# Managing produced water from European unconventional gas production

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**Project Background:** Unconventional gas resources offer a domestic energy source which has significantly less inherent greenhouse gas emissions than current coal combustion or imported gas[1]. Additionally, the economic and energy security benefits that domestic energy supplies can provide makes unconventional gas a potentially attractive option for Europe in the near future. However, it is imperative that all of the issues surrounding extraction activities are fully understood prior to any large scale developments taking place. One of the key issues which requires informed debate is the impact of produced water disposal and how this impact can be managed safely.

This project aims to address this need and determine how unconventional gas extraction could impact Europe's water resources. In the USA and Australia where extraction of unconventional gas is more established, the vast majority of the produced water is injected into the subsurface for disposal[2,3]. However, evidence is building to suggest that subsurface injection of such large volumes of water is increasing the risk of seismic events[4]. As a result of strong public concern regarding induced seismicity, and groundwater pollution, arising from shale gas exploration activities in the north west of England, subsurface injection of produced water has been ruled out in the UK. Hence, it is also unlikely to be approved in the rest of Europe and other options for produced water disposal or utilisation will be required.

Studies of produced water from coal bed methane (CBM) and shale gas operations in the USA[2,3] and Australia have identified trends in produced water constituents and composition relating to a number of factors. For CBM this includes the coal deposition environment, the methane generation pathway and the proximity to freshwater recharge[2]. For shale gas this included the time the water has spent in the formation, location in the basin and number of reinjections the water had undergone[3]. These studies have enabled prediction of the composition of produced water in exploration activities and helped to develop management strategies in the USA. However, the geological settings of sedimentary basins in which coal and shale was deposited in Europe are considerably different to those in the USA and currently very little is known about the composition of both formation waters and any future produced waters[5].

**Key Research Question:** This project aims to provide a predictive model for the composition of produced water to be expected from areas in Europe where unconventional gas extraction is proposed.

**Methodology and Project Scope:**

1. Use existing produced water data from UK and European coal bed methane and shale gas exploration activities to determine how water produced in Europe compares to the comprehensive datasets existing from the USA and Australia.

2. Investigate the factors inherent in European coals and shales, such as mineralogy and organic content, which will control the dissolved salts, heavy metals and radioactive element composition of the produced waters.

3. Undertake a series of batch reaction experiments using selected European coal and shale samples exposed to brine at reservoir temperature, allowing determination of the composition of produced water which will arise from those formations.

4. Develop a predictive model for the composition of produced water to be expected from areas in Europe where unconventional gas extraction is proposed.

5. Inform on the necessary regulation, treatment and water management regimes that need to be put in place in advance of unconventional gas extraction activities to protect European water environment and supplies.

**Training:** A comprehensive training programme will be provided comprising both specialist scientific training and generic transferable and professional skills. The student will be trained in sediment basin and subsurface geological interpretation and analysis. Training will be given in batch reaction experimental techniques and laboratory analysis procedures for measuring inorganic and organic water geochemistry including ICP-MS. Sample analysis will be undertaken using existing state of the art experimental equipment at the University of Edinburgh. Fieldwork in the UK and EU to sample produced waters may be required.

**Requirements:** Applications are invited from UK graduates holding at least an upper second class degree or equivalent in a natural science (Geology, Earth Science, Physics, Environmental Science, Chemistry, or similar).

**References:** [1]MacKay and Stone 2013, Potential Greenhouse Gas Emissions Associated with Shale Gas Extraction and Use, DECC https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/237330/MacKay_Stone_shale_study_report_09092013.pdf
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[4]Keranen et al., 2013, Geology http://geology.gsapubs.org/content/early/2013/03/26/G34045.1
[5]The Royal Society, 2012, Shale Gas Extraction in the UK www.raeng.org.uk/shale