Introduction to this special section: engineering geophysics

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In the context of our growing population, new paradigms are required for, e.g., the monitoring and management of infrastructure and buildings, and the use of the subsurface and its resources. Increasing energy demands entail continuous improvement of imaging techniques to better understand subsurface resources and to maximize production in an environmentally safe manner. Climate change, in combination with rapid population growth, puts increasing pressure on freshwater resources and groundwater systems, as well as urban living environments. Many subdisciplines and areas within geophysics, including Engineering Geophysics, are increasingly involved in tackling these global challenges.

Engineering Geophysics covers a wide variety of topics that are of paramount importance to our growing and developing society in a dynamic environment with changing boundary conditions. Topics include: hydrogeophysics, near-surface geophysics to improve exploration geophysics, geotechnical engineering, artificial intelligence and machine learning, advances in acquisition and sensor technologies, high resolution imaging, and environmental and geohazard studies.

The importance and continuing growth of Engineering Geophysics is also reflected by the overwhelming success of the Sixth International Conference on Engineering Geophysics (ICEG 2021). This conference was organized by the United Arab Emirates University and Al Ain City Municipality in partnership with the Society of Exploration Geophysicists. The conference was held virtually (COVID) from 25 to 28 October, 2021. ICEG 2021 has focused on global innovation, creativity, advances, and new approaches in the field of engineering and environmental geophysics and related fields. This focus was also reflected by the ICEG Innovation Award competition: the many participants in this highly competitive contest have presented outstanding and innovative scientific and technological advances at the forefront of the field of Engineering Geophysics. The Innovation Award competition at ICEG 2021 had the following winners: 1. Sjoerd de Ridder (University of Leeds), 2. Daniele Colombo (Saudi Aramco) and 3. Chenyan Wu (Southern University of Science and Technology).

The current special section presents a selection of studies, giving an idea of the breadth of Engineering Geophysics and its positive impact on our society.

Niu et al. (2022) characterize the physical properties of two different types of reclaimed lands in Singapore, through active and passive seismic surveys and comparison with natural geological formations. Complex subsurface structures are identified from the multi-channel surface wave analysis, as features related to mode kissing, mode jump, and mode loss on the dispersion spectra on the reclaimed lands are observed.

Aldawood et al. (2022) present a case study of seismic-while-drilling (SWD) analysis for the provision of high-resolution information and characterization of the near-surface geology in a desert environment. Data were acquired over a complex overburden with a system of wireless surface geophones, top-drive and downhole sensors. The drill-bit noise data were reprocessed using a specialized workflow. The model closely ties with the geology of the near surface, and information on soft and compacted formations are also retrieved.

Colombo et al. (2022) propose an airborne transient electromagnetic (TEM) solution for seismic imaging in sand covered areas, such as in desert environments, where the acquisition instrumentation, parameters and inversion strategies are tuned to the ultra-shallow depth of the target (2-20 m). The imaged resistivity boundary provides an excellent match to the existing uphole data, and indicates the presence of a long wavelength mismatch with the previously interpreted base of sand.

Economou et al. (2022) present a case study for the detection of subsurface weak areas and voids in the karstic area of the Chania International Airport in Crete, Greece. This is important, e.g., in the context of building foundation stability. The authors use electrical resistivity tomography (ERT) and borehole data. A fast post-acquisition borehole program is driven by ERT and supplemented by information from in-borehole video recordings. Following inversion of 3D ERT data, the area is classified as highly karstified and fractured, with detected voids size ranging from 0.5m to 6m.

Kasahara et al. (2022) propose an investigation into seismic exploration technologies with distributed acoustic sensing (DAS) in the Mori-Nigorikawa geothermal field at the Nigorikawa caldera basin, Japan, for locating supercritical geothermal reservoirs. An optical fibre system and an array of geophones are installed to 2,100m depth in a little deviated high-temperature geothermal production well, and along a road surface for approximately 1.2km. Results from the use of DAS waveforms demonstrate the capability of the proposed approach to detect reservoirs and work at a closer distance from deep targets.

Takekawa et al. (2022) present a novel multi-component sensor prototype, consisting of an optical fibre wound around a polyvinyl chloride frame, using DAS technology. The sensor is tested on site by recording seismic waves generated by a wooden hammer and comparing these data with the data from a conventional geophone array. The results show good agreement between the two, with an ellipsoidal motion of waveforms from the new DAS sensor prototype and a propagating velocity matching the Rayleigh waves' velocity as estimated from the geophone data.

Chen and Jeng (2022) present a systematic review with a technical tutorial on the evolving, advanced data processing method: Multi-marginal Hilbert-Huang transform (HHT) spectral analysis. This is followed by a field example on refraction and reflection short-period ocean bottom seismograph (OBS) data to indicate the possible application to engineering geophysics.

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