壓溶作用對於天然裂隙之滲透率演變

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報告者：許鎧麟
指導教授：王士榮 老師
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摘要

在天然環境中，岩石受到力學以及化學作用時會使得其產生大小形狀不一的裂隙。由於位於地底之地層會因載重的緣故而壓實，當排列緊密的顆粒互相受力作用時會在高壓應力區發生溶解，在低壓應力區沉澱，造成孔隙率以及滲透率降低，此現象稱為壓溶作用(Pressure Solution)。本研究透過建置機制模型以描述石英岩裂隙在受到壓溶作用下裂隙開口寬隨時間的變化以及裂隙開口寬減少速率隨接觸面積比的變化，藉由將 Polak 等人所提供之實驗資料進行比較，因應數據結果不同處引入粗糙度因子 f_r 進行擬合。模擬結果顯示，起初裂隙開口寬隨時間的變化的模擬結果與實驗結果並不相符，當考慮了粗糙度因子的影響下，兩者的結果成功地吻合。然而，孔隙中的矽濃度在模擬結果與實驗結果始終不一致，初步判斷可能是因自由面的溶解所導致。

關鍵字: 岩石滲透率、壓溶作用、裂隙。

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Evolution of permeability in a natural fracture: Significant role of pressure solution

Hideaki Yasuhara and Derek Elsworth
Department of Energy and Geo-Environmental Engineering and Energy Institute, Pennsylvania State University, University Park, Pennsylvania, USA

Amir Polak
Department of Civil and Environmental Engineering, Technion-Israel Institute of Technology, Haifa, Israel

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[1] A mechanistic model is presented to describe closure of a fracture mediated by pressure solution; closure controls permeability reduction and incorporates the serial processes of dissolution at contacting asperities, interfacial diffusion, and precipitation at the free face of fractures. These processes progress over a representative contacting asperity and define compaction at the macroscopic level, together with evolving changes in solute concentration for arbitrarily open or closed systems for prescribed ranges of driving effective stresses, equilibrium fluid and rock temperatures, and fluid flow rates. Measured fracture surface profiles are applied to define simple relations between fracture wall contact area ratio and fracture aperture that represents the irreversible alteration of the fracture surface geometry as compaction proceeds. Comparisons with experimental measurements of aperture reduction conducted on a natural fracture in novaculite [*Polak et al.*, 2003] show good agreement if the unknown magnitude of microscopic asperity contact area is increased over the nominal fracture contact area. Predictions of silica concentration slightly underestimate the experimental results even for elevated microscopic contact areas and may result from the unaccounted contribution of free face dissolution. For the modest temperatures (20–150°C) and short duration (900 hours) of the test, pressure solution is demonstrated to be the dominant mechanism contributing to both compaction and permeability reduction, despite net dissolution and removal of mineral mass. Pressure solution results in an 80% reduction in fracture aperture from 12 μm, in contrast to a ~10 nm contribution by precipitation, even for the case of a closed system. For the considered dissolution-dominated system, fracture closure rates are shown to scale roughly linearly with stress increase and exponentially with temperature increase, taking between days and decades for closure to reach completion. *INDEX TERMS:* 5104 Physical Properties of Rocks: Fracture and flow; 5120 Physical Properties of Rocks: Plasticity, diffusion, and creep; 5139 Physical Properties of Rocks: Transport properties; 8045 Structural Geology: Role of fluids; 8160 Tectonophysics: Rheology—general; *KEYWORDS:* permeability, pressure solution, fracture

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