



Preface to the special issue of the Division Energy, Resources and the Environment at the EGU General Assembly EGU22

Viktor J. Bruckman¹, Gregor Giebel², Christopher Juhlin³, Sonja Martens⁴, and Michael Kühn^{4,5}

¹Commission for Geosciences, Austrian Academy of Sciences, Vienna, 1010, Austria

²Department of Wind & Energy Systems, Technical University of Denmark, Roskilde, 4000, Denmark

³Department of Earth Sciences, Geophysics, Uppsala University, Uppsala, 75236, Sweden

⁴GFZ German Research Centre for Geosciences, Fluid Systems Modelling, Potsdam, 14473, Germany

⁵University of Potsdam, Institute of Geosciences, Potsdam, 14476, Germany

Correspondence: Viktor J. Bruckman (ere@egu.eu)

Received: 16 November 2022 – Published: 8 December 2022

Abstract. The European Geosciences Union (EGU) is one of the leading global bottom-up societies that promotes earth, planetary and space sciences. In its annual general assemblies, EGU brings together experts from all over the world to discuss cutting-edge research and implementation of findings in their respective disciplines and beyond via its inter- and transdisciplinary sessions, and thus offers a unique forum for scientific exchange, science-policy interaction, and joint development of strategies for future research endeavours. Within that framework the Energy, Resources and the Environment (ERE) Programme Group provides the platform for discussion about adequate and reliable supplies of affordable energy and other georesources in environmentally sustainable ways. This special issue in *Advances in Geosciences* comprises a collection of contributions from the ERE Programme Group, which were presented at the General Assembly 2022. It was held in hybrid mode for the first time from 23–27 May 2022, after two virtual assemblies in 2020 and 2021.

After a careful assessment of risks, it was decided to reschedule the meeting, still as a hybrid event, but also to ensure all possible measures would be in place to minimize infection risks. Poster sessions were skipped to comply with initial safety measures during the planning phase, and all contributions therefore were held in (shorter than usual) oral slots. Moderate registration fees were charged for online participation and slightly increased fees (compared to 2019) were collected from regular (on-site) participants to account for increasing costs resulting from the hybrid conference mode. A General Assembly participation and travel support scheme was developed to allow a participation for a broader community.

Feedback from participants was overwhelmingly positive. The fact that a physical gathering was possible again, and that the EGU General Assembly 2022 marked a great step towards inclusivity, since all sessions were accessible online, was well received by the entire community. In total, 14 317 registered participants, of which 7315 (89 countries) attended onsite and 7002 (116 countries) virtual, formed the programme in 791 scientific sessions, four Union Symposia, six Great Debates, 53 Short Courses and 34 Medal and Award Lectures. In addition, 73 Networking and Community Events, as well as seven press conferences were organized.

The division and its Programme Group “Energy, Resources and the Environment” (ERE) is one of 22 divisions that helps organise the EGU scientific activities around its expertise. In 2022, it led 26 sessions (including two inter- and transdisciplinary sessions, ITS) with 472 contributions and co-organised another 12 sessions together with other

1 Introduction

The EGU General Assembly 2022 was held from 23 to 27 May after postponing it from its initially planned dates in April (3–8 April 2022) to cope to restrictions in order to minimize COVID-19 spreading. After two years of virtual meetings, the geosciences community expressed a strong wish to meet in person again, although infection risk and restrictions were still high at the stage of planning the event.

Programme Groups (EGU, 2022). ERE is highly interdisciplinary, reflected by the largest share of ITS contributions (9.3 %). Although the EGU General Assembly 2022 received on average 24 % less abstract submissions relative to the last onsite meeting in 2019, ERE was the only Programme Group that was able to sustain the number of abstract submissions despite the challenging conditions and restrictions. Based on statements concerning research funding to achieve the European Green Deal (European Commission, 2022) and current geopolitical issues, we envision that the EU and other research funding organizations will invest more in energy research and that this may then be reflected in increasing interest and contributions in the forthcoming years.

This volume of *Advances in Geosciences* spans a wide range of topics in the fields of energy, resources and the environment which were presented in May 2022 and hereby continues a series of nine ERE special issues over the course of the last years (Bruckman et al., 2021; Kühn et al., 2013, 2015, 2016; Juhlin et al., 2014; Martens et al., 2017, 2018, 2019, 2020).

2 ERE Programme at EGU22

The ERE Programme Group for EGU22 consisted of five sub-programme groups, namely:

- Integrated studies
- Renewable energy
- Geo-storage
- Raw materials, and
- Process coupling and monitoring related to geoenergy applications.

The sub-programme group (SPG) on fossil energy was discontinued, since interest has generally been decreasing over the last years with only a single remaining session in 2021. The ERE Division Meeting 2022 was organized virtually in the week prior to the General Assembly (16 May 2022) with a comparatively high attendance of more than 80 individuals, perhaps due to questions concerning the new format of the General Assembly 2022. Several networking events (e.g. ERE early career scientists meeting, ERE meet the president) were organised throughout the week to foster networking and to share ideas among peers.

2.1 Integrated studies

The Integrated studies SPG combines integrative, systems-based approaches in the Energy, Resources and the Environment domain. It is a cornerstone of the division and demonstrates its interdisciplinary focus. Consequently, two ITS and five co-organized sessions with other divisions were included in this SPG.

Five sessions with ERE in the lead were listed in this SPG:

- Changes in energy and material demand as drivers, outcomes and solutions of the climate and environmental crisis, convened by Jarmo Kikstra, Volker Krey, Jan Streeck and Jefim Vogel
- Climate change and cultural heritage: impact, vulnerability, adaptation, convened by Luigi Germinario, Alessandra Bonazza and Peter Brimblecombe
 - Paper in this Issue: Frost damage risk assessment of a historic masonry wall due to climate change by Petros Choidis et al.
- Anthropogenic geomaterials for a sustainable future, convened by John M. MacDonald, Susan Cumberland, Marta Kalabová, Faisal W. K. Khudhur and Joanna Renshaw
- Impacts and co-benefits of the energy transition on hosting ecosystems – implications and prospects for Natural Capital and Ecosystem Services, convened by Fabio Carvalho, Alexander Cagle, Kathryn G. Logan, and Olga Turkovska
- “Geospatial analysis for sustainable development” combined with “Carbon emissions/removals estimates under Land use, land-use change and forestry (LULUCF) sector”, convened by Giacomo Falchetta, Maša Zorana Ostrogović Sever, Hrvoje Marjanovic, Anikó Kern, Olha Danylo, and Ahmed Hammad

2.2 Renewable energy

The Renewable energy SPG has received a steadily growing number of contributions over the last years and is also characterized by its multidisciplinary contributions. A good balance between well-established sessions and emerging topics guarantees a satisfying experience for long-term ERE members as well as for new members or participants whose interests are focussed in other divisions.

The SPG Renewable energy featured five sessions with ERE in the leading role:

- Energy Meteorology, convened by Xiaoli Larsén, Gregor Giebel, Somnath Baidya Roy, and Philippe Blanc
 - Paper in this issue: Storm Kyrill and the storms of mid-January 2007: Societal and Energy Impacts in Europe by Anthony James Kettle
- Spatial and temporal modelling of renewable energy systems, convened by Luis Ramirez Camargo and Johannes Schmidt
 - Paper in this issue: Spatially resolved generation profiles for building, land and water-bound PV: a case study of four Dutch energy transition scenarios by Nick Nortier et al.

- Geothermal resources in the framework of climate change and sustainability, convened by Annette Dietmaier, Ingrid Stober, and Tobias Björn Weisenberger
- Exploration, utilization and monitoring of conventional and unconventional geothermal resources, convened by Eugenio Trumpy, Maren Brehme, Anne Pluymakers, Chris Boeije and Martijn Janssen
 - Paper in this issue: Geothermal exploitation in the inverted part of the Lower Saxony Basin: A case study from the Minden area by Alexander Jüstel et al.
 - Paper in this issue: Inverse flow zone characterization using distributed temperature sensing in a deep geothermal production well located in the Southern German Molasse Basin by Felix Schölderle et al.
 - Paper in this issue: Forecasting changes of the flow regime at deep geothermal wells based on high resolution sensor data and low-resolution chemical analyses by Annette Dietmaier and Thomas Baumann
- Shallow geothermal systems for heating and cooling: geoscience and engineering approaches, convened by Giorgia Dalla Santa, Jean de Sauvage and Francesco Cecinato
 - Paper in this issue: Laboratory assessment of corrosion rate of carbon steel ground heat exchangers by Gianluca Cadelano et al.

2.3 Geo-storage

Within the SPG Geo-storage, three sessions were organized focussing on storage of gases or liquids to facilitate a safe energy transition, as well as an established session on nuclear waste repository research:

- Secure subsurface storage for future energy systems, convened by Johannes Miodic, Niklas Heineemann, Katriona Edlmann, Qi Li, Eike Marie Thaysen, Darja Markova, David Finger, Massimiliano Capezzali, and Horst Steinmüller
- Towards a safe nuclear waste repository – assessment of barrier integrity, geoscientific, technological, societal and regulatory challenges and approaches, convened by Thomas Nagel, Václava Havlová, Axel Liebscher, Jobst Maßmann, and Klaus-Jürgen Röhlig
 - Paper in this issue: ransPyREnd: A code for modelling the transport of radionuclides on geological time scales by Christoph Behrens et al.
 - Paper in this issue: The influence of sedimentary heterogeneity on the diffusion of radionuclides in the sandy facies of Opalinus Clay in the field scale by Chaofan Chen et al.

- Paper in this issue: Reactive transport simulations of uranium migration in the Opalinus Clay depend on ion speciation governed by underlying thermodynamic data by Theresa Hennig and Michael Kühn
- Deep geological repositories – Geosciences in the site selection process, convened by Vanessa Montoya, Koen Beerten, Andreas Reinicke, and Alwina Hoving

2.4 Raw materials

The Resources aspect of our division is covered by the SPG Raw materials. Four sessions on advanced mining technologies, waste recycling, circular economy, and research progress on geoheritage sites were organized:

- Heritage Stone Subcommittee: A Global Perspective, convened by Gurmeet Kaur, Angela Ehling, Eliane Del Lama, and Francesca Gambino
- Circular economy and resource recovery: from waste to raw material, convened by Ana Teresa Lima, Pierluigi Zerbino, Davide Aloini, Lisbeth M. Ottosen, and Alexandra Escobar
 - Paper in this issue: Metakaolin-based geopolymers for stone conservation: preliminary results on alkaline activation by Sophie Eline van Roosmale et al.
- Environmentally sustainable transformation of waste from mining and quarrying activities for their valorisation, convened by Elena Marrocchino, Chiara Telloli, and Richard Prikryl
- Automation and robotics for raw material exploration and production in Europe, convened by Giorgia Stasi, Claudio Rossi, Eva Hartai, and Michael Berner

2.5 Process coupling and monitoring related to geoenergy applications

The process coupling and monitoring SPG focuses on the understanding and modelling of geoenergy aspects, including storage. It features some of the most established sessions within ERE, but also relatively new approaches, and deals also with topics of high political and public interest (e.g. induced seismicity). Seven sessions were organized with ERE in the leading position:

- Induced/triggered seismicity in geo-energy applications: monitoring, modelling, mitigation, and forecasting, convened by Antonio Pio Rinaldi, Rebecca M. Harrington, Nadine Igonin, Marco Maria Scuderi, and Victor Vilarrasa
- Faults and fractures in geoenergy applications 1: Monitoring, laboratory and field work results, convened by Roberto Emanuele Rizzo, Catalina Sanchez-Roa, Nathaniel Forbes Inskip, and Sarah Weihmann

- Paper in this issue: CHENILLE: Coupled Behavior Understanding of Faults: from the Laboratory to the Field by Audrey Bonnelye et al.
- Faults and fractures in geenergy applications 2: Numerical modelling and simulation, convened by Sarah Weihmann, Reza Jalali, Clare Bond, and Florian Amann
- Underground Thermal Energy Storage, applications and associated processes in porous and fractured aquifers, convened by Martin Bloemendal, Bastian Welsch, Peter Bayer, Kathrin Menberg, Claire Bossennec, and Stijn Beernink
- Coupled thermo-hydro-mechanical-chemical (THMC) processes in geological media, convened by Silvia De Simone, Francesco Parisio, Keita Yoshioka, Roman Makhnenko, and Victor Vilarrasa
- Process quantification and modelling in subsurface utilisation convened by Thomas Kempka, Sebastian Bauer, and Holger Class
 - Paper in this issue: Numerical investigations to assess ground subsidence and fault reactivation during underground coal gasification by Mansour Heyatzadeh et al.
 - Paper in this issue: Hysteresis in permeability evolution simulated for a sandstone by mineral precipitation and dissolution by Maria Wetzel et al.
 - Paper in this issue: Verification of TRANSPORT Simulation Environment coupling with PHREEQC for reactive transport modelling by Thomas Kempka et al.
 - Paper in this issue: Upwelling mechanisms of deep saline waters via Quaternary erosion windows considering varying hydrogeological boundary conditions by Elena Chabab et al.
 - Paper in this issue: Numerical Analysis of Potential Contaminant Migration from Abandoned In-Situ Coal Conversion Reactors by Christopher Otto et al.
 - Paper in this issue: Environmental hazard quantification toolkit based on modular numerical simulations by Morgan Tranter et al.
 - Paper in this issue: Geographic Information System (GIS) as a basis for the next generation of hydrogeological models to manage the geothermal area Waiwera (New Zealand) by Michael Kühn et al.
- Reservoir stimulation and environmental impacts of geo-energy production, convened by Jingqiang Tan, Songqi Pan, David Wood, Amin Ghanizadeh, and Andreas Busch

3 Conclusions

The EGU General Assembly 2022 was, for the first time, held as a fully hybrid meeting. The Programme Group on Energy, Resources and the Environment organized 26 sessions with 472 presentations and co-organised another 12 sessions. With this special issue in *Advances in Geosciences*, we are pleased to present a collection of contributions from the ERE Programme Group in 2022 and look forward to the General Assembly 2023.

Acknowledgements. We would like to thank all participants for their contributions to EGU2022. Our special thanks go to the conveners, who made it possible that the ERE division was the only division that did not suffer from decreasing abstract submissions relative to 2019. Without their support, EGU2022 would not have been the success that it was, despite the challenging restrictions and short-term changes caused by the global pandemic. We would also like to thank all reviewers for their effort and time put into the evaluations of the contributions within this special issue.

Financial support. The article processing charges for this open-access publication were covered by the Commission for Geosciences of the Austrian Academy of Sciences.

References

- Bruckman, V. J., Giebel, G., Juhlin, C., Martens, S., Rinaldi, A. P., and Kühn, M.: Preface to the special issue of the Division Energy, Resources and the Environment at vEGU2021: Gather online, *Adv. Geosci.*, 56, 13–18, <https://doi.org/10.5194/adgeo-56-13-2021>, 2021.
- EGU – European Geosciences Union General Assembly 2022: Selected program groups: ERE – Energy, Resources and the Environment, <https://meetingorganizer.copernicus.org/egu2022/meetingprogramme>, last access: 18 August 2022.
- European Commission: Current funding – Leveraging energy efficiency investments via tailored instruments and project development assistance, https://energy.ec.europa.eu/topics/energy-efficiency/financing/eu-programmes/current-funding_en, last access: 18 August 2022.
- Juhlin, C., Hangx, S., Ask, M., and Bruckman, V. J.: Energy, Resources & the Environment: Current Status, *Energy Proced.*, 59, 440–444, <https://doi.org/10.1016/j.egypro.2014.10.400>, 2014.
- Kühn, M., Juhlin, C., Held, H., Bruckman, V. J., Tambach, T., and Kempka, T.: Energy, Resources & the Environment – Some Future Challenges, *Energy Proced.*, 40, 1–5, <https://doi.org/10.1016/j.egypro.2013.08.001>, 2013.
- Kühn, M., Ask, M., Bruckman, V. J., Hangx, S., and Juhlin, C.: Sustainable Supply of Resources and Energy is a Challenge, *Energy Proced.*, 76, 1–6, <https://doi.org/10.1016/j.egypro.2015.07.833>, 2015.
- Kühn, M., Ask, M., Juhlin, C., Bruckman, V. J., Kempka, T., and Martens, S.: Interdisciplinarity to tackle the

- challenges of the future, *Energy Proced.*, 97, 1–6, <https://doi.org/10.1016/j.egypro.2016.10.004>, 2016.
- Martens, S., Hangx, S., Juhlin, C., Kühn, M., and Kempka, T.: Energy, Resources and the Environment: Meeting the challenges of the future, *Energy Proced.*, 125, 1–5, <https://doi.org/10.1016/j.egypro.2017.08.301>, 2017.
- Martens, S., Juhlin, C., Bruckman, V. J., Mitchell, K., Griffiths, L., and Kühn, M.: Editorial: Energy, Resources and the Environment – Interdisciplinary answers to approach the sustainable energy and resources conundrum, *Adv. Geosci.*, 45, 163–166, <https://doi.org/10.5194/adgeo-45-163-2018>, 2018.
- Martens, S., Juhlin, C., Bruckman, V. J., Giebel, G., Nagel, T., Rinaldi, A. P., and Kühn, M.: Preface: Interdisciplinary contributions from the Division on Energy, Resources and the Environment at the EGU General Assembly 2019, *Adv. Geosci.*, 49, 31–35, <https://doi.org/10.5194/adgeo-49-31-2019>, 2019.
- Martens, S., Brehme, M., Bruckman, V. J., Juhlin, C., Miocic, J., Rinaldi, A. P., and Kühn, M.: Preface: Special issue from the Division on Energy, Resources and the Environment at EGU2020: Sharing geoscience online, *Adv. Geosci.*, 54, 1–5, <https://doi.org/10.5194/adgeo-54-1-2020>, 2020.