British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Separation of aquifers & shales: a national screening tool from the UK

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Context

The risk of contamination of an overlying aquifer from shale gas development is a function of: i) the separation of the potential shale gas source rock and the aquifer, ii) the hydraulic characteristics (e.g. hydraulic conductivity, storage and hydrogeochemistry) of the rocks in the intervening interval, and iii) regional and local physio-chemical gradients. Here we report on a prototype national-scale screening tool from the UK to assess the former, i.e. the vertical separation between potential shale gas source rocks and major aquifers (such as those in **Figure 1**), as a contribution to more informed management of the risks associated with shale gas development if and when it takes place in the UK.

Figure 1 Examples of a Principal Aquifer (Triassic Sandstone aquifer in NW England — left) and the underlying Bowland Shale Formation (right) at outcrop. Maps of the corresponding full crops of these two units and their vertical separation are shown in **Figure 4** below.

Methods

Eleven aquifers are considered in the study. These have been designated by the environment agencies of England and Wales under the EU Water Framework Directive as being nationally important (Principal Aquifers). One of the Principal Aquifers, the Triassic Sandstone is shown in **Figure 1**. Six shale gas source rocks have been defined on best publically available evidence for potential gas productivity and include both shales and clay formations. The Bowland Shale Formation at outcrop is shown in **Figure 1**. Based on a national geological fence diagram consisting of 84 geological sections, totalling ~12 000 km in length, down to >5 km in depth, and with a typical spacing of 30 km **(Figure 2)**, the lower surfaces of each aquifer unit and upper surfaces of each shale/clay unit have been estimated at a spatial resolution of 3 x 3 km. These surfaces have then been used to estimate vertical separations between pairs of shale/clay and aquifer units **(Figure 3)**.

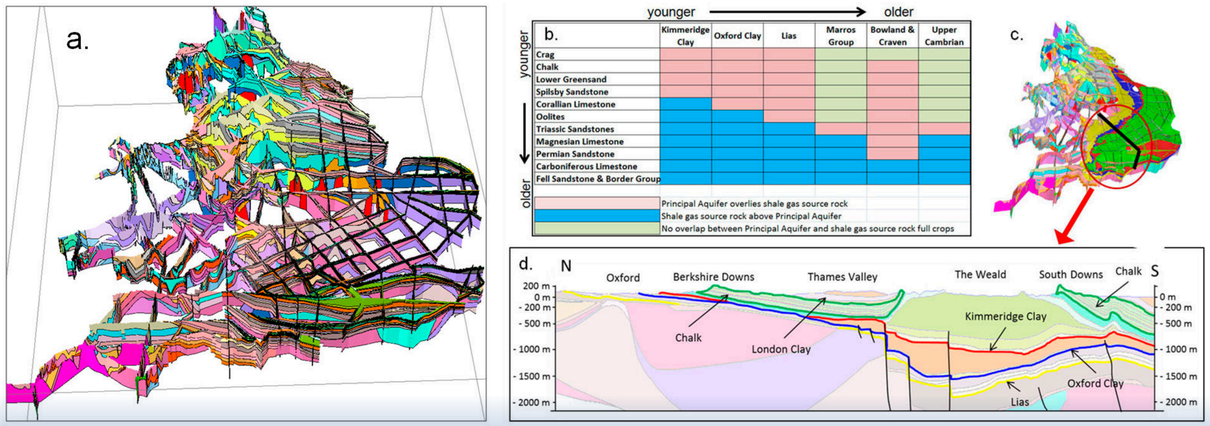

Figure 2 National geological fence diagram for England and Wales **(Figure 2a)** consisting of 227 designated unique geological classes. 'Stratigraphy' of the 11 aquifers and 6 shales **(Figure 2b)** showing aquifer/shale pairs where aquifers overlay a shale (pink), where there is no overlap (green). Example of the extent of the Chalk aquifer in the national fence diagram model **(Figure 2c)** and location of a representative section **(Figure 2d)** illustrating multiple underlying shales (Lias, Oxford Clay and Kimmeridge Clay) below the Chalk and the varying vertical separations.

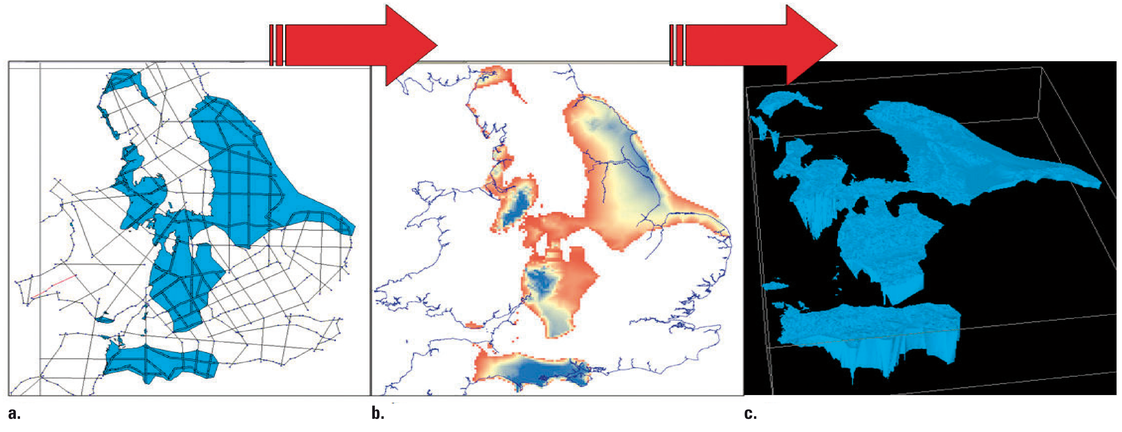

Figure 3 Illustration of the project workflow from identification of the presence of an aquifer or shale on lines of section from the national fence diagram **(Figure 3a)**, to generation of base of aquifer (in the case illustrated, top of Triassic sandstone, **Figure 3b**) or top of a shale and then finally export into ArcGIS for visualisation and manipulation of the surfaces **(Figure 3c)**.

Results

Results of the modelling are available as surfaces in an ArcGIS project and will be used by environmental regulators to help in the process of regulation and management of future shale gas development in the UK. The results include maps of: the full crop of the Principal Aquifers and depth to the base of each aquifer **(Figure 4a)**, the full crop of the shales and depth to the top of each shale **(Figure 4b)**, and the vertical separation between top of shale and base of overlying aquifer where two such units are present **(Figure 4c)**. The maps are available through a series of web pages on the BGS web site http://www.bgs.ac.uk

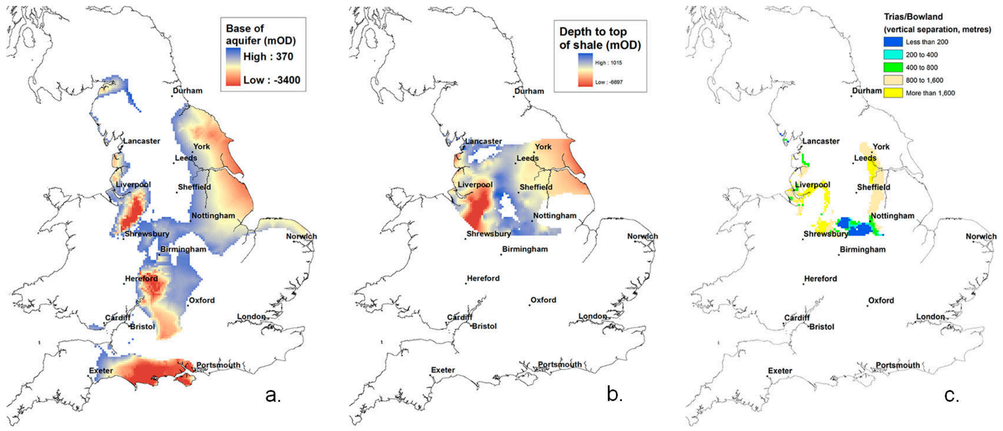

Figure 4 Maps illustrating the base of the Triassic sandstone aquifer **(Figure 4a)**, base of the Bowland and Craven Shale **(Figure 4b)** and separation between the two units **(Figure 4c)**.

Future work

BGS are continuing to refine the mapping of key geological surfaces and plan to undertake further work to better understand the national-scale hydrogeoloigical implications of shale gas development. This will incorporate information on the 3D hydraulic properties of the rock volumes between shales and aquifers to better inform risk assessment and regulatory decision making.

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http://www.bgs.ac.uk/research/groundwater/shaleGas