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Editorial: Geoscientific visualization in solid earth geophysics

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Editorial on the Research Topic
Geoscientific visualization in solid earth geophysics

Geoscientific visualization has become a prominent aspect of research result representation and a tool that enables researchers to enhance their knowledge in the course of their research investigation as well as divulge this information in a compact, easily understandable way as part of scientific communications and educational purposes. Understanding how the planet Earth changes, transforms, and evolves with time, is one of the major challenges in studying the physics of Earth's interior, a subject called "*Solid Earth Geophysics*".

Geological and geophysical activities occur because our planet is in a dynamic state. Two planetary scale processes are at the origin of the Earth's dynamics. The first process is the convection in the Earth's liquid-iron outer core that powers the geomagnetic field. The second process is the Earth's cooling through mantle convection, characterized by the inducing currents of cold sinking and hot rising materials. At the earth surface, plate tectonics is strongly marked by crustal deformation, seismic and volcanic activities. In present day, all these activities are now easily observable and measurable with the advent of various modern methods and techniques.

Solid Earth Geophysics research is fundamentally multidisciplinary in its constitution. A large variety of observational, experimental, and theoretical approaches is used to investigate the structure and dynamics of the Earth. This Research Topic, *Geoscientific visualization in solid earth geophysics*, covers high-quality original research contributions concerning innovative methods, techniques and their applications to actual geological and geophysical systems. Its main purpose is to solve the key problems related to theories/methods and prospective technologies from different areas, which can be helpful for improving the developments of accurate exploration methods.

The eight papers collected mainly cover the following subtopics:

- Image Segmentation and Analysis of Pore Network Geometry in Two Natural Sandstones.
- Well-Posed Geoscientific Visualization Through Interactive Color Mapping.
- The NEWTON-g Gravity Imager: Toward New Paradigms for Terrain Gravimetry.

- 3D Convolution Conjugate Gradient Inversion of Potential Fields in Acoculco Geothermal Prospect, Mexico.
- Seismic Imaging of Lithospheric Structure Beneath Central-East Java Region, Indonesia: Relation to Recent Earthquakes.
- Seismic Tomography and Earthquake Relocation in North China Craton From 2008 to 2017.
- Geophysical data fusion of ground-penetrating radar and magnetic datasets using 2D wavelet transform and singular value decomposition.
- A submarine morphotectonic analysis combining GIS-based methods and virtual reality: Case study of the low-rate active thrust faulting off Boumerdès (Algeria).

Thomson et al., report the results of a pore-network analysis of. high-resolution synchrotron microtomographic images of Fontainebleau and Berea Sandstones. The authors analyse the relationship between the porosity and the number of pores, their median coordination number, and fraction of connected pore space. Their fluid flow simulation results highlight anisotropic permeability, which is probably due to heterogeneity in the sample, rather than that caused by the variation in orientation of grains and pores in each direction.

The contribution of Morse et al. focuses on Geoscientific visualization through Interactive Color Mapping, based on a suite of newly developed computer applications, which enable them to display spatially varying data in a performant graphics environment. The authors produce color-mapping that accommodate the non-uniformity of human color perception, thus producing an image where genuine features are observed. This study will lead to wider usage of informed color-mapping in the field of geosciences.

Through the NEWTON-g project, Carbone et al. propose a gravity imager based on a field-compatible measuring system, able to real-time monitor the evolution of the subsurface mass change. This innovative tool can be used to resolve important societal Research Topic as sustainable management of energy resources (e.g., hydrocarbons and geothermal energy), management of water resources, and assessment of hazard (e.g., volcanic eruptions). In fact, most geophysical phenomena underlying the dynamics of hydrological, volcanic, hydrothermal and petroleum systems involve underground mass transport and can induce changes in the gravity field measurable at the surface. In this study, the authors show that the gravimetry, using the proposed gravity imager, is thus an important geophysical method, able to provide unique insight into natural phenomena that have strong societal implications.

Calderón and Gallardo have developed a convolution-based conjugate gradient 3-D inversion algorithm of joint gravity and magnetic data for a geothermal prospect in the Acoculco caldera in Mexico. The results show an intrusive bodies play an important role either as a low-permeability host of the heated fluid or as the heat source for the potential development of an enhanced geothermal system. A 3D model has been presented that clearly show the distribution of the existing volcanic infill in the caldera as well as the interrelation of various intrusions in the basement of this area.

Muttaqy et al. determine a 3-D seismic velocity structure of the crust and upper mantle using 1,488 seismic events. Consequently, their study reveals the occurrence of the subducted slab, volcanic sources, and seismogenic features in the Central and East Java region (Sunda Arc). Moreover, other interesting results are presented as the rising fluids that feed the volcanoes of the studied region (Merapi-Merbabu, Wilis, Pandan, Semeru, Bromo and Ijen), the relocation of the hypocenter of the Malang earthquake of 2021 (Mw6.1) as well as the tsunamigenic origin of the earthquake that occurred in Banyuwangi in 1994 (Mw7.8).

Seismic tomography and earthquake relocation in north China craton from 2008 to 2017 has been studied by Wu et al. Using a double-difference tomography (tomoDD) method, they have established a new 3-D seismic lithospheric structure consolidated by high-precision earthquake relocations in North China. Their analysis shows that the majority of earthquakes in North China occurred at the junction of the low-velocity zone and the high-velocity zone. The joint inversion results demonstrates that there is a narrow low-velocity anomaly perpendicular to the surface at 20–25 km in the Tangshan area and there are no earthquakes in this anomaly area. The authors hypothesize that this anomaly will continue to erode the Tangshan subsurface structure and may cause strong earthquakes in the future. This study provides the groundwork for future earthquake prevention and mitigation in North China.

Oliveira et al. investigate the variation, in particular the lack, of perceptibility in geophysical data. In this work, the authors showed that the fusion of the data makes it possible to provide a source of much improved information concerning the structures buried in the ground. They developed a strategy by integrating ground-penetrating radar (GPR) and magnetic data collected at the Roman Villa of Pisões (Beja, Portugal). Their study aims to create an image of better quality, with the fusion of data allowing a better understanding of the object of concern. The images produced by the proposed data fusion approach suggest that the perceptibility has increased, leading to conclusions to be drawn about the existence of buried structures. In this article, the authors demonstrate that the geophysical data fusion approach is effective in obtaining an improved image with increased perceptibility that gives a clear picture about the existence of buried structures.

Finally, the 2003 M_w6.8 Boumerdès event has been studied by several authors. In this article Déverchère et al. explore where, how and when the tectonic inversion of the margin off Boumerdès has left witnesses in the seafloor morphology and whether the observed submarine deformation correlates with the 2003 coseismic rupture zone and with the Plio-Quaternary sedimentation pattern. The authors' aims are: 1) to clarify the debate on the Boumerdès fault outcrop at the seafloor, 2) to reveal the potential of virtual reality applied to the visualization of submarine structures and 3) to discuss the consistency of strain indicators.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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