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岩石蠕变过程的不可逆热力学分析

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摘要: 岩石蠕变产生的内部结构变化和损伤导致其过程呈现非线性特性, 为此, 采用不可逆热力学方法, 在Biot粘弹性发展方程的基础上引入能反映材料内部结构变化和损伤的结构参数按其 Helmholtz 自由能和发展方程的影响, 推导出岩石非线性蠕变一般发展方程, 并研究了单轴蠕变时岩石的非线性蠕变行为. 分析结果表明: 岩石蠕变时存在某一极限应力值, 当轴向应力低于此值时, 蠕变将以递减的速率趋近于某一常数; 当轴向应力高于此值时, 蠕变开始以递减的速率增加, 随后, 当蠕变量达到一定数值时, 蠕变率以递增的速率进入加速段, 从而解释了岩石蠕变中的现象.

关键词: 岩石; 蠕变; 非线性; 不可逆热力学; 发展方程

Analysis of rock creep by means of irreversible thermodynamics

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Abstract: The nonlinear process of rock creep results from the change and damage of the internal configuration and structure of the rock material. On the basis of Biot's evolution equation about the viscoelasticity, the paper introduces the so-called structure parameters reflecting the change and damage of the internal configuration and structure of the rock material to indicate their influence on Helmholtz free energy and the evolution equation, and then derives a new evolution equation which is applied to the nonlinear creep of the rock by means of irreversible thermodynamics. As a specific application of the new evolution equation, the paper studies the nonlinear creep behavior of rock under uniaxial load and gains the analytic results, that is, there is a limit stress value when rock creeps. If the applied longitudinal stress is below the value, the creep strain approaches an asymptotic value at a decreasing strain rate, and when it is over the value, the creep strain initially increases at a decreasing strain rate and then it increases at an accelerating rate. These results explain some practical creep phenomena of the rock such as the stable creep, the unstable creep and the long strength etc.

Key words: rock; creep; nonlinear; irreversible thermodynamics; evolution equation

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