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Experimental study on effect of cyclic loading on deformation and AE characteristics of sandstone: Relevant for energy storage

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With the advent of climate change, a successful transition towards cleaner renewable energy calls for effective storage options. The utilization of underground energy storage (UES), such as depleted porous reservoirs, can help to overcome the balance between the production and demand of renewable energy. All underground energy storages, such as compressed air energy storage and hydrogen storage, are subjected to cyclic loading due to the sequence of production and injection operations. Thus, understanding the geomechanical behavior of porous reservoir rock under cyclic loading is essential to designing and operating underground storages. This study presents results from the 12 triaxial cyclic laboratory experiments performed on the Red Felser sandstone samples with identical porosity and dimensions. In total, eight triangular cycles were applied for each test, and six piezoelectric sensors recorded the acoustic emission (AE) activities during the experiments. The main objective is to explore how cyclic-related parameters (frequency and amplitude of cycles) affect the deformation mechanism and acoustic emission (AE) evolution in elastic and brittle stress regimes. Results regarding mechanical behavior showed that the total axial inelastic deformation increases by increasing the stress regime and amplitude of cycles. However, this parameter reduces by increasing the frequency of cycles. In addition, Young's modulus computed in the loading ramps of the cycles increased significantly from the first cycle to the second cycle for all the tests. For tests in the brittle regime, the larger the amplitude of cycles, the lower the increase in Young's modulus. The AE analysis showed that major events were recorded in the first cycle, and by increasing the number of cycles number of events, the maximum AE and average AE amplitude decreased. Our experimental results highlight that major mechanical changes and AE activities occur during the first cycle, and the stress regime influences the intensity of AE and mechanical changes. These outcomes can be used to study subsidence, fault reactivation, uplift, and other physical phenomena impacting the reservoir's storage capacity, which are influenced by cyclic sandstone deformation.

Participation

In-Person

References

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