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

PRESENTATION TO THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

SUBJECT: PACE-90 OVERVIEW AND PROBLEM DEFINITION

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ARLINGTON, VIRGINIA
MAY 20-21, 1991

PACE-90 OVERVIEW AND PROBLEM DEFINITION

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May 20, 1991

COVE-2A and HYDROCOIN

- Precursors to PACE
- Code verification exercises
- 5-layer geologic model
- Calculated groundwater flow in the unsaturated zone

COVE-2A

- 1-D only
- YMP Performance Assessment codes used: TRACR, NORIA, LLUVIA, TRUST, TOSPAC

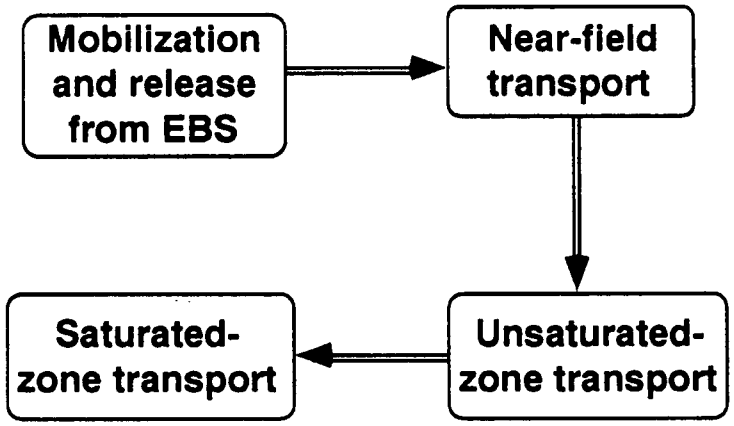
HYDROCOIN

- 1-D and 2-D
- Explored some parameter sensitivities
  - infiltration
  - anisotropy
- YMP Performance Assessment codes used: NORIA, LLUVIA

Important Issues Identified

- Parameters with greatest sensitivity were those that induce transition from matrix- to fracture-dominated flow
- 1-D calculations not adequately realistic
- Transport must be incorporated

Total System Analysis Requirements



Origin of PACE-90

- Analysis teams organized in PACE-89 continued with PACE-90
- Limited suite of analyses formulated by PIs to fit short deadline
- Major departure from prior analyses was reinterpretation of existing site data

Participants in PACE-90

- Lawrence Berkeley Laboratory (LBL)
- Lawrence Livermore National Laboratory (LLNL)
- Los Alamos National Laboratory (LANL)
- Pacific Northwest Laboratory (PNL)
- Sandia National Laboratories (SNL)
- SAIC
- University of California, Berkeley (UCB)
- Yucca Mountain Project Office (YMP)

Objectives of PACE-90

- Demonstrate participants' computational capabilities
- Identify critical elements and processes
- Demonstrate ability to work interactively
- Perform elements of a total-system analysis

PACE-90 Was Not:

- A code benchmarking exercise
- Intended to answer conceptual model questions
- Intended to represent calculational "reality" at Yucca Mountain

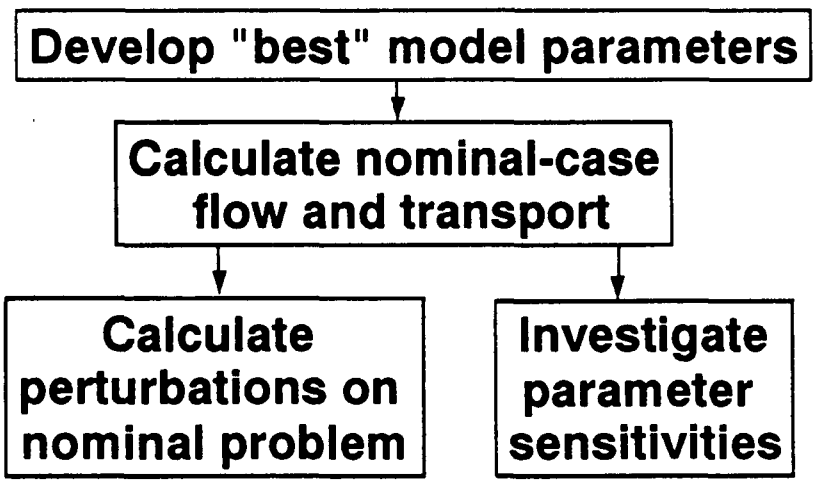
Elements of PACE-90

1) "Nominal configuration" problem calculation

2) "Disturbed" case definitions

3) Sensitivity studies

Analysis Approach



Definition of "Nominal Configuration"

- PACE-90 calculations represent only one component of "expected" conditions
- The analyses reflect some realizations using:
  - variably saturated sequence of tuffs
  - limited suite of nuclides
  - groundwater transport

Comparison to Prior Analyses

- Similarity
  - flow problem
- Differences
  - new hydrostratigraphy
  - separate gas-phase analysis
  - radionuclide transport incorporated

Nominal-Case Problem Development

- All calculations began with the same input data and boundary conditions
- Subsequent problem specification and data interpretation were open

Fixed Problem Inputs

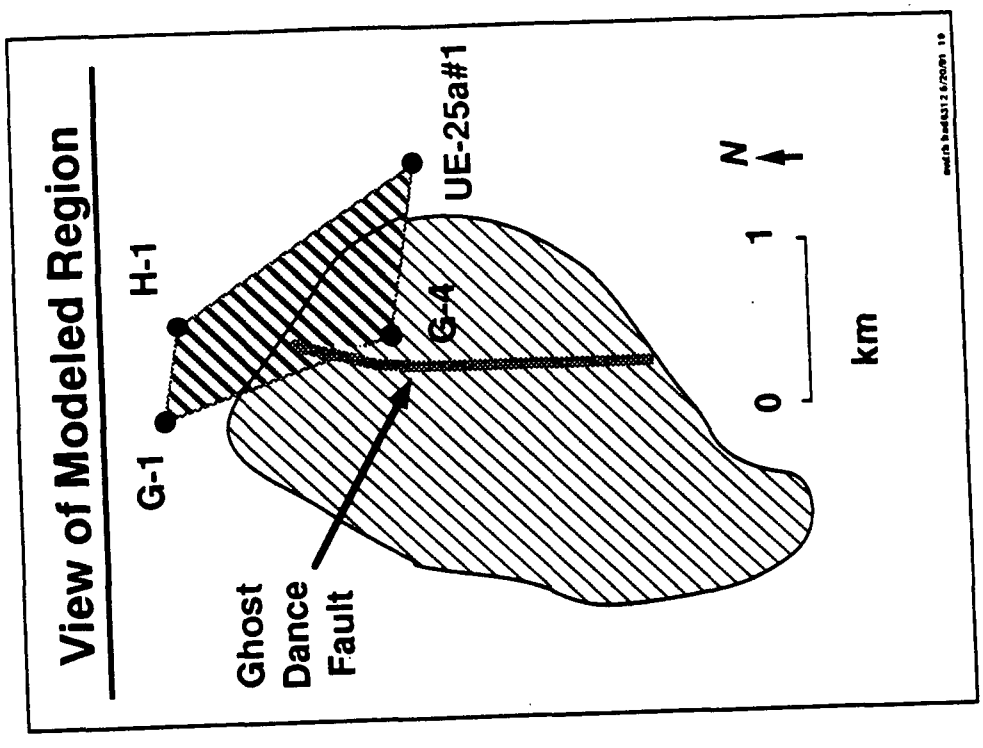
- Unsaturated (and locally saturated) materials
- 4 long-lived nuclides in source term:
  - ^{237}Np: typical actinide, solubility limited
  - ^{129}I: no sorption, rapid release
  - ^{135}Cs: high sorption, rapid release
  - ^{99}Tc: weakly sorbing, rapid release
- Steady-state flux for 10,000 years
- Separate flow field and transport calculations

Groundwater Codes

PARTI-CIPANTS	FLOW CODE	TRANSPORT CODE	DIMEN-SIONS
PNL	SUMO	SUMO	2-D
LANL	TRACRN	TRACRN	1-D
SNL	TOSPAC	TOSPAC	1-D
SNL	DCM-3D	NEFTRAN	1-D
SNL	LLUVIA NORIA	LLUVIA-S FEMTRAN	1-D 2-D

Modeled Region

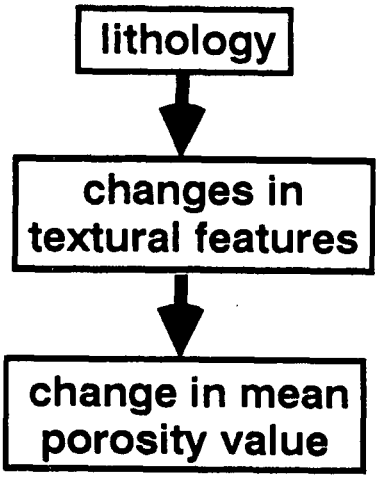
- In NE quadrant of potential repository block
- Represents a range of conditions
- Selected because it:
  - extends beyond repository boundaries
  - is bounded by four drill holes
  - includes a segment of the Ghost Dance fault



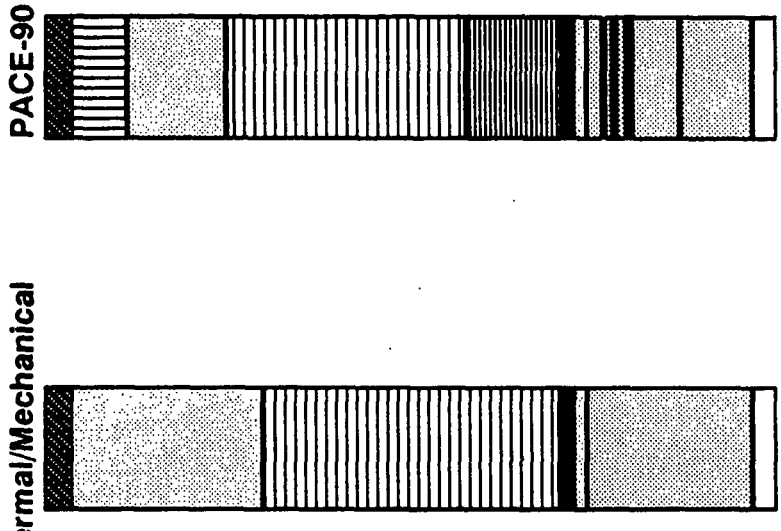
Hydrostratigraphy Development

- Thermal/mechanical hydrologic stratigraphy:
  - 16 reference units in 1250 m
  - no rock mass properties
- PACE-90 stratigraphy:
  - 19 units defined in 600 m
  - zonation based on rock mass hydrogeologic properties

Hydrostratigraphic Zone Definition



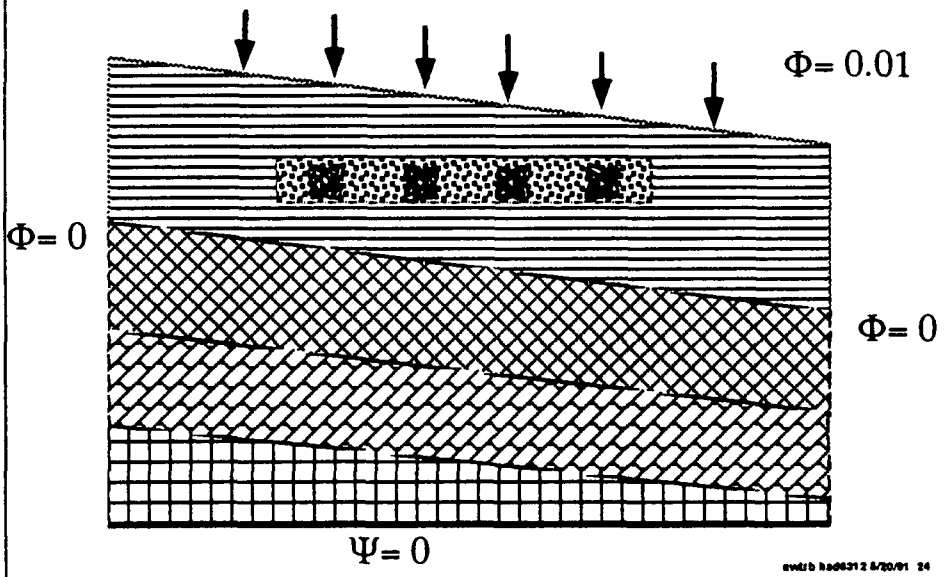
Stratigraphy Comparison



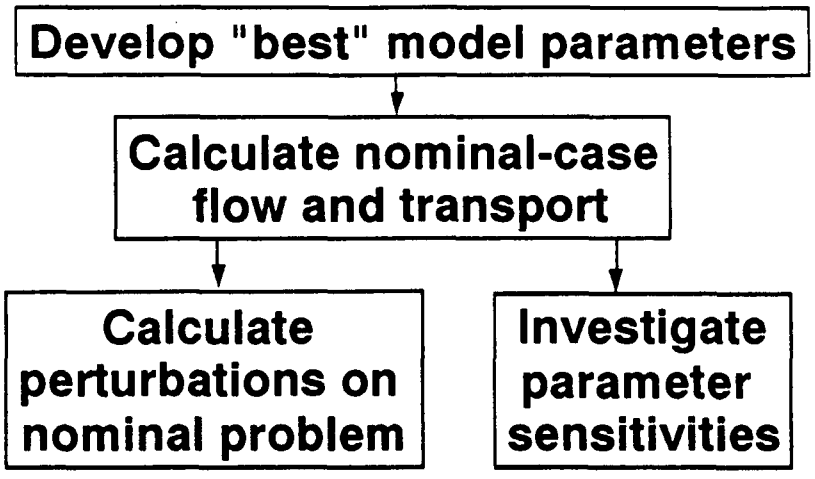
Hydrogeologic Data Development

- Data from G-1, G-4, H-1, and Ue25a#1
- Stratigraphic contacts and physical characteristics from core
- Limited hydrologic data from core, applied throughout modeled region
  - high and low matrix conductivities included
- Fracture density from well logs

Nominal-Case Summary



Analysis Approach



Disturbed Case Development

- Problem definitions requested for disturbances on the nominal case
  - problem set-up often requires scoping calculations
- Disturbances included:
  - climate change
  - human intrusion
  - basaltic igneous activity

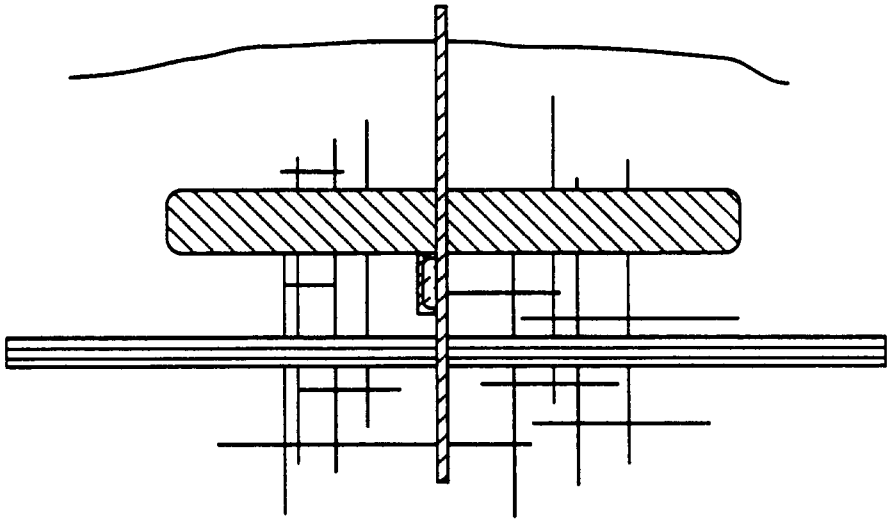
Climate Change

- Expressed as variation in infiltration rates (10x and 50x nominal)
- Also investigated effect of 50m rise of water table

Human Intrusion

- Developed scenario for drilling into the potential repository block
  - flooding
  - mechanical intersection
- Intent was to calculate flow and transport through:
  - interconnected fractures
  - high permeability zone

Drilling Scenario



Basaltic Igneous Activity

- **Effect of intrusion into repository:**
  - **estimate length, orientation, location, etc.**
  - **calculate thermal excursion**
  - **probability of wp intersection**
  - **effect of interception**
  - **type and amount of nuclide transport**
  - **consequence analyses**

Disturbed-Case Summary

- Calculated results for climate change
- Defined problems for:
  - human intrusion
  - igneous activity

Sensitivity studies

- Compare PACE-90 nominal case with
  - COVE-2A
  - HYDROCOIN
- Investigate relationship between infiltration and observed saturation
  - "inverse problem"

Inverse Problem Question

- Using 1-D steady-state flow calculation, what infiltration rate gives the observed values for saturation in the unsaturated zone at Yucca Mountain?

Inverse Problem Methodology

- Multiple flow calculations performed
  - 11 layers sampled
  - 95 data values
  - 300 of $>10^6$ possible realizations
  - realizations restricted to data values
- Calculated saturations accumulated for each layer
  - infiltration=0, 0.01, 0.1, and 0.5 mm/yr

Summary

- PACE-90 problem definitions
  - Drew on experience
  - Developed new hydrostratigraphy
  - Integrated participants' efforts
    - modeling
    - hydrology
    - source term