The Maurice A. Biot Lecture

Department of Civil Engineering and Engineering Mechanics
Columbia University

Electrokinetic and Chemical Effects in Poromechanics Through the Solution of the Inclined Wellbore Problem

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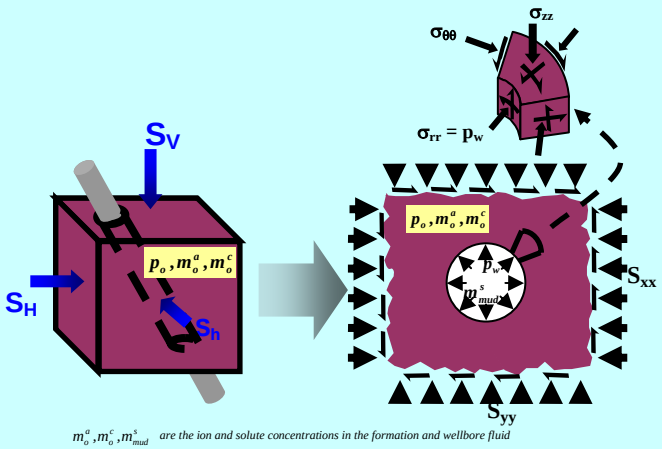
Mudd Building - Room 644

Abstract: Porochemoelectroelastic theoretical models have been proposed to describe the response of chemically active and charged saturated porous media, such as shales, clays and biomaterials, based on Biot theory (1941). However, due to the complexity of the associated coupled physical phenomena and mathematical formulations, there is a rarity of analytical solutions that are of practical applications to bioengineering or geoengineering. More often, analyses for such problems are performed numerically using finite element methods with little or no validation due to the lack of the analytical solutions. Attempts at these solutions have been limited to one-dimensional consolidation problems which are almost nonexistent in engineering practice or as valid bench marks for numerical validation. The analyses are, therefore, restricted and fall short in terms of the 3-D field and laboratory geometries.

The presentation will address the general porochemoelectroelastic formulation and solution of an inclined wellbore drilled in a shale formation subjected to a 3-D in-situ state of stress. The poromechanics solution to this geometry incorporates the coupled solid deformation and fluid/ion flows induced by the combined influences of mechanical pressure, and chemical and electrical gradients under isothermal conditions. The shale pore fluid is modeled as an electrolyte solution comprised of a solvent and one type of dissolved cation and anion. The porous solid matrix and/or pore solution could be ionized or electrically neutral but the whole fluid-saturated porous medium is electrically neutral. The analytical approach also integrates the use of the cation exchange capacity (CEC) commonly obtained from laboratory rock shale measurements. The results on stresses and pore pressure distributions due to the coupled chemico-electrical effects are illustrated in the vicinity of the inclined wellbore compared to the classical poroelastic solution.



m_o^a, m_o^c, m_{mud}^s are the ion and solute concentrations in the formation and wellbore fluid

Past Speakers

2007: Prof. John W. Rudnicki, Northwestern University
True Triaxial Testing and the Failure of Rocks
2006: Prof. Van C. Mow, Columbia University
The Role of Biomechanics in Cartilage Tissue Engineering
2005: Prof. James R. Rice, Harvard University
Biot Poromechanics in Earthquake and Faulting Phenomena
2004: Prof. Stephen C. Cowin, City University of New York
Strain Amplification in the Mechanosensory System in Bone

The Maurice A. Biot Lecture was established at Columbia University in remembrance of the late Prof. Maurice Anthony Biot and his renowned achievements as an engineer, physicist, and applied mathematician. Biot was a professor of mechanics at Columbia University in the period 1937-1945.

Columbia University - The Organizer for *Fourth Biot Conference* in 2009 (June 8-10)
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