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

NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: THREE-DIMENSIONAL SITE-SCALE MODEL OF UZ FLOW AT YUCCA MOUNTAIN

PRESENTER: GUDMUNDUR BODVARSSON

PRESENTER'S TITLE AND ORGANIZATION: STAFF SCIENTIST, EARTH SCIENCES DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA, BERKELEY
BERKELEY, CALIFORNIA

PRESENTER'S TELEPHONE NUMBER: (510) 486-4789

RENO, NEVADA
APRIL 21-22, 1993

Coworkers

- C. Wittwer, LBL
- G. Chen, LBL
- M. Chornack, USGS
- A. Flint, USGS
- L. Flint, USGS
- E. Kwicklis, USGS
- R. Spengler, USGS
- C. Rautman, Sandia

Presentation Overview

- Objectives of the study
- General approach
- Data needs and contributions from other studies
- Numerical modeling approach
- Results to date
- Current work
- Future work
- Credibility of the study

Why a Model?

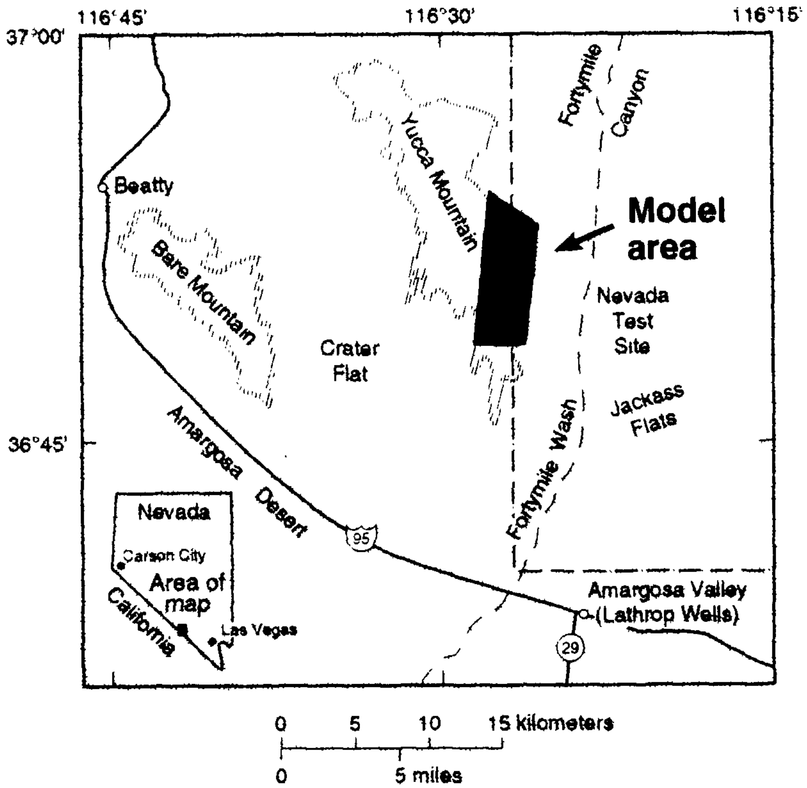
- The 3-D model will integrate the available data and information on Yucca Mountain
- The 3-D model will provide estimates of moisture, heat, and gas flow within the mountain
- The 3-D model will be used to guide in the site-characterization effort ("enough" or "more" data)

Why a Model?

(Continued)

- The 3-D model will be used in sensitivity studies of the effects of spatial and temporal infiltration variations
- The 3-D model will be used to predict effects of future climate changes on moisture, heat, and gas flow within the unsaturated zone

Model Area



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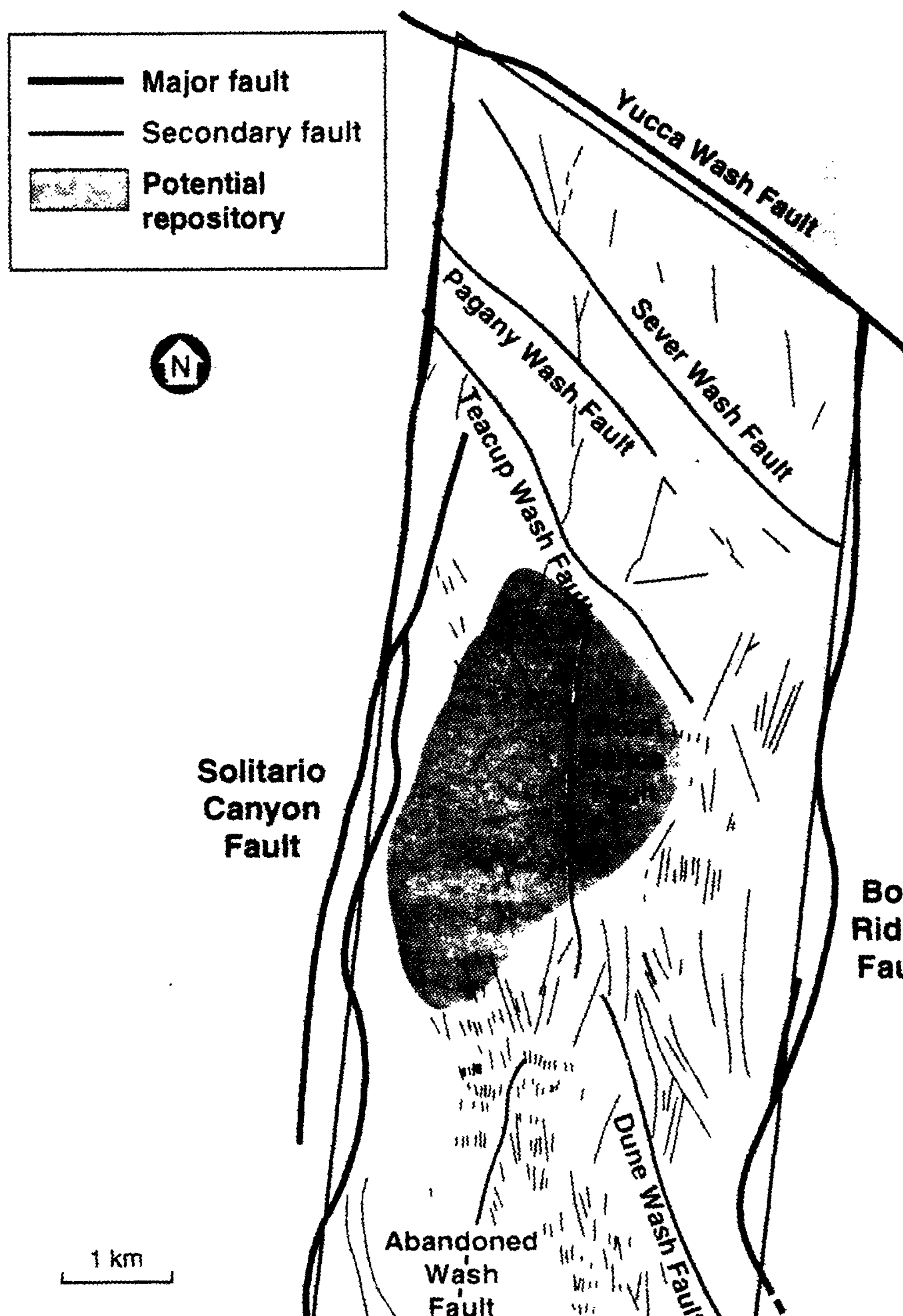
Areal Extent of the Site-Scale Model



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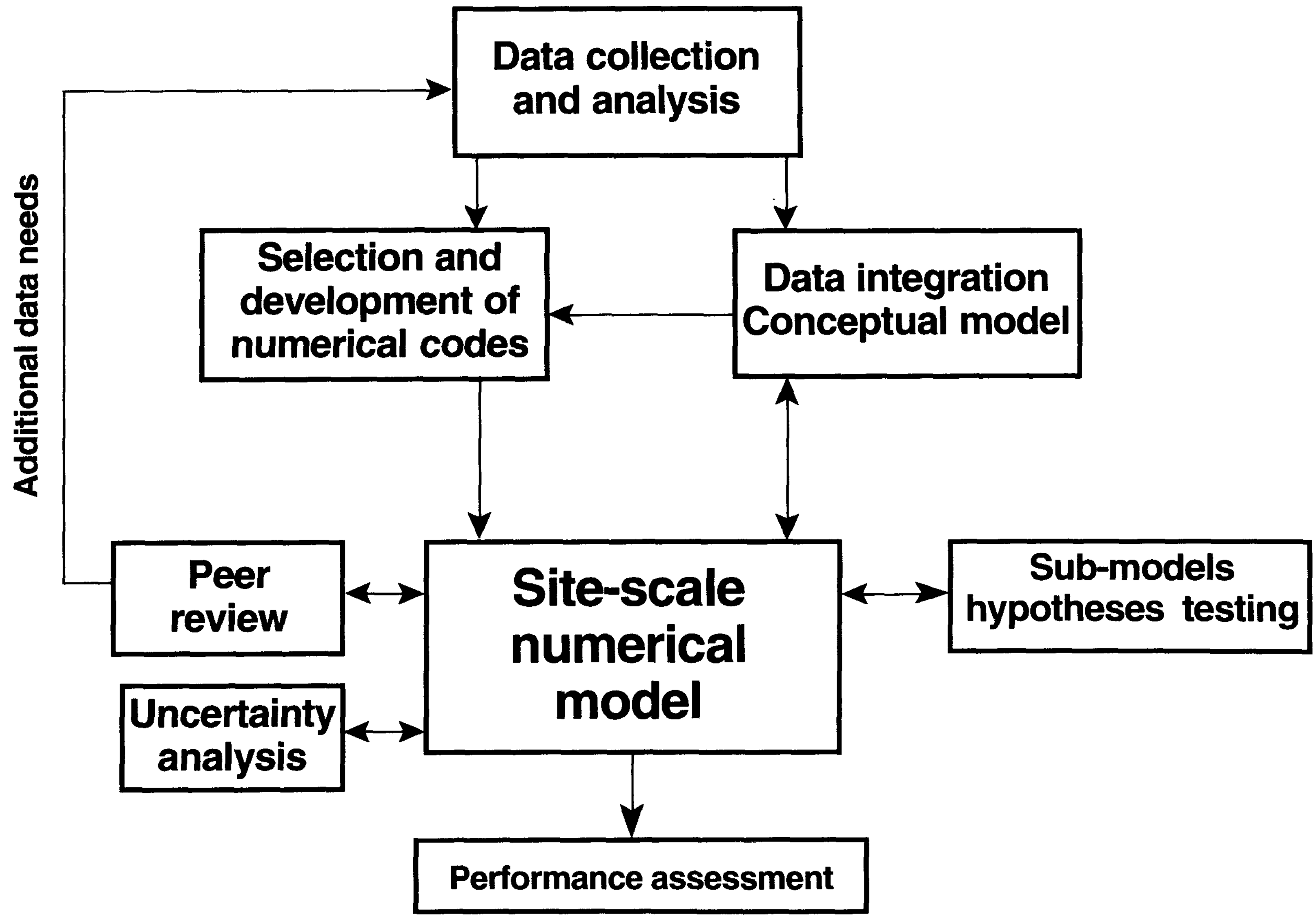
How will we Proceed?

- General approach
- Important hydrogeologic issues
- Model development steps



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Some Site-Scale Modeling Issues

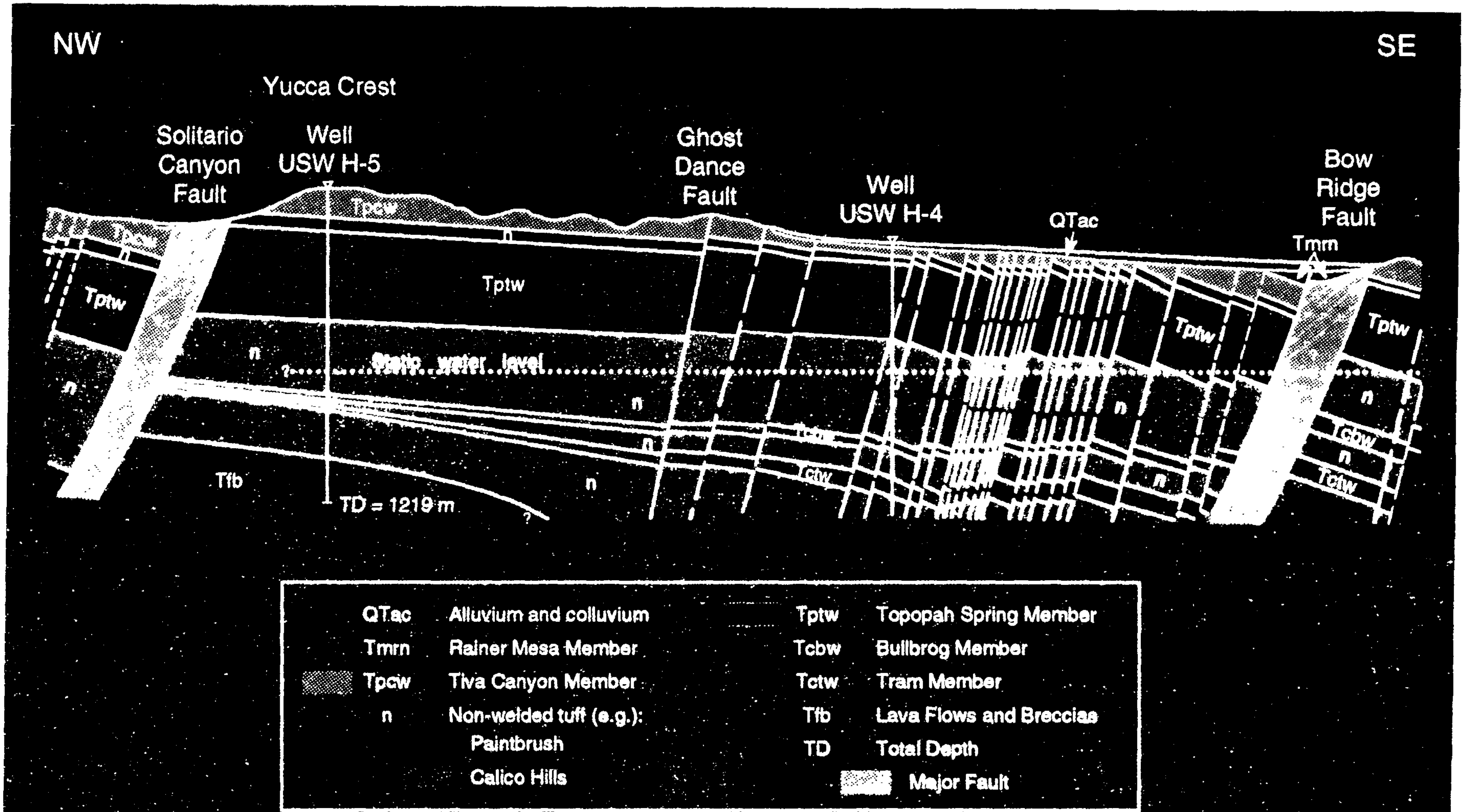
- Uncertainties in flux determination
- Densely fractured welded units; millions of fractures and matrix blocks
- Flow characteristics of major faults (e.g. Ghost Dance Fault)
- Matrix vs. fracture flow
- Gas flow (air + water vapor)
- Thermal effects on fluid flow
- Lateral flow and perched water
- Fracture and capillary barriers

Model Development Steps

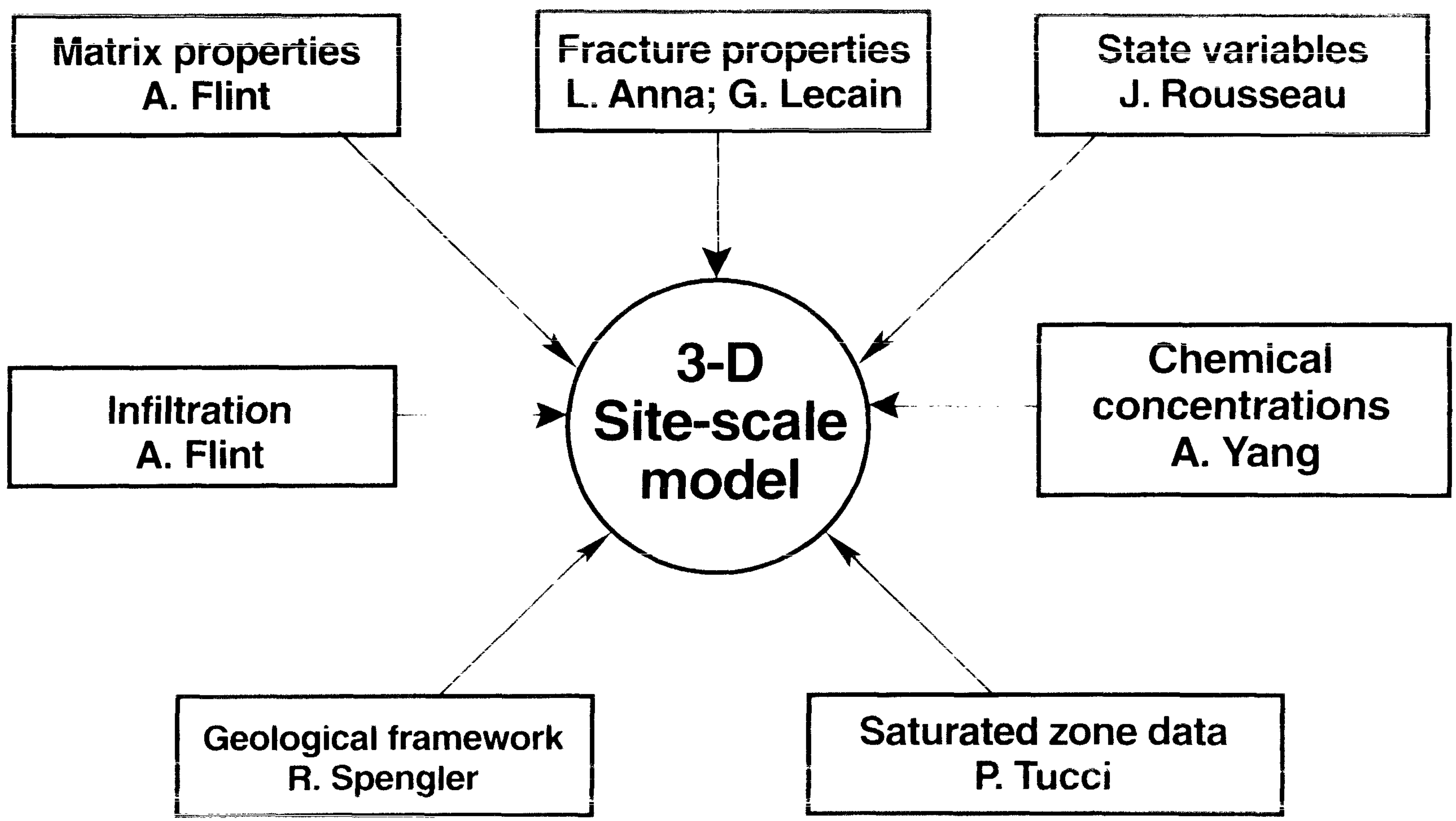
- Development of a moisture flow model
- Incorporation of geothermal gradient
- Incorporation of gas flow components
- Periodic calibration of model against observed data (moisture tension, saturation, gas pressure, temperature, chemical concentrations)
- Periodic use of model for prediction of state variables at new well locations
- Periodic use of model for sensitivity studies of further data needs ("enough or not")
- Continuous use of submodels for hypothesis testing

What Data are Essential?

- Data needs and contribution of other studies
- Hydrogeologic maps
- Important hydrological parameters



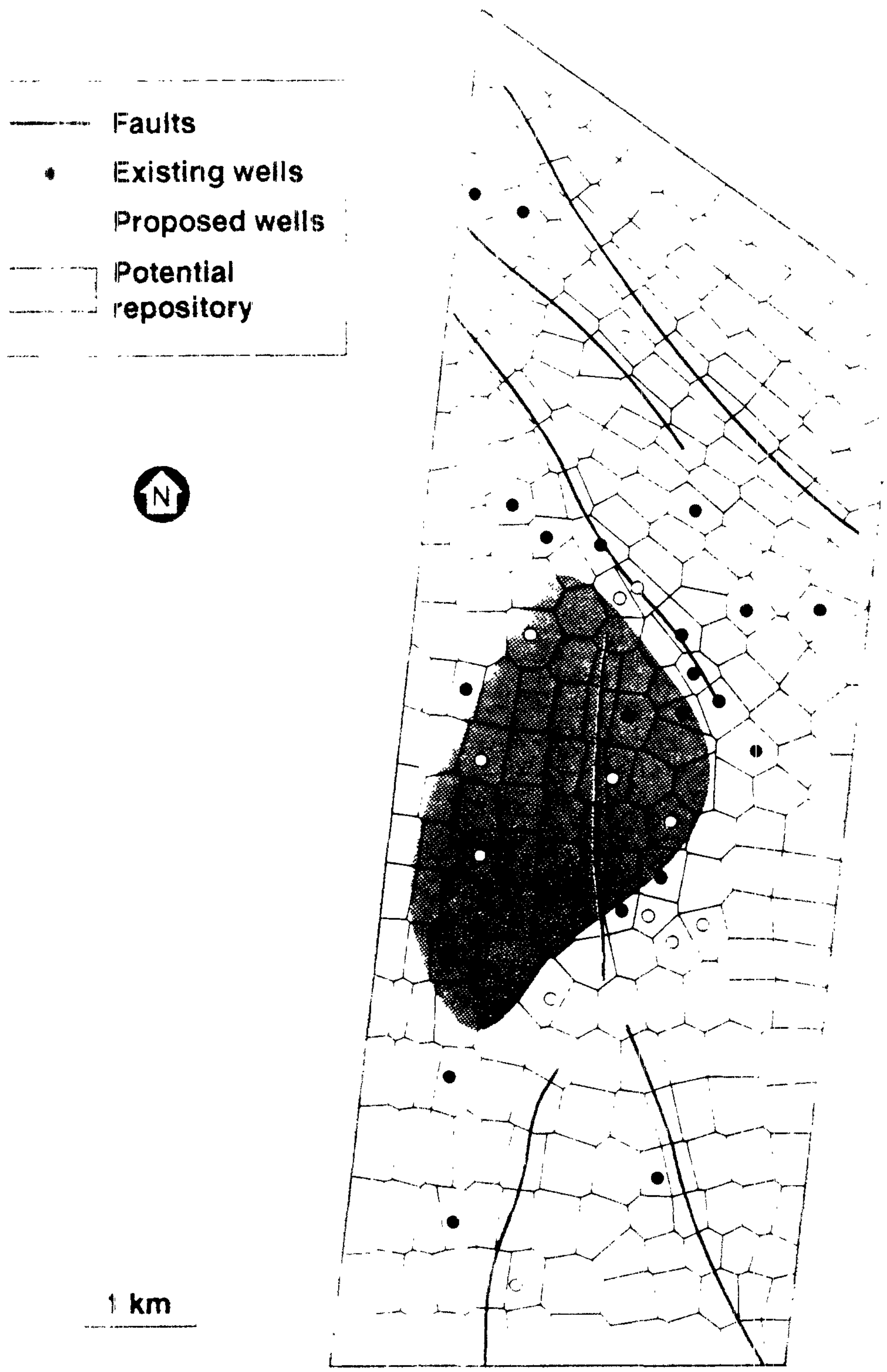
Modified from Scott and Bonk (1984)


Matrix properties
A. Flint
Fracture properties
L. Anna; G. Lecain
State variables
J. Rousseau
Infiltration
A. Flint
3-D
Site-scale
model
Chemical
concentrations
A. Yang
Geological framework
R. Spengler
Saturated zone data
P. Tucci

How will We "Grid" the Mountain?

- Factors controlling horizontal gridding
- Factors controlling vertical gridding
- Incorporation of faults and fractures
- Flexibility for grid modifications
- Development of new simulation techniques

Horizontal Grid



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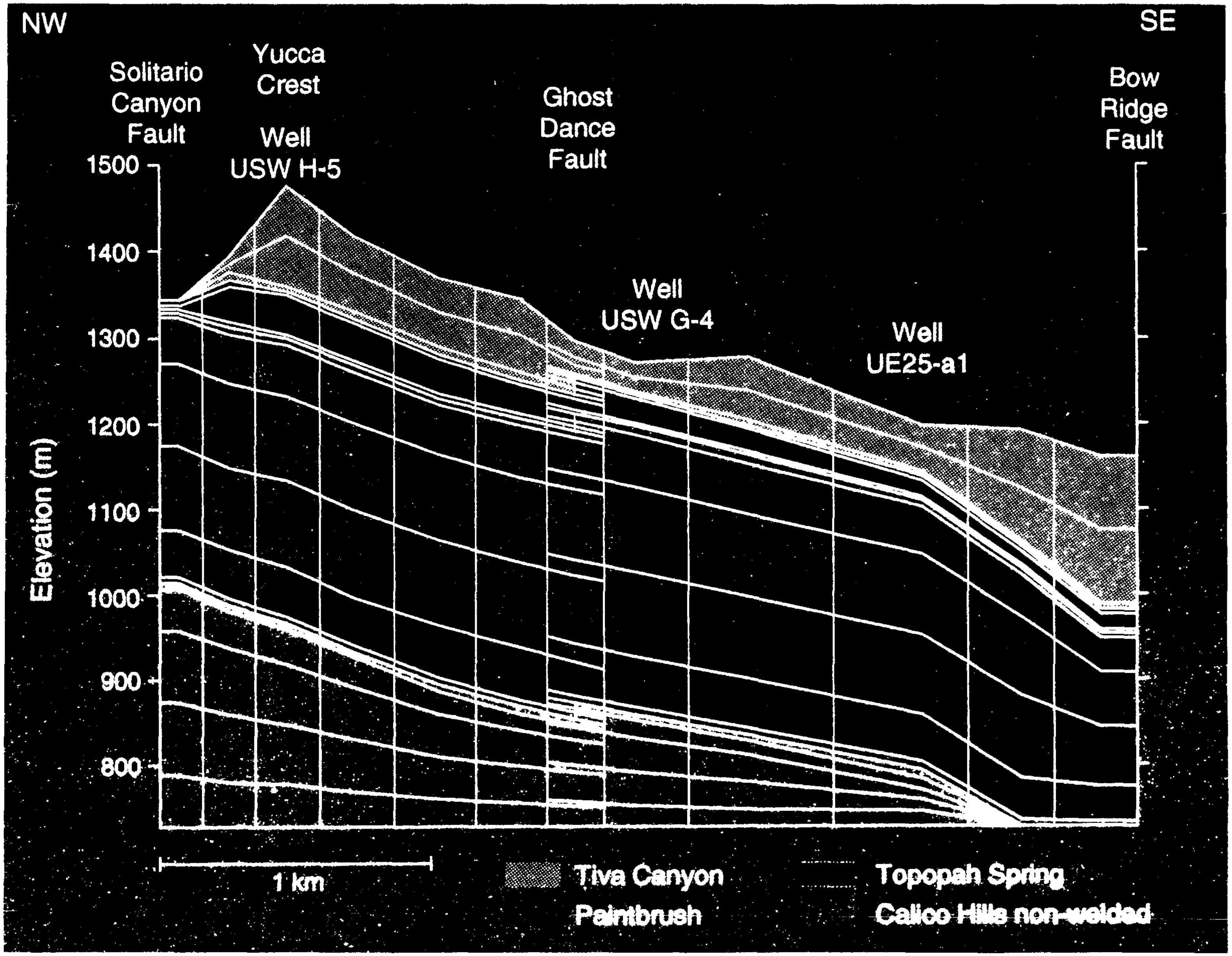

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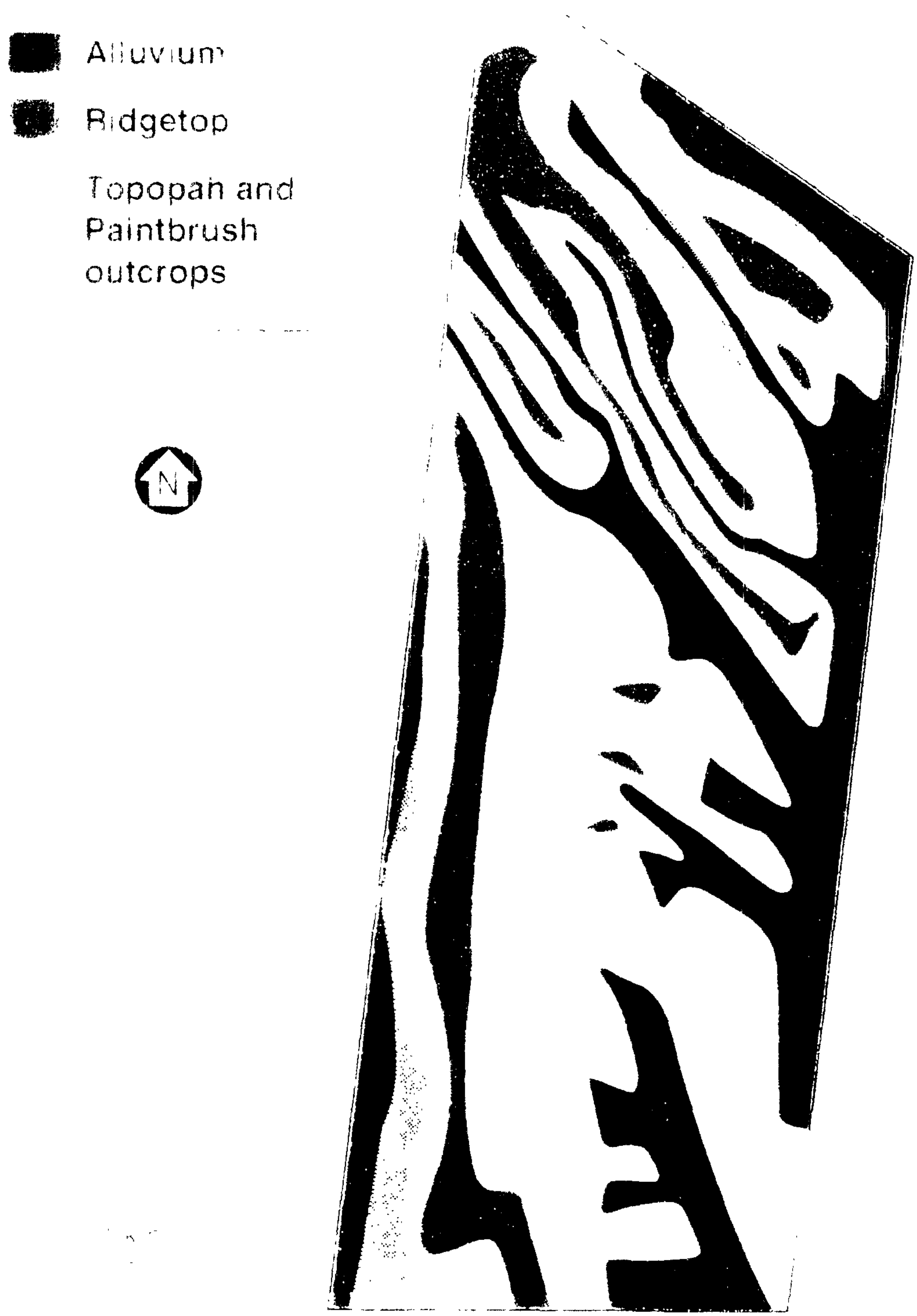
Simplified Map of Infiltration Zones and Outcrops



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Development of New Simulation Techniques

- Decoupling of TOUGH
- Analytical fracture/matrix model
- Numerical fracture/matrix grid generator

Flexibility for Grid Modifications

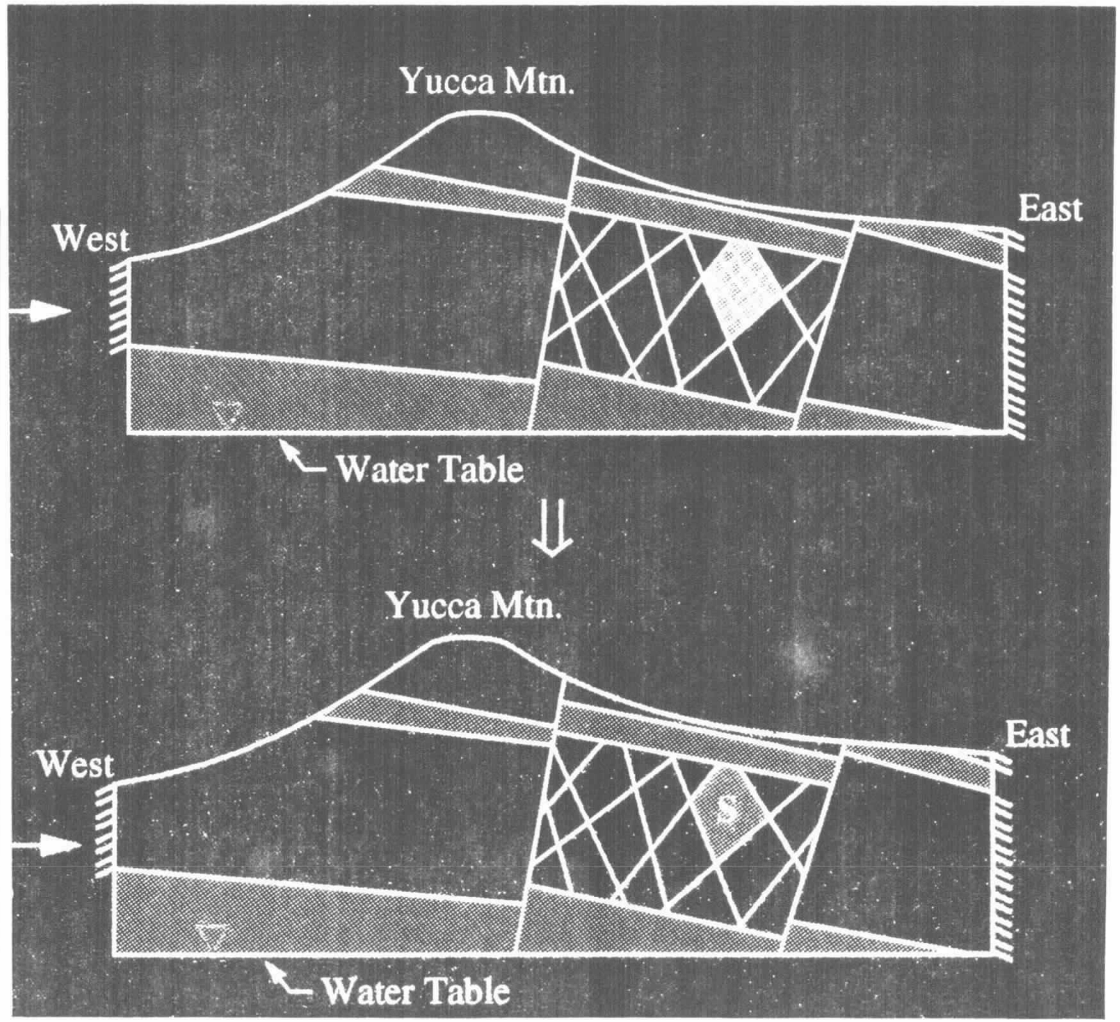
- The three-dimensional grid is *almost completely* computer-generated
- Some manual patching of grid elements near faults is necessary

What Have we Learned so Far?

- Two-dimensional simulation
- Effects of major faults
- Other important issues

Semi-Analytical Dual-Porosity Model

"Old" method
Fully discretized
matrix blocks



"New" method
Semi-analytical
sink/source term

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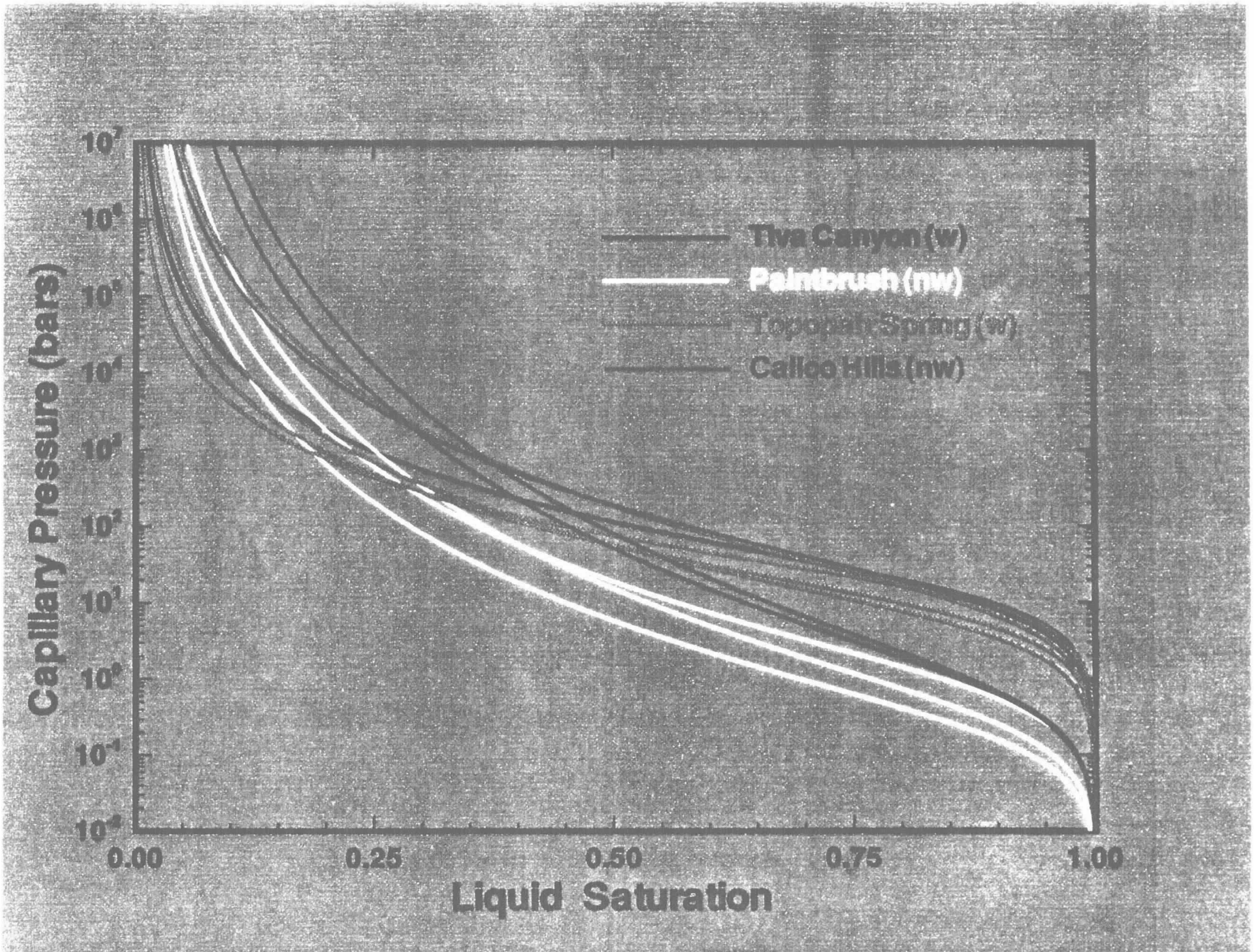

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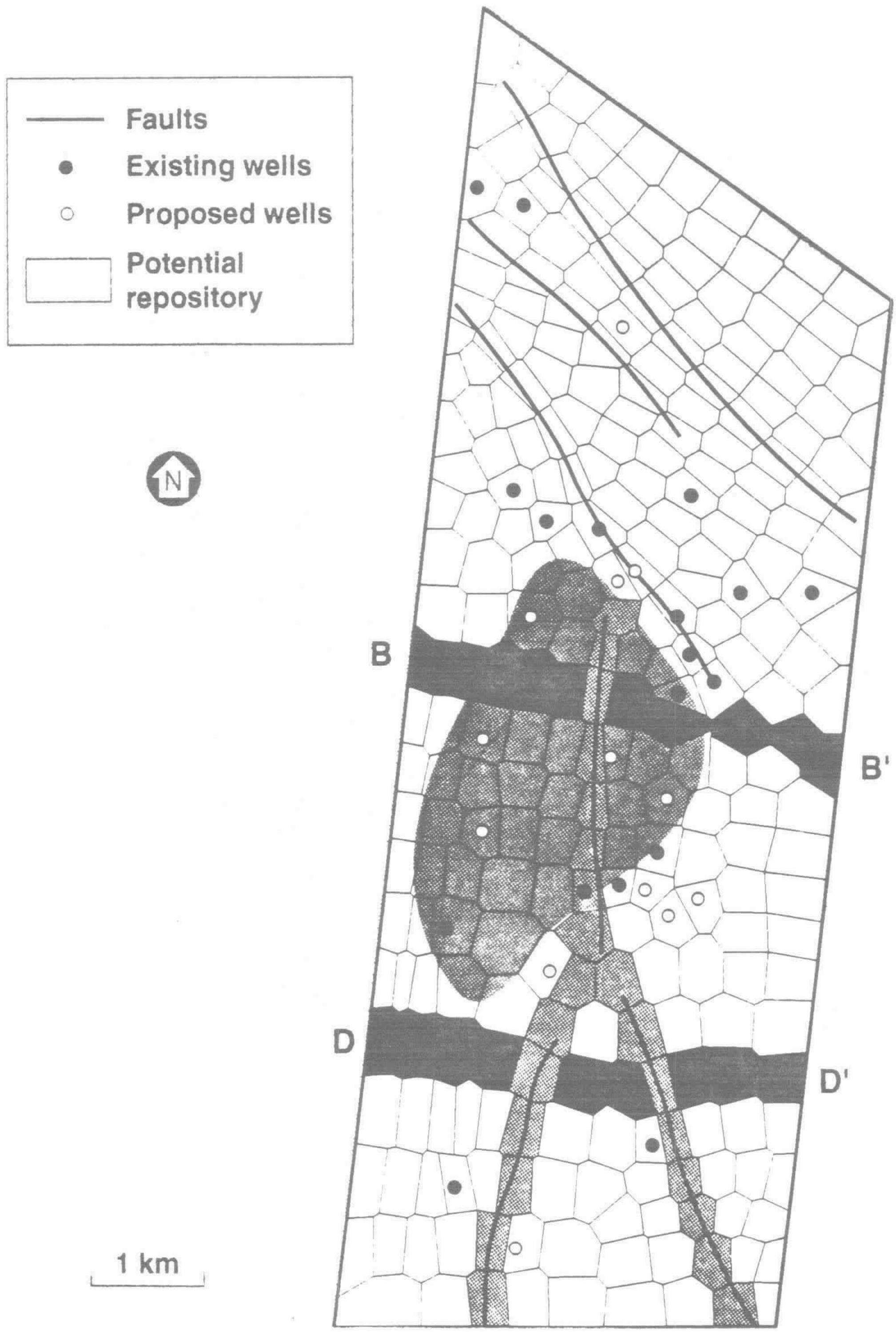
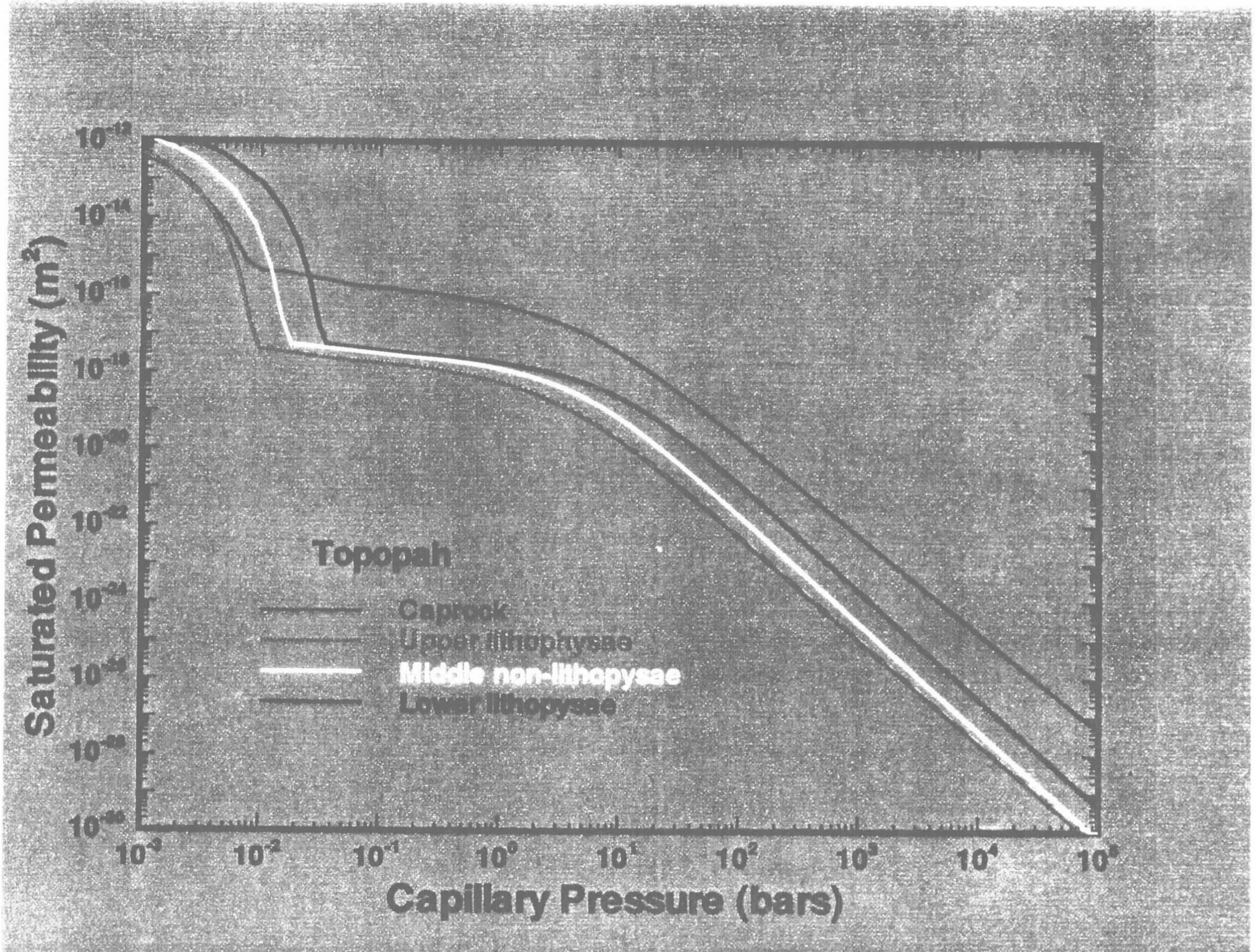
Horizontal Grid





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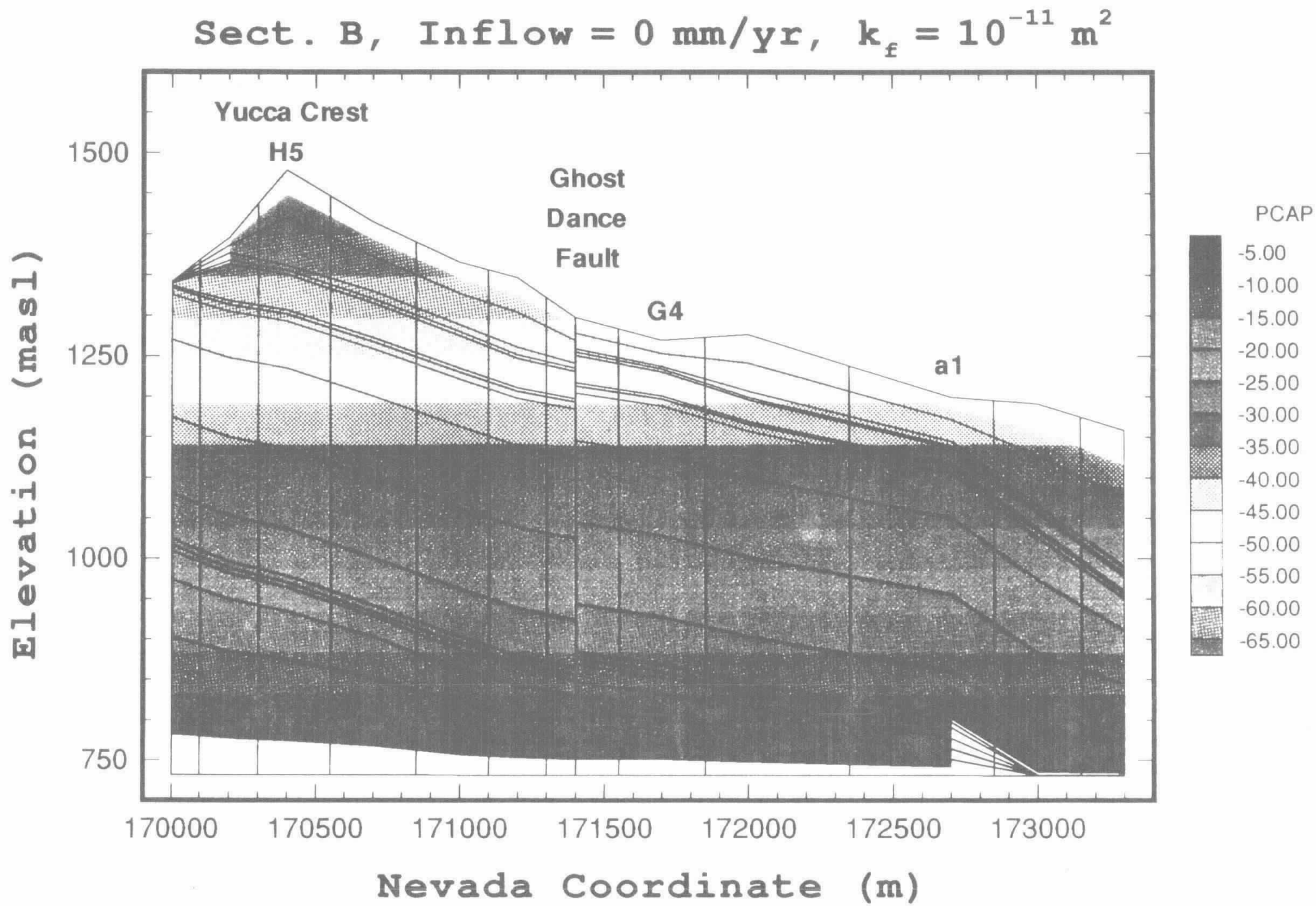

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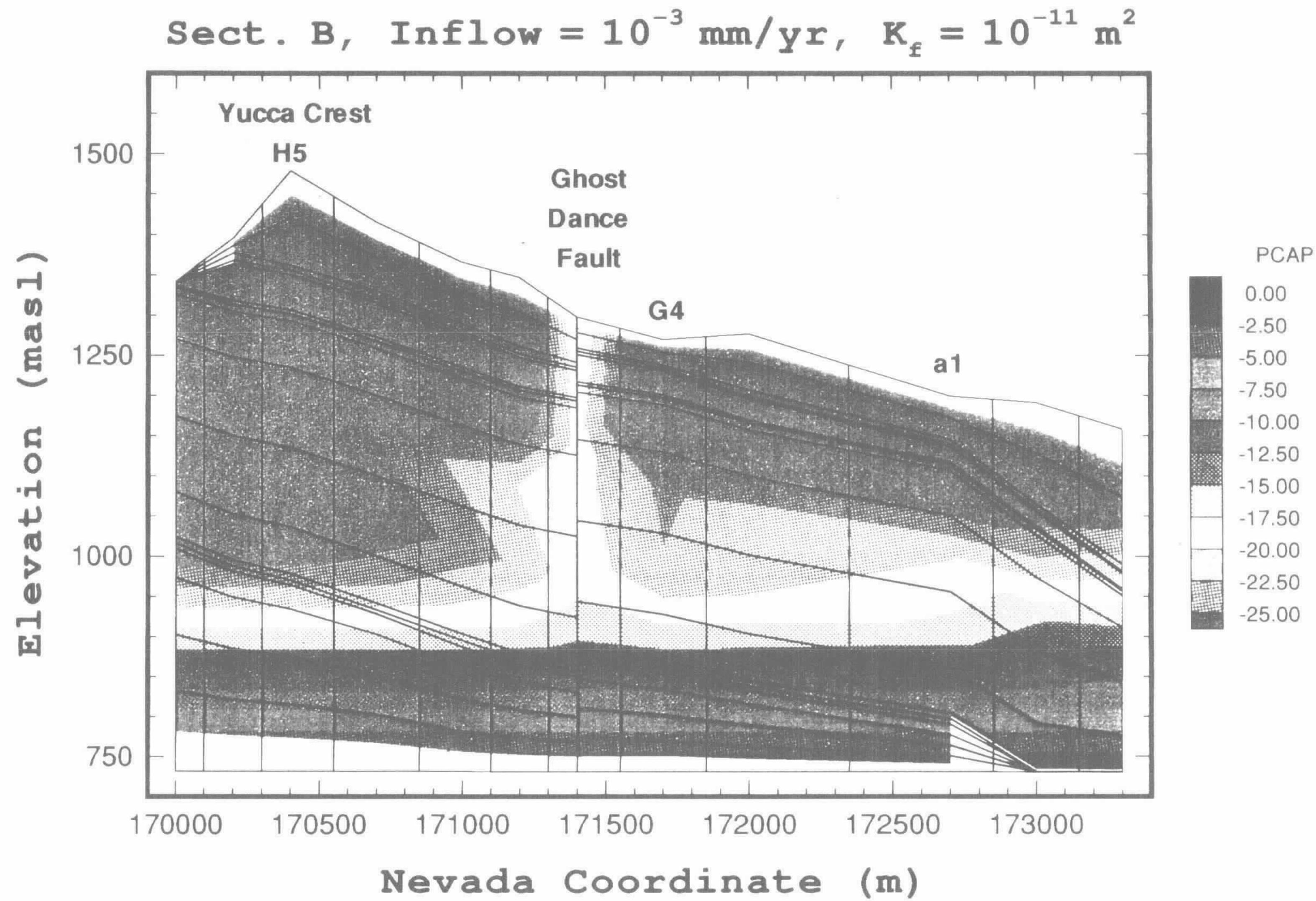

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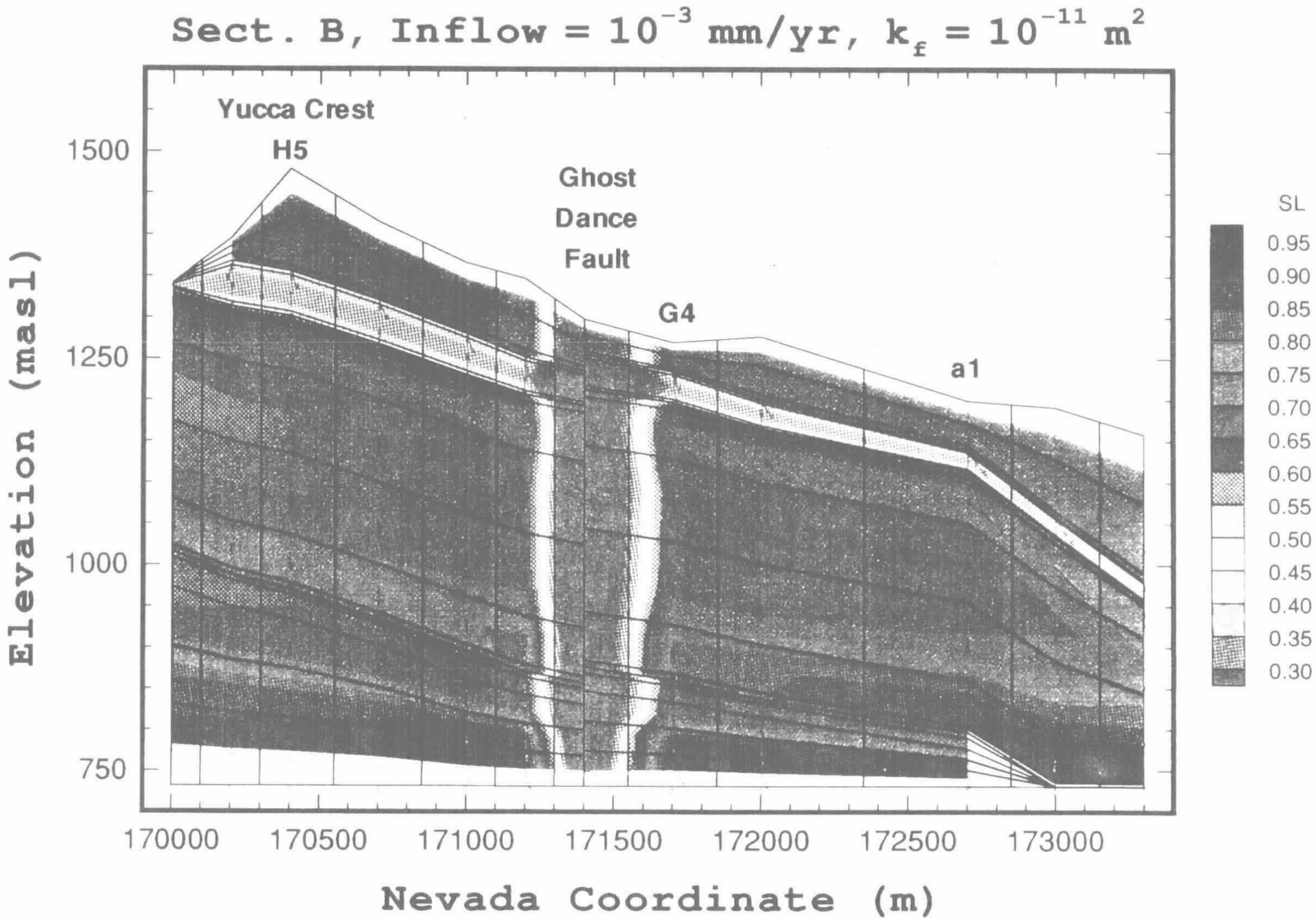

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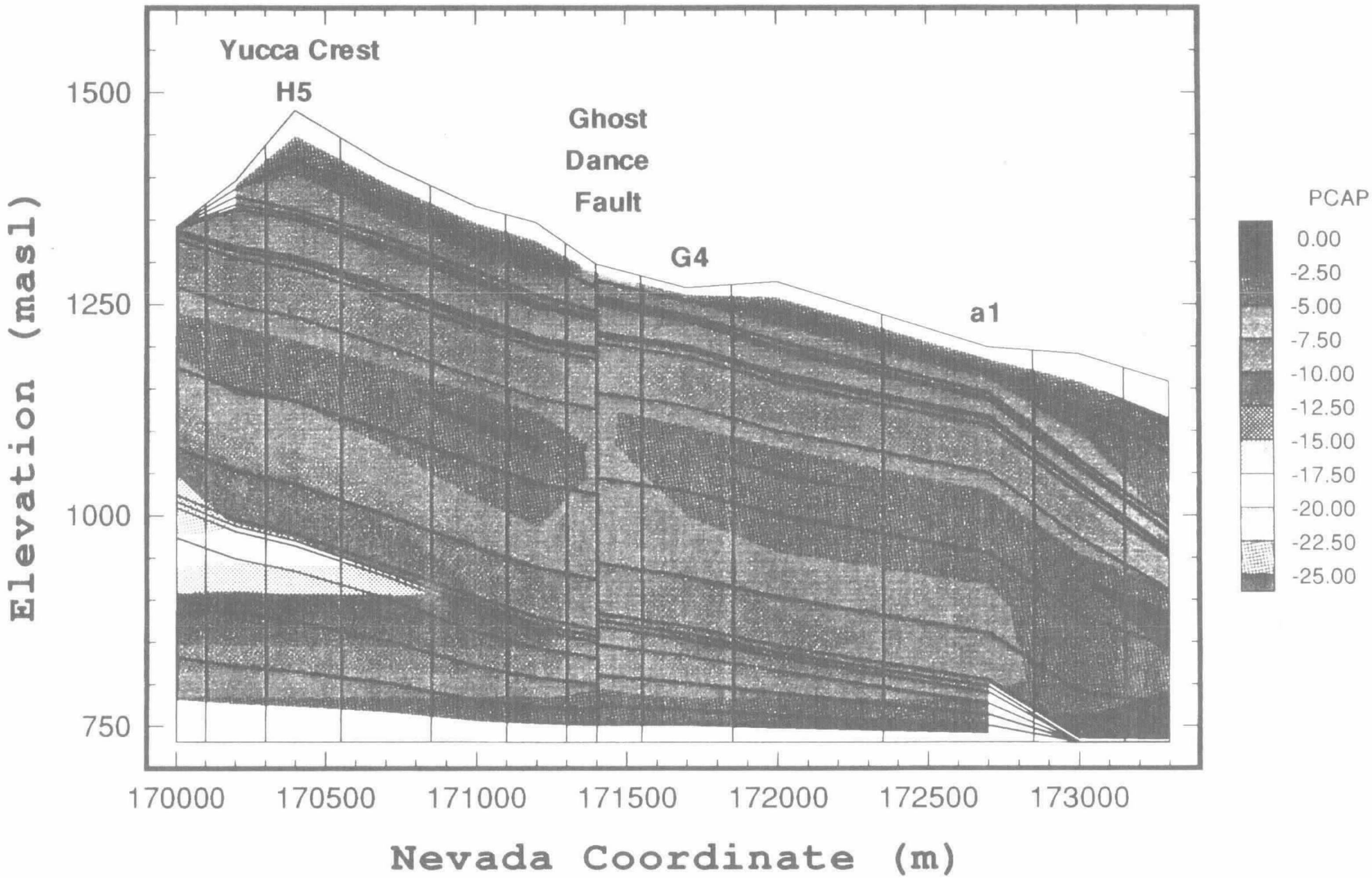
Sect. B, Inflow = 10^{-1} mm/yr, $K_f = 10^{-11}$ m^2



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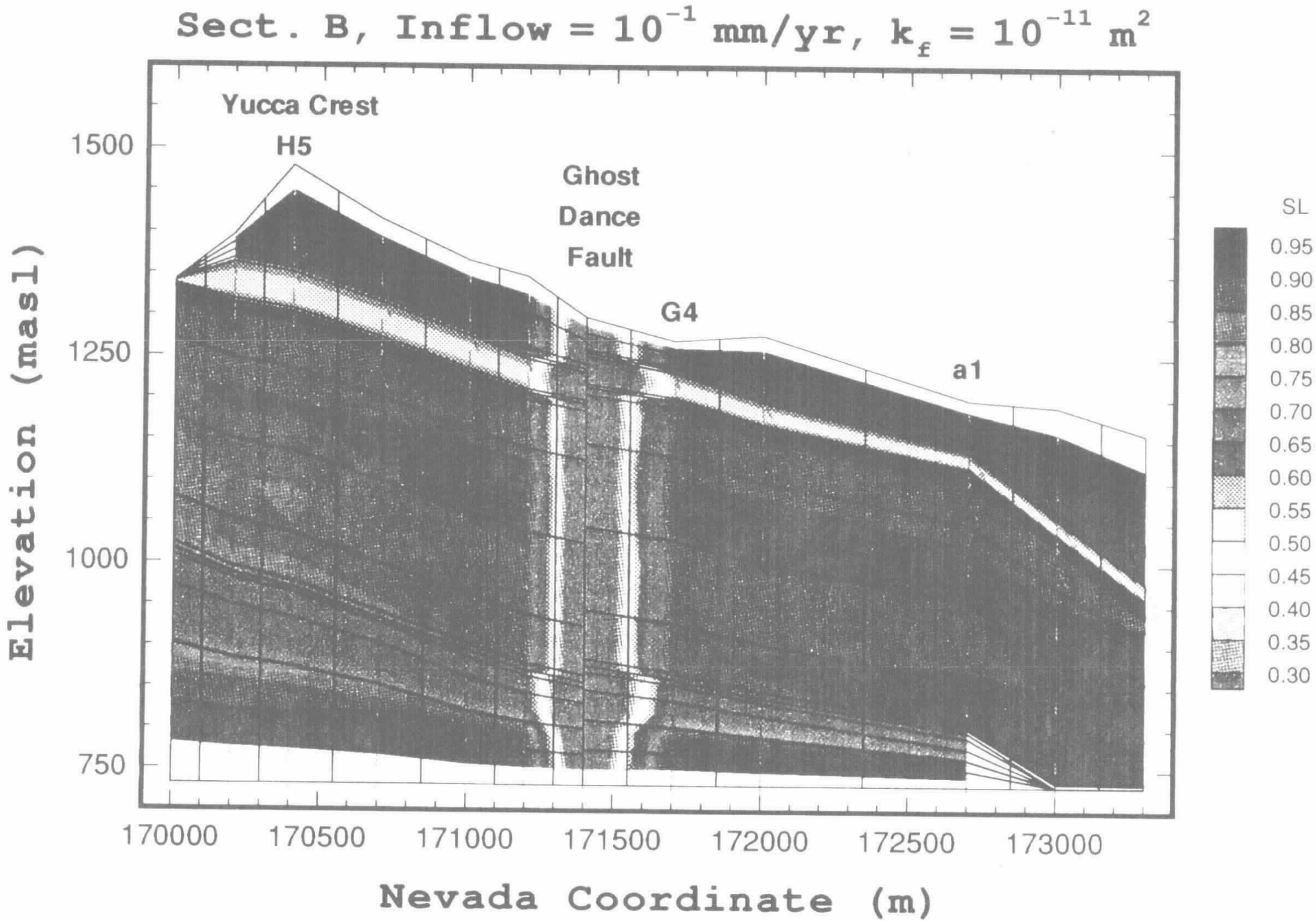

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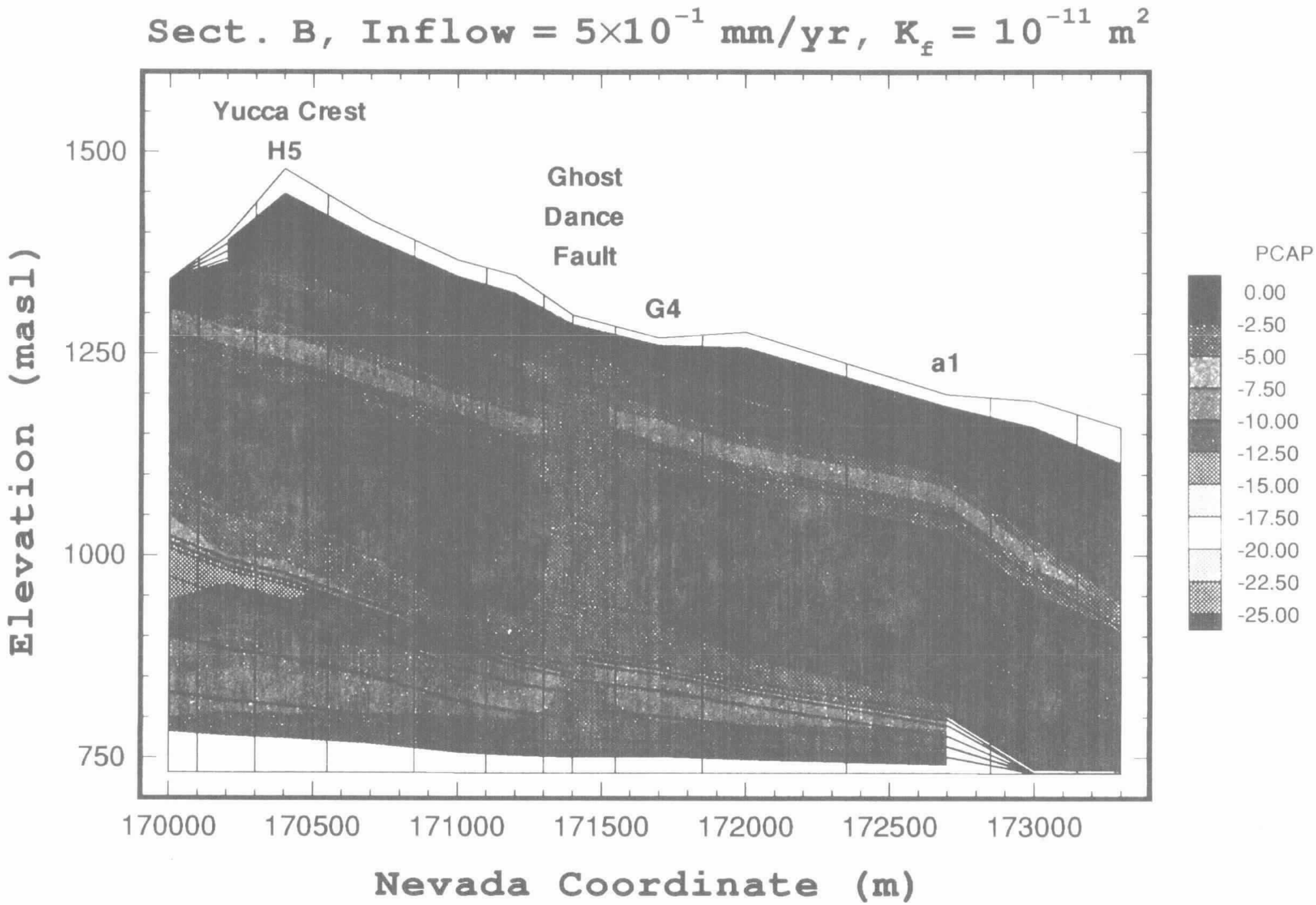

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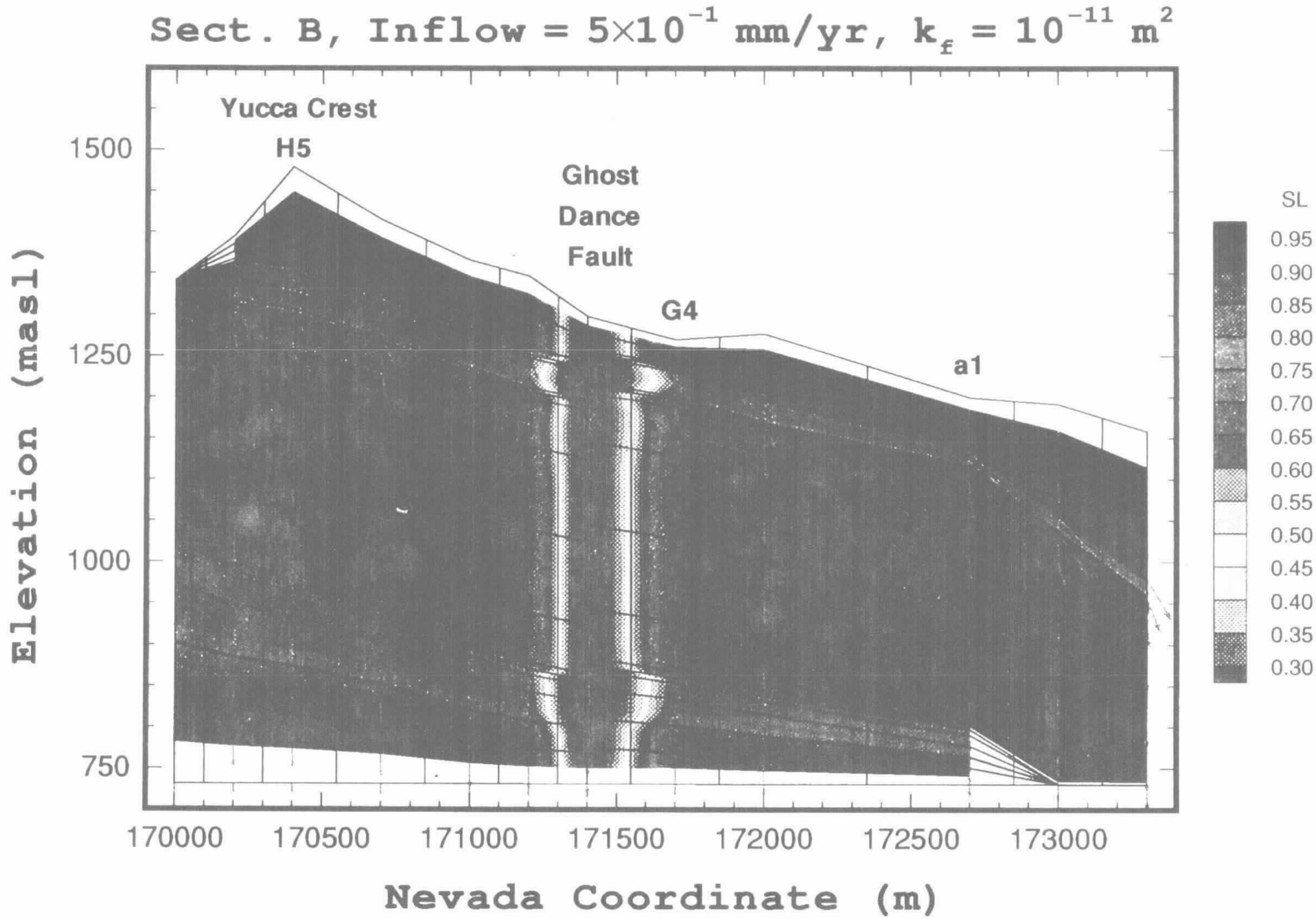

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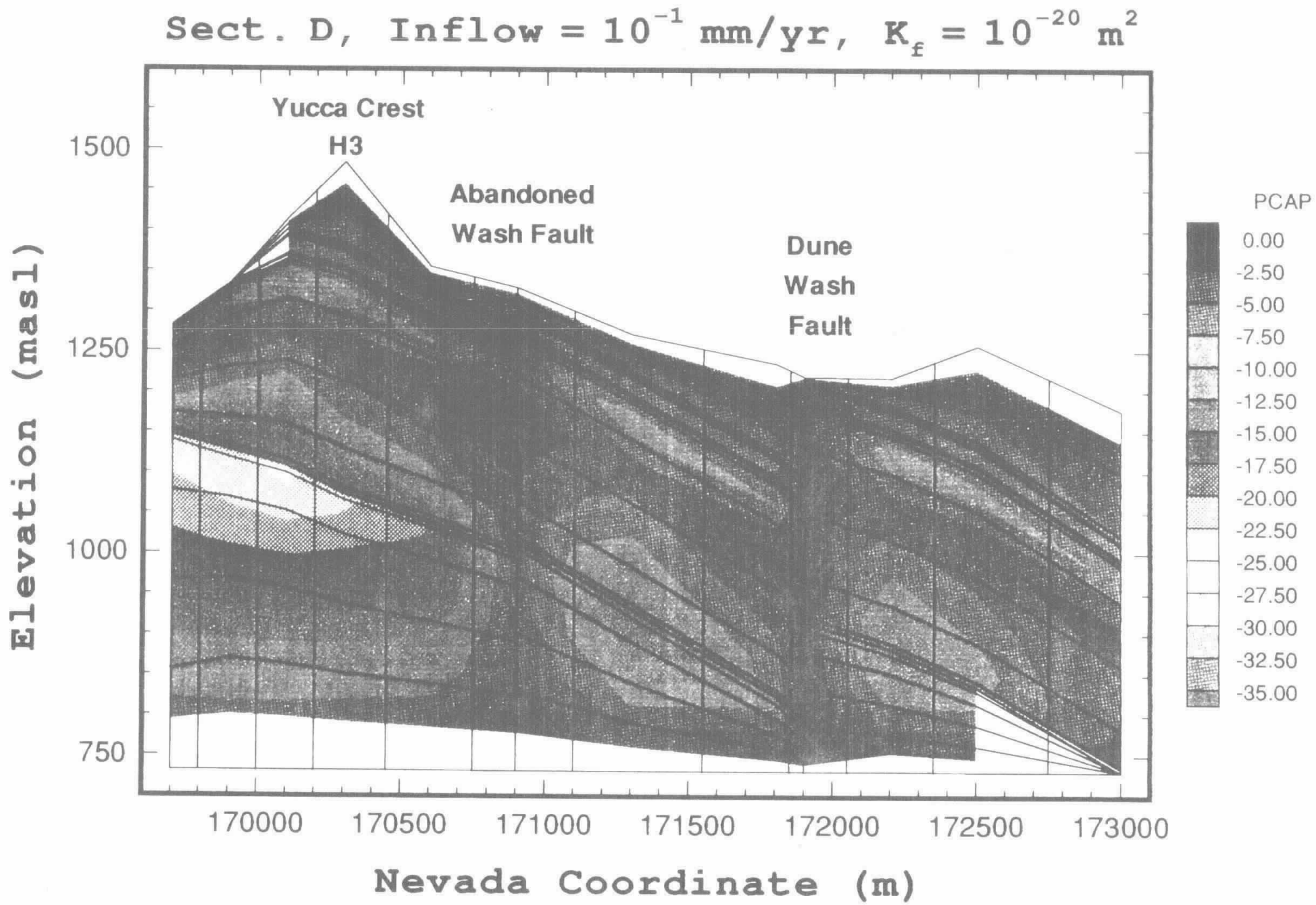

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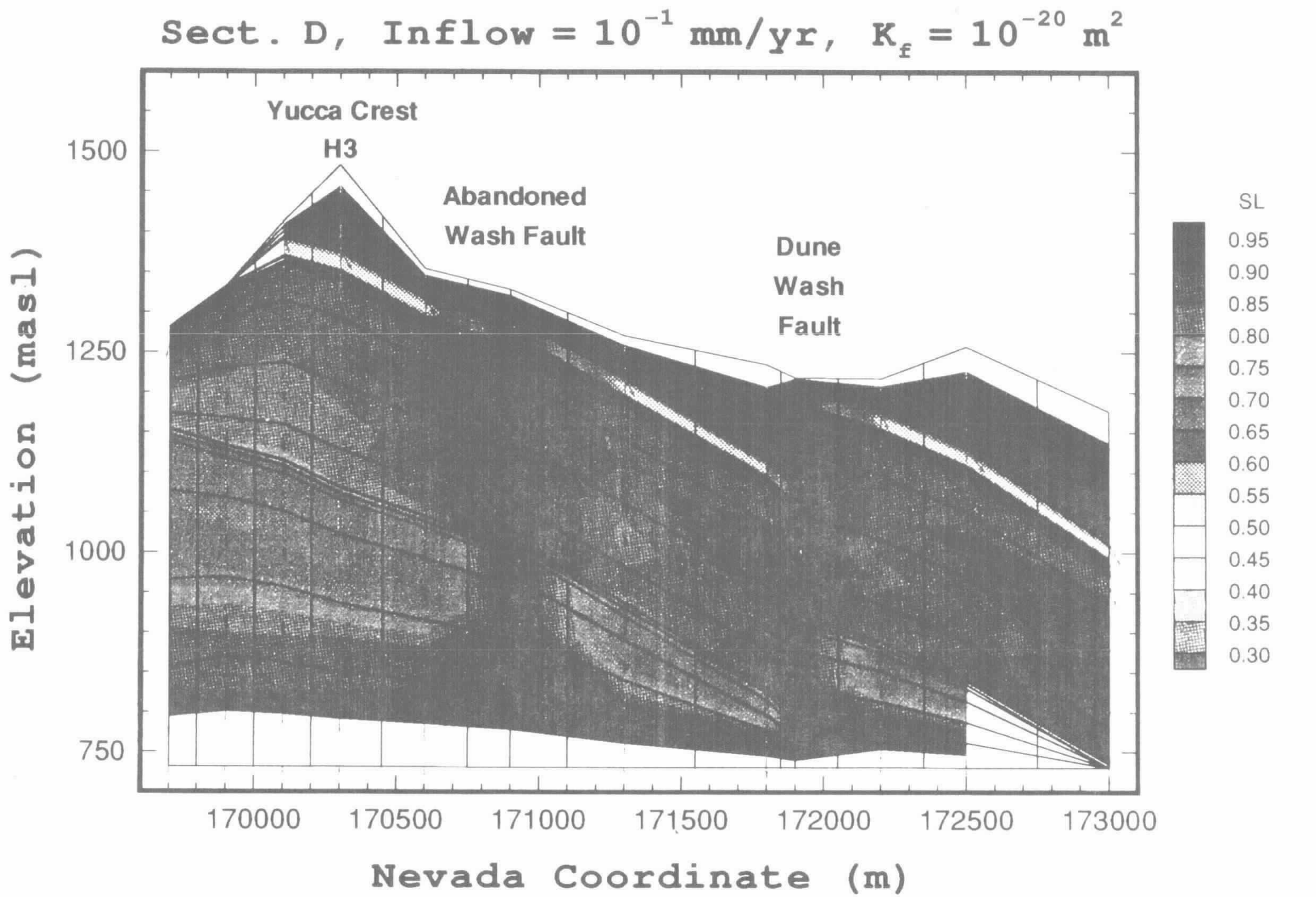

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What are We Doing Now?

- Moisture flow report
- Investigation of grid effects
- 3-D simulations

Where are We Going?

- Incorporation of geothermal gradient
- Incorporation of gas flow
- Development of predictive capability
- Model sensitivity ("enough data")
- Tool for performance assessment

Why is the Work Technically Sound?

- Quarterly modeling meetings
- Publications in Inrernational High Level Radioactive Waste meetings and refereed journals
- Periodic peer review (LBL, USGS, DOE, NRC, NWTRB, etc.)
- Documentation through USGS QA program

Summary

- 3-D site-scale model under development
- Major purpose of model to *integrate* the available data and to *guide* in the site-characterization process
- Model will address sensitivity of infiltration changes both spacially and temporally and predict the effects of future climate changes