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Bubbles attenuate elastic waves at seismic frequencies

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The vertical migration of multiphase fluids in the crust can cause hazardous events such as eruptions, explosions, pollution and earthquakes. Although seismic tomography could potentially provide a detailed image of such fluid-saturated regions, the interpretation of the tomographic signals is often controversial and fails in providing a conclusive map of the subsurface saturation.

Seismic tomography should be improved considering seismic wave attenuation (1/Q) and the dispersive elastic moduli which allow accounting for the energy lost by the propagating elastic wave. In particular, in saturated media a significant portion of the energy carried by the propagating wave is dissipated by the wave-induced-fluid-flow and the wave-induced-gas-exsolution-dissolution (WIGED) mechanisms. The WIGED mechanism describes how a propagating wave modifies the thermodynamic equillibrium between different fluid phases causing the exsolution and the dissolution of the gas in the liquid, which in turn causes a significant frequency dependent 1/Q and moduli dispersion.

The WIGED theory was initially postulated for bubbly magmas but only recently was extended to bubbly water and experimentally demonstrated. Here we report these theory and laboratory experiments. Specifically, we present i) attenuation measurements performed by means of the Broad Band Attenuation Vessel on porous media saturated with water and different gases, and ii) numerical experiments validating the laboratory observations. Finally, we will extend the theory to fluids and to pressure-temperature conditions which are typical of phreatomagmatic and hydrocarbon domains and we will compare the propagation of seismic waves in bubble-free and bubble-bearing subsurface domains.

With the present contribution we extend the knowledge about attenuation in rocks which are saturated with multiphase fluid demonstrating that the WIGED mechanism could be extremely important to image subsurface gas plumes.