Sonic wave velocity and X-ray tomography images for partially saturated rocks. Evidence of microscopic fluid distribution effect on acoustic properties.

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Abstract Elastic waves velocities were measured in the laboratory on partially water-saturated limestones using large (1 meter length) and homogeneous resonant bars.

We used two different saturation methods: 1/ Drying, which is a drainage process. 2/ Spontaneous imbibition followed by progressive depressurization in order to increase water saturation (S_w).

In both cases, shear velocity (V_s) is not dependent on saturating method whereas compressional velocity (V_p) shows a clear dependence on it. This is observed at high levels of saturation where V_p exhibits a large increase with increasing S_w in the drying experiment. In contrast, V_p remains relatively constant with increasing S_w using the depressurization method.

To study the fluid distribution in the samples, we performed X-ray tomography at different values of S_w for both saturation methods. Images of depressurized samples show a great homogeneity of saturation at the millimetric scale at all saturations. In the drying experiment, X-ray images at high water saturation levels reveal heterogeneous saturation in the form of centimetric clusters.

From these experimental results, we conclude that the discrepancy between P-wave velocity during drainage and imbibition is related to clear differences in fluid repartition.