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Geomechanics Investigations in Support of the Large Block Test at Fran Ridge, Nye County, Nevada

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Lawrence Livermore National Laboratory

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Geomechanics Investigations in Support of the Large Block Test at Fran Ridge, Nye County, Nevada.

Stephen C. Blair, Patricia Berge, Edward Kansa, Wunan Lin, and Jeff Roberts

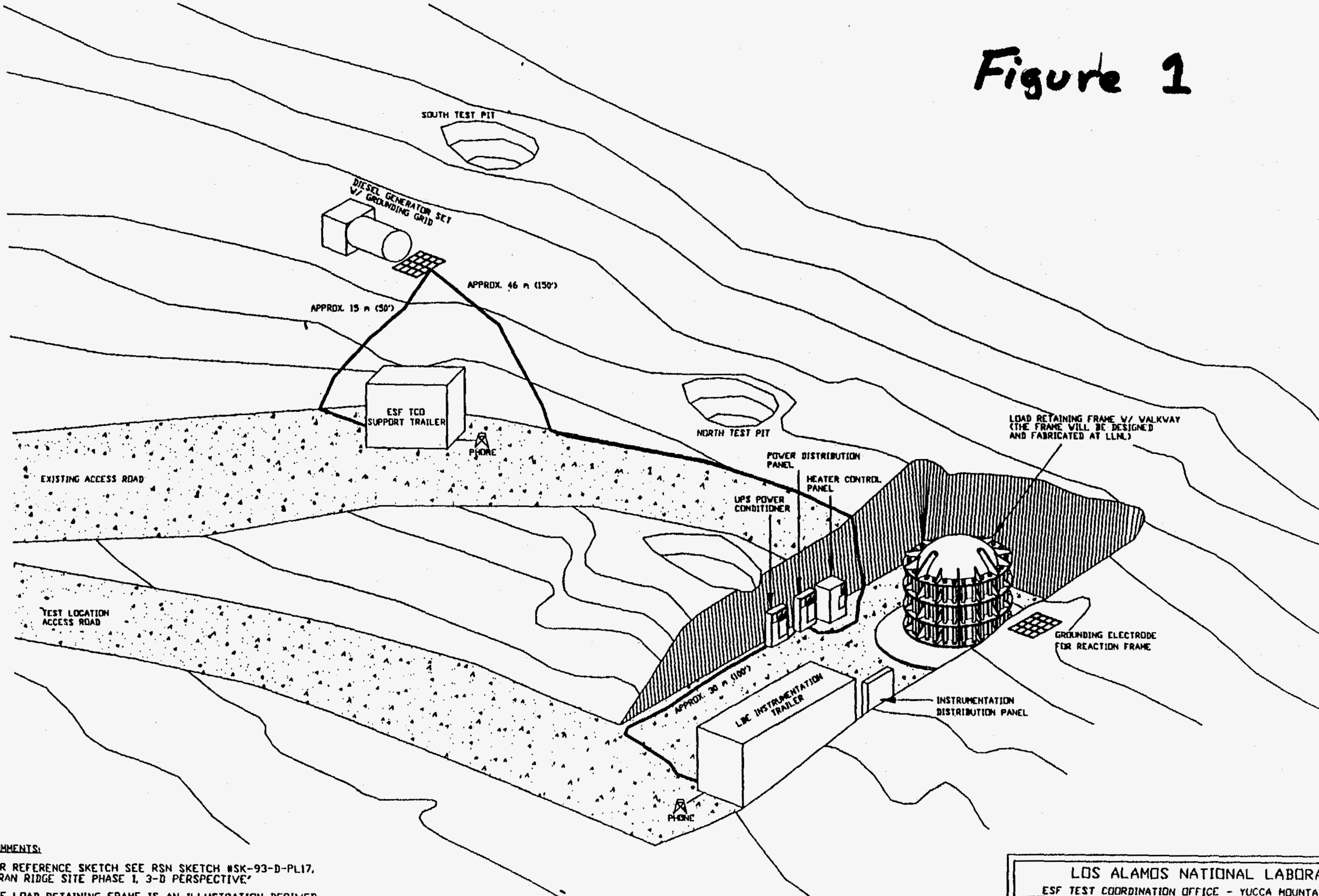
Lawrence Livermore National Laboratory.

Introduction

The Yucca Mountain Site Characterization Project is investigating the Topopah Spring Tuff at Yucca Mountain, Nevada for its suitability as a host rock for the disposal of high level nuclear wastes. The Lawrence Livermore National Laboratory is planning a large block test (LBT) to investigate coupled thermal-mechanical-hydrological and geochemical processes that may occur in the repository near-field environment. The LBT will be performed on an excavated block of Topopah Spring Tuff with approximate dimensions of 3 m x 3 m x 4.5 m and will provide information at an intermediate scale that will help evaluate existing models for repository performance. To simulate underground stress conditions, a horizontal stress of about 4 MPa will be applied to the four sides of the block and a vertical stress of similar magnitude will be applied to the top surface. The stresses will be retained by a frame 4.9 m in dia. and 6 m high. The frame assembly will be anchored to the outcrop with rock bolts. While these stress levels do not simulate the exact stress conditions expected in the potential repository horizon, they do provide known boundary conditions that are similar to conditions expected in the potential repository. The block will also be loaded thermally by establishing a thermal gradient along its vertical axis. This will be accomplished by heating a horizontal cross section located 1.5 m up from the base of the block. The LBT is sketched in Figure 1. Additional detail regarding the large block test has been presented in a paper by Lin et al.[1] .

7 PAGES

Figure 1



COMMENTS:

FOR REFERENCE SKETCH SEE RSN SKETCH #SK-93-D-PL17, "FRAN RIDGE SITE PHASE 1, 3-D PERSPECTIVE"

THE LOAD RETAINING FRAME IS AN ILLUSTRATION DERIVED FROM FIGURE 4 OF SIP-NF-02, REV.0 AND IS NOT INTENDED TO BE USED FOR DESIGN.

TEST CONSTRUCTION ACTIVITIES WILL DISTURB THE MINIMUM AMOUNT OF SURFACE AREA REQUIRED FOR THE EFFICIENT CONSTRUCTION OF THE FACILITY.

VERTICAL CONTROL IS BASED ON BLM DATUM MEAN SEA LEVEL (MSL) 1928. HORIZONTAL CONTROL IS BASED ON NEVADA CENTRAL STATE STATE PLANE COORDINATE SYSTEM.

SURFACE CONTOURS FURNISHED BY RSN YMP SURVEY.

CONTOURS AND ARRANGEMENT IS APPROXIMATED FROM RSN SKETCH #SK-93-D-PL17.

LEGEND:

SAW CUT
HIDDEN SURFACE
FINAL BLOCK SURFACE
CONTOUR LINES

LOS ALAMOS NATIONAL LABORATORY				
ESF TEST COORDINATION OFFICE - YUCCA MOUNTAIN PROJECT				
PROJECT: ENGINEERED BARRIER - LARGE BLOCK TESTS: PHASE II PROPOSED LAYOUT SCENARIO				
CAD FILE: FINALP2.DWG	AUTOCAD R12	SIZE A	SCALE NOTED	REVISION A1
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NOTES: ADMINISTRATIVE/ILLUSTRATIVE USE ONLY			PLOT DATE: 4/25/94	

PRELIMINARY

In support of the LBT a series of geomechanical studies has been planned to investigate and characterize the fundamental geomechanical behavior of the fractured rock system to the mechanical and thermal loads and to provide mechanical data to support the hydrological and geochemical investigations also planned for the LBT. The geomechanical investigations include in situ measurement of stress, displacement, elastic velocity and acoustic emissions to be done on the block itself, a series of laboratory tests on smaller blocks quarried from the site, and a series of modeling studies of the thermomechanical response of the large block.

The LBT offers a unique opportunity to determine the deformational response for a fractured rock mass at an intermediate scale and under conditions where the three-dimensional geometry of the natural fracture system is known and the boundary conditions are well controlled. It also offers opportunity for comparison of static and dynamic moduli of a fractured rock mass as a function of applied stress and temperature conditions and as a function of time.

Description of Work to Date

Geomechanical studies on the large block are focussed on 1) the overall rock mass deformation vs. applied stress, temperature and time, 2) the decomposition of the deformation into components due to deformation of fractures and matrix material, and 3) the effect of temperature and related movement of fluids and geochemical effects on deformation, rock damage, and static and dynamic properties. Geomechanics measurements planned for the LBT include static deformation at a series of scales using a new optical borehole extensometer as well as strain gauge techniques, monitoring of acoustic emission, and a series of acoustic tomography measurements. Instrumentation will be installed in vertical and horizontal boreholes and on the surface of the block. All holes will be cored and fractures will be mapped to provide additional constraints on the block structure. A prototype of the optical extensometer is currently under construction, and results from preliminary tests of the new instrument will be reported. The surfaces of the large block are also being mapped and Figure 2 shows the fracture map of the top surface of the block with all dead end cracks removed.

Laboratory tests on smaller blocks will be used to determine deformation of the host rock at the one-half meter scale as well as static and dynamic mechanical properties of individual fractures. These tests will also be used to characterize the mechanical, hydrological, and geochemical behavior at conditions of elevated temperature and pressure, and to evaluate and/or develop diagnostic techniques to be used during the LBT. This includes evaluation of the transducer emplacement technology, evaluation of the optical extensometer mentioned above, testing of monitoring systems, and testing of transducers and transducer mounting techniques for the electrical resistivity tomography measurements.

A series of modeling studies is also underway. The purpose of the modeling is to aid in the experimental design of the Large Block Test, and to evaluate various thermal and material models, and numerical methods for predicting the block response by comparing observed with estimated response. We are analyzing the geomechanical response using both a time-dependent finite difference method, and a discrete element method. The finite difference code being used (FLAC) is capable of treating both mechanical and thermally induced stresses and deformations. It is a two-dimensional code in which materials are represented by arbitrarily-shaped, quadrilateral zones and is based on a Lagrangian scheme and is capable of using several built-in material models, including the ubiquitous joint model that has previously been used to simulate thermal-mechanical behavior in tuff. Predicted temperature and horizontal displacement fields after forty-one days of heating are shown in Figures 3 and 4 respectively. These were predicted using a purely elastic constitutive model. Simulations using other constitutive models are underway and will be reported at the meeting.

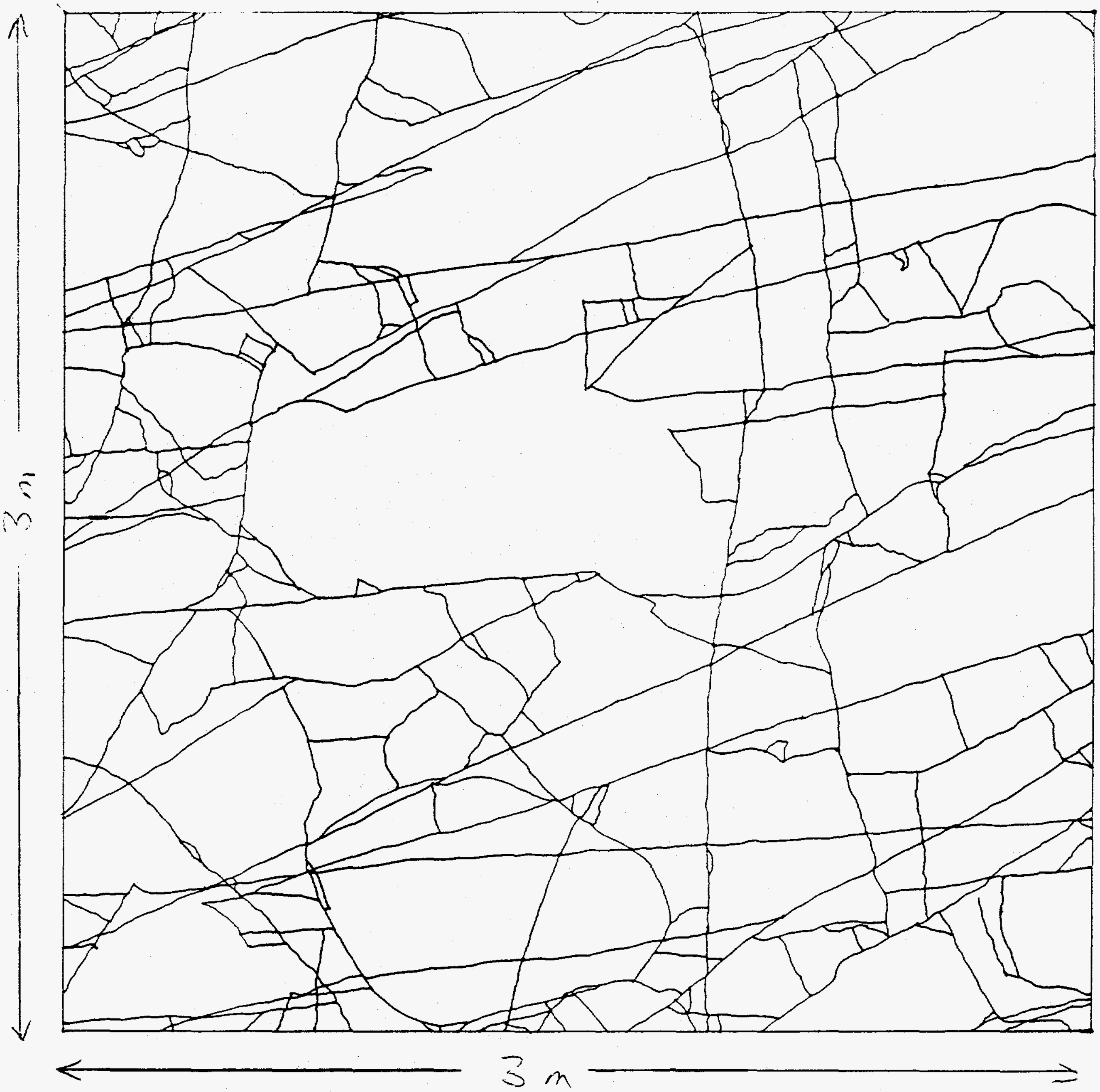

Figure 2

← Z

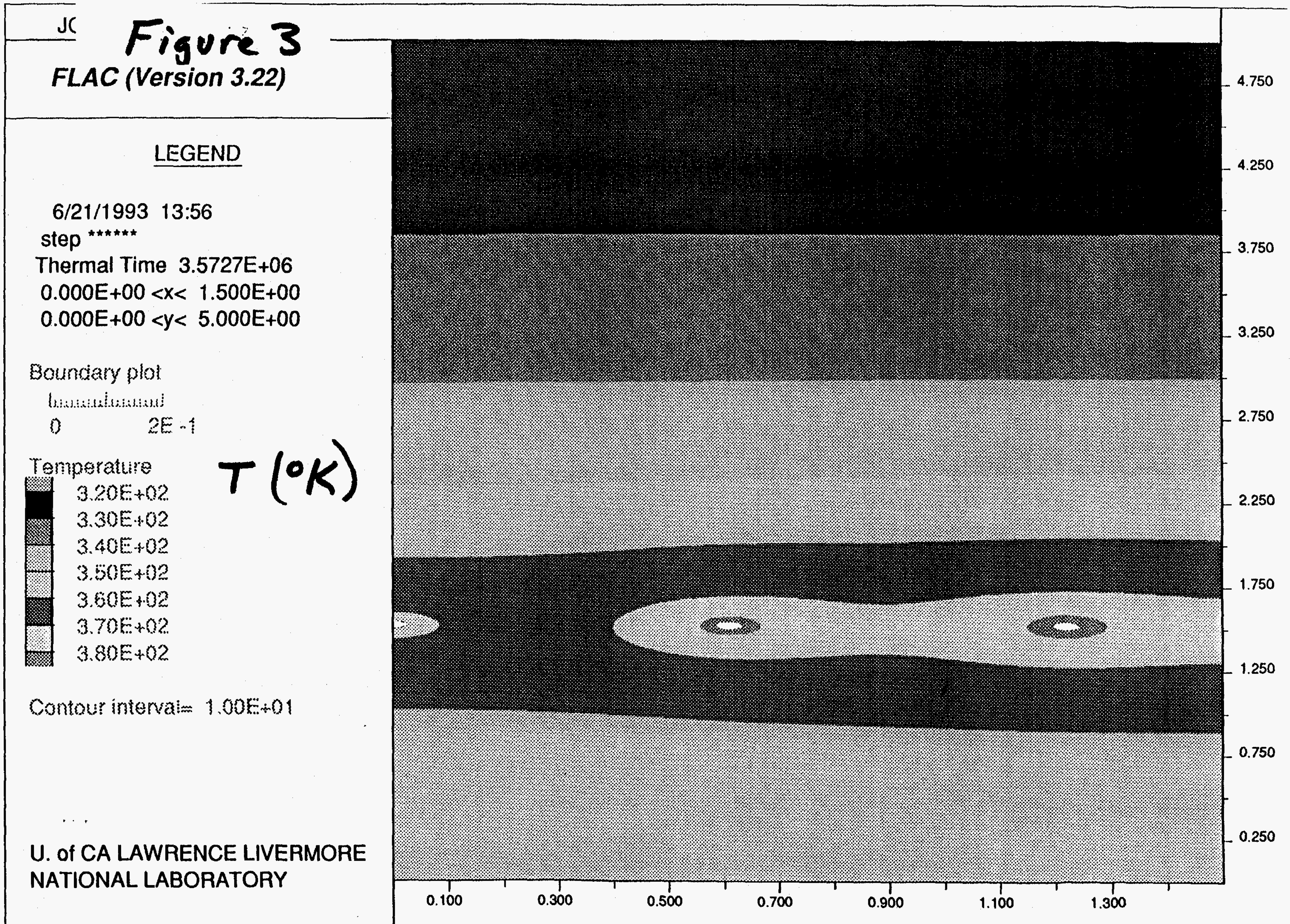
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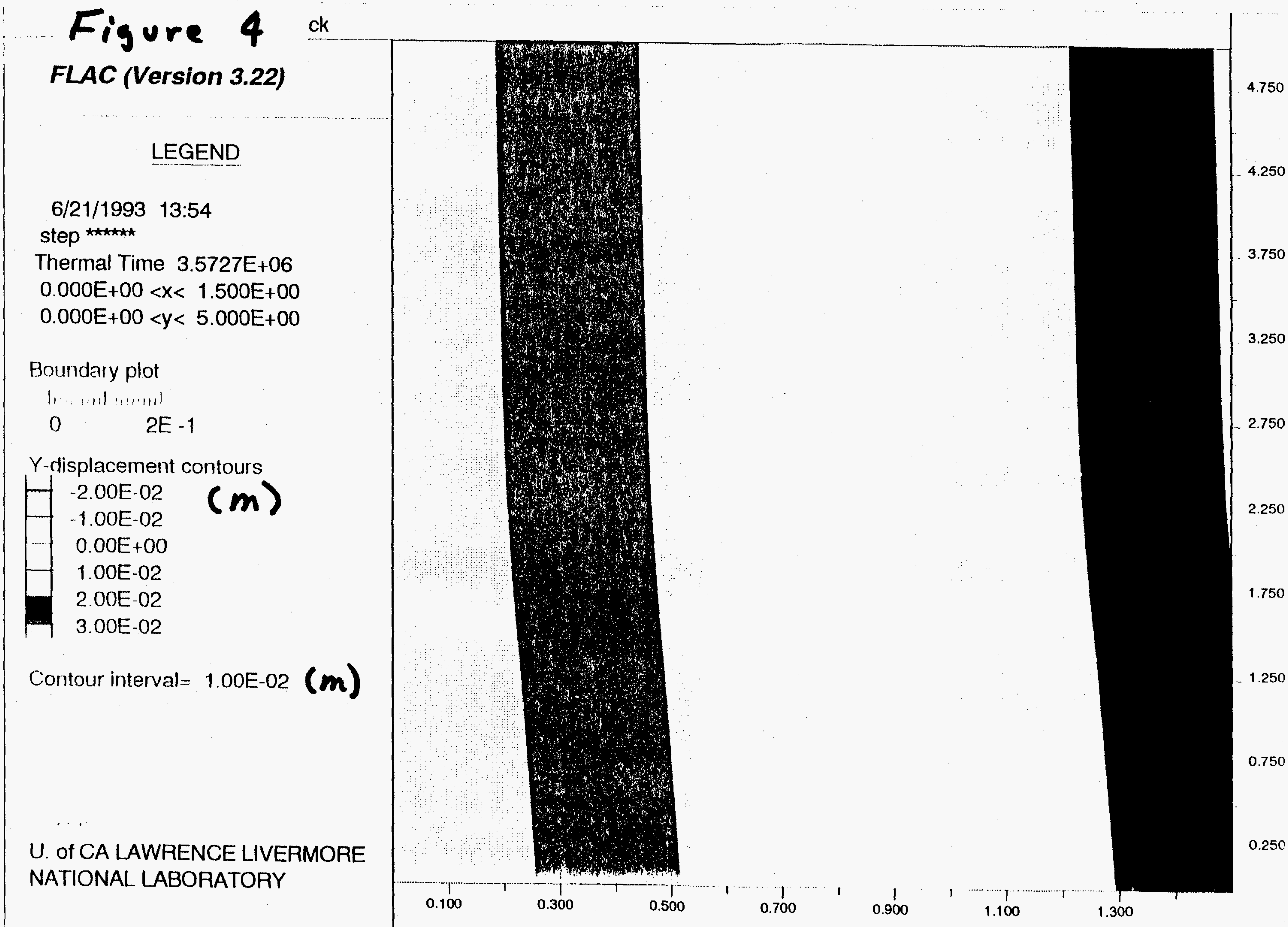
Figure 3

Figure 4



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The geomechanical behavior of the block is also being analyzed using the discrete element method in which fractures are modeled discretely, and analysis of the mechanical behavior at test conditions of the blocks and fracture system shown in Figure 2 is currently underway using the discontinuous displacement analysis (DDA) approach discussed by Shi and Goodman[2]. Preliminary results of this two-dimensional analysis will be reported.

Summary

A series of geomechanics measurements and modeling studies have been planned in support of the large block test. These include field measurements of static and dynamic properties on the block, laboratory measurements on smaller blocks excavated from the outcrop to establish properties at a scale of a few tens of centimeters, and equivalent continuum and discrete element modeling studies of the block behavior. Excavation of the block is now underway along with model simulations. Laboratory tests are scheduled to start in September, 1994, and field tests on the large block are set to begin in the spring of 1995.

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References

1. Lin, W., D. G. Wilder, J. A. Blink, S. C. Blair, T. A. Buscheck, D. A. Chesnut, W. E. Glassley, and J. J. Roberts, "The Testing of Thermal-Mechanical-Hydrological-Chemical Processes Using a Large Block," submitted to *1994 International High-Level Radioactive Waste Management Conf.*, May 22–26, 1994, Las Vegas, NV.

2. Shi, G., and R. E. Goodman (1988), "Discontinuous Deformation Analysis—A New Method for Computing Stress, Strain and Sliding of the Block Systems," in *Proc. 29th U.S. Symposium on Rock Mechanics*, Minneapolis, MN, (Balkema, Rotterdam).