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EDITORIAL

Guest editorial for the topical collection: sustainable development and utilization of geothermal systems

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1 Introduction

In recent years, climate change has accelerated progressive renewable energy programs, including the Sustainable Energy for All Initiative (UN), the United States Environmental Protection Agency's Green Power Partnership, and the European Green Deal, the main aims of which are to reduce anthropogenic greenhouse gas emissions and dependence on fossil fuels and enhance resource efficiency. Geothermal energy, which utilizes the thermal energy stored in the earth's crust, can play a significant role in the transition from fossil fuels as it is clean energy which is continuously renewed. The heat stored in the earth's crust within a 10 km depth is estimated to contain 50,000 times more energy than all the worldwide energy from oil and other gas resources (Shere 2013). Of the other renewables, geothermal energy also plays an important role by being available in all seasons of the year, irrespective of the weather conditions, whereas solar and wind energy exhibit great variability. In terms of total CO_2 emissions during the lifecycle of a geothermal power plant and the equivalent solar PV, geothermal energy will also have a substantial net positive impact on the environment (Chandrasekharam and Pathegama 2020).

Heat, permeability, and fluids are the key elements of a commercially-viable geothermal resource. The geothermal resources with the greatest potential lie close to tectonic boundaries, volcanoes, and locations where the crust is fractured, causing heat sources to be accessible (DiPippo 2012). In these systems, significant volumes of fluid are available and the heat of the earth is carried to the surface by convective circulation, the energy coming in either vapor-dominant or liquid-dominant forms. The utilization of deep/unconventional geothermal resources is currently a great challenge for the geothermal industry, and it requires high levels of innovation, research, and development and technological advances. Critical challenges which demand basic and applied research, technological development, and demonstration include enhancing the permeability of rock by different stimulation technologies (hydraulic, thermal, and chemical) to enlarge the extent of productive geothermal fields, improving reservoir exploration and drilling

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technology for deep geothermal reservoirs, improving reservoir assessment, analysis, and modelling of the coupled thermo-hydro-chemical–mechanical processes in geothermal reservoirs, and introducing innovative fracturing and circulation fluids, including supercritical fluid systems (Isaka et al. 2019; Kumari and Ranjith 2019; Tester et al. 2006).

The production of commercially-viable geothermal power is the main challenge faced by current conventional/unconventional development due to the lack of understanding of the governing factors and their influence on each phase of projects. Decision-makers, together with the general public, demand assurance that the technical and economical challenges and the environmental risks associated with resource exploration, deep drilling, stimulation, seismic control, and long-term production (which involve multiphase flow, coupled with chemical, thermal, and mechanical interactions between fluids and reservoir rocks) are fully researched.

2 Scope of the special issue/topical collection

This special issue aims to address these challenges. We have collected papers on recent developments in resource exploration and assessment, detailed modelling, and state-of-the-art experimental approaches, which together will guide the design and implementation of future geothermal developments. Devoted to sustainable development and the utilization of geothermal systems, the issue includes contributions that advance our understanding of the modeling of hydraulic fracture initiation and propagation, coupled thermal–mechanical-fluid flow systems, the use of innovative fracturing and circulation fluids, the innovative conceptualization of future geothermal systems, and balanced overviews of the field. The special issue has been very successful in publishing 17 excellent papers covering both fundamental and applied state-of-the-art works in the geothermal discipline. Some papers (e.g. CO_2 emissions from renewables: solar PV, hydrothermal and EGS sources) have already have received significant media coverage. The Guest Editors are very much appreciating and acknowledging the contributions from the authors and their support during the peer-review stages. Also, special thanks go to the Springer team of the G4 journal, for their support in the publication process of the special issue contributions.

We outline the contributions below.

1. "Deep geothermal resource assessment of the St. Lawrence Lowlands sedimentary basin (Québec) based on 3D regional geological modelling" by Bédard et al. (2020).
2. "Numerical investigation of the effects of the fracture network pattern on the heat extraction capacity of dual horizontal wells in enhanced geothermal systems" by Xin et al. (2020).
3. "Energy potential of a single-fracture, robust, engineered geothermal system" by Danko et al. (2020).
4. "Geothermal energy potential of Indian oilfields" by Singh (2020).
5. "Conceptualization and evaluation of the exploration and utilization of low/medium-temperature geothermal energy: a case study of the Guangdong-Hong Kong-Macao Greater Bay Area" by Xie et al. (2020).
6. "Potential of CO_2-based geothermal energy extraction from hot sedimentary and dry rock reservoirs, and enabling carbon geo-sequestration" by Singh et al. (2020b).
7. "CO_2 emissions from renewables: solar PV, hydrothermal and EGS sources" by Chandrasekharam and Pathegama (2020).
8. "Near-room-temperature thermoelectric materials and their application prospects in geothermal power generation" by Yu et al. (2020).
9. "Studies of the heat and mass transfer phenomena when flowing a vapor–water mixture through the system of a geothermal reservoir–well" by Alkhasov et al. (2020b).
10. "A preliminary investigation of the assessment of geothermal potential at Eastern Peninsular India" by Singh et al. (2020a).
11. "Temperature effect on thermal-diffusivity and heat-capacity and derived values of thermal-conductivity of reservoir rock materials" by Abdulagatova et al. (2020).
12. "Technologies of geothermal resources development in south Russia" by Alkhasov et al. (2020a).
13. "Excavation-based enhanced geothermal system (EGS-E): introduction to a new concept" by Zhao et al. (2020).

14. “Technological design and efficiency assessment of heat production from the dry rock with different energy potential” by Alkhasova (2020).
15. “A global review of deep geothermal energy exploration: from a view of rock mechanics and engineering” by Zhang and Zhao (2020).
16. “Use of abandoned oil wells in geothermal systems in Turkey” by Kaplanoğlu et al. (2020).
17. “An analytical model for heat extraction through multi-link fractures of an enhanced geothermal system” by Tang et al. (2020).

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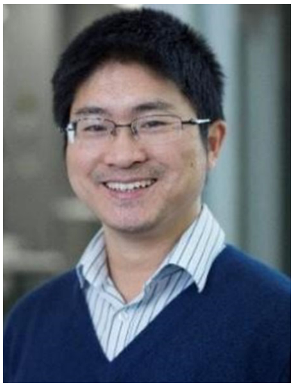

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