Hindawi
Geofluids
Volume 2017, Article ID 5687586, 2 pages
https://doi.org/10.1155/2017/5687586

Editorial

Coupled Geoflow Processes in Subsurface: CO_2-Sequestration and Geoenergy Focus

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Received 27 September 2017; Accepted 28 September 2017; Published 20 November 2017

Global efforts to control greenhouse gas emissions into the atmosphere are currently made in two parallel aspects. One focuses on developing non-fossil energy technologies which generate no carbon. These include extensive use of solar, wind, and nuclear energies, acceleration of the pace of replacing fuel-powered vehicles by electric ones, and development of new techniques to boost the performance of energy storage devices. The other aspect is dedicated to using geology-based technologies to process carbon generated by the combustion of fossil fuels, namely, using carbon capture and storage (CCS) and geothermal energy techniques to mitigate greenhouse gas emission.

Although progress in pursuing those non-fossil energy technologies has been rapid, they still "satisfy only a small portion in the global energy demand" [1]. Even from the most optimistic point of view, the transition would need at least several decades for the fossil energy system on which modern civilisation is built to be replaced by these clean renewables or zero-carbons. On the other hand, the global emission of carbon is estimated currently at over 35,000 million tonnes per annum [2], and that emission rate may persist or even continue to increase until 2030 or later [3]. According to the IEA analysis, the world needs to capture and store around 4,000 million tonnes per annum (Mtpa) of CO_2 in 2040 till the end of this century. Otherwise, the ultimate goal of the Paris Agreement (limiting the temperature increase to "well below" 2°C) would not be reached [4]. In short, in terms of today's knowledge, geology-based technologies are considered to be the most realistic and a less costly major way to achieve reduction in global carbon emission. Development in this aspect is encouraging. For example, the "Global Status of CCS: 2016 Summary Report" listed 38 large-scale CCS projects launched or to be launched shortly around the world. These major projects, plus some others, were/are operated in North America (USA, Canada), South America, Europe, the Asia-Pacific region (China, Australia, Japan, Korea, etc.), and the Middle East. These projects will provide further insights into the safety, reliability, adaptability, and cost-efficiency involved.

This special issue provides some of the latest research outcomes in this aspect, and we want to share them with relevant communities of interest. The 11 articles published here are selected from 24 submissions. Many of the unselected ones contained valuable insights but regrettably did not meet the reviewers' strict standards. Of the 11 papers, 6 are related to CO_2-sequestration and the other 5 deal with geothermal energy utilisation. These articles, except for one review paper, demonstrate the relevant theoretical, numerical, laboratory, and field efforts at various organisational levels. A brief summary of the selected topics is given below.

For CO_2-sequestration, we have the following:

(i) The paper by A. R. Adebayo et al. presents an experimental study. The authors used Berea sandstone and Indiana limestone core samples to investigate the directional effect of water/gas flow that is associated with the CO_2-flow behaviour in pertinent sedimentary rocks.

(ii) The papers by both G. Yang et al. and L. Shi et al. are concerned with the Shenhua CCS demonstration project in China, respectively. The former paper considers the relevant geochemistry in the formation, using numerical simulation to investigate the CO_2-injectivity there. The latter paper, based on analytical analyses, discusses the potential reservoir/wellbore failure risks during CO_2-sequestration in the formation where multilayered geological structures are present.

(iii) B. Bai et al. present a CO_2-EOR case study in the Shengli oilfield in China, while Y. Diao et al. propose a new method for assessing the suitability of a geological formation for CO_2-sequestration or CO_2-EOR/EGR/EWR and apply the method to analyse the suitability of the targeted Sichuan Basin (China) for these CO_2-related operations.

(iv) H. J. Liu et al. present a state-of-the-art review to the status of carbon capture, utilisation, and storage (CCUS) in the world, particularly summarising the latest progress of CCUS in China.

For geothermal energy utilisation, we have the following:

(i) K. J. Bakhsh et al. discuss the transport mechanisms within a thin thermally shocked region of an enhanced geothermal system (EGS) reservoir.

(ii) G. Jansen and S. A. Miller discuss the effect of thermal stresses during hydraulic stimulation of geothermal reservoirs.

(iii) F. Pan et al. conduct a field-scale geochemical simulation to investigate the CO_2-fluid-rock interaction in EGS reservoirs.

(iv) T. Xu et al., on the basis of the geological conditions of the Qingshankou Formation, Songliao Basin (China), investigate the CO_2 flow behaviour in a CO_2-plum geothermal system (CPG).

(v) B. Wu et al. work out an approximate solution for predicting heat extraction and preventing heat loss from a closed-loop geothermal reservoir.

We trust these works can further improve our understanding of the complex coupled geoflow processes in the subsurface in relation to CCS and the utilisation of geothermal energy. We expect these new observations, along with the previous knowledge and experience already disclosed elsewhere, may help further minimise the relevant risks and maximise operational efficiency. We look forward to seeing the implementation of more CCS and geothermal projects in the near future. The current scale of projects is far from sufficient to reach the Paris Agreement's goal. We wish that the formidable climate scenario which has been projected by various scientific analyses can ultimately be avoided through more active and effective human action.

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