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KG²B, a world-wide inter-laboratory benchmark of low permeability measurement and modelling

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A benchmark of low permeability measurements has been organized by the Geosciences and Environment Laboratory at University Cergy-Pontoise over the period 2015-2018. The objective of this benchmark was to measure or estimate through modelling the permeability of a single material, selected for its low permeability. A wide range of different approaches were covered, classified into (i) direct measurement methods, including steady-state, transient pulse and oscillatory techniques and (ii) models using microstructural data obtained from imaging or porosimetry techniques. At the beginning, 30 laboratories in 8 different countries volunteered to participate, and at the end results from 24 labs were collected which is remarkable.

The selected rock was the Grimsel granodiorite (Switzerland), so the benchmark was called "KG²B", which means "K for Grimsel Granodiorite Benchmark". Two fresh cores with diameter 85 mm and about one meter long each were provided by colleagues from ETH Zürich. The cores were drilled in the Swiss Grimsel test site, an underground research laboratory in hard rock, at a distance between 4 and 6 meters from the tunnel, away from the EDZ. The cores were cut into small pieces (between 2 and 10 cm long) and sent to the participants. The porosity of the Grimsel Granodiorite is less than 1%, and the permeability is in the 10^{-18} m² range.

The expected outcomes of the benchmark were: (i) to compare the results for each method separately and (ii) between the different methods/models, (iii) to assess the precision of each method, (iv) to study the influence of experimental conditions, especially sample size and the nature of pore fluid, (v) to gather information on the know-how in each laboratory, and finally (vi) to suggest good practice for low permeability measurements.

The benchmark was designed as a blind test, i.e. the results from each lab were not known by the other labs except for the organizers. A dedicated website [1] was constantly updated to allow the participants to follow the progression of the benchmark. It took about three years to manage the benchmark, collect all the data, complete the dataset analysis and publish the results [2,3]. The results collected allowed us to discuss the influence of pore-fluid, measurement method, sample size and pressure sensitivity, as well as the relevance of various models for permeability estimation. The most striking and unexpected result was that regardless of the method used, the mean gas permeability was higher than the mean liquid permeability by a factor approximately 2.

As an introduction to the session, our aim is to show how conducting such a benchmarking exercise can help to answer the questions raised by the session: - How repeatable are permeability measurements, and how dependent are they on the apparatuses and methods? - Which experimental pitfalls exist, what are the underlying assumptions and how might they impact permeability? - Can we define standard experimental procedures to improve permeability measurements in low permeability materials?

- [1] https://labo.u-cergy.fr/~kg2b
- [2] *Geophys. J. Int.*, 215, 799-824, doi: 10.1093/gji/ggy304, 2018.
- [3] *Geophys. J. Int.*, 215, 825-843, doi: 10.1093/gji/ggy305, 2018.