Van: [redacted]@iftechnology.nl]
Verzonden: dinsdag 22 maart 2016 13:21
Aan:

Onderwerp: Minutes of Meeting - SHA Groningen Warmtestad - IF, Qcon, SodM, KNMI

Dear all,

In the attachment you will find the Minutes of Meeting for our meeting March 2nd at Arnhem.
Three action points have been formulated for KNMI and SodM:

1b. Two events (M=0,5-1,0) have taken place close to the Groningen area. KNMI will provide the location errors of these events (ACTION KNMI)
1d. KNMI will sent the most recent monitoring network set-up in the area, incl. the plans to expand the network in near future (ACTION KNMI)
1l. Q-cons figures and info are mostly based on 2013 reports. There are updates for this report. SodM will sent the most recent information (ACTION SodM).

I hope you can help us with this information.

Best regards,

[redacted]
Projectmanager Geothermal Projects

T: 026 [redacted]
M: 06 [redacted]
F: 026 [redacted]
E: [redacted]@iftechnology.nl

IF Technology
Velperweg 37
Postbus 605
6800 AP Arnhem
www.iftechnology.nl

Engineering the earth

not in office on Friday

Kijk op onze nieuwe website wat onze adviseurs (nog meer) voor u kunnen betekenen!

Minutes of Meeting

Project:	SHA Groningen Warmtestad
Subject:	Meeting Warmtestad, SodM, KNMI, Q-con and IF
Date Meeting:	March 2nd, 2016
Present:	(Q-con), (SodM), (SodM), (KNMI), (Warmtestad), (IF), Benno Drijver (IF)
Date Minutes:	March 22nd, 2016
Reference:	65308/BP/20160322
Minutes made by:	
Checked by:	

Agenda

- Introduction: Geothermal project Groningen
- Specific challenges for a seismic hazard analysis (SHA) at the site
- Outline of the approach for the SHA
- Mitigation scheme: Seismic Monitoring (TLS)
- Monitoring capabilities of KNMI and data access

Minutes

presented a powerpoint presentation. This is included in the appendix.

In the minutes below the most important remarks, issues and conclusions are given.

1. KNMI related input and info:
   a. Two events (M=0,5-1,0) have taken place close to the Groningen area.
   b. KNMI will provide the location errors of these events (ACTION KNMI)
   c. Monitoring network KNMI has improved. There are new detailed velocity models to find out depth and location of events.
   d. KNMI will sent the most recent monitoring network set-up in the area, incl. the plans to expand the network in near future (ACTION KNMI)
   e. Uncertainty for monitoring network KNMI
      - <1,5 years old: 100 in monitored area (100-200 vertical)
      - >1,5 years old: 500-1000m in monitored area (2-4 km vertical)
   f. KNMI monitoring network can be used for the Warmtestad Project or single stations from KNMI network can be integrated into a local monitoring network.
   g. Operator will be responsible after all. If KNMI monitoring network/station will fail, KNMI cannot be held responsible. Redundancy should be taken into account.
   h. KNMI cannot do real-time monitoring during drilling and/or during the first stage of exploitation until the flows/pressures are stabilized ("stabilized flow regime").
   i. KNMI can provide continuous data streams of their monitoring network to the operator Warmtestad for local monitoring purposes.

j. During the "stabilized stadium" of the exploitation, KNMI can take over the locally installed monitoring network. KNMI will respond directly (roughly within 0.5 hours during office hours) after an alarm and contact the operator.
k. For NAM purposes this alarm is set on Magnitude 2.
l. Q-cons figures and info are mostly based on 2013 reports. There are updates for this report. SodM will sent the most recent information (ACTION SodM).

2. Seismic risks and challenges
   a. Challenges as presented by Q-con (see presentation in appendix)
      (1)Discrimination by hypocenter location. (NAM vs Geothermal events)
      (2)Stress interactions of geothermal & gas production activities that may cause seismicity in geothermal reservoir.
   b. Two SHA scenario's: depleted and non-depleted.
   c. Both will be considered in SHA.
   d. For depleted reservoir the actual stress situation is unknown/unsure.
   e. SodM suggestion: do you take into account that you could mitigate risks after drilling, logging and testing the first well (minifrack, stress analyses, reservoir pressures could conclude if it is depleted or not)?
   f. Q-con: this can be done, though still it is only very locally measured. It could be discussed if this extra information is valuable to the total project area.
   g. SodM: Simulation of effect of depletion on state of stress in reservoir for depleted scenario?
   h. Q-con: Cumbersome task that is time consuming and subject to large uncertainties.
   i. The system is most likely a normally faulting system
   j. For gas fields in the NL it is estimated that seismic events can only occur after a depletion of >90 bars (TNO).

3. Thresholds/Magnitudes
   a. The detection and location threshold level for O&G in medium category is M=1.5
   b. The threshold for monitoring network NAM gasfield is circa 0.0-0,5.
   c. SodM: first indicative ideas as discussed it is thought that the Groningen Warmtestad field will also need a detection threshold of about M=0.0-0.5.
   d. SodM: Perceptibility and damage thresholds should be taken into account, also considering a possible trailing effects.
   e. Q-con: Maximum trailing effect observed in geothermal stimulation: Basel with M=0.5.
   f. If possible local monitoring network and KNMI network could be combined.

g. KNMI expects that the new thresholds around the border of the NAM gasfield will be improved up to ca. M=0.5-1 (of course getting worse in more far distance from the border.
h. Langelo/Norg and Grijpskerk are quite some distance from the project location of Warmtestad

4. Other issues
   a. SodM: Why should you put the producer most closely to the NAM gasfield border as depletion could be an important issue?
      Warmtestad: in worst case (though still a business case) the depletion is >100 bars. In this case the pump has to be installed very deep. This means that it is technically preferred to drill vertically as deep as possible at the drilling location. If the depletions is not that much, the producer and injector could be exchanged.
   b. KNMI uses PGA for reporting purposes. This is because of the Civil Engineering standards used. For in Groningen PGA max (damage) of 0.04 is used and in south of Groningen 0.1 is used. Q-con outlines advantages of using PGV (as used in previous geothermal hazard studies for the NL) instead of PGA
   c. Warmtestad: a public project has started for installing an independent monitoring system. For now, not many details are known. It is unlikely Warmtestad will use this monitoring network.
   d. Depth of faults: Annemarie noted that Permian faults generally do not extend through Zechstein
   e. SodM: what is feeling about the public acceptance now?
      Warmtestad: For now there seems to be a positive mindset, even after the council meeting last time. Communication strategy is intensive towards local communities.
   f. Warmtestad about the timing: the municipality needs to be informed April 13th, although this project is already delayed significantly. Decisions for a "go" will be on June first.
   g. The "voorgenomen ontwerpbesluit winningsplan" will be final in September, so the concept will be available from the end of July. Here the new guidelines for SRA procedures in O&G will then also be published.

Geothermal Project Groningen
Seismic Monitoring

Q-con GmbH
Geothermal reservoir engineering

Q-con GmbH / IF Technology

Arnhem, 2nd March 2016

Overview

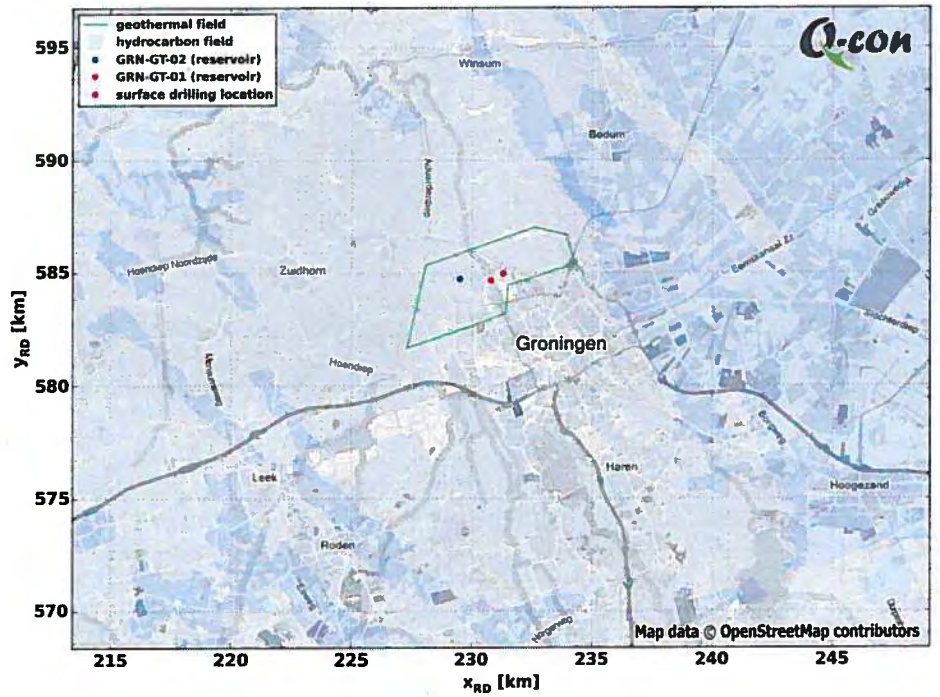
Objective: Quick-scan of the seismic hazard
(Q-con / IF Technology)

- Introduction: Geothermal project Groningen
- Specific challenges for a seismic hazard analysis (SHA) at the site
- Outline of the approach for the SHA
- Mitigation scheme: Seismic Monitoring (TLS)
- Monitoring capabilities of KNMI and data access

Q-con GmbH
Geothermal reservoir engineering

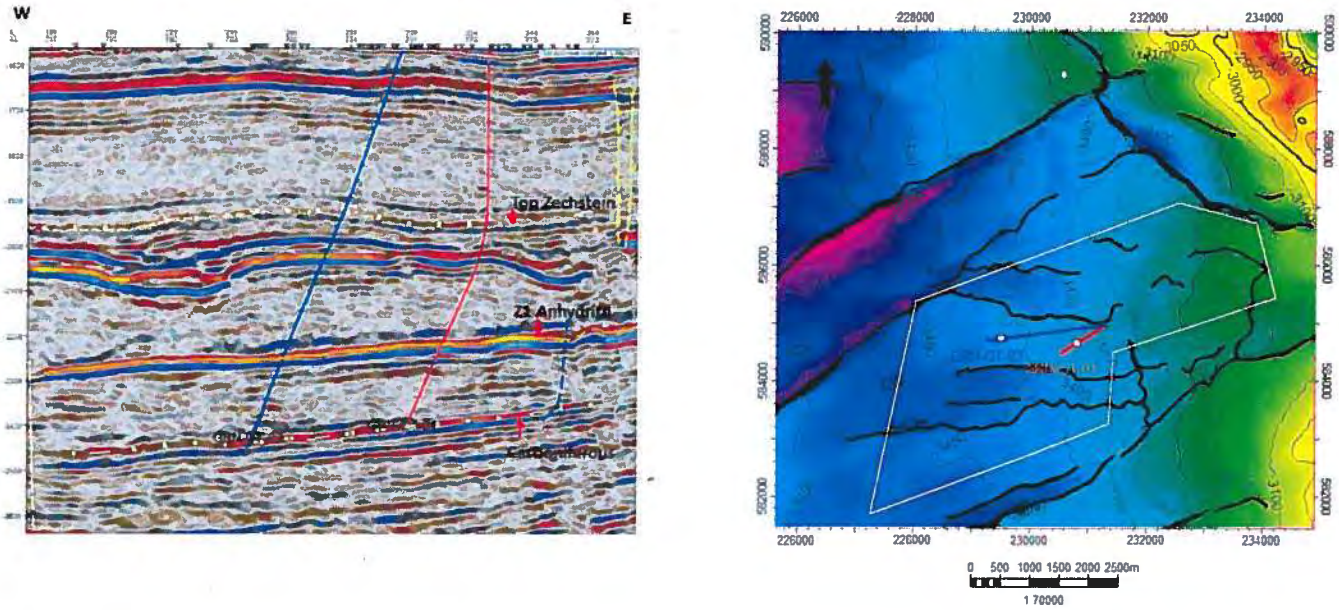
Geothermal Project Groningen

- Project location



Geothermal Project Groningen

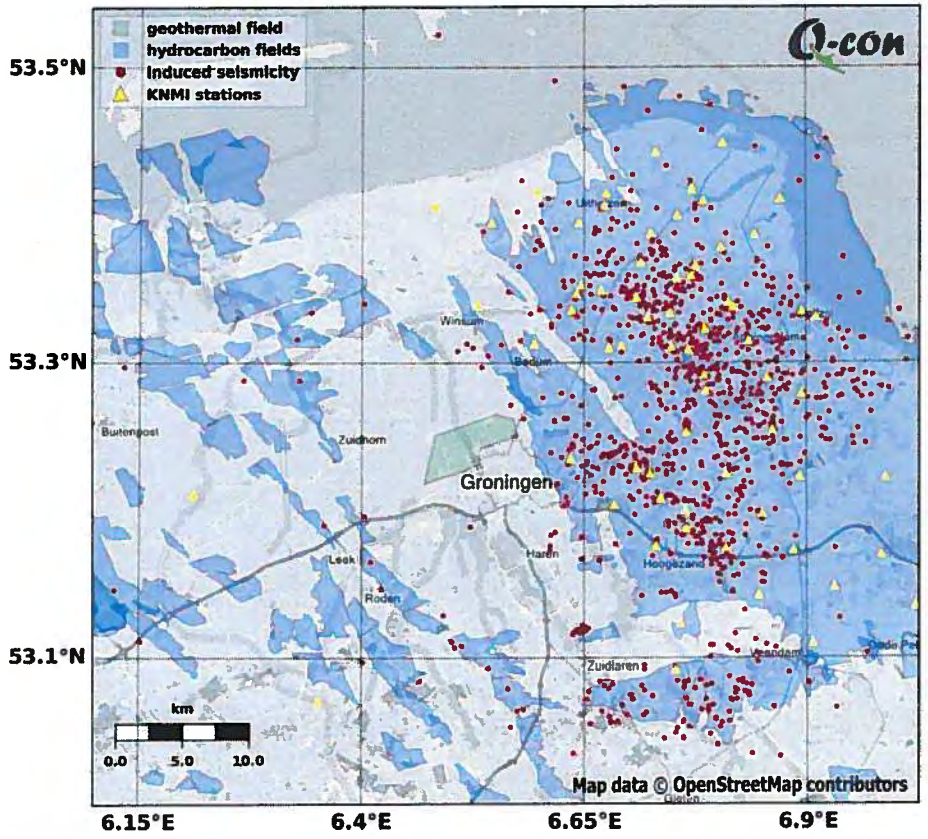
- Target horizon: Slochteren formation
- Doublet system
- Depth ~3.2 km, expected T ~ 120°C



Seismic section (EW) of the reservoir (left) and depth map of Slochteren sandstone (from well-design study, WEP, 2014)

Specific Challenges

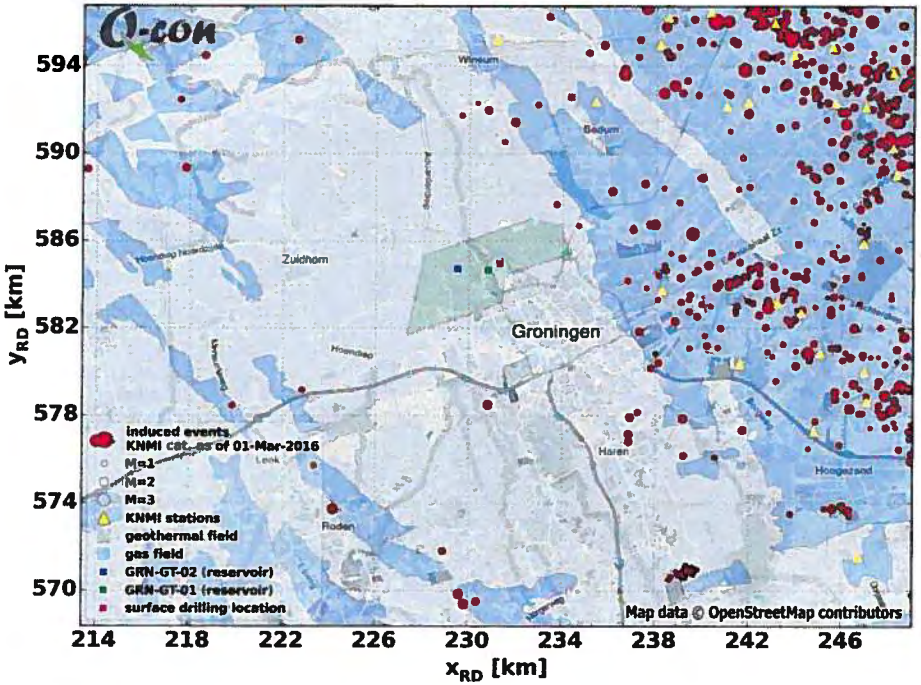
- Gas producing fields and associated seismicity



Q-con GmbH
Geothermal reservoir engineering

Specific Challenges

- Gas producing fields and associated seismicity



Specific Challenges

Seismicity is induced by nearby gas field

(1) Discrimination by hypocenter location.

(2) Stress interactions of geothermal & gas production activities cause seismicity in geothermal reservoir.

Q-con GmbH
Geothermal reservoir engineering

Specific Challenges

Stress interactions

- Literature scan NAM, TNO etc. reports, discussions with involved parties →
  Inconclusive results regarding the level of depletion to be expected in the geothermal reservoir.

→ Depleted geothermal reservoir scenario must also be considered in the SHA.

Q-con GmbH
Geothermal reservoir engineering

SHA Approach

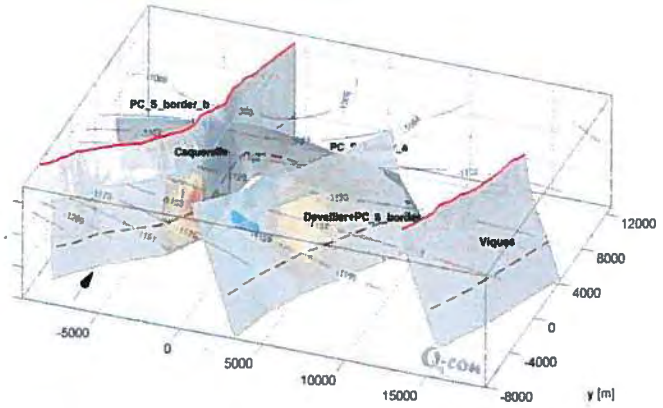
- Consideration of different hazard scenarios.
  - Non-depleted reservoir (original approach).
  - Depleted or partially depleted reservoir.

Q-con GmbH
Geothermal reservoir engineering

SHA Approach

Non-depleted geothermal reservoir

- Reservoir/fault model setup.
- Numerical simulation of stress perturbations related to operating the geothermal facility.
- Computation of Coulomb stress changes ΔCS on mapped faults.
- Assessing the seismic hazard based on magnitude and extend of stress perturbations on faults.
- Qualitative risk matrix.



Q-con GmbH
Geothermal reservoir engineering

SHA Approach

Partially depleted reservoir

- Impact on risk matrix prior and after mitigation.

Seismic Monitoring

- Risk mitigation (TLS)
- Requirements for the monitoring:
  - Detection threshold
  - Location accuracy → discrimination against gas production related seismicity (requires clear spatial separation of the 2 types of seismicity, which needs to be larger than location uncertainty)
- Role of KNMI stations? Independent local network?

Q-con GmbH
Geothermal reservoir engineering