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EDITED AND REVIEWED BY
Carmine Galasso,
University College London,
United Kingdom

*CORRESPONDENCE
Ernest Rutter,
e.rutter@manchester.ac.uk

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Editorial: Recent advances in mechanics and physics of rock fractures across scales

Ernest Rutter [1]*, Yingchun Li [2], Junlong Shang [3] and Yinlin Ji [4]

[1]Department of Earth and Environmental Sciences, The University of Manchester, Manchester, United Kingdom, [2]School of Civil Engineering, Dalian University of Technology, Dalian, China, [3]James Watt School of Engineering, University of Glasgow, Glasgow, United Kingdom, [4]Geoenergy, Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences, Potsdam, Germany

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Editorial on the Research Topic
Recent advances in mechanics and physics of rock fractures across scales

Rock discontinuities, including bedding, open fissures, joints and faults, are ubiquitous in the Earth's upper crust. They occur at different length scales ranging from mm to km. Such discontinuities govern the physical, mechanical, and hydraulic responses of rock masses under various loading conditions. The substantive flow of gases and liquids in the subsurface is dominantly controlled by the density and distribution of rock fractures, especially for low-permeability rock formations. The failure of rock fractures may cause both natural geological disasters such as rockslides and earthquakes, and anthropogenic catastrophes such as water inrush and induced earthquakes. Under this theme six original research articles are gathered together in the special issue "*Recent Advances in Mechanics and Physics of Rock Fractures across Scales*". The breadth of the topic is wide, and these papers illustrate some of the range of current research in this field.

Faults form as a result of the localization of microfractures, commonly on the grain scale, to form a shear band in which there is intense comminution of granular material ultimately to form a fault gouge. The localization phenomenon and the peak strength have been the focus of intense study using experimental rock mechanics methods and modelling over many decades, but advances have commonly come about through the application of new experimental and observational techniques.

Three papers in this collection demonstrate this approach. Cheng et al. demonstrate the potential of passive 3D acoustic emission tomography to map the development of fault localization and the resulting anisotropic changes in acoustic wave velocities, using both Brazilian test geometries and conventional axisymmetric compression tests. McBeck et al. use *in-situ* X-ray tomography to follow the localization of initially distributed microfracturing to form a macroscopic fault, via conventional triaxial experiments on granitoids tested over a range of confining pressures. Fattaruso et al. also study the growth and eventual localization of microfractures to produce a macroscopic fault using the Boundary Element Method for numerical simulation, constrained by reference to experimental results on real rocks.

The physical size of rock specimens used in laboratory rock mechanics experiments is limited by the practicalities of working with progressively larger specimens. Therefore modelling approaches must be used for upscaling to the size of rock bodies encountered in the field. For this purpose it has been generally supposed that for larger sizes the chance of encountering debilitating heterogeneities will increase, so that the rock mass will be weaker. However, Xiao et al. consider the influence of the granularity of the rock relative to the specimen size, and find that over a six-fold range of scale that the larger specimen size will be slightly stronger, because the heterogeneities represented by the granularity are relatively smaller in a larger sample.

In a consideration of the shear strength of fractures, Guo et al. report an experimental study of the weakening effects of multiple cycles of wetting and drying on the peak shear strength of experimentally-induced extensional cracks in a chemically aggressive pore fluid environment. This is inferred to be analogous to the degradation of the strength of natural weakness planes in rocks in the near surface environment, such as in reservoir embankments, and as such it is an important consideration in the design of such engineered structures.

Finally, rather than working only with laboratory-scale samples, Rysak et al. begin by examining the occurrences of natural hydraulic fractures in a 180 m section of borehole core, finding that many show complex morphology. For comparison, they carried out comparative laboratory study of hydraulic fracture geometries and found similar developments of complexity, including fracture networks involving multiple strands, in contrast to the simple, single planar crack models usually assumed for the development of hydro-fractures.

Only six papers cannot possibly encompass the full range of the phenomenology of brittle failure of rocks, but the collection does illustrate some of the novel approaches being applied, and how they can lead to new insights into multi-scale rock fracture mechanics and physics.

Author contributions

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

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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