A novel theory of elastic wave propagation in a multi-porous medium with multi-permeability

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Abstract

The work presents a theoretical development of elastic wave propagation in multi-porosity with multi-permeability porous media. We have developed a novel theory for elastic waves after single and double porosities. The theory features n distinct pore fluid phases and considers solid-fluid interactions as well as fluid-fluid interactions. The governing equation of motion for elastic wave propagation in complex multi-porous systems has been formulated using Lagrangian mechanics. The derivation of mass and dissipation coefficients in terms of known measurable parameters is a notable contribution of this research. In order to determine dissipation coefficients, Darcy's law of multi-phase systems was applied. The constitutive equation of an isotropic linear elastic multi-porous medium was also determined through the Gedanken experiments. In a subsequent step, equations of motion and dispersion for compressional and rotational waves within a multi-porous medium are developed. The dispersion equations for these waves in a specific case, like a triple porosity medium, are graphically represented and numerically explained. The validity of the theory is demonstrated by comparison with the existing theory of single porosity and double porosity. It is observed that the solid phase is associated with (n+1) compressional waves, whereas a fluid phase is associated with only one rotational wave. The Love wave and torsional wave, examples of surface waves have been studied in this medium. The concept of multi-porosity theory can contribute to a deeper understanding of wave behaviour in a porous medium.

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