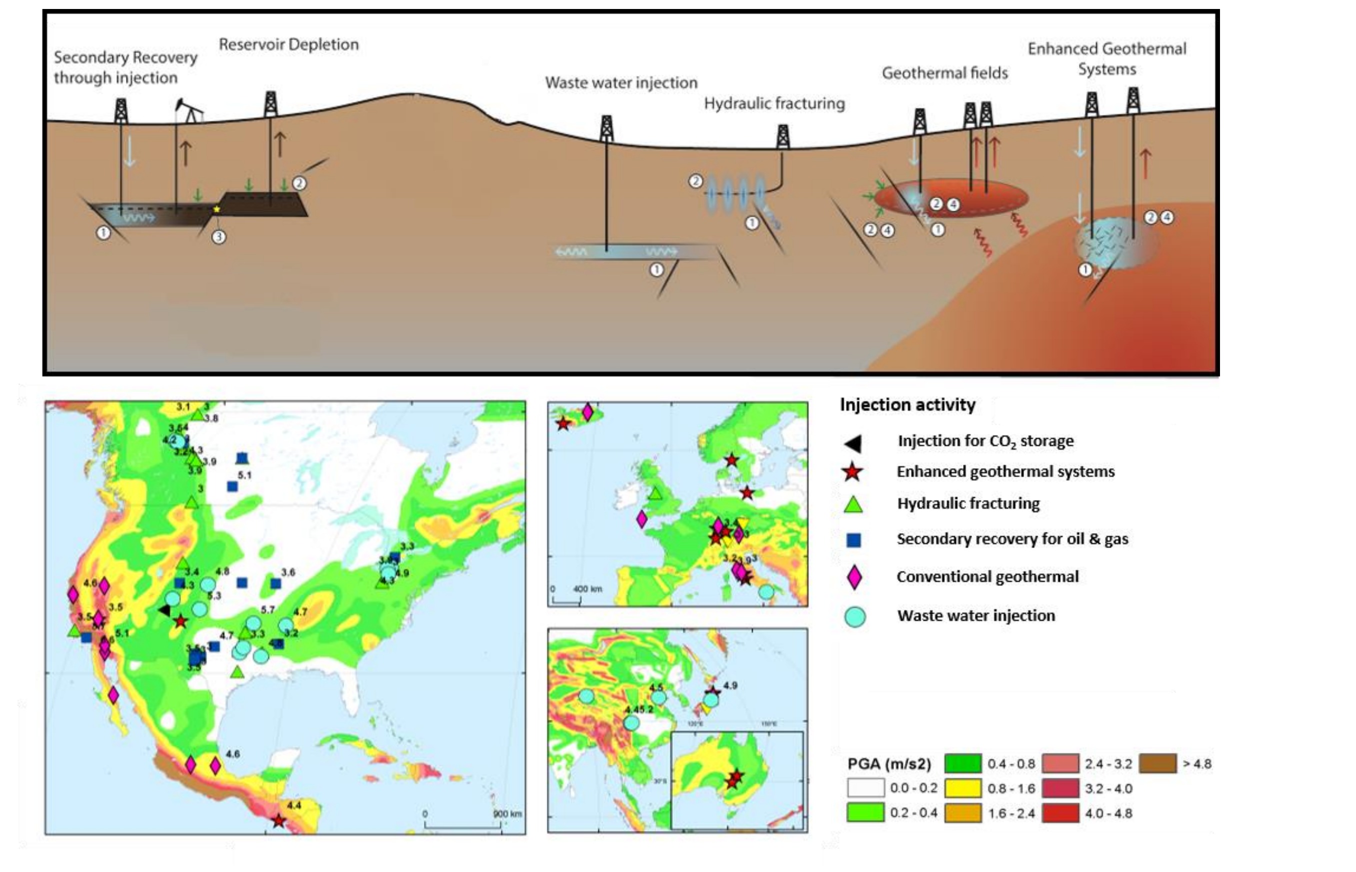
RECOMMENDATIONS FOR MINIMISING SEISMIC RISKS AND MITIGATION MEASURES FOR INDUCED SEISMICITY

M4ShaleGas
Measuring, Monitoring, Mitigating, Managing the Environmental Impact of Shale Gas

TNO

B. WASSING, J. TER HEEGE



Background

A specific concern related to shale gas operations is the occurrence of induced seismicity. Hydraulic fracturing operations and injection activities for waste water disposal, which are related to shale gas operations, may cause seismicity. Even though felt induced seismicity appears to be associated with only a small fraction of the injection wells, records of induced earthquakes in shale gas plays (e.g., in the UK and Canada) show that magnitudes of earthquakes can be significant and can cause public concern or damage to (sub)surface infrastructure. It is thus important to mitigate induced seismicity during shale gas operations. The potential of induced seismicity during injection operations for shale gas production is expected to be controlled by geological and operational factors. Aim of this research is to identify key factors as well as mitigation measures.

Study

To further our understanding of what drives seismicity during the injection operations for shale gas (i.e. hydraulic stimulation and waste water injection), we performed a study on an extensive dataset of worldwide injection-induced seismicity. The dataset included cases of injection-induced seismicity related to shale gas operations, waste water injection, but also injection cases for conventional and enhanced geothermal systems, underground gas storage and secondary oil & gas recovery. Based on this dataset, we identified a number of key operational and geological factors controlling injection-induced seismicity. The information obtained from our analyses was used to developed a workflow that can be used to classify European shale gas sites in terms of their induced seismicity potential, and adapt planned operations to reduce risk of induced seismicity.

Results

The presence and density of large critically stressed or active fault structures, especially those extending into crystalline basement, and the distance of the planned shale gas operations to these fault structures are considered to be key geological factors for classification of the seismicity potential of shale gas sites. The net-volume of the injected fluids is considered to be a key operational factor. In addition to these factors others were identified, such as the presence of seismogenic rocks, promoting seismicity, or the presence of thick viscoplastic sedimentary sequences, reducing the seismicity potential. These key geological and operational components for the classification workflow, and mitigation measures that aim to reduce the seismicity potential are summarized on the next page.

RECOMMENDATIONS FOR MINIMISING SEISMIC RISKS AND MITIGATION MEASURES FOR INDUCED SEISMICITY

B. WASSING, J. TER HEEGE

Science-based Recommendations for mitigation of induced seismicity

- Before operations: Assessment of the induced seismicity potential of the shale gas site based on key geological and operational factors, as specified in the workflow in Figure 1.
- Planning of the injection activities at a safe distance from large pre-existing critically stressed, or seismically active, faults.
- Optimization of the hydraulic fracturing operations for efficient stimulation with minimum injected fluid volume; minimizing the zone of induced stress changes, pore pressure diffusion and affected volume of rock, e.g. by application of flow back immediately after the injection phase.
- (Micro)seismic monitoring with focus on changing rates, magnitudes, b-values, and events lining up in directions of critically stressed faults. Establish a traffic-light system before the start of the operations.
- Account for uncertainty in analyses in an injection trial period, and compare observed and predicted response
- Site-specific analysis of the shallow sub-surface and surface in terms of vulnerable constructions and infrastructure, population and building density, construction quality, and potential for ecological and environmental damage in case of a seismic event.

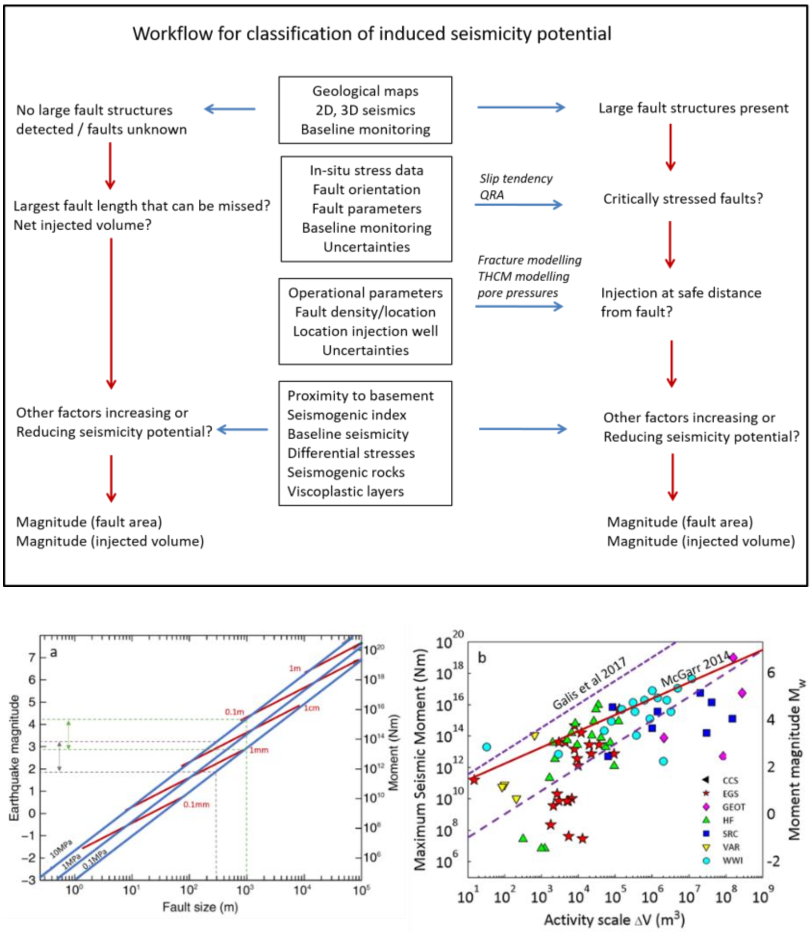
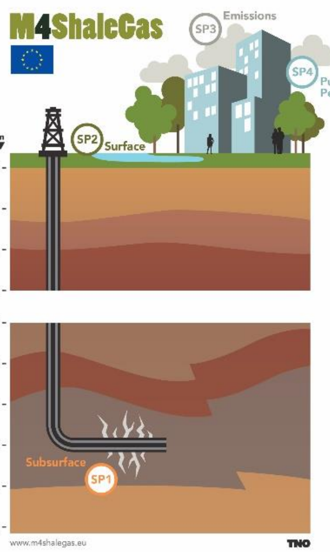


Figure 1. Upper: workflow for assessment of induced seismicity potential of shale gas sites. Lower: Relation between fault size (left) and activity scale or injected volume (right), seismic moment release and earthquake magnitude.

The Project

M4ShaleGas examines the potential environmental impacts and risks related to **shale gas** exploration and exploitation in Europe with the goal to build a technical and social knowledge base on best practices and innovative approaches for **m**easuring, **m**onitoring, **m**itigating, and **m**anaging these impacts.



4 sub-programs:

- SP1-subsurface
- SP2-surface
- SP3-air emissions
- SP4-public perceptions

Funding:
The project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 640715.

Horizon 2020 Topic LCE-16-2014:
Understanding, preventing and mitigating the potential environmental impacts and risks of shale gas exploration and exploitation.

Project duration:
1 June 2015 – 30 November 2017

Coordination:

Published December 2017 by M4ShaleGas Consortium