惠特比泥岩中的裂縫誘發滲透率

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摘要

頁岩母岩和控制潛能很大程度上由岩石中的連接孔隙網路決定，孔隙網路與自然存在或力學誘發的裂縫網路之間的連接共同決定了整體的滲透率。已知頁岩中的孔隙連通性非常差，因為大部分孔隙率存在於通過奈米級孔喉（pore throat）連接的亞微米大小的孔隙中。我們使用了許多不同的技術來研究英國早侏羅紀頁岩（惠特比泥岩）在完整和破裂條件下的滲透率。惠特比泥岩是一種富含黏土基質的岩石（50～70%），具有亞毫米級的不同礦物層和非常低的自然滲透率（10^{-19}～10^{-22} m^2），代表了歐洲存在的許多氣頁岩和冠岩（caprock）。該頁岩的人工裂縫在低圍壓（5 MPa）下的滲透率增加 2～5 個數量級。在高圍壓（30 MPa）下，滲透率變化相對層理傾向的測量方向更敏感。大部分滲透率增加是由裂縫滲透率所控制，裂縫滲透率對於裂縫對流體的耦合水化學力學反應很敏感。

關鍵字：惠特比泥岩、滲透率、裂縫、圍壓、層理傾向

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Article

Fracture-Induced Permeability in Whitby Mudstone

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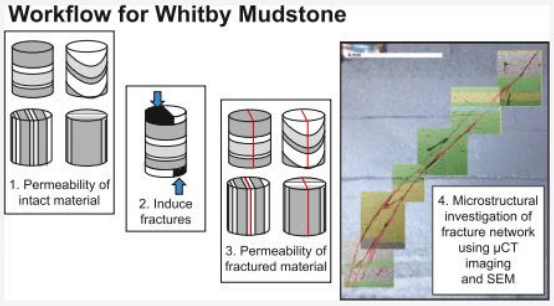
ABSTRACT: Shale host rock and containment potential are largely determined by the connected pore network in the rock, and the connection between the pore network and the naturally present or mechanically induced fracture network together determines the total bulk permeability. Pore connectivity in shales is poorly understood because most of the porosity is present in sub-micrometer-sized pores that are connected through nanometer-sized pore throats. We have used a number of different techniques to investigate the microstructure and permeability of Early Jurassic shales from the UK (Whitby Mudstone), under intact and fractured conditions. Whitby Mudstone is a clay matrix-rich rock (50−70%), with different mineralogical layers on the sub-millimeter scale and very low natural permeability (10^{-19} to 10^{-22} m^2), representative of many gas shales and caprocks present in Europe. Artificial fracturing of this shale increases its permeability by 2−5 orders of magnitude at low confining pressure (5 MPa). At high confining pressures (30 MPa), permeability changes were more sensitive to the measuring direction with respect to the bedding orientation. Given the distinct lack of well-defined damage zones, most of the permeability increase is controlled by fracture permeability, which is sensitive to the coupled hydro-chemo-mechanical response of the fractures to fluids.



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