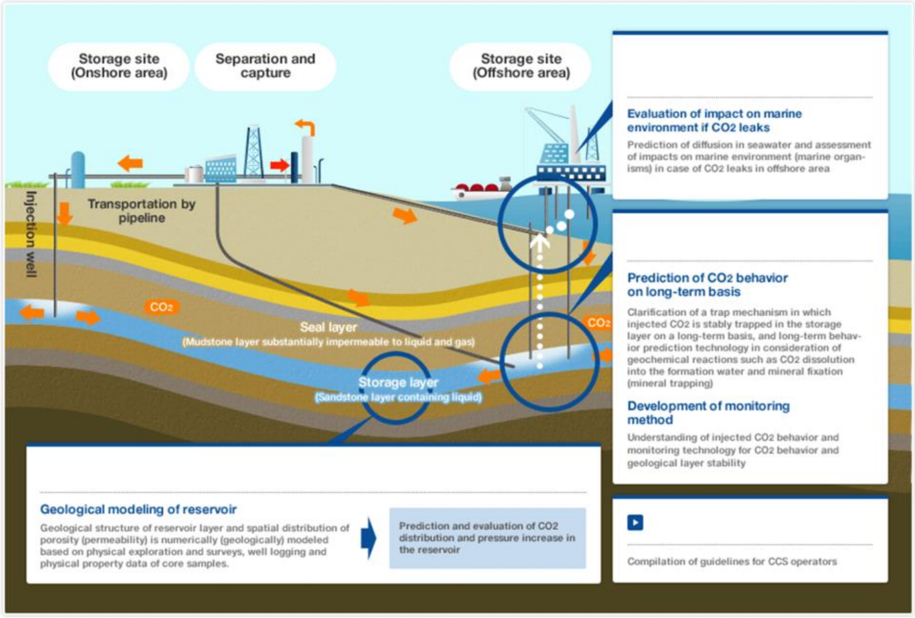

Figure 7 CCS Example reservoir.

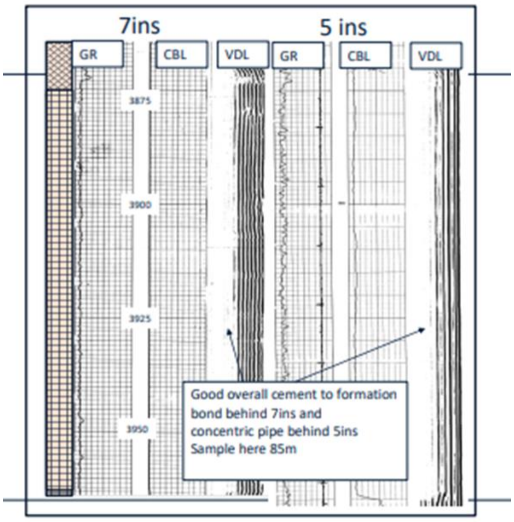

Figure 8 Using archived old Cement bond data to asses well integrity

In Most cases, the Operations Geologist has the skill set and knowledge base to lend valuable support to the planning and execution of energy renewable projects.