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UNDERSTANDING THE NEW THREAT FROM BELOW – REVERSE VULNERABILITY ASSESSMENT OF THE RISK OF DEEP GEOLOGICAL STORAGE

1. Background

The Onshore, deep sub-surface energy extraction and storage requires the injection of fluids into deep strata. The integrity of those deep strata is a requirement for the efficient use of deep energy resources or energy storage and, hydrological connection between deep strata and the surface would represent a loss of efficiency and a risk to water resources in the overlying shallow aquifer and surface water. There is, therefore, a need to explore whether linkages from deep to shallow and on to the surface exist; and how they can be identified prior to development of sub-surface resources to minimise loss and damage to water resources. The vulnerability of aquifers has traditionally been assessed through mapping the risk from surface threats to groundwater, the reverse situation of vulnerability with any threat from depth has not been considered, It is therefore **the aim of this project is to develop methods for assessing the reverse vulnerability of surface and near-surface resources from the risks of the development of the deep sub-surface for energy resources.** Based upon numerical modelling, Wilson et al. (2018) showed that reverse vulnerability would be driven by: aquifer compartmentalisation; overpressure; lack of a diffusing, permeable strata; and the presence of through-going impermeable faults. This project will use a range of innovative approaches to test whether these identified features control where deep groundwater will emerge into the surface and near-surface environments; and develop methods to predict reverse vulnerability for future deep sub-surface developments.

2. Aims and methods

The aim of this project is to develop methods for assessing the reverse vulnerability of surface and near-surface resources from the development of the deep sub-surface. Specifically:

- Develop methods for assessing where deep groundwaters are coming near to surface;

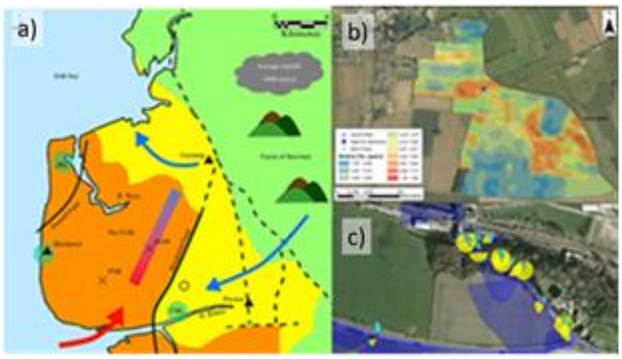

Fig 1. a) Schematic diagram of aquifer compartmentalisation of the Permo-Triassic aquifer of the Fylde coast (Wilson et al., 2018); b)Map of soil gas CH4 anomalies across the Vale of Pickering aquifer; and c)CH4 isotopic anamolies across a fault in the Tyne Valley.

- Map thermal anomalies across landscapes to find groundwater seepage points;
- Assess CH_4 concentrations and isotopic compositions to locate pathways from depth to surface; and
- Use machine learning to analyse patterns of groundwater-surface water interactions across the UK.

3. Scientific approach

This project will use a range of innovative approaches to test whether these identified features control where deep groundwater will emerge into the surface and near-surface environments; and develop methods to predict reverse vulnerability for future deep sub-surface developments. These approaches include: assessment of regional diffuse gas emissions across a landscape by analysing soil gas concentration and isotopic composition; measuring release of naturally-occurring radon gas release; surveying land surface temperature anomalies by infra-red drone; and identification of geochemical indicators of deep fluids. We in Durham are uniquely placed to supervise this project as we have already published statistically rigorous studies that have identified the risk of aquifer compartmentalisation to surface and near-surface water resources. Secondly, we have experience with the multivariate and geo-spatial statistical methods required to analyse the data that arise from national monitoring programmes to identify signatures of deep groundwaters. Thirdly, we have identified a series of UK aquifers where it would be suitable to test our proposed approaches. Finally, we have the range of equipment capable making regional surveys of such things as CH_4 isotopic compositions (cavity ring down spectroscopy) and thermal anamolies (infra-red drones).

4. Training

As a PhD student in the Durham Earth Sciences Department you will become part of a vibrant research culture in which ~70 postgraduate students work on a wide range of Earth Science research projects. In particular, you will closely collaborate with the academic staff, postdoctoral researchers and fellows, and postgraduate students in your research group. Training will be provided in the range of techniques being applied including field and data analysis techniques. The CDT studentship incorporates a 20 week bespoke residential classroom and field-based training programme spread out over the first 3 years of the studentships. The aim of this training is to broaden your understanding of the applications of geoscience and provide you with additional skills valued by future employers.

5. Further reading & information

Boothroyd, IM., Almond, S., Worrall, F., Davies, RJ., (2017). Science of the Total Environment 580, 412-424.

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The work of the research consortium can be found at:
http://www.refine.org.uk/

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