GEOMECHANICS INITIATIVE

http://geomechanics-initiative.com

Geomechanics Initiative Meeting – 18th and 19th June 2020

Topic: Sand Prediction / Injection modelling and monitoring (incl. 4D), integrated with fracture analysis

Host: Virtual meeting via 'WebEx'

Date: 18th-19th June 2020

Time: Day 1: 12:30 to 17:00

Day 2: 12:30 to 16:55

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18th June 2020 – Sand Prediction			
1	Introduction to Geomechanics Initiative	OTM, Richard Shelton	12:30
2	OMV experiences in sand production prediction	OMV, Manuel Blumenthal	12:45
3	Sand production modelling - Are we sure we understand everything?	Total SA, Philippe Marchina	13:30
4	Sand prediction experience in Aker BP	Aker BP, Olav-Magnar Nes	14:15
Break			15:00
5	Sand management on Buzzard	CNOOC, Murat Kece	15:20
6	Nuanced business decision-making based on combined sand failure prediction and sand production 'forecast'	Shell, Isaac Foo	16:05
7	Meeting wrap up	OTM, Richard Shelton	16:50
End of day one			17:00

19th June 2020 - Injection modelling and monitoring (incl 4D), integrated with fracture analysis			
8	Day two welcome	OTM, Richard Shelton	12:30
9	Injection modelling and monitoring (incl 4D), integrated with fracturing analysis experiences in Aker BP	Aker BP, Tron Golder Kristiansen	12:35
10	F17 Asset Integrity study	Wintershall Dea, Roger Sonwa/ George Röser	13:20
Break			14:05
11	Shell experience of produced water injection	Shell, Sergio De-Gennaro	14:25
12	TBC	Guest Speaker	15:10
12	Geomechanics Initiative: - Feedback from meeting; your technical takeaways – each company. - Date/Topics for future meeting(s) - Host offers - AOB	All	16:10
13	Meeting close	All	16:55
End of day			

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Presenter's times are inclusive of questions and answers (30-minute presentations with 15 minutes for questions and answers afterwards) – please plan for no longer than 30 minutes presentation time (~15-20 slides).

1. Sand prediction

Sand production poses multiple threats to the production system from downhole impacts to oil/gas export facilities. It is often a key cause for choke and flowline erosion which raises its profile to a HSE-critical threat to surface facilities, especially in gas fields. In addition, accumulation of sand downhole could compromise well productivity over time, while sand production to surface could ultimately choke-up flowlines, separators and surface facilities. These could have with wide-ranging knock-on effects to the ultimate production. To counter the threat, decisions have to be made on how to pre-empt or manage sand production, either proactively or retroactively. These often involve sand control completion and to a lesser extent designing surface facilities to handle sand production, all of which could be costly and often introduce additional issues to be solved, e.g. reduced well productivity. Therefore, considerable effort has been expended over the last few decades in developing sand failure prediction capabilities, frequently in collaboration with the academia. The focus has started to shift towards transitioning from predicting onset of sand failure to quantifying potential sand production in order to inform sand management decisions, for example: whether the severity of sand production merits upfront sand control completion or subsequent interventions during the life cycle of the well.

Both sand failure prediction and quantification are essentially underpinned by geomechanics. Topics of interest include but are not limited to the following:

- State-of-the-art in sand prediction
- Modelling approach - finite element models/(semi-)analytical models/empirical, 3D vs 1D etc.
- Material models
- What tools are being used (including service provider software)
- Integration with reservoir simulation and production system models
- Experience in sand prediction – cumulative or latest insights (examples?)
- Comparison between model prediction and actual sand failure/production (examples?)
- Shortcomings in current models/approaches and areas for improvement
- Potential joint industry synergies/collaboration
- How sand prediction influences decisions and adds (or destroys) value (business, safety-critical etc.)

2. Injection modelling and monitoring (incl 4D), integrated with fracture analysis

Well injection operations and placement of fluid or solids into appropriate geological strata is challenging. The most critical issue of any injection operation is conformance and containment. Uncontrolled injection operations often occur because the lack of an appropriate injection modelling study or a failure to monitor injection pressure as a function of volume. In almost all cases, an injection program is preceded by a fracture analysis study using numerical predictive models of various degrees of sophistication. These models are used to indicate the likely propagation behaviours of an injection fracture as a function of the injected volume and the rheological characteristics of the injected slurry. However, and regardless the sophistication of the modelling work, detailed monitoring of the injection process is essential to demonstrate conformance and containment and to provide early warning of any deviations from predicted injection behaviour. Tiltmeter surveys, micro-seismic surveys and 4D-seismic surveys are among the most important techniques to demonstrate containment, and no environmental impact.

Topics of interest include, but are not limited to:

- State-of-the-art in injection modelling
- Numerical vs analytical, and rules of thumb
- Modelling uncertainties and risks
- Soft rock injection modelling
- Calibration and verification
- Conformance and containment
- Completion design for conformance and containment
- Conventional and specialized monitoring and analysis techniques

- Emerging techniques and technologies in monitoring
- Risk management and assurance
- Compliance and regulatory considerations

3. Presentations

Each company is asked to prepare slides for approximately 30 minutes of presentation and 15 minutes for Q&A.

We politely request that presentations are sourced from each company's global resource pool and not only from the North Sea (unless of course your company only holds North Sea acreage). The meeting is a technical forum and these presentations are intended to provide a background to stimulate discussion.

Please ensure you include case studies; and come armed with company and other industry experiences, to bring the lessons learnt and best practices to life.

4. Organisation

Please advise OTM who will be attending if you have not done so already.

Abstracts

1. Manuel Blumenthal, OMV - OMV experiences in sand production prediction

The objective of the presentation is to cover OMV sanding prediction experience; one case study of a project done in cooperation with a service provider will be presented in more detail. The case study was done using a numerical approach; OMV has in-house capabilities for sanding prediction with an analytical approach, which will also be discussed briefly. During the presentation we will discuss advantages and disadvantages of different sanding prediction methods, data requirements, preferred laboratory rock testing procedures and rock strength scaling methods.

2. Philippe Marchina, Total SA - Sand production modelling - Are we sure we understand everything?

Sand production modelling is a well established routine in the oilfield geomechanics toolkit. Yet it happens that some data come in contradiction with the expectations based on the outcome of the models that are used.

In this presentation, we will show some puzzling field data and try to put forward some reasons as to why our modelling cannot always be reconciled with reality.

Nevertheless a tentative way forward, still under development, will be presented and discussed.

3. Olav-Magnar Nes, Aker BP – Sand prediction experience in Aker BP

This presentation will show how Aker BP perform sand prediction. We will cover onset of sand calculations as well as volume of sand predictions. We show some field examples where we have applied the current workflow. We will also discuss improvements we have identified in our workflow. We will also share our more than 30 years of experiences from managed solids production in a large chalk field.

4. Murat Kece, CNOOC - Sand management on Buzzard,

A case study is presented on the development of a revised sand management strategy for the Buzzard Field located in the North Sea. Buzzard wells were originally completed with selective and oriented perforations, and without active downhole sand control. Sand was then managed by drawdown control (using an empirical rule of thumb) and a minimum bottom hole pressure. The overall philosophy was to maximise well inflow performance by accepting “limited” sand production from producing wells and to enable a proven method of isolating reservoir intervals. The production facilities were designed to handle sand. The installation of downhole sand control equipment to exclude sand from entering the wellbore has been on an exception only basis.

Sand production has been observed on Buzzard from the start of production and the production facilities handle the produced sand successfully. A thorough understanding of the sand management issues experienced during the initial 10 years of operating the Buzzard field made it possible to exceed the Field Development Promise.

This presentation focuses on some key points including mechanisms of sand production on Buzzard, the experience gained, recent well completions and their impact on our approach to sand control.

5. Isaac Foo, Shell - Nuanced business decision-making based on combined sand failure prediction and sand production ‘forecast’

The risk of sand failure is often a crucial factor in deciding sandface completion and surface facility design, with significant ramifications on well productivity and project cost. Thus Shell had invested in the development of in-house sand failure prediction capability since the 1970s. This culminated in a sand failure prediction model which was later complemented by a sand production ‘forecast’ model. The combined modelling framework has been deployed in-house and operationalised since late 2000s. While predicting the onset of failure and the underlying

conditions continues to provide the basic parameters that inform the choice of completion and well operating strategy, the value of sand production forecast has steadily increased by enabling Shell companies to better gauge the potential severity of sand production over time and tailor business decisions, e.g. running sand control vs. managing sand at surface. Examples of application of the combined modelling framework in business decisions are discussed.

6. Tron Golder Kristiansen, Aker BP - Injection modeling and monitoring (incl 4D), integrated with fracturing analysis Experiences in Aker BP

This presentation will share Aker BP's experience with injection modeling, monitoring and fracturing analysis. We will include cases with 4D seismic as well as micro-seismic event monitoring. We will also show our experiences with injection in reservoirs as well as drill cuttings re-injection. In terms of reservoir we also have cases of thermal fracturing as well as soft rock injection. We will show how we approach injection modeling in Aker BP, what a typical workflow may be in different cases. We will also share our view of the improvement areas we see as well in our workflow.

7. Roger Sonwa/ George Röser, Wintershall Dea - F17 Asset Integrity study

This study considers an offshore field, F17, whose reservoirs are located in the Upper and Lower Maastrichtian chalk. It is relatively thin (30-40m), naturally fractured and overlain by the Upper, Middle and Lower North Sea Groups. F17 is situated at a depth of around 1250 m TVDSS, with an initial reservoir pressure and temperature of 200 bar and 75°C, respectively, at a reference depth of 1430 m TVDSS. The chalk reservoir is underlain by a salt dome, which is a result of salt migration from deeper salt layers over geological time due to a combination of a huge overburden load and weak chalk layers situated on top of the dome structure.

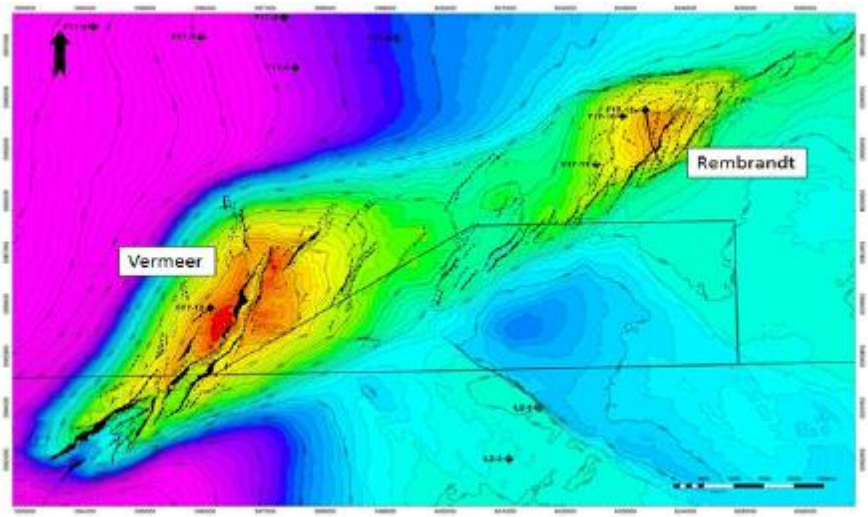

Fig. 1: Top Chalk depth map showing the Vermeer and Rembrandt structures

Similar chalk fields in the North Sea have experienced significant compaction and subsidence leading to well-known wellbore instability problems, completion failures and consequently high costs of remedial work. The impact of compaction and subsidence on reservoir performance and drilling operations has already been observed in some fields such as Valhall and Ekofisk in the North Sea region. Therefore, this study investigates the potential of pore collapse which can possibly lead to compaction and subsidence of the reservoir.

Availability of 3D depth converted seismic attributes enabled further geological studies to derive fracture systems, lineaments and faults. Core laboratory tests and analysis were also performed by external partners such as FraTech, NGI and Weatherford, providing data for rock mechanical and strength properties. Results of these tests and analyses were then calibrated against log interpretations and used in the generation of a 3D MEM model.

The Critical State theory model was then used in the coupled Petrel RG/ECLIPSE/VISAGE 3D geomechanical simulator to simulate the various behaviors of the chalk reservoir under different scenarios, such as injection, depletion, injection and depletion. The aim is to predict the onset and extent of reservoir compaction and subsidence, as well as fracture re-opening during depletion and injection, so they can be accounted for by surface facilities planning, wellbore and caprock stabilities.

This presentation aims at sharing knowledge about the benefits of carrying out an asset integrity study in order to improve the understanding of cost control and economic aspects of such a project. The study intends to use basic theory and real field examples to demonstrate how an early stage assessment of a project can help to avoid exorbitant costs incurred for remedial workovers in the advanced stages of the field development phase.

8. Sergio De-Gennaro, Shell - Shell experience of produced water injection

Over the past years, major advances have been made in understanding the impact of fracturing on produced water injection operations. Water injection has been applied for reservoir management (e.g. voidage replacement), to improve sweep (waterflooding), and to dispose produced water into the subsurface. In this communication, we present our current views of the processes which control the performance of injection wells under fracture conditions taking examples from global Shell. The long-term impacts on injection performance of produced water quality, fluid temperature, fracture growth, and other factors will be discussed.