

NOV 15 1990

MEMORANDUM FOR: Ronald L. Ballard, Chief
Geosciences & Systems Performance Branch
Division of High-Level Waste Management, NMSS

Melvin Silberberg, Chief
Waste Management Branch
Division of Engineering, RES

FROM: Rex G. Wescott, Senior Hydrologist
Hydrologic-Transport Section
Geosciences & Systems Performance Branch
Division of High-Level Waste Management, NMSS

Timothy McCartin
Waste Management Branch
Division of Engineering, RES

Thomas Nicholson
Waste Management Branch
Division of Engineering, RES

SUBJECT: TRIP REPORT: TOUGH WORKSHOP, LAWRENCE BERKELEY
LABORATORY; BERKELEY, CA; SEPTEMBER 13-14, 1990

On September 13 and 14, 1990, Lawrence Berkeley Laboratory, Earth Sciences Division, sponsored a workshop for users of the TOUGH Computer Program for numerical simulation of multiphase fluid and heat transfer. The workshop was hosted by Karsten Pruess, the major developer of TOUGH and was attended by a significant number of international TOUGH users. Timothy McCartin of NRC presented a paper entitled "Two Phase Flow and Solute Transport in a Tuff Drill Core", and Thomas Nicholson of NRC was chairperson for a session on "Code Enhancements". Ron Green of CNWRA presented a paper entitled "Use of TOUGH Computer Code to Simulate a Laboratory-Scale Experiment".

Presentations at the workshop were categorized into one of 6 subtopics:

- Unsaturated Zone Hydrology
- Environmental Issues
- Geothermal Reservoir Studies
- Code Enhancement (2 sessions)
- Two Phase Flow Experiments
- Performance Assessment

Some significant observations from the presentations were:

- 1) Most of the international presentations were in the area of geothermal reservoir modeling and involved design or enhancement of operating geothermal fields.

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- 2) TOUGH is being used for transport of gases other than water vapor and for transport of volatile organic compounds in soil.
- 3) There appears to be wide spread interest in improving or adding to some of the modules in the code while keeping the overall framework the same.
- 4) All the users appear to be satisfied that the program was adequately simulating the physics contained in the model. Enhancements were generally of the form of adding additional complexity to the model (e.g. vapor pressure lowering) to more accurately simulate the particular two-phase flow problem being simulated.

We believe that the significance of these observations is that TOUGH has already built a reputation as an accurate and reliable computer program that is more likely to be improved and built upon than to be superseded by a new computer model.

Abstracts of the presentations made at the workshop are attached.

RS
Rex G. Wescott

TS
Timothy McCartin

TS
Thomas Nicholson

DISTRIBUTION:

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DChery, HLGP
TNicholson, RES
MSilberberg, RES

OFC : HLGP *AW* : HLGP *DB* RES *GM* : RES *TS*

NAME: RWescott/ga : DBrooks : TMcartin : TNicholson

Date: 11/8/90 : 1/90 : 11/8/90 : 11/8/90

PROGRAM
TOUGH WORKSHOP
September 13-14, 1990

Thursday, September 13, 1990

A.M.

7:30 Registration: Building 70A, Room 3377

8:30 Welcome and Introduction

9:00 **Session 1: Unsaturated Zone Hydrology**

Two-Phase Nonisothermal Hydrologic Transport Simulations at the Apache Leap Tuff Site
M. Shaikh, T.-C. J. Yeh, and T. C. Rasmussen, University of Arizona, Tucson, Arizona

Modeling Hydrothermal Flow in Variably Saturated, Fractured, Welded Tuff During the Prototype Engineered Barrier System Field Test of the Yucca Mountain Project

T. A. Buscheck and J. J. Nitao, Lawrence Livermore National Laboratory, Livermore, California

Unsaturated Zone Moisture and Vapor Movement Induced by Temperature Variations in Asphalt Barrier Field Lysimeters

D. J. Holford and M. J. Fayer, Pacific Northwest Laboratory, Richland, Washington

10:30 Coffee Break

11:00 **Session 2: Environmental Issues**

Gaseous Transport of Volatile Organics in Porous Media: Comparison of Mathematical Models
J. M. Farr, Levine-Fricke, Inc., Emeryville, California

STMVOC: A Numerical Simulator for Three Phase Contaminant Transport in Nonisothermal Systems

R. W. Falta and K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

P.M.

12:00 Lunch Break

1:30 **Session 3: Geothermal Reservoir Studies**

A Simple Model of a Vapour-Dominated Geothermal Reservoir

M. J. O'Sullivan, The University of Auckland, New Zealand

Injection of Cold Water and Air into a Two-Phase Volcanic Hydrothermal System

M. C. Suarez and A. M. Manon, Comision Federal de Electricidad, Morelia, Mexico

Water-CO₂ Version of MULKOM: A Tool for Studying the Origin and Trends of CO₂ in Geothermal Reservoirs

C. Calore and G. Gianelli, Istituto Internazionale per le Ricerche Geotermiche, Pisa, Italy, and K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

Case Study Using Faster TOUGH

T. Okabe, K. Osato, and S. Takasugi, Geothermal Energy Research and Development Co., Tokyo, Japan

3:30 Coffee Break

4:00 Session 4: Code Enhancements I

Incorporation into TOUGH of an Analytical Source/Sink Term for Fracture/Matrix Flow
R. W. Zimmerman and G. S. Bodvarsson, Lawrence Berkeley Laboratory, Berkeley, California

On Verification, Use, and Treatment of Non-Newtonian Behavior of the Numerical Simulator MULKOM-GWF
Y. S. Wu, HydroGeoLogic, Inc., Herndon, Virginia, and K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

Overview of TOUGH2, a General-Purpose Numerical Simulator for Multiphase Nonisothermal Flows
K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

5:30 Adjourn

7:00 Banquet

Friday, September 14, 1990

A.M.

8:30 Session 5: Two-Phase Flow Experiments

Modeling Studies of Gas Movement and Moisture Migration at Yucca Mountain, Nevada
Y. W. Tsang and K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

Phasic Pressure Difference Effects in Two-Phase Flow for Dissolved Gas Exsolution
S. W. Webb, Sandia National Laboratories, Albuquerque, New Mexico, and J. C. Chen, Lehigh University, Bethlehem, Pennsylvania

Verification of TOUGH2 Against a Semianalytical Solution for Transient Two-Phase Fluid and Heat Flow in Porous Media
C. Doughty and K. Pruess, Lawrence Berkeley Laboratory, Berkeley, California

10:00 Coffee Break

10:30 Session 6: Performance Assessment

Use of TOUGH Computer Code to Simulate a Laboratory-Scale Experiment
R. T. Green and R. H. Martin, Southwest Research Institute, San Antonio, Texas

Two-Phase Flow and Solute Transport Simulations in a Tuff Drillcore
T. McCartin, R. Codell, T. Nicholson, Nuclear Regulatory Commission, Washington, DC, and T. Rasmussen, University of Arizona, Tucson, Arizona

Interpretation of Hydraulic Tests in a Two-Phase Flow System Using TOUGH
S. Finsterle, Swiss Federal Institute of Technology, Zurich, Switzerland, and S. Mishra, Intera, Inc., Austin, Texas

P.M.

12:00 Lunch Break

1:30 Session 7: Code Enhancements II

Making MULKOM/TOUGH Faster and Easier to Use
D. Bullivant, The University of Auckland, New Zealand

Increasing the Efficiency of the TOUGH Code for Running Large-Scale Problems in Nuclear Waste Isolation
J. J. Nitao, Lawrence Livermore National Laboratory, Livermore, California

Speeding up TOUGH
S. White, Department of Scientific and Industrial Research, Wellington, New Zealand

3:00 Coffee Break

3:30 Session 8: Open Discussion: Whither TOUGH?

5:30 Adjourn