SECURe
Subsurface Evaluation of CCS and Unconventional Risks
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GOOD PRACTICE AND RISK MITIGATION
FACTSHEET #6

Unconventional hydrocarbons exploration:

Release of natural gas from shale production zone

SECURe employed the Bow Tie risk assessment approach, which identifies a series of barriers that prevent a principal hazard ("top event") from occurring. This factsheet outlines recommendations, which address a single top event that can occur if control of a hazard is lost: the release of natural gas from the shale production zone. It should be read in conjunction with the Participatory Monitoring Factsheet, which provides overall guidance on project construction.

The issue

Although unlikely, the release of natural gas from the production zone must be fully assessed. Such releases could result in the emissions of hydrocarbons to the atmosphere and/or impacts to ecosystems and people. Release from the production zone could arise through abandoned, monitoring or verification wells, via the well annulus, through cements or casing/production liners or along tubing. A range of well engineering assessments, appropriate material selection and monitoring provides effective barriers to prevent the release of hydrocarbons. If unplanned releases were to occur, then remediation options include monitoring, operational responses, well engineering interventions, and the use of natural geological properties to slow the release. These barriers, and preventive and remedial actions, are discussed in detail in SECURe report BGS-01-R-11.

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Risk mitigation recommendations

Monitoring approach

- **A multi-disciplinary approach to assessing fault leakage rates should be taken**, requiring suitable field and laboratory investigations (e.g. analogue studies using outcrop and core) and upscaled hydromechanical modelling (D2.6). This may require the involvement of analogue sites to access suitable sample material and geological outcrops.
- **The potential impact of fractures with high fracture roughness and relatively high permeabilities should be considered** in leakage management scenarios (D2.6) for the most prospective shale gas reservoirs. These have high contents of so-called brittle minerals (e.g. quartz, feldspars, carbonates), making these rocks mechanically strong and brittle, and therefore high in fracture permeability.
- **Thresholds should be set** for hydrochemical parameters that could indicate contamination related to unconventional hydrocarbon exploration (UHE) operations in the future (D3.6). Thresholds should be established using environmental baseline data to calculate concentrations of parameters that would indicate excessive natural temporal variation.
- **Hydrochemical parameters to be used as indicators of contamination should be selected** based on the mineralogy of the aquifer, the characteristics of the potential contaminant (for example, hydraulic fracture fluid release), and the nature of any likely reaction between the two (for example, decreased pH) (D3.6).
- The sampling network for environmental baseline monitoring, ongoing monitoring throughout operation and post-operation monitoring of groundwater should ensure that **sampling is undertaken in all major hydrogeological units at suitable depths** (D3.6). Existing relevant boreholes should be utilised and bespoke boreholes drilled, where necessary.
- Extended datasets of groundwater and soil gas chemistry should be acquired from dedicated monitoring wells to history match and **validate the simulation model** (D3.6).
- **There is a need for independent means to estimate the key subsurface pressure parameters** (formation breakdown pressure, threshold displacement pressure) of the potential leakage pathways to validate pressure management and injection strategies (D3.6).
- **Reliable geochemical monitoring of the formation confinement should include data acquired during the whole lifecycle of a hydrocarbons extraction site** (including the baseline results before injection or production phase), both from the formation and overburden (D3.6). Reliable datasets (e.g. seismic and wireline-logging datasets) of sufficient quality and quantity should contribute to fault-sealing models.
- There is a strong need for **close cooperation of industry and researchers** in planning and conducting both baseline studies and further monitoring activities (as recommended in D3.7 and D3.8). The possibility of connecting observation results with an industrial process is crucial for the interpretation of phenomena observed in the environment. Results obtained from all observation systems should be reported to the site operator and controlling bodies. This will ensure that any adverse changes and causes are identified and appropriate actions undertaken to minimise any impact and further risk.

Risk mitigation recommendations (cont.)

Use of models

- **Geomechanical models should be calibrated using detailed data of geomechanical rock properties of the structure and its surroundings** (D3.6). The Shale Gouge Ratio (SGR) can indicate fault-sealing potential but, for reliable outcomes, calibration of accurate thresholds using available geological information is needed; application to rock types other than sedimentary clastic rocks can be unreliable.
- **Geochemical analyses should be utilised supplementary to fault (and/or fracture) modelling and analyses** to indicate fluid exchange within aquifer/reservoir, migration paths (e.g. along faults and fractures), and possible current leaks within reservoirs (D3.6).

Development of technology

- **Technology development** for both monitoring measurements and interpreting of results should be foreseen. All changes in monitoring scope and schedule should be introduced gradually and in parallel to ensure that new and former results are comparable, if not directly then by means of recounting techniques. (D3.8)
- **Characterisation and monitoring of deep fluids**: gas, noble gases and isotopic compositions are essential parameters for gas storage/formation characterisation and accident prevention. A known disadvantage of conventional industrial sampling equipment is the outgassing of volatiles from in-situ sampling for compositional and isotopic analysis in the laboratory. The downhole sampler and the integrated analysis system developed in SECURe's Work Package 4 (described in D4.8) enable improved characterisation and monitoring of deep fluids.

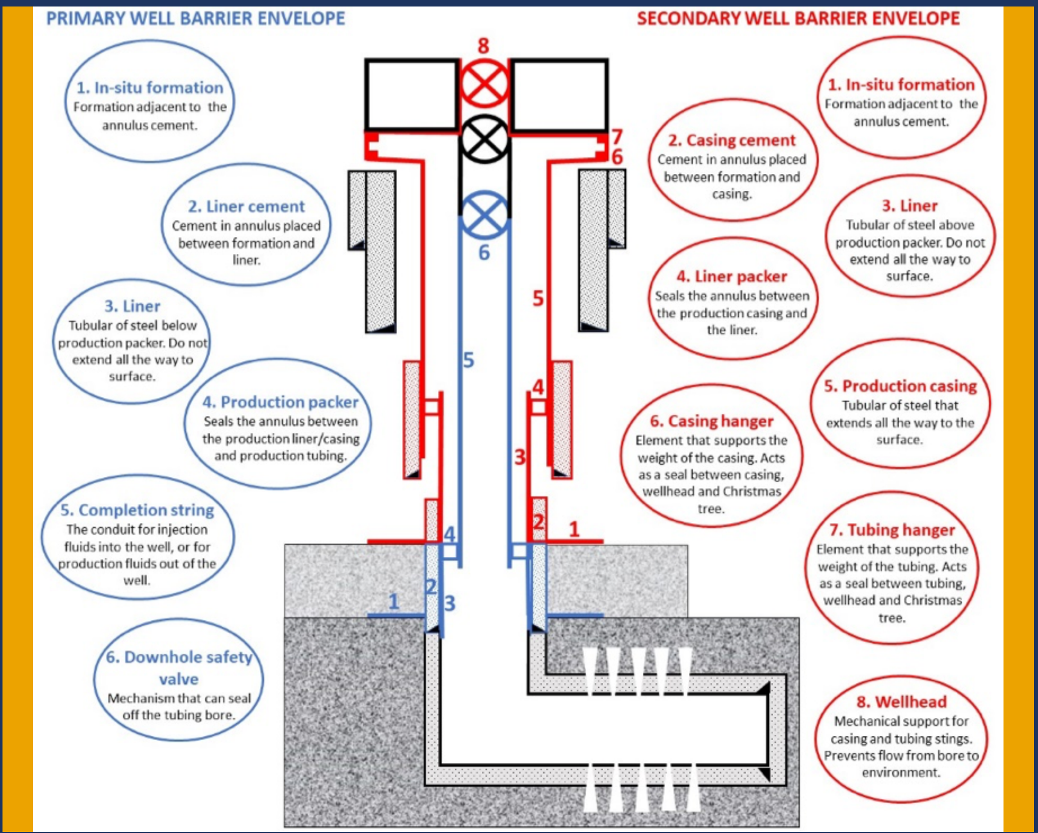

Figure 1: Simplified illustration of well barriers for a typical active shale gas well. Primary well barrier envelope in blue and secondary well barrier envelope in red (from D5.3).