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ROCK FRACTURES AND FLUID FLOW

Contemporary Understanding and Applications

Committee on Fracture Characterization and Fluid Flow
U.S. National Committee for Rock Mechanics

Geotechnical Board
Board on Energy and Environmental Systems
Commission on Engineering and Technical Systems
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1996

7241

NOV-25-96 WED 15:57 DANIEL B STEPHENS FAX NO. 5058228877 P. 02

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

This report was prepared with the support of the U.S. Department of Energy (DOE), Grant Nos. DE-AC01-89DP48070, DE-FG22-91BC14837, DE-FG05-91ER40668, and DE-FG08-92NV11227 and Contract No. DE-FG01-92CE31021, and the Nuclear Regulatory Commission (NRC), Grant Nos. NRC-G-04-91-089 and NRC-04-91-089. Any opinions, findings, conclusions, and recommendations expressed herein are those of the authors and do not necessarily reflect the views of DOE or NRC.

SPONSORS: This project was sponsored by the following federal agencies: Department of Defense (Air Force Office of Scientific Research, Defense Nuclear Agency); Department of Energy (Office of Energy Research, Office of Environmental Restoration and Waste Management, Office of Fossil Energy, Geothermal Division of the Office of Conservation and Renewable Energy, Office of the Superconducting Super Collider, Yucca Mountain Site Characterization Project Office); Department of the Interior (Bureau of Land Management, Bureau of Mines, Bureau of Reclamation); Environmental Protection Agency (Robert S. Kerr Environmental Research Laboratory, Environmental Monitoring Systems Laboratory); Federal Transit Administration; National Science Foundation; and the Nuclear Regulatory Commission. In addition, the Gas Research Institute and Dowell-Schlumberger, Inc., provided support for this project. The National Research Council, through its Day Fund, extended financial support for the publication and dissemination of the report.

Library of Congress Cataloging-in-Publication Data

Rock fractures and fluid flow : contemporary understanding and applications / Committee on Fracture Characterization and Fluid Flow . . . [et al.].
p. cm.
Includes bibliographical references and index.
ISBN 0-309-04996-2 (alk. paper)
1. Rocks—Fracture. 2. Rock mechanics. 3. Fluid dynamics. 4. Hydrogeology. I. National Research Council (U.S.). Committee on Fracture Characterization and Fluid Flow.
TA706.R525 1996 96-14613
624.1'5132—dc20 CIP

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The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. William A. Wulf is interim president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. William A. Wulf are chairman and interim vice-chairman, respectively, of the National Research Council.

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Field-Scale Flow and Transport Models

Previous chapters have addressed fracture geometry, physical and geomechanical properties of single fractures, fracture detection, and the interpretation of hydraulic and tracer tests. All of these elements must be integrated when develop- [illegible] mathematical model to represent fluid flow and solute transport in fractured media. The process [illegible] this chapter is mathematical models and the model-building process. The process [illegible] a hydrogeological model crosses discipline boundaries, demanding the coming [illegible] of geologists, geophysicists, and hydrologists.

The hydraulic properties of rock masses are likely to [illegible] even within a single lithological unit if the rock is fractured. The main difficulty in modeling fluid flow in fractured rock is to describe this heterogeneity. Flow paths are controlled by the geometry of fractures and their open void spaces. Fracture conductance is dependent, in part, on the distribution of fracture fillings and the state of stress. Flow paths may be erratic and highly localized. Local measurements of geometric and hydraulic properties cannot easily be interpolated between measurement points. In contrast, granular porous media, although also heterogeneous, commonly exhibit smoothly varying flow fields that are amenable to treatment as equivalent continuua. Model studies of fluid flow and solute transport in fractured media that do not address heterogeneity may be doomed to failure from the outset.

The formulation of a hydrogeological simulation model is an iterative process. It begins with the development of a conceptual model describing the main features of the system and proceeds through sequential steps of data collection and model synthesis to update and refine the approximations embodied in the