

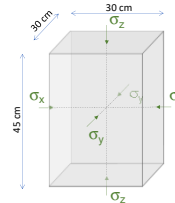


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True Triax Rock tests at GUT

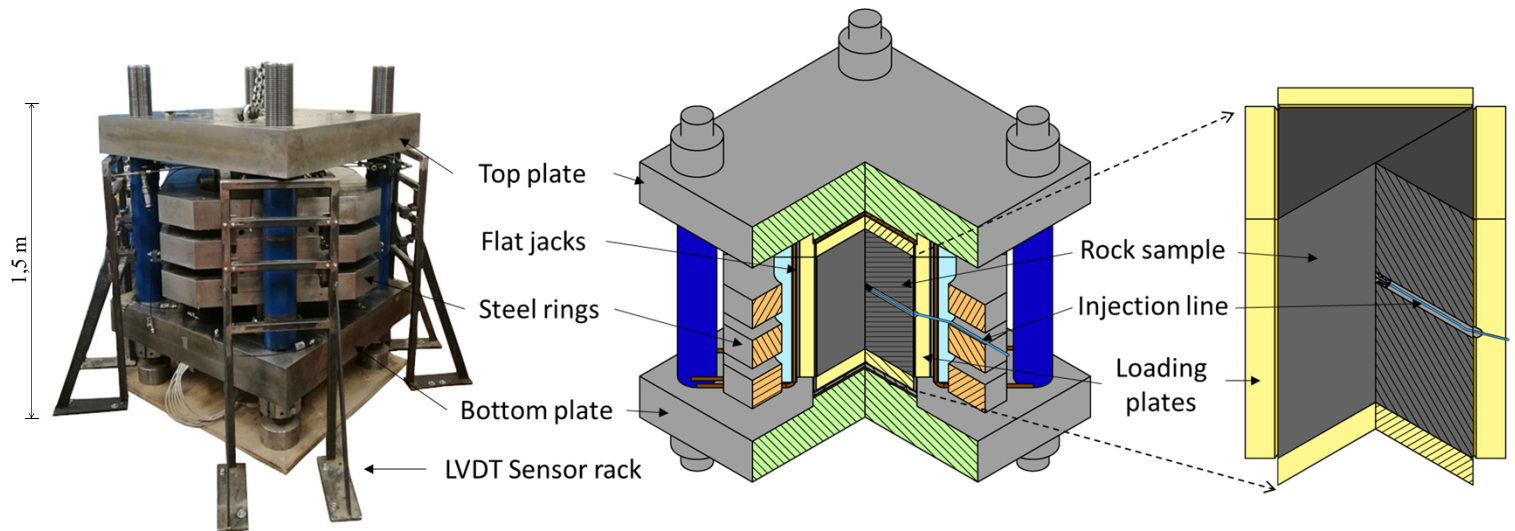
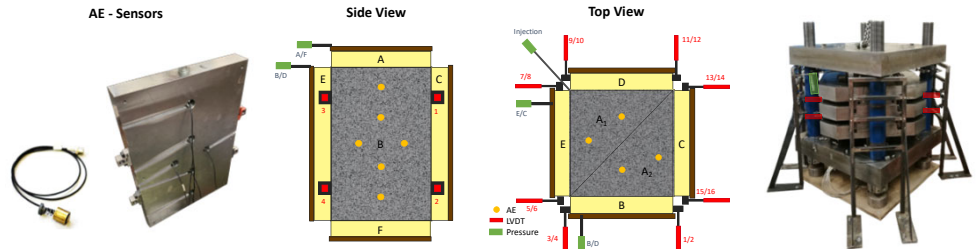
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- True anisotropic
- All principle stresses independent
- Large sample sizes (30 x 30 x 45 cm³)
- Up to 30 MPa
- Injection tests
- Fracture localisation



Measurements

Within the set up, different measurement tools are used to investigate the processes inside the sample. First of all the pressure in the flat jacks and of the injection line are monitored by using pressure sensors. Also the pumps connected to the flat jacks and the injection system monitor the pressure and volume change. To determine the compression and expansion and possible movements (shearing experiments) of the sample, 16 LVDTs are connected to the loading plates. Inside these loading plates 32 acoustic emission (AE) sensors are placed to be able to detect seismic micro events due to fracture opening or breaking asperities. To ensure a good coupling the sensors are pushed against the sample with small springs.



Geothermal application

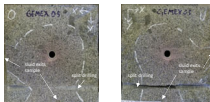


In a Europe-Mexico collaboration for development of Enhanced Geothermal Systems (EGS) and Superhot Geothermal Systems the set up has been used to perform hydraulic fracturing tests on Mexican rock samples. The results helped to estimate the potential for EGS of the sample area in Mexico.

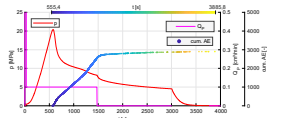
Samples from Mexico



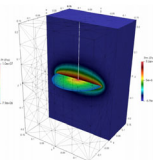
Created fracture plane



Results

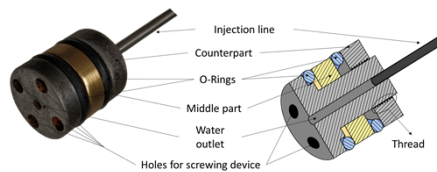


Num. Model

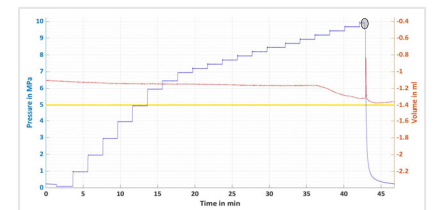


Figures and pictures: Stephan Düber

Injections



One sided packer for hydraulic shearing tests



Results of a HTPF test in the set up

The results shown on the right, represent the stepwise pressure increase of the injection pressure during a HTPF (hydraulic testing of pre-existing fractures) test (blue curve). The confining pressure chosen for this experiment is an isotropic pressure of 5 MPa (yellow curves). The results show the same behavior as known from field tests and can therefore determine the injection pressure needed to open fractures (black circle) under known conditions. The red curve shows the volume change in the flat jacks. This change is a proof of rock opening since the flat jacks are set to keep the same pressure and therefore need to change the volume when they are compressed from the expanding rock in the set up.

Publications

Deb, P., Salimzadeh, S., Vogler, D. et al. Verification of Coupled Hydraulic Fracturing Simulators Using Laboratory-Scale Experiments. *Rock Mech Rock Eng* 54, 2881–2902 (2021). <https://doi.org/10.1007/s00603-021-02425-y>

Siebert, P., Willbrand, K., Feinendegen, M., Ziegler, M., Clauser, C. (2015). Hydraulic fracturing of large igneous rock samples under triaxial compression. *ISMR Congress 2015 – Int'l Symposium on Rock Mechanics*. Canada

Düber, S., Deb, P., Clauser, C., Feinendegen, M. (2018, 2022). Report on the laboratory fracturing experiment, its boundary conditions, and its flow rates and fracture aperture versus time curves: Work package 6, D6.4. Report. RWTH Aachen University

Deb, P., Düber, S., Guarnieri Calo' Carducci, C. et al. Laboratory-scale hydraulic fracturing dataset for benchmarking of enhanced geothermal system simulation tools. *Sci Data* 7, 220 (2020). <https://doi.org/10.1038/s41597-020-0564-x>

Alternative Set-Up

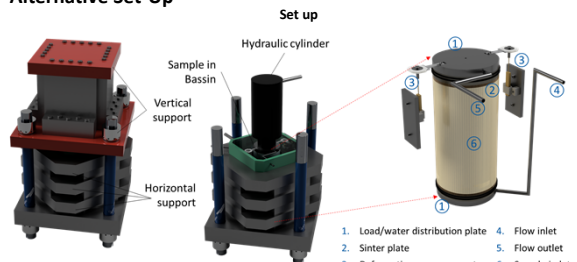


Figure and Picture: Sven F. Biebricher

Sample after testing



With some adjustments and additional parts the set up can also be used for compaction-induced permeability test. The system combines a classic triaxial cell for cylindrical samples of 45 cm height and 25 cm diameter with a flow rate test. The vertical load is applied by a hydraulic cylinder whereas the horizontal load is controlled by a water basin in which the sample is situated. The steel rings and bottom and top plate build the counterpart to the applied stresses.

