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Investigating signatures of fracture evolution during the drying of clay-rich architected porous media

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Chemo-mechanical coupling in rock is known to result in the generation of cracks from volumetric changes in minerals caused by hydration, carbonation, oxidation, precipitation, and mineral dissolution. Alterations to the microstructures and changes in the chemical and mechanical properties of materials resulting from these processes can produce different types of acoustic activity as fracturing occurs. Here we examine the acoustic emissions (AE) in polymineralic synthetic rock samples during dehydration to distinguish the signals that arise from the movement of fluid through a rock, debonding of clay structures and, the development, nucleation, growth, and coalescence of fractures.

The synthetic rock was composed of Ordinary Portland Cement (OPC), Ottawa sand, and montmorillonite clays. Four types of samples were made which consisted of (1) OPC only, (2) OPC and Ottawa Sand (mortar), (3) mortar and Montmorillonite clay, and (4) embedded bodies of Montmorillonite clay in mortar. Samples with clay contained either a random distribution of clay (sample 3) or an architected structure (e.g. clay balls, thin sheet, etc.) (sample 4). Unbounded geo-architected samples were also monitored during drying as moisture was removed from the medium, with intermittent 3D X-Ray Microscopy (Zeiss Xradia 510 Versa) to visualize the state of the system. The resolution of the X-ray images was 40 micrometers pixel edge length. The AE were recorded using a Mistras - Physical Acoustics (PAC) AE recording system with a 10MHz sampling frequency, threshold amplitude of 27dB, and PAC F15-alpha sensors which were connected to the AE system via preamplifiers and affixed to the sample with hot gorilla glue.

During drying fractures developed in the clay-rich medium as a result of shrinkage, which coalesced into intricate fracture networks with distinct features. No fractures were observed in the samples with no clay and the same background medium. The peak frequencies of AE events generated during dehydration varied for the different samples. While the frequencies obtained for mortar samples occurred within a well-defined range (200-250 kHz.), a wider frequency band (50 –300 kHZ.) with lower frequencies was observed for the samples with distributed clay. The clay-rich specimens were found to produce a significantly large number of AE resulting from the development and growth of the microfracture networks. The AE data are supported by 3D X-Ray Microscopy data which shows the progression of dense fracture networks in the clay-rich samples during the period of dehydration.

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Time Block Preference

Time Block C (18:00-21:00 CET)

References

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