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Assessment and Management of Anthropogenic Risks Associated with the Utilisation of Depleted Reservoirs for CO_2 Storage.

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Abstract

Depleted oil & gas reservoirs, a primary candidate for large-scale CO_2 storage, are in many cases likely to be a lower cost and lower uncertainty geological storage solution. However, whilst these reservoirs are often well characterised, issues resulting from production operations, such as low pressure or legacy wells' integrity may require further assurance or interventions to ensure an acceptably low operational and containment risk for CO_2 storage. A CO_2 Depleted Reservoir Storage (DRS) project was established by CO2CRC, to identify current technical challenges, and methodologies to assess and manage specific risks associated with the anthropogenic changes in these fields. Key depleted reservoirs, where CO_2 storage field development plans have been established, were utilised, along with existing literature and CO2CRC's knowhow to develop this study's outcomes. CO2CRC undertook the following studies related to CO_2-DRS:

- Flow assurance issues in highly depleted reservoirs
- Geomechanical integrity assurance for reservoir re-inflation
- Well integrity

CO_2 flow assurance into a strongly depleted storage site requires a comprehensive understanding of changing CO_2 phase behaviour, to enable the design of a fit for purpose risk mitigation plan. Common flow assurance concerns in a highly depleted reservoir storage site include: vaporization which can cause a hydrate issue at the wellhead; abrupt CO_2 phase and density transition that could cause tubing erosion or corrosive concern and; wellbore and/or formation plugging risk that can cause injectivity loss. The flow assurance study determined several topside and subsurface mitigations to prevent the flowing pressure and temperature conditions crossing the vaporization curve, thereby avoiding phase changes throughout the network and the wells. Ultimately, the best practice is to have an integrated modelling workflow to highlight the possible risks and enable operators to predict and design a fit for purpose injection strategy for the associated storage site.

Geomechanical integrity assurance during depletion and repressurisation is a complex topic. While depleted reservoirs are prime targets for CO_2 storage with well understood sealing properties and reservoir response, the inelasticity of system from the depletion stage to the CO_2 storage phase must be considered. Pore pressure stress coupling and the potential for undesirable geomechanical behaviour during depletion and repressurisation varies from field to field, based on several parameters. To geomechanically de-risk a CO_2-DRS project, a comprehensive

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data acquisition and field interpretation, including during operations, would be used to assess reservoir stress path effects and determine if they are a risk for a CO_2 storage project. This would include where possible: multi-location, repeated leak off tests during depletion and repressurisation to determine fracture pressure; characterisation of temporal changes to the in situ stress field; multi-locational, repeated FMI logs to assess fracture density changes; rock mechanical testing to assess depletion related damage; and cyclic loading experiments on core to determine whether any hysteresis is expected during loading and unloading cycles.

A key challenge to CO_2-DRS is the presence of legacy wells, which can create leakage risk from the storage zone into upper formations, aquifers and the surface. As such, wellbore leakage risk must be determined and a fit for purpose management plan implemented. To address well leakage risk, CO2CRC developed a risk and uncertainty characterisation methodology, in which each well can be mapped onto a well leakage likelihood v severity risk matrix. Key factors affecting wellbore leakage likelihood (spud date, treatment, plug type, well type / usage and cement condition) are mapped against the severity of a leakage event. Risked wells then undergo a process of well leakage risk identification and reduction flow chart process, which enables operators to systematically identify high risk wells and conduct risk mitigation activities to reduce the risk of legacy wells. This study also reviewed possible well integrity validation and improvement opportunities that currently exist in the industry. Well integrity evaluation methods are discussed with pros and cons of the various techniques. The possibility of reusing legacy wells for in-zone or above-zone monitoring is also proposed and considered possible with the appropriate level of risk mitigation in place.

Keywords: Well integrity; flow assurance; repressurisation; geomechanics; risk