KEM Research review, evaluation and interpretation (max. 4 pages + annex)

KEM-07: Geomechanical analysis for investigating the occurrence of induced seismicity in small gas fields in The Netherlands

KEM Quality review

The project was commissioned in 2018 to Q-con GmbH.

The final (draft) report was issued in December 2018.

The expected deliverables were as follows:

1. A physics-based analysis of why induced seismicity occurs in some gas fields and not in other gas fields, using evidence of (non)seismicity in small fields and geomechanical analysis methods.

Comments: A framework for the physics-based analysis of induced seismicity was developed, and analysis was conducted for all small gas fields. It can be concluded that such an analysis can technically been executed in a reasonable amount of time, when the critical parameters are included in the model, and sufficient calibration data (seismic event data) are available.

2. A physics-based, proven methodology to derive the hazard of induced seismicity for new and producing small gas fields in the Netherlands.

Comments: The method has been applied to the small fields of The Netherlands. Although the model produces some "false positive" predictions, in the sense of sometimes predicting seismicity to occur fields in which no seismicity was observed, it does not ever produce "false negatives". Hence, the method is overly conservative, and can therefore be said to be partially successful, as it never fails to predict seismicity in reservoirs in which seismicity occurs

3. Scientific report of the methodology and project results.

Comments: Overall, the work performed in this study was of a high technical quality. Good knowledge and understanding of the relevant geomechanical issues was exhibited by the researchers. The amount of work performed was commensurate with the budget and timeframe. Lacking more detailed data on specific reservoirs, the project has probably gone as far as possible, and in doing so has developed some useful seismic risk assessment methodology. It is therefore deemed that the work performed has fulfilled the intended goals of the project.

Additional Comments:

Technical: The Biot coefficient was taken to be 0.8 for all reservoirs in this study. The authors should supply a reference for this value. Alternatively, given that the elastic moduli and mineralogy seem to be known for each reservoir, they could estimate the Biot coefficient based on its definition involving the ratio of the bulk modulus of the of the porous rock to the bulk modulus of the mineral phase.

Editorial: The report was very well structured and written. However, a few improvements should be made, to fix some minor problems with the English:

p. 5, par. 3: Change "parameter" to "parameters". Likewise, p. 7, par. 2, and p. 3, TOC.
p. 6, par. 1, and elsewhere: Change "data base" to "database".
p. 7, par. 1: Change "set-up" to set up".
p. 17, par. 2: Change "question," to "question:".
p. 21, par. 1: Change "is depending" to "depends".
p. 22, par. 3: Change "are not critically depending" to "do not critically depend".
p. 23, par. 1: Change "are depending on" to "depend on".
p. 25, par. 2: Change "(Figure 16)" to "Figure 16".
p. 36, par. 1: Change "leaving" to "abandonment".

KEM Evaluation of the results

The central research question is why seismicity has occurred in certain gas fields, whereas other gas fields remained seismically quiet. The objective is to develop a physics based numerical based 2D geomechanical analysis method of induced seismicity, which can also be used in scenarios that lie outside the range of previous experience.

The main outcome of the project was a model and workflow to predict whether or not a given gas field will suffer from induced seismicity. Although the model produces some "false positive" predictions, in the sense of sometimes predicting seismicity to occur fields in which no seismicity was observed, it does not seem to ever produce "false negatives". Hence, the method is overly conservative, and can therefore be said to be partially successful, as it never fails to predict seismicity in reservoirs in which seismicity is known with certainty to have occurred.

Many of the parameters were assigned universally, due to lack of field-specific data. Since the model is based on sound physics, and has already achieved a reasonable consistency with the (seismic / non-seismic) data, it can reasonably be concluded that

the model is fundamentally sound, and that more accurate predictions could be made if better reservoir-specific data were available – particularly, data on fault dip and throw.

KEM interpretation of the outcome

The main implications of the outcome of the KEM-07 projects for current practices recommended by the KEM scientific expert panel are:

1. A rational and sound basic model has been developed to predict the occurrence (or not) of induced seismicity in small gas fields in the Netherlands.

2. Although many of the reservoir parameters are not known, sensible results were obtained by assuming universal and plausible values for some of the parameters.

3. It is reasonable to assume that the methodology would yield more accurate predictions if better reservoir-specific data were available – particularly, data on fault dip and throw, as well as more dense network of quality seismic seismological recordings and subsequent more accurate seismic event datasets.

4. Nevertheless, the model in its current state has already shown its usefulness, in that if a seismic event can unequivocally be associated with a particular field, the model would have invariably predicted this seismic event to occur.

Closure text for the website

The KEM-07 research project “Geomechanical analysis for investigating the occurrence of induced seismicity in small gas fields in The Netherlands” was commissioned to Q-con in 2018, and completed in 2019.

The central research question is: why has seismicity occurred in certain gas fields, whereas other gas fields remained seismically quiet? The objective was to develop a physics-based numerical based 2D geomechanical analysis method of induced seismicity, which can also be used in scenarios that lie outside the range of previous experience.

A rational quantitative model, based on sound principles of rock mechanics, was developed. Although in many cases the required subsurface data were unknown and had to be estimated in a general way, the model showed a large degree of consistency with the observed seismicity results.

The model in its current form can successfully identify some fields in which induced seismicity should be expected. Collection of more reservoir-specific data on fault properties will undoubtedly make the predictions more accurate.