U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: SCENARIO DEVELOPMENT, VOLCANIC PROCESSES AND MATHMATICAL MODELS

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DIRECT EFFECTS OF IGNEOUS ACTIVITY AT THE REPOSITORY:

SCENARIO DEVELOPMENT, VOLCANIC PROCESSES, AND MATHEMATICAL MODELS.

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SUMMARY:

1. Introduction

2. Subaerial (eruption) processes

   Hydrovolcanism
   Strombolian eruption
   Lava flow
   Example eruption modeling

3. Subsurface processes

   Dike emplacement
   Thermal effects (unsaturated zone)
   Long term effects
   Example subsurface calculation

4. Plans

1. INTRODUCTION

Purpose of volcanic effects studies - to assess the amount of waste that can be transported to accessible environment as a result of volcanism.

Interfaces with other parts of Volcanism Task by providing information on probability of exceeding release limits (P_3).

Interfaces with Performance Assessment and Site Suitability by providing "effects" for risk calculations.

General Approach - base conclusions as much as possible on field observations, using theoretical modeling when necessary.

Level of accuracy for effects studies is partially determined by values of other terms in conditional probability.

2. SUBAERIAL ERUPTION PROCESSES

Scenarios - based on observed Quaternary & Pliocene volcanic features in Death Valley-Pancake Range volcanic field.

Small volume basaltic centers produced by three eruption mechanisms:

(1) Hydrovolcanic explosion
(2) Scoria cone (Strombolian/Hawaiian) eruption
(3) Small-volume lava flows

Problem - If a (conservatively) typical basaltic center formed in the repository block, how much waste could be erupted onto the surface by each of the three eruption mechanisms, and how will this waste be dispersed?

2. SUBAERIAL ERUPTION PROCESSES (cont.)

Hydrovolcanic explosion - DV-PR basaltic centers commonly record hydrovolcanic components to eruptions.

Driven by explosive interaction between groundwater and rising magma.

Explosivity depends on mass ratio of *accessible* groundwater to hot magma.

Can be violent, ejecting large quantities of lithic material derived from intrusion walls.

Approaches to understanding effects on repository:

(1) field measurements of hydrovolcanic eruptive components (volume of ejected wall rock per eruption, grain size distribution, dispersal pattern, depth of wall rock erosion). Analog studies.

(2) theoretical considerations of depth of magma-water interaction, effects on surrounding rocks.

2. SUBAERIAL ERUPTION PROCESSES (cont.)

Strombolian/Hawaiian eruption - The main scoria cone construct of DV-PR basaltic centers is due to this type of activity.

Steady to pulsing fountaining of magma clots (fire fountaining).

Driven mainly by expansion of magmatic volatiles.

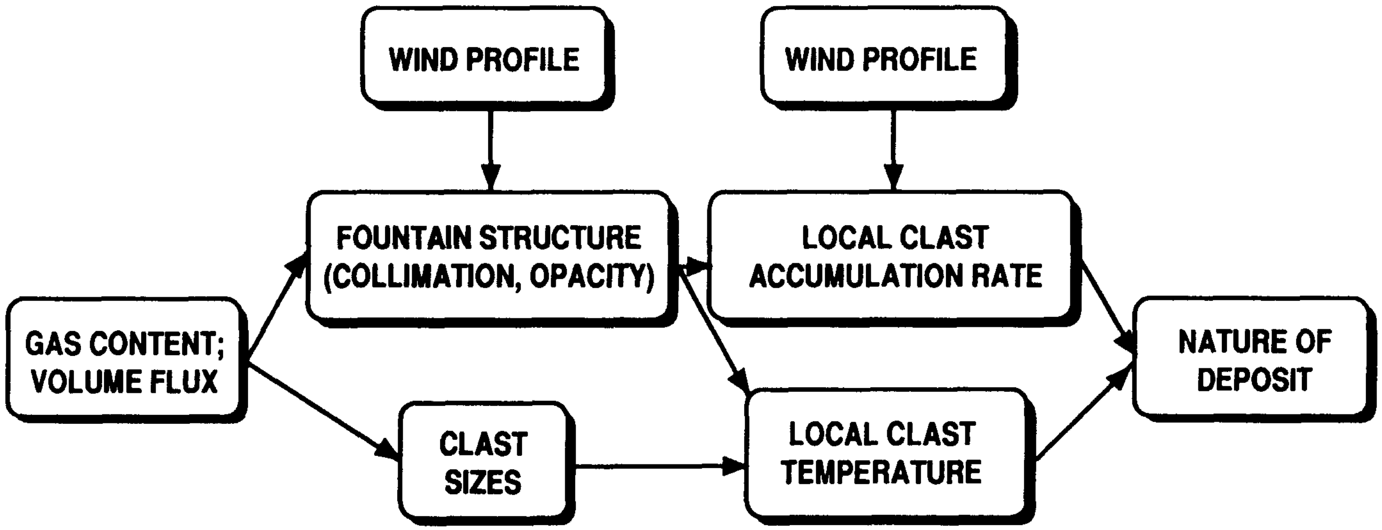
Typically >1% lithic fragments.

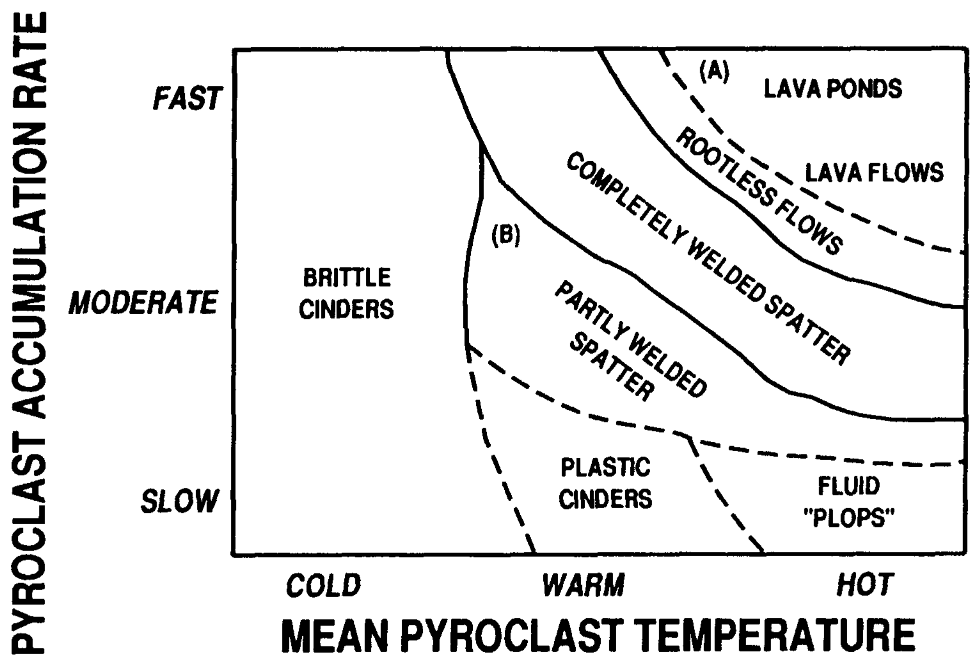
Approaches to understanding effects on repository:

(1) field measurements of eruptive products and their facies. Analog studies to determine conduit erosion processes.

(2) theoretical modeling to determine eruption dynamics, volatile content, depth of fragmentation.

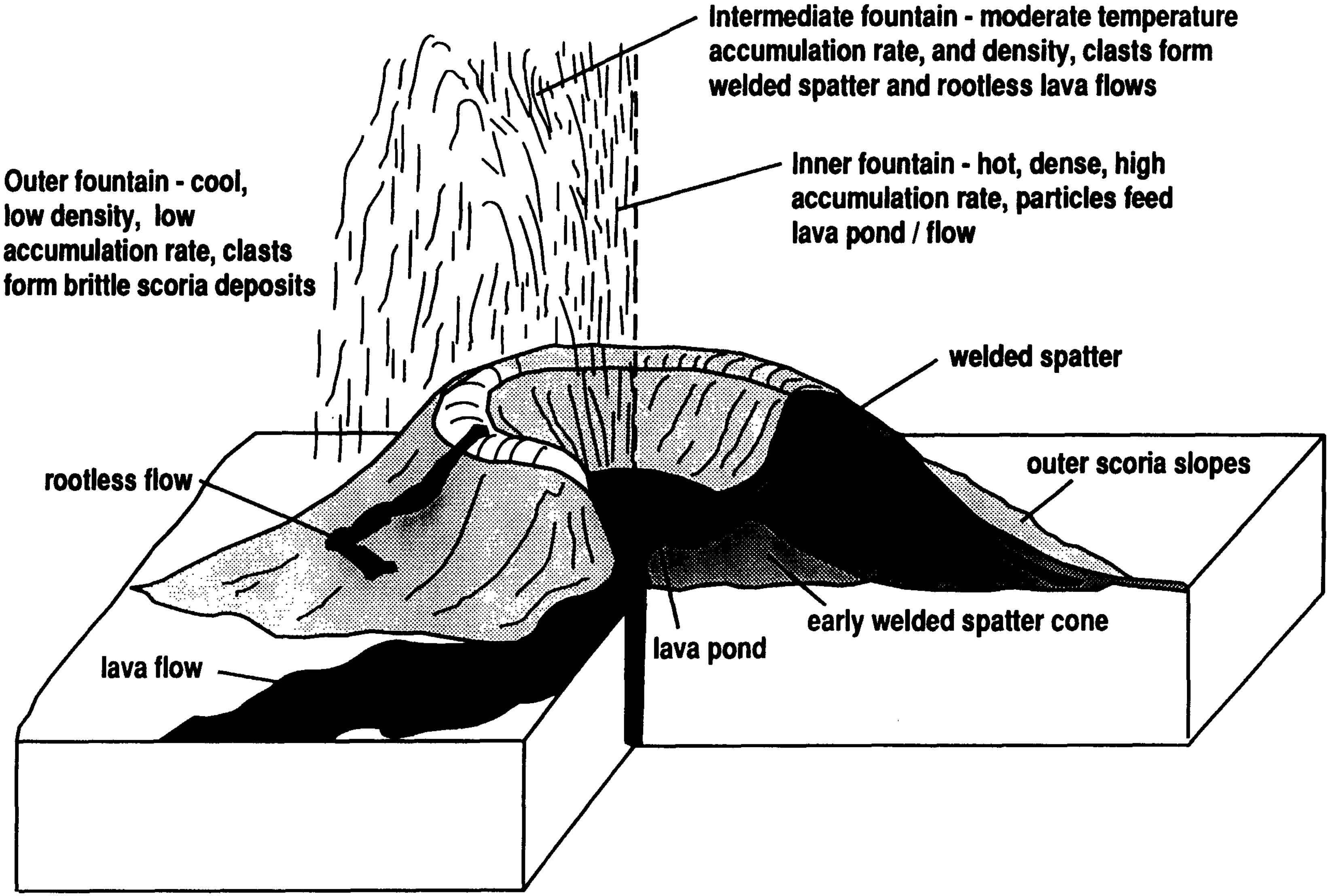
ERUPTION MODEL



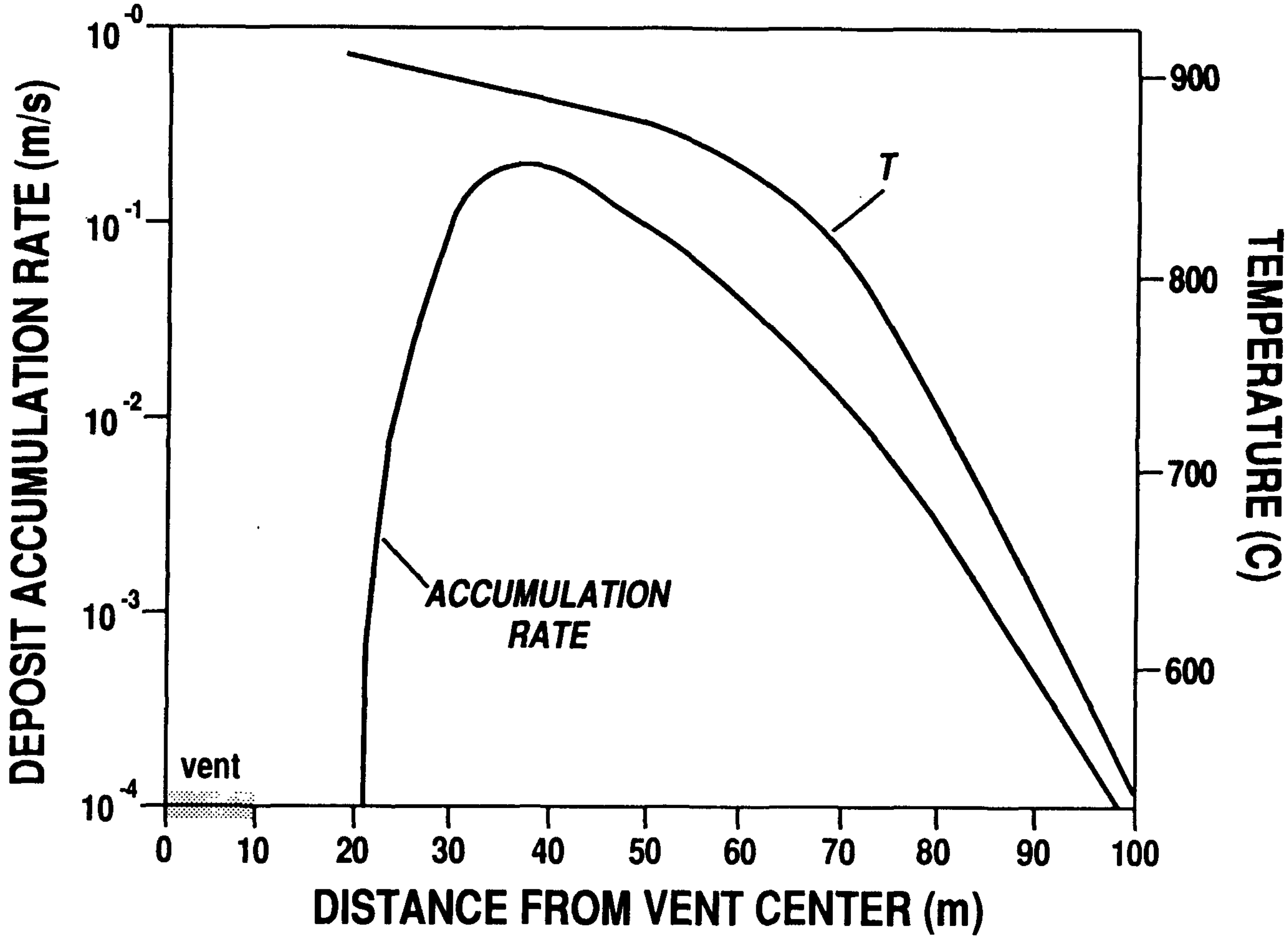


BASALT ERUPTION MODEL 1989

(ADAPTED FROM HEAD AND WILSON)



Hawaiian / Strombolian Fire Fountain Structure and Facies (adapted from Head and Wilson, 1989)



EXIT CONDITIONS —
- velocity = 33 m/s
- pressure = 0.1 MPa
- temperature = 1200 K
- volatiles → 0.06% H_2O
- effusion rate = 3×10^6 kg/s

ERUPTION CONTROLS CONE GROWTH

3. SUBSURFACE EFFECTS

BASALTIC DIKE INTERSECTING REPOSITORY

Three-stage approach:

A. Analyze the intrusive event.

- primarily the magnitude, duration, and extent of the thermal pulse. Use observations from DV-PR for constraints.

B. Effects on waste packages.

- volatiles released from magma
- thermodynamic effects
- effects due to locally-altered hydrology

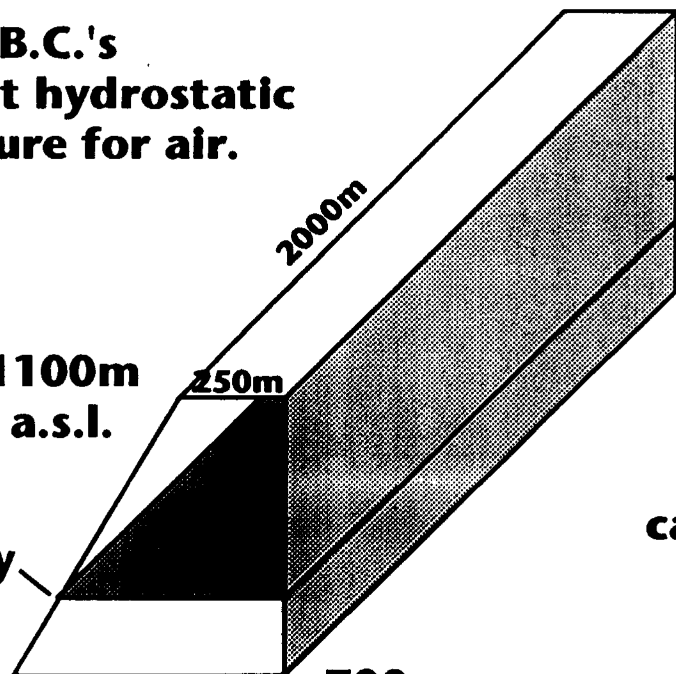
C. Radionuclide transport.

- gas-phase transport of volatiles due to thermal convection
- liquid phase transport in altered hydrologic flow field.

DIKE EMPACEMENT EFFECTS

3-D

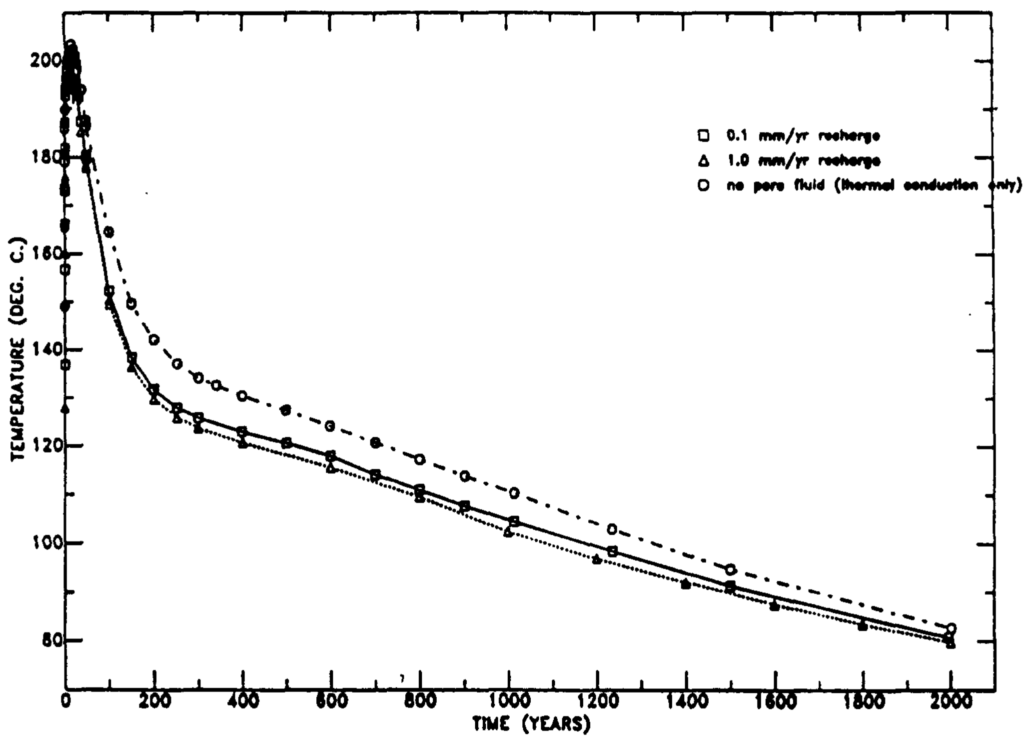
-Calculate full air convection in a 3-D block of Yucca Mountain.



Repository heat source calculated for 5000 years, then dike emplaced.

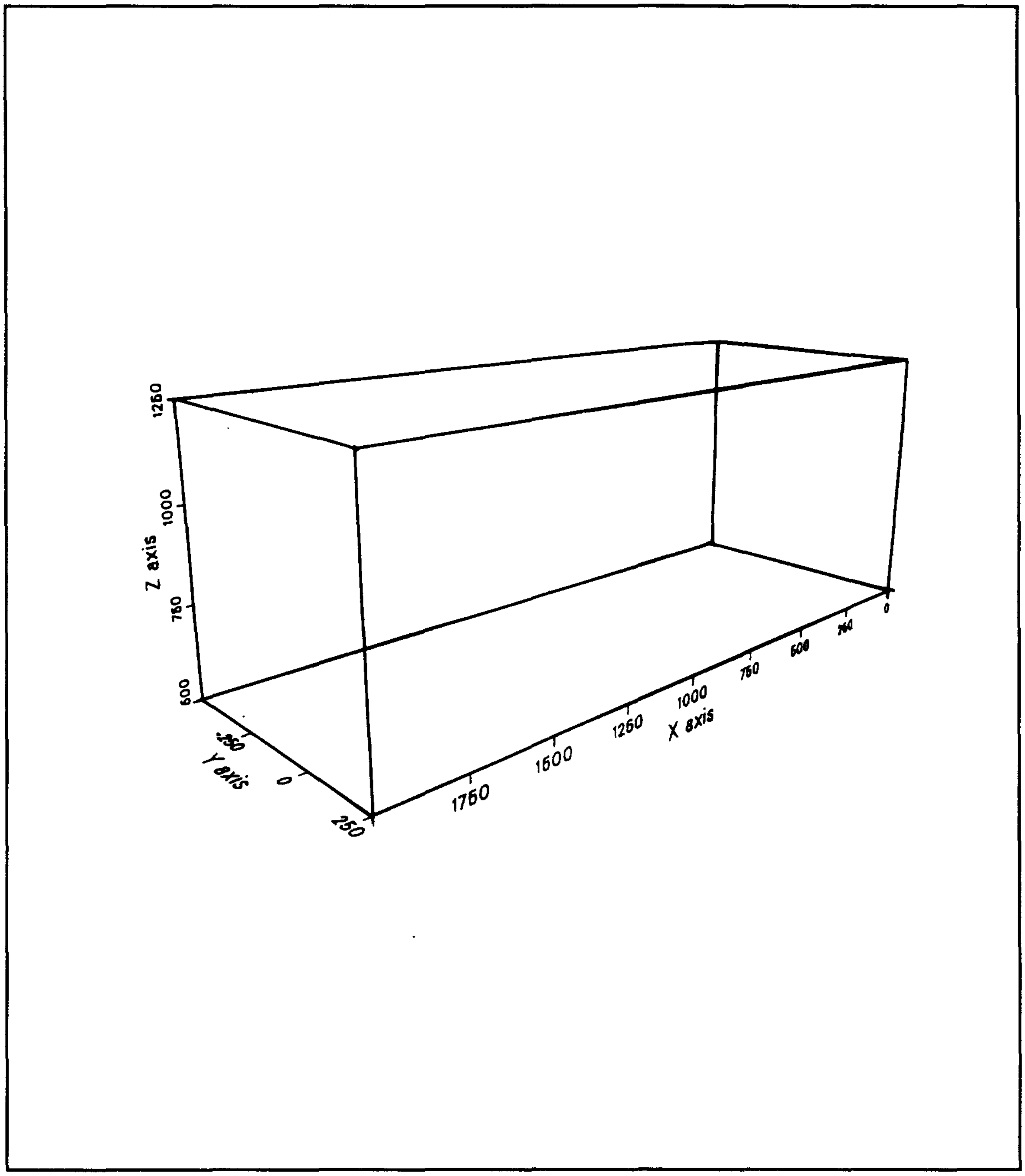
WASTE PACKAGE HEAT SOURCE TERM

Comparison of Temperature at Waste Package
0.1 mm/yr, 1.0 mm/yr, and no pore fluid



(from Nitao, J.J., 1988, *Numerical modeling of the thermal and hydrological environment around a nuclear waste package using the equivalent continuum approximation: horizontal emplacement.* LLNL Report UCID-21444)

THREE-DIMENSIONAL MODEL



3. SUBSURFACE EFFECTS (cont.)

ISSUES THAT MAY NEED TO BE ADDRESSED FOR BASALTIC DIKE INTERSECTING REPOSITORY

A. INTRUSIVE EVENT

- What types of fractures/joints can form due to dike propagation through Yucca Mtn. tuffs?
- What determines dike vs. sill in Yucca Mountain conditions?

B. EFFECTS ON WASTE PACKAGE

- What is the character of metamorphism around dikes in Yucca Mountain-like tuffs?
- What types of volatiles can be expected, how much can their concentrations vary?
- How do geologically inferred cooling histories compare with calculated histories?

C. LONG-TERM HYDROLOGIC EFFECTS

- Can analog examples be found that show whether dikes/sills form hydrologic barriers or fast paths?
- Are we using realistic hydrologic properties for the intrusion?

FUTURE WORK

4. PLANS

- Study conduit erosion as a function of depth for scoria cone and hyrdovolcanic eruptions, using analog volcanoes where basement stratigraphy is well constrained.

- Combine numerical modeling and facies analysis to characterize eruption dynamics.

- Continue subsurface modeling in collaboration with performance assessment studies.