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The influence of gas bubble interfaces on the acoustic properties of partially saturated poroelastic media

Wednesday, 1 June 2022 14:50 (1h 10m)

The present work focuses on the impact of gas bubble dynamics on effective acoustic properties in partially saturated poroelastic media. It's key objective is the bubbles'interface mechanics on various length scales. The analysis starts from a single air bubble embedded in surrounding water. The classical Minnaert solution [Minnaert 1933] is covered by first taking into account the bulk compressibility. Turning the view towards smaller scales, we extend the description by surface tension and capillary effects [Leighton 1994, de Gennes 2003]. This does not only modify the bubbles'stiffness, it also introduces new oscillation modes. The length-scale analysis of the interface mechanics is eventually completed by incorporation of higher-order curvature effects [Helfrich 1986] such as the Tolman-length [Tolman 1949].

A macroscopic acoustic model is then derived for multiple gas bubbles in saturated porous media. The system thus contains a poroelastic frame (e.g., rock) [Biot 1956a,b], a continuous wetting phase (e.g., water) and a discontinuous non-wetting phase (e.g., air bubbles). Homogenization of the gas bubble ensemble yields a set of continuum equations that account for the individual bubbles'resonance frequencies and damping [Frehner 2010, Steeb 2012, Kurzeja 2014a,b]. Like in Biot's theory, the model accounts for two propagating P-waves and one shear wave, respectively. In addition to classical poroelasticity, the discrete (discontinuous) bubble oscillation contribute to the dispersive behaviour of the system.

The evolution of wave speed and intrinsic attenuation of waves is illustrated numerically for water-saturated rock with air bubbles of various size and distribution. Respective assumptions and limitations are summarized in this process to provide a quick reference for choosing the best compromise between a model's complexity and applicability. Opportunities and limitations of the predictions are discussed with respect to characterization. Open questions in terms of material parameters and simplifying assumptions will conclude the discussion and shall motivate subsequent investigations across disciplines.

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Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Online

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