Drilling in carbonate formations with karst and open fractures

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Petroleum Safety Authority
Drilling in carbonate formations with karst and open fractures

Report Acona has prepared at the request of the Petroleum Safety Authority Norway.

The report deals with karstified formations

How to identify karst

How to reduce risk while drilling
Drilling in carbonate formations with karst and open fractures

**Carbonate** constitutes a large group of minerals. One of the earth's most common minerals is calcium carbonate, CaCO3, lime, which occurs in many different forms, for example limestone, marble and chalk.

**Karst** is a disintegrate/degrade phenomenon with caves and cracks, often occurring in limestone.
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Karstification and cave formation mainly occurs along weakness zones, cracks and faults where freshwater can flow and gradually expand cracks and cavities.

The speed of this process depends on the mineralogy and the solubility of the rock.

Also requires that formations have been above sea level / groundwater level.
Profile which illustrating stages in development of karst

Fra Esteban og Klappa, 1983
Examples of karst

Salangen, Troms

Evenestangen, Nordland

Kristihola, Fauske, Nordland
Then it will last for a few years

250 million years

Karst formation has been buried down to today's depth, 1800 – 3000 m
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During the burial history, karstified formations have for a period of time been raised above sea levels and subjected to erosion and karstification before they were again buried.

In the Barents Sea this is primarily known from the Lopphøgda area.
In the Norwegian Sea, the northern part of Norlandsryggen is affected.
Utsirahøgda in the Johan Sverdrup area represents example in the North Sea.
Drilling in carbonate formations with karst and open fractures poses a risk because there may be sudden and large loss of drilling fluid, and thereby severe weakening of the primary barrier.

Ongoing exploration drilling in areas with carbon-dominated formations in the Barents Sea has raise awareness to this issue.

In 2016 the Petroleum Safety Authority Norway decided to start a project with knowledge acquisition and mapping of methods and tools that could reduce risk.
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Norwegian Oil and Gas Association:
Sharing to be better #13
Total mud loss followed by a kick in "karstified carbonates".
During cutting of core, the bit dropped 2m and an immediate severe mud loss was followed by a kick.
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The area Norlandsryggen is also mentioned in the report with Well 6608/8 (Drilled in 1997). Major mud losses (1700 l/min) followed by well control situations.

The combination of an open fracture system and significant overbalance was probably the cause of the massive loss of drilling fluid.
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The report has examples of several places on the globe where one drills for oil in carbonate reservoirs.

The main author have also experience from carbonate reservoir in Iran.
Seismic methods

3D seismic with optimal acquisition and processing parameters is the most important tool for identifying both karst-related features and potential loss zones associated with faults.
Lopphøgda in 3D with eroded carbonates

Gipsdalengruppen eroderte og karstifiserte karbonatavsetninger
Doliner og erosjonskanaler
Synkehull
Drilling in carbonate formations with karst and open fractures

The risk of drilling can be significantly reduced by using new drilling methods with the common term "Managed Pressure Drilling" - MPD. One technology that recently has been applied in some wells in the Barents Sea is called CML (Controlled Mud Level).

This equipment allows drilling with a bottom hole pressure that can be adjusted to near the pore pressure. This is done by adjusting the level of drilling fluid in the riser.
ACONA report

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Summary

- The industry has experience with karst
- Drilling technology and methods to deal with the issue have been developed
- Risk can be managed and reduced by paying necessary attention to the issue of karst
Report (Acona) can be downloaded from: www.ptil.no

Thank you for your attention