Semi-analytical model of brine and CO2 leakage through an abandoned plugged well. Applications for determining an Area of Review and CO2 leakage rate.
Arnaud Réveillère, Jérémy Rohmer, Frédéric Wertz

To cite this version:
Arnaud Réveillère, Jérémy Rohmer, Frédéric Wertz. Semi-analytical model of brine and CO2 leakage through an abandoned plugged well. Applications for determining an Area of Review and CO2 leakage rate.. 11th Annual Conference on Carbon Capture Utilization and Sequestration 2012: CCUS 2012, Apr 2012, Pittsburgh, United States. <hal-00709355>

HAL Id: hal-00709355
https://hal-brgm.archives-ouvertes.fr/hal-00709355
Submitted on 18 Jun 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
Semi-analytical model of brine and CO₂ leakage through an abandoned plugged well. Applications for determining an Area of Review and CO₂ leakage rate

Introduction

- Many CO₂ storage projects target deep saline aquifers located in sedimentary basins. In these regions, historical oil & gas operations have often left abandoned wells with sometimes undetermined plugging records.
- The risk of leakage through abandoned wells should therefore be assessed, notably for preventing two adverse effects: (i) the pollution of overlying fresh water aquifers through the migration of saline brine, and (ii) the emission of large fluxes of CO₂ in the atmosphere. The present model may be used for describing both.

Position of the model

- Existing semi-analytical models can estimate the leakage flow rate of brine, possibly followed by CO₂, from the storage aquifer to overlying ones (cf. publications by Nordbotten, Cola and co-authors, 2004-2009).
- Based on these approaches, this work includes several novelties:
  - It considers the pressure increase under the leak when the dense saline brine from the storage reservoir progressively fills in the leak and replaces the native fluid of the wellbore, and then its decrease when the lighter CO₂ breaks through.
  - The leak is composed of an open wellbore and a porous column of varying height & permeability, which may present various leaks, from an empty wellbore to a flow in a porous media such as the annular cementation. It either reaches the surface or an overlying aquifer.

Application (i): Determining an Area of Review

- “Area of review” defined as the area where the pressure changes due to the injection can drive the reservoir brine up to a shallower layer of interest.
- Application of the injection scenario to the PICOREF sector in the Paris basin (France). The Oolithe Blanche layer, or “Dogger”, is used for CO₂ storage. 135 abandoned wells reach this layer and the overlying Albian aquifer in the sector.
- Prioritization of the areas to review supposing a minimum cement plug height on permeability ratio.

Application (ii): CO₂ leakage to the surface

- Same case study as Application (i), except that the leak directly connects the Dogger aquifer to the surface. A weak cement plug (hₜ = 1 m, kₜ = 10⁻¹² m²/s) is considered in the leak, which is located 5 km away from the injection point.
- Borehole filling until 2.6 years.
- CO₂ breakthrough at 34 years.
- During the brine leakage, a pressure increase under the leak Pᵢ(t) is considered due to the density difference between native and reservoir brine salinities.
- During the CO₂ leakage, pressure decrease under the column of fluid after its filling with a lighter mixture of brine.

Conclusions

- The model describes the leakage of brine through the leak, and of CO₂ as a first approach. Compared to the state of the art, it adds the possibility of accounting for density change within the leak, due to either the incoming of dense brine or light CO₂.
- It shares the advantages (immediate computation) and drawbacks (homogeneous layers) of semi-analytical models.
- Compared to a static approach, this dynamic model enables less conservative estimation of the “Area of Review”, by including effects of cement plugs, of brine density differences and of leakage-induced pressure effects.

Arnaud Réveillère, Jérémy Rohmer, Frédéric Wertz / contact: a.reveillere@brgm.fr