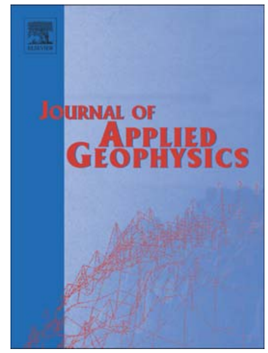
Accepted Manuscript



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S.T. Nguyen, M.-H. Vu, M.N. Vu, A.M. Tang

PII: S0926-9851(17)30312-9
DOI: doi:10.1016/j.jappgeo.2017.03.018
Reference: APPGEO 3250

To appear in: *Journal of Applied Geophysics*

Received date: 18 January 2016
Revised date: 6 January 2017
Accepted date: 29 March 2017

Modeling of heat flow and effective thermal conductivity of fractured media: analytical and numerical methods

S.T. Nguyen[(a,b,)], M.-H. Vu[(b)], M.N. Vu[(b)] and A.M. Tang[(c)]*

(a) Euro-Engineering, Pau, France

(b) R&D Center, Duy Tan University, Da Nang, Viet Nam

(c) Université Paris-Est, Laboratoire Navier (ENPC-IFSTTAR-CNRS) 77455 Marne la Vallée, France

(*) Corresponding author: stuan.nguyen@gmail.com

Abstract

The present work aims at modeling the thermal conductivity of fractured materials using homogenization-based analytical and pattern-based numerical methods. These materials are considered as a network of cracks distributed inside a solid matrix. Heat flow through such media is perturbed by the crack system. The problem of heat flow across a single crack is firstly investigated. The classical Eshelby's solution, extended for the calculation of the conductivity of a mixture of an ellipsoidal inclusion in an infinite homogeneous matrix, gives an analytical solution of temperature discontinuity across a non-conducting penny-shape crack. This solution is then validated by the numerical simulation based on the finite elements method. The numerical simulation allows analyzing the effect of crack conductivity. The problem of a single crack is then extended to media containing multiple cracks. Analytical estimations for effective thermal conductivity, that take into account the interaction between cracks and their spatial distribution, are developed for the case of non-conducting cracks. Pattern-based numerical method is then employed for both cases non-conducting and conducting cracks. In the case of non-conducting cracks, numerical and analytical methods, both account for the spatial distribution of the cracks, fit perfectly. In the case of conducting cracks, the numerical analyzing of crack conductivity effect shows that highly conducting cracks weakly affect heat flow, and the effective thermal conductivity of fractured media.