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Advanced computation models for the evolution of fracture networks in shale during hydraulic fracturing

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Advances in horizontal drilling and multistage hydraulic fracturing have enabled extraction of oil and gas from nano-porous shales, paving the way for economically viable exploitation of an abundant resource. Even though the commercial development of this vast resource is a modern day reality, the industry faces significant challenges stemming from poor recovery rates and undesirable environmental consequences. Recovery rates can be improved, and the environmental impact can be minimized through a detailed quantitative understanding of the hydrogeomechanical interactions that occur during hydraulic fracturing. This presentation focuses on the development and application of novel numerical methods, developed specifically for discretely simulating the evolution of fracture networks in the subsurface under hydraulic fracturing conditions. We will also discuss recent activities related to proppant transport in the fracture network, and the connection between the hydrogeomechanics, which governs the evolution of the fracture network, and microseismicity, which is the primary diagnostic currently used to monitor hydraulic fracturing operations. We will describe the important features of the modeling approach, and discuss simulation results that provide new insights into the behavior of the rock during fracturing, and the sensitivity of this response to rock properties and hydraulic fracturing parameters like flow rate and pumping pressure.

Keywords: hydraulic fracturing; evolution of fracture networks; advanced computation models; hydrogeomechanics

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水力压裂页岩裂隙网络演进过程之高级计算模型

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水平钻井和多级水力压裂的进展已使纳米多孔页岩石油天然气的开采成为可能；这为丰富资源的经济可行开发的铺平了道路。即使这片广袤资源的商业开发是一个现代事实，此行业还是面临源自于低可采系数和不良环境后果的重大挑战。通过对水力压裂过程中发生的水地质力学（hydrogeomechanics）相互作用的详细定量理解，可以提高可采系数，并且尽量减少对环境的影响。本演讲专门针对离散模拟水力压裂条件下地下裂隙网络的演化，将重点放在新数值方法的开发应用。我们也将讨论最近对裂缝网络中的支撑剂输送过程的相关研究，以及水地质力学（主导裂缝网络的演进）与微震（目前用来监测水力压裂作业的主要诊断方法）之间的关联。我们将描述建模方法的一些重要特征，并讨论为岩石压裂过程行为提供新见解的模拟结果，以及这种反应依赖于岩石性质和水力压裂参数（如流量和泵送压力）的敏感性。

关键词：水力压裂；裂隙网络演进；高级计算模型；水地质力学