See Pocket 2 for encl.

48

Type

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

February 12, 1985

Linda,

I am sending this along to you--thought you would be interested.

Paul

WM Record File 102

WM Project 11
Docket No.
PDR ✓
LPDR ✓

Distribution:
LKovach

(Return to WM, 623-SS)

WM DOCKET CONTROL CENTER
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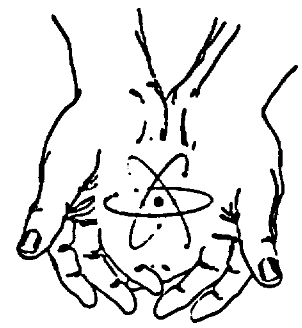
NNWSI PROJECT



Los Alamos NNWSI PROJECT

Geochemistry Presentation to January TPO Meeting

255

NNWSI PROJECT

Los Alamos

OVERVIEW

G. L. DePOORTER

102

Encl. to note
to L. Kovach
2/12/85

NNWSI PROJECT

LOS ALAMOS LABORATORY
CONTRIBUTION TO SITE AND
REPOSITORY INVESTIGATIONS

Los Alamos

WBS 2.3.4.1 GEOCHEMISTRY

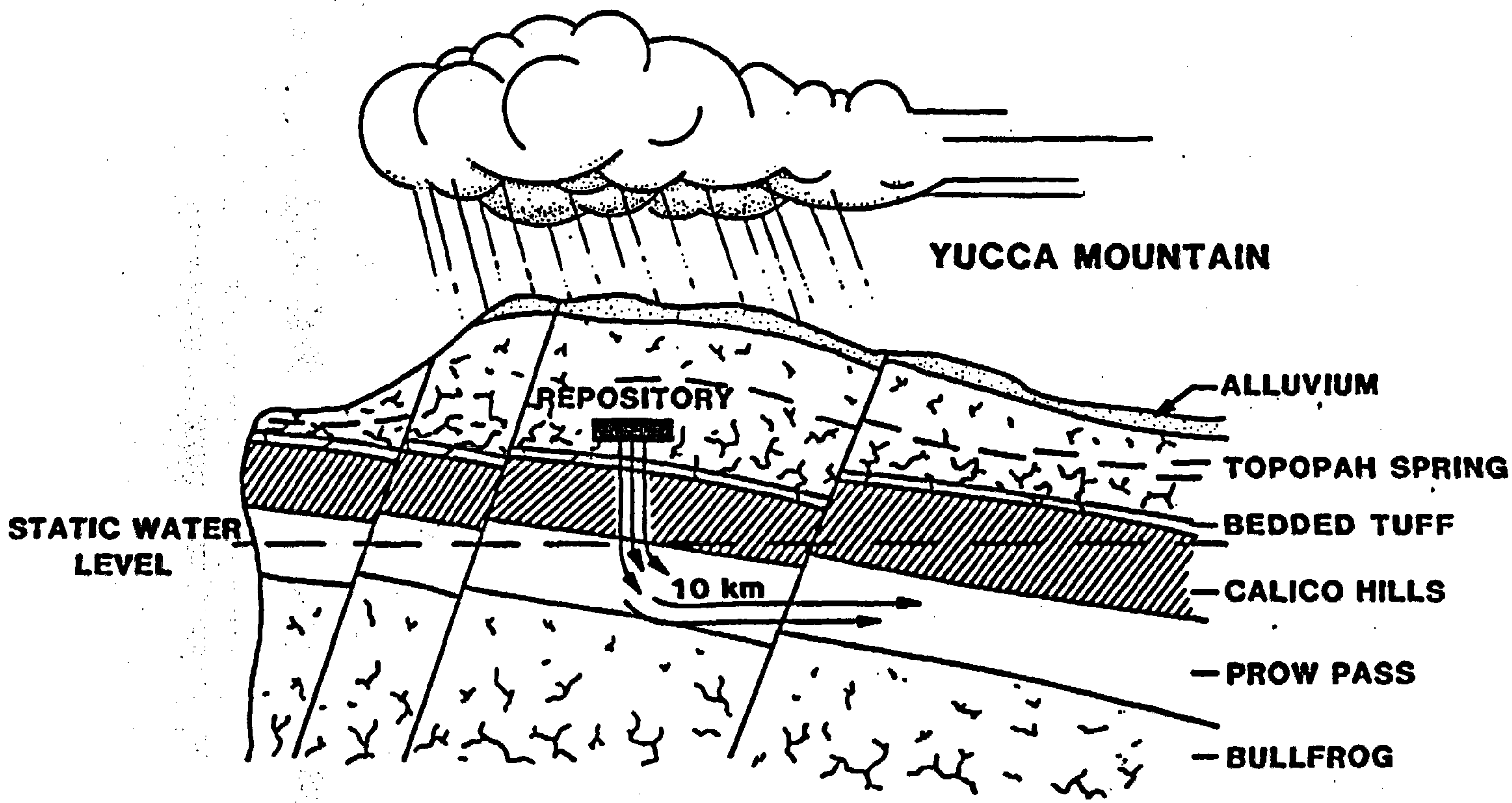
WBS 2.3.4.2 MINERALOGY/PETROLOGY

WBS 2.4.2.3.2 SEALING MATERIALS EVALUATION

CONCEPTUAL RADIONUCLIDE TRANSPORT PATH

Los Alamos

NNWSI PROJECT



NNWSI PROJECT

GEOCHEMISTRY TESTS IN EXPLORATORY SHAFT

Los Alamos

CHLORINE-36 TEST

COLLECT SAMPLES FROM THE EXPLORATORY SHAFT AS IT IS MINED AND USE COSMOGENIC ^{36}Cl AS A TRACER TO DETERMINE THE VELOCITY OF WATER MOVEMENT THROUGH THE UNSATURATED ZONE

APPLIED DIFFUSION

DETERMINE WHETHER THE RESULTS OF LABORATORY-SCALE DIFFUSION MEASUREMENTS CAN BE EXTRAPOLATED ACCURATELY TO PREDICT THE RATES OF AQUEOUS TRANSPORT OF NONSORBING RADIOACTIVE WASTE SPECIES

NNWSI PROJECT

Los Alamos

WBS 2.3.4.1
GEOCHEMISTRY TOPICS

- GROUNDWATER CHEMISTRY (A. E. OGARD)
- NATURAL ISOTOPE CHEMISTRY (A. E. NORRIS)
- HYDROTHERMAL GEOCHEMISTRY (C. J. DUFFY)
- SOLUBILITY DETERMINATION (J. F. KERRISK)
- SORPTION AND PRECIPITATION (K. W. THOMAS)
- DYNAMIC TRANSPORT PROCESS (R. S. RUNDBERG)
- RETARDATION SENSITIVITY ANALYSIS (B. J. TRAVIS)

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WBS 2.3.4.2.
MINERALOGY/PETROLOGY

- ALTERATION MINERALOGY
- MINERAL STABILITY
- MINERALOGY OF TRANSPORT PATHWAYS
- EXPLORATORY SHAFT MINERALOGY/ PETROLOGY

NNWSI PROJECT

NRC DOCUMENTS ADDRESSED BY GEOCHEMISTRY-MINERALOGY/ PETROLOGY WORK

Los Alamos

- 10 CFR 60
- REGULATORY GUIDE 4.17
- NRC DRAFT TECHNICAL POSITION ON RADIONUCLIDE SOLUBILITY IN GROUNDWATER
- CLOSEOUT COMMENTS FROM JANUARY 1983 GEOCHEMISTRY WORKSHOP
- CLOSEOUT COMMENTS FROM JULY 1984 GEOCHEMISTRY WORKSHOP

KEY ISSUES FROM ORANGE Los Al

DRAFT SCR

NNWSI PROJECT

TASK	MINERALOGY/ PETROLOGY	GROUNDWATER CHEMISTRY	NATURAL ISOTOPE CHEMISTRY	HYDROTHERMAL GEOCHEMISTRY	SOLUBILITY	SORPTION/ PRECIPITATION	DYNAMIC TRANSPORT	RETARDATION SENSITIVITY	APPLIED DIFFUSION	SEAL MATERIAL EVALUATIO
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1.1.2				◆						
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3.5.4					◆					

NNWSI PROJECT

CORRELATION OF LANL WORK WITH NRC ISSUES FROM ISTP FOR NNWSI

Los Alamos

NRC ISSUE	MINERALOGY/ PETROLOGY	GROUNDWATER CHEMISTRY	NATURAL ISOTOPE CHEMISTRY	HYDROTHERMAL GEOCHEMISTRY	SOLUBILITY	SORPTION/ PRECIPITATION	DYNAMIC TRANSPORT	RETARDATION SENSITIVITY	APPLIED DIFFUSION	SEAL MATERIAL EVALUATION
3.1										
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Los Alamos

MINERALOGY AND PETROLOGY

WBS 2.3.4.2

D. T. VANIMAN

MINERALOGY–PETROLOGY: ISSUE 1.2

Los Alamos

CT

LOGIC PATHS, FLUXES, VELOCITIES, AND TRAVEL TIMES"

ATION NEEDS:

1 – CONSTRAINTS ON DEPTH AND EXTENT OF EMPLACEMENT HORIZON ?

2 – DEFINITION OF ACCESSIBLE ENVIRONMENT ?

3 – WHAT ARE THE UNSATURATED FLOW PATHS ?

4 – WHAT ARE THE SATURATED FLOW PATHS ?

5 – EFFECTS OF THERMAL PULSE ON ROCK PROPERTIES, PERMEABILITY, SATURATION ?

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MINERALOGY-PETROLOGY: ISSUE 1.3

Los Alamos

"WHAT DEGREE OF RADIONUCLIDE RETARDATION WILL BE ATTAINED?"

INFORMATION NEEDS:

- 1.3.1 – SORPTION PROCESSES?
- 1.3.2 – PRECIPITATION PROCESSES?
- 1.3.4 – BOUNDS ON OVERALL RETARDATION?

MINERALOGY-PETROLOGY: ISSUE 3.3

Los Alamos

"IMPACTS ON COST OR SAFETY"

INFORMATION NEEDS:

- 3.3.1 – TARGET HORIZON CONTINUITY ?

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MINERALOGY–PETROLOGY: Los Alamos
ISSUE 3.4

"COST-EFFECTIVE FOR TRANSPORT, EMPLACEMENT, AND POSSIBLE RETRIEVAL"

INFORMATION NEEDS:

- 3.4.1 – BOUNDARIES OF THE REPOSITORY BLOCK ?
- 3.4.2 – ALLOWABLE GROSS THERMAL LOADING ?

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ISSUES/TASKS MATRIX FOR MINERALOGY-PETROLOGY

Los Alamos

	PATHWAYS (2.1)					RETARDATION (1.3)			TARGET HORIZON (3.3)	THERMAL LOADING (3.4)	
	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5	1.3.1	1.3.2	1.3.4	3.3.1	3.4.1	3.4.2
ALTERATION MINERALOGY			X	X							
MINERAL STABILITY	X	X			X	X				X	X
MINERALOGY OF TRANSPORT PATHWAYS	X	X				X	X	X	X	X	X
EXPLORATORY SHAFT	X	X	X						X	X	

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MINERALOGY-PETROLOGY STUDIES ARE SUBDIVIDED INTO FOUR ELEMENTS

Los Alamos

- ALTERATION MINERALOGY
- MINERAL STABILITY
- MINERALOGY OF TRANSPORT PATHWAYS
- EXPLORATORY SHAFT MINERALOGY AND PETROLOGY

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ALTERATION MINERALOGY

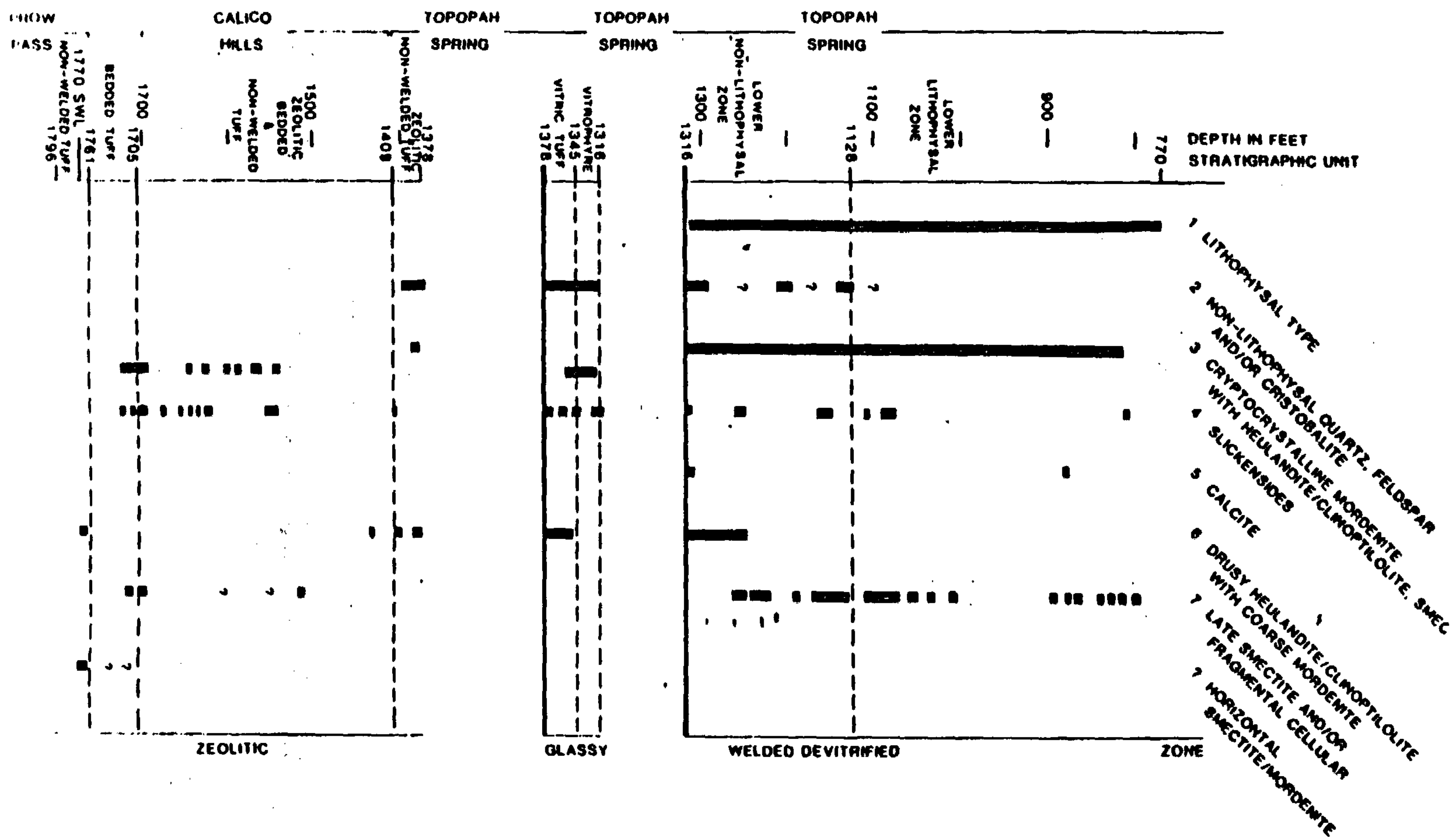
Los Alamos

FRACTURE MINERALOGY –

- PAST FLOW PATHS, FLOW TIMES, AND TRANSPORT PHENOMENA

NATURAL ALTERATION –

- TIMING, TEMPERATURES, AND TECTONIC RELATIONS OF PAST ALTERATION



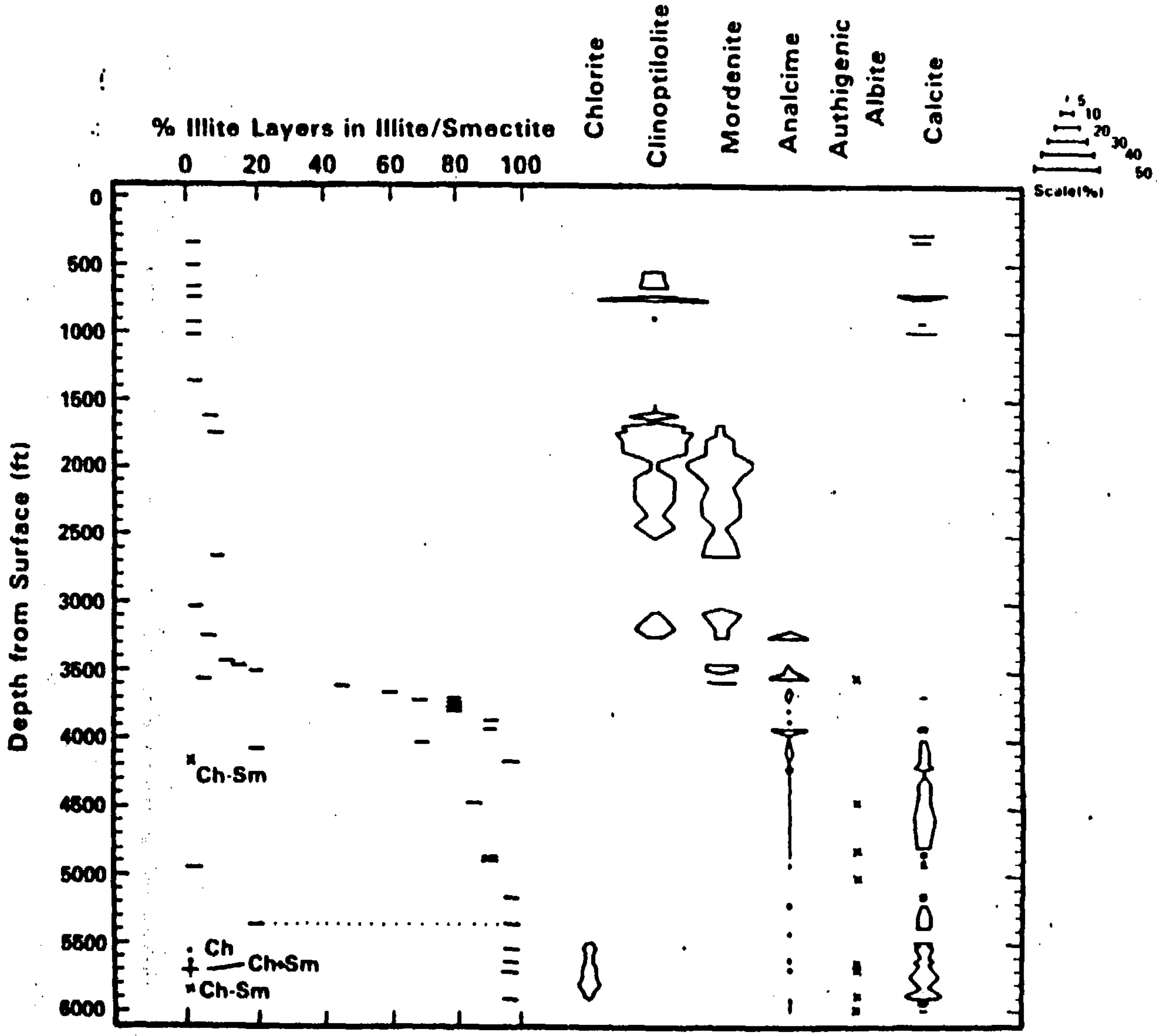
PROW PASS
CALICO HILLS
TOPOPAH SPRING
TOPOPAH SPRING
TOPOPAH SPRING
DEPTH IN FEET
STRATIGRAPHIC UNIT
NON-WELDED TUFF
BEDDED TUFF
ZEOLITIC BEDDED & NON-WELDED TUFF
ZEOLITIC NON-WELDED TUFF
VITRIC TUFF
VITROPHYRE
LOWER NON-LITHOPHYSAL ZONE
LOWER LITHOPHYSAL ZONE
1 LITHOPHYSAL TYPE
2 NON-LITHOPHYSAL QUARTZ, FELDSPAR AND/OR CRISTOBALITE
3 CRYPTOCRYSTALLINE MORDENITE WITH HEULANDITE/CLINOPTILOLITE, SMEC
4 SLICKENSIDES
5 CALCITE
6 DRUSY HEULANDITE/CLINOPTILOLITE WITH COARSE MORDENITE
7 LATE SMECTITE AND/OR FRAGMENTAL CELLULAR
7 HORIZONTAL SMECTITE/MORDENITE
ZEOLITIC
GLASSY
WELDED DEVITRIFIED
ZONE

NNWSI PROJECT

Los Alamos

MINERAL STABILITY

- GEOLOGIC RECORD OF HYDROTHERMAL ALTERATION AT YUCCA MOUNTAIN
- DEHYDRATION KINETICS IN SMECTITES, ZEOLITES, AND GLASSES
- CATION–EXCHANGE CAPABILITIES OF ZEOLITES AFTER PROLONGED HEATING
- EXPERIMENTS ON LOW–TEMPERATURE ALTERATION, TOPOPAH SPRING VITROPHYRE (LLNL)



HYDROTHERMAL ALTERATION AT DEPTH IN USW G-2

NNWSI PROJECT

MINERAL STABILITY EXPERIMENTS

Los Alamos

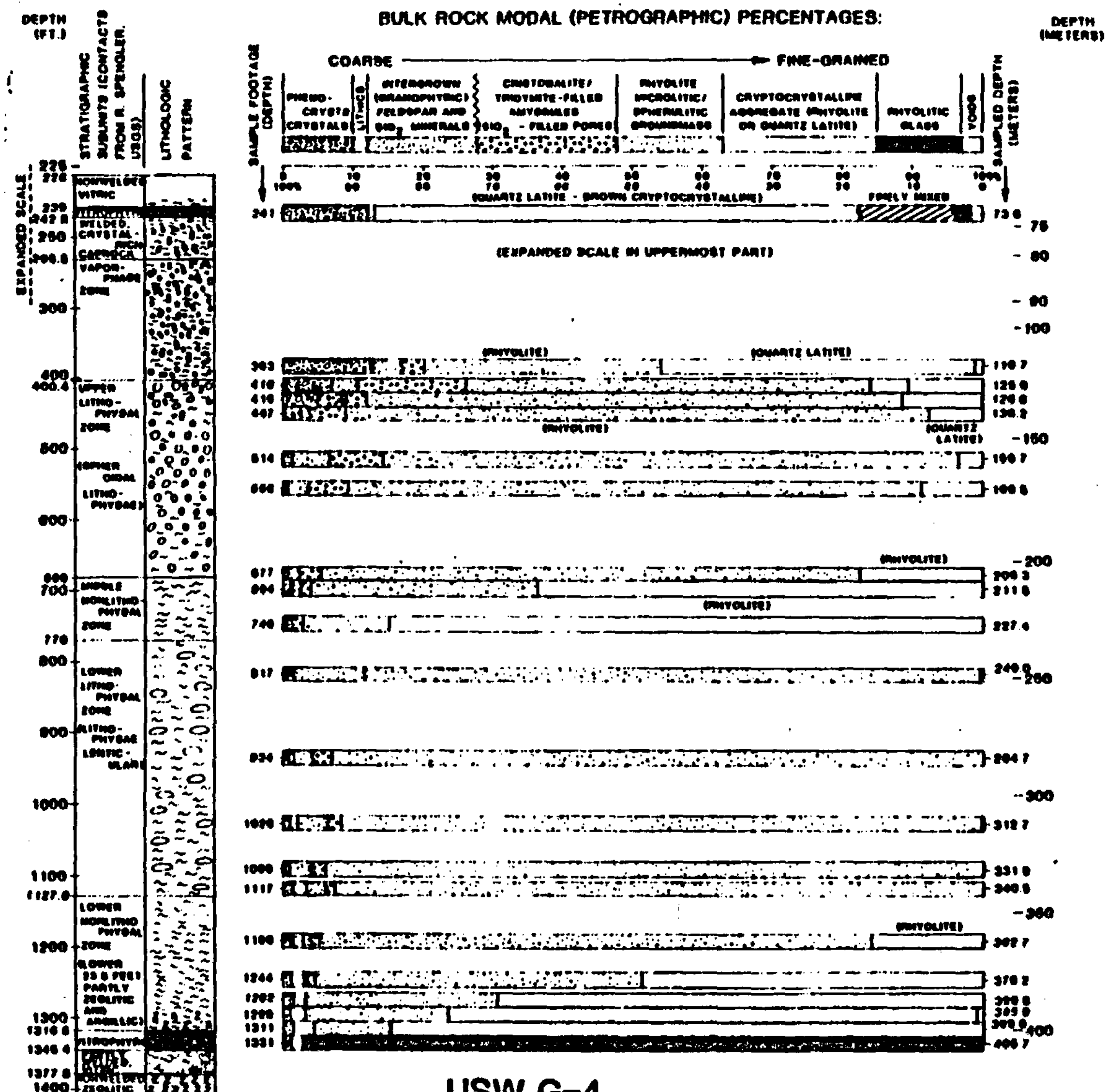
- HYDRATION CAPABILITY IS COUPLED TO SORPTION CAPABILITY. WILL ZEOLITES REHYDRATE AFTER 100–1000 YEARS AT 100°C ?
- WILL THE CATION EXCHANGE CAPACITY OF ZEOLITES BE AFFECTED AFTER 100–1000 YEARS AT 50–100°C ?
- WILL GLASS ALTERATION BE SIGNIFICANT ? (TOPOPAH VITROPHYRE EXPERIMENTS WITH LLNL)

NNWSI PROJECT

MINERALOGY OF TRANSPORT PATHWAYS

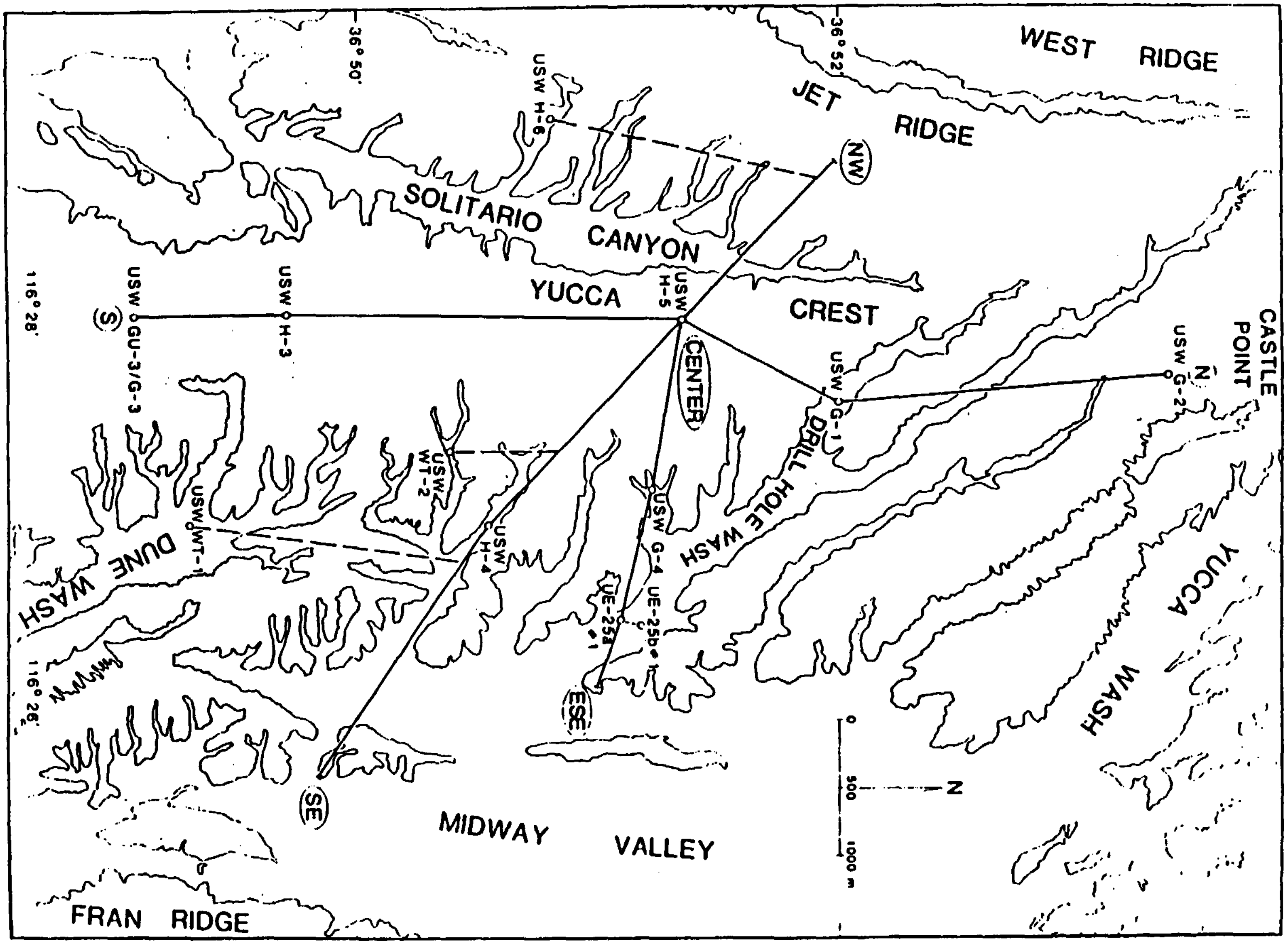
Los Alamos

- HOST ROCK PETROGRAPHY; MEASURES OF CONTINUITY AND OF VARIABILITY
- THREE DIMENSIONAL MINERALOGIC MODEL OF YUCCA MOUNTAIN
- LIMITS ON DISTRIBUTION AND ABUNDANCE OF FERROUS IRON
- QUANTITATIVE X-RAY DIFFRACTION ANALYSIS
- STATISTICAL EVALUATION OF THREE-DIMENSIONAL MINERALOGIC MODELS

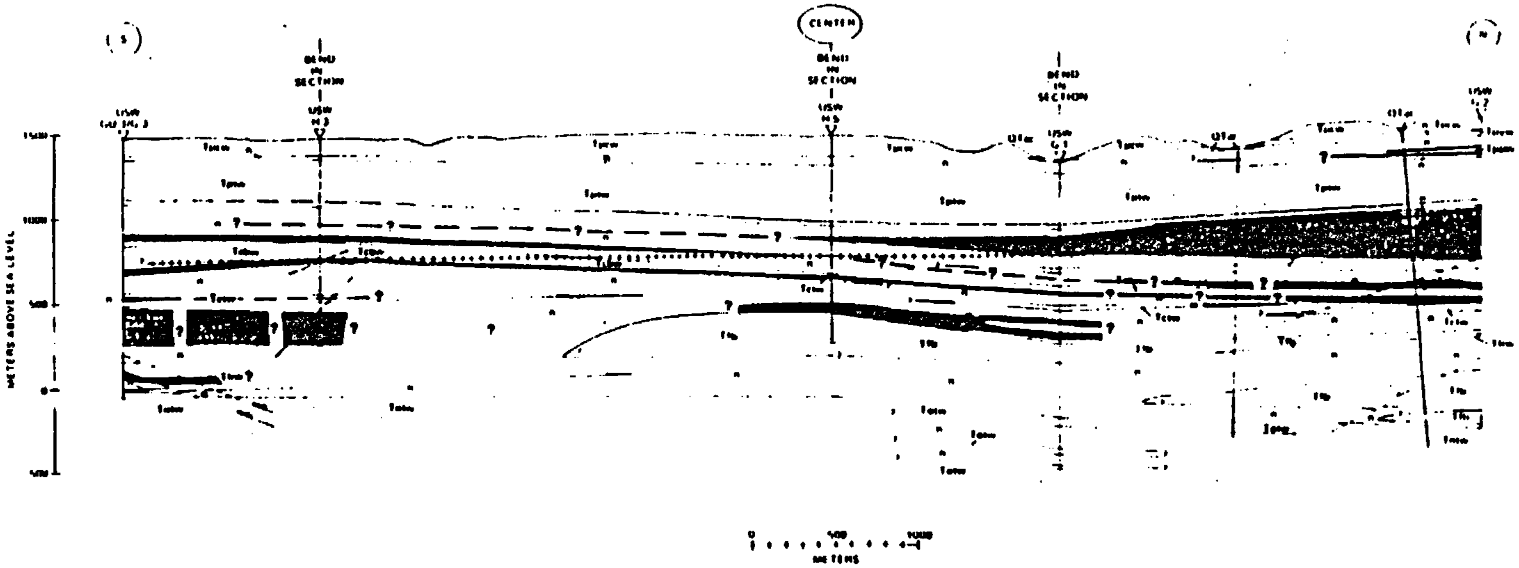


DEPTH (FT.)
STRATIGRAPHIC SUBUNITS (CONTACTS FROM R. SPENGLER, USGS)
LITHOLOGIC PATTERN
EXPANDED SCALE
BULK ROCK MODAL (PETROGRAPHIC) PERCENTAGES:
COARSE
FINE-GRAINED
SAMPLE FOOTAGE (DEPTH)
CRYPTOCRYSTALLINE AGGREGATE (RHYOLITE OR QUARTZ LATITE)
RHYOLITIC GLASS
VOIDS
SAMPLED DEPTH (METERS)
DEPTH (METERS)
(EXPANDED SCALE IN UPPERMOST PART)
(RHYOLITE)
(QUARTZ LATITE)

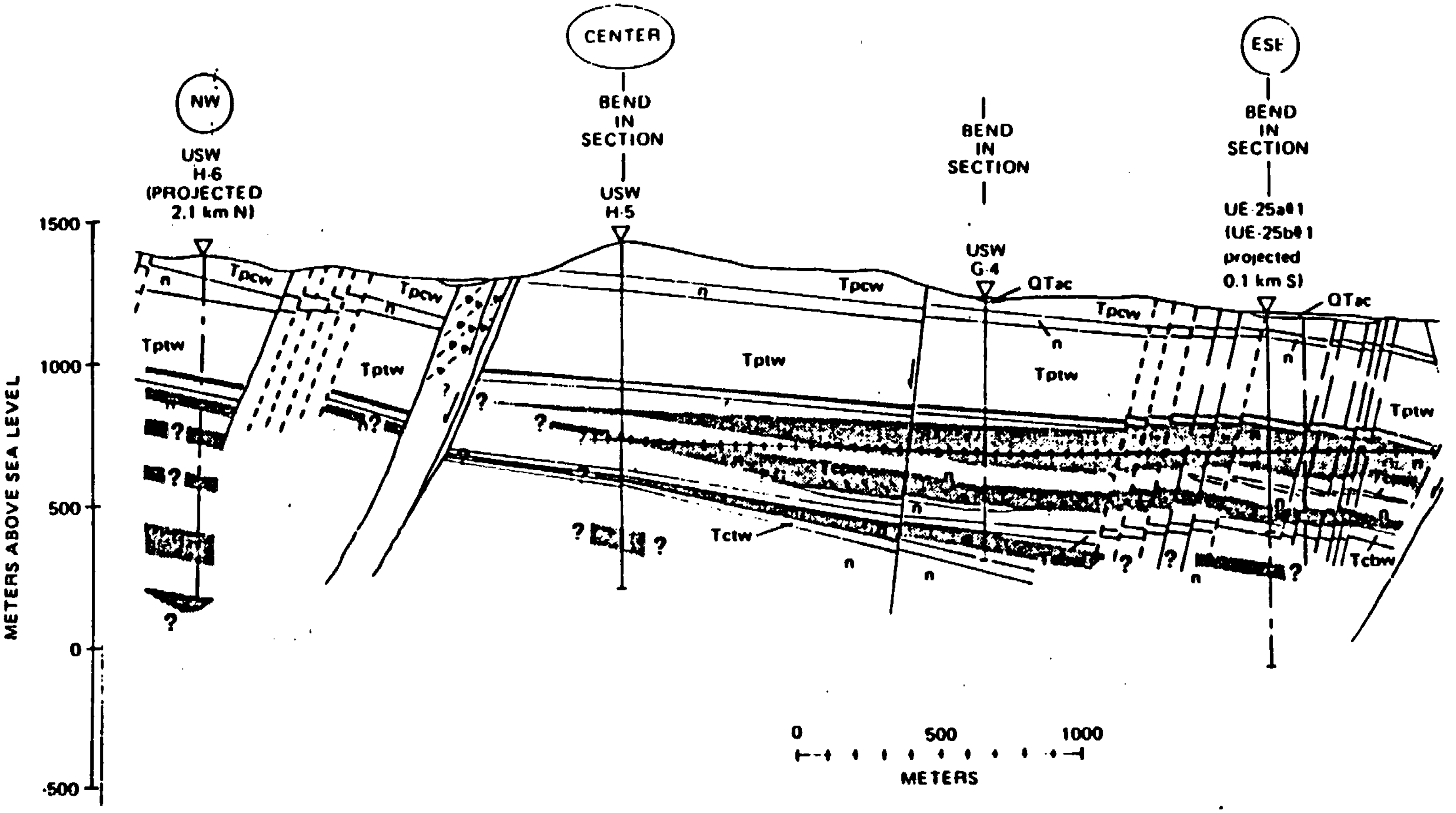
USW G-4



WEST RIDGE
JET RIDGE
SOLITARIO CANYON
YUCCA CREST
CASTLE POINT
DRILL HOLE WASH
DUNE WASH
YUCCA WASH
MIDWAY VALLEY
FRAN RIDGE
NW
S
CENTER
N
SE
ESE
USW H-6
USW H-5
USW H-3
USW GU-3/G-3
USW G-1
USW G-2
USW WT-2
USW WT-1
USW H-4
USW G-4
UE-25a #1
UE-25b #1
36° 50'
36° 52'
116° 28'
116° 26'
0
500
1000 m
N



Major Clinoptilolite/Mordenite Intervals



Major Clinoptilolite/Mordenite Intervals

H-5 below 760 m from Beatly, et al.
central part of H-6 from Craig, et al.

NNWSI PROJECT

EXPLORATORY SHAFT MINERALOGY AND PETROLOGY

Los Alamos

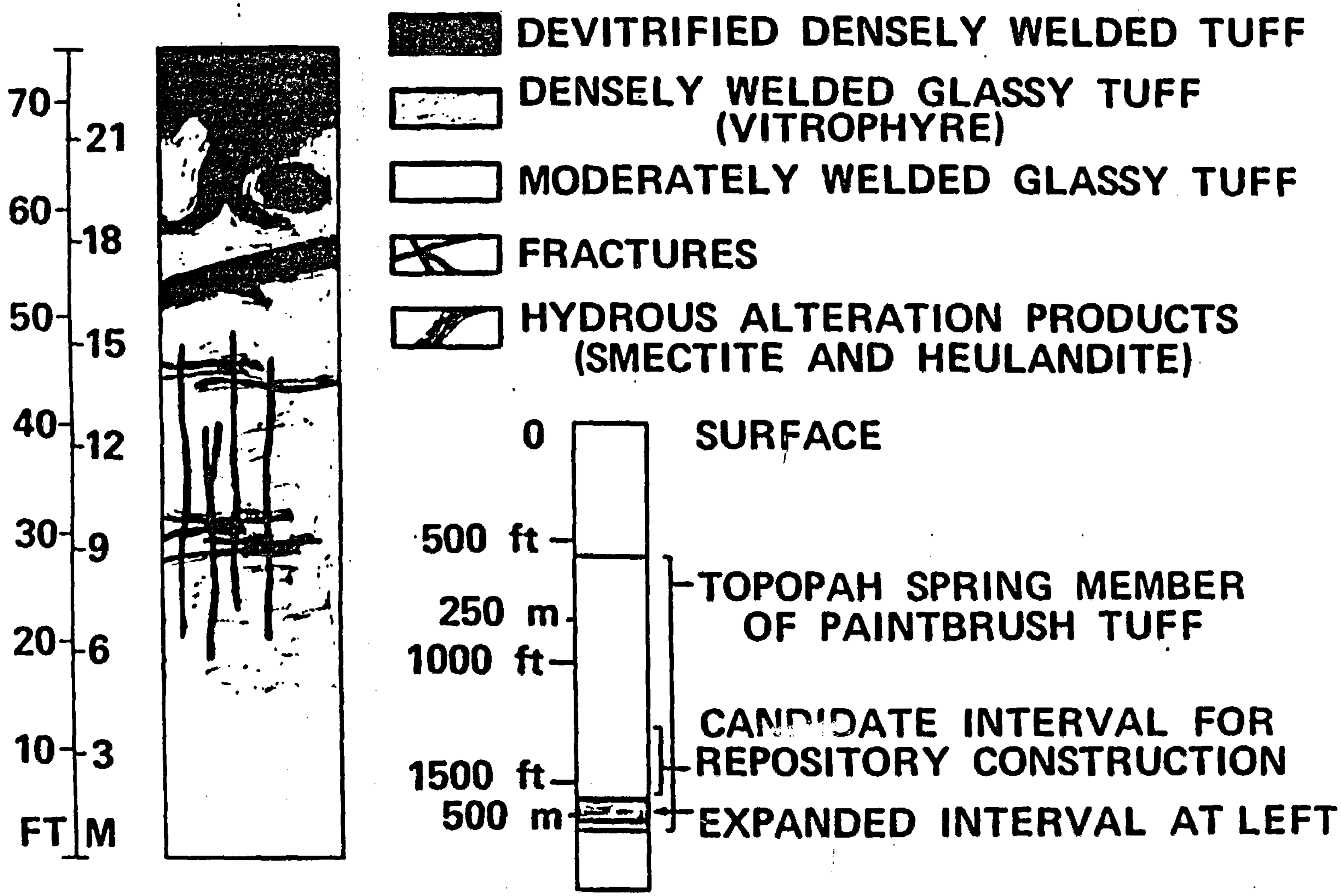
- IMPROVEMENTS ON AND TESTS OF TOPOPAH SPRING INTERNAL PETROLOGY: REALISTIC MINING ENVIRONMENT

- CRITICAL PETROLOGIC TRANSITIONS UNDERLYING THE DEVITRIFIED TOPOPAH SPRING MEMBER: ZEOLITE/CLAY, VITROPHYRE, VITRIC NONWELDED, ZEOLITE

- FRACTURE MINERALOGY IN LARGE SAMPLES: SPOILS OF MINING

- MAPPING SUPPORT (USGS)

GENERALIZED LITHOLOGY OF TOPOPAH SPRING VITROPHYRE



NNWSI PROJECT

TIMETABLE FOR MINERALOGY-PETROLOGY COMPLETIONS

Los Alamos

- ALTERATION MINERALOGY 6/86
- MINERAL STABILITY 12/86
- MINERALOGY OF TRANSPORT PATHWAYS 6/89*
- EXPLORATORY SHAFT MINERALOGY AND PETROLOGY 3/89*

*DEPENDENT ON ES SCHEDULE

NNWSI PROJECT

Los Alamos

HYDROTHERMAL GEOCHEMISTRY WBS 2.3.4.1.3

C. J. DUFFY

OBJECTIVE

- PRODUCE A CONCEPTUAL MODEL FOR THE EVOLUTION OF YUCCA MOUNTAIN TO ITS PRESENT MINERALOGIC STATE
- PREDICT THE FUTURE STATES OF YUCCA MOUNTAIN FOR TIMES IMPORTANT FOR A REPOSITORY
  - INCLUDES
    - NATURAL CHANGES
    - CHANGES DUE TO REPOSITORY EMPLACEMENT

NNWSI PROJECT

Los Alamos

ISSUES

1.1.1 ESTIMATES OF AND BOUNDS ON THE FLOW OF STEAM, AIR, AND WATER IN THE WASTE PACKAGE EMPLACEMENT ENVIRONMENT

1.1.2 ESTIMATES OF AND BOUNDS ON THE CHEMICAL CHARACTERISTICS OF STEAM, AIR, AND WATER, IN THE HORIZON AND WASTE PACKAGES

1.2.1 ESTIMATES OF BOUNDS ON THE GEOLOGIC FRAMEWORK OF THE SITE, INCLUDING THE LOCATIONS OF ANY STRATIGRAPHIC OR STRUCTURAL CONSTRAINTS ON THE DEPTH AND LATERAL EXTENT OF THE WASTE-EMPLACEMENT HORIZON

1.2.3 ESTIMATES OF AND BOUNDS ON HYDROLOGIC FLOW PATHS, FLUXES, WATER VELOCITIES, AND TRAVEL TIMES IN THE UNSATURATED ZONE

1.2.5 ESTIMATES OF AND BOUNDS ON THE EFFECTS OF THE REPOSITORY-INDUCED THERMAL PULSE AND ROCK EXCAVATIONS ON ROCK-MASS PROPERTIES AND THE RESULTING EFFECTS ON THE PERMEABILITY AND DEGREE OF SATURATION IN THE UNSATURATED AND SATURATED ZONES

1.3.1 ESTIMATES OF AND BOUNDS ON RADIONUCLIDE RETARDATION BY SORPTION PROCESSES

1.3.2 ESTIMATES OF AND BOUNDS ON RETARDATION BY PRECIPITATION PROCESSES

1.3.4 CALCULATED ESTIMATES OF AND BOUNDS ON RADIONUCLIDE RETARDATION ALONG THE HYDROLOGIC FLOW PATHS WITHIN THE REPOSITORY AND BETWEEN THE REPOSITORY AND THE ACCESSIBLE ENVIRONMENT

1.4.1 DEFINITION OF BOUNDARIES OF THE WASTE PACKAGE, ENGINEERED BARRIER SYSTEM, DISTURBED ZONE, AND ACCESSIBLE ENVIRONMENT

1.4.2 CALCULATED ESTIMATES OF AND BOUNDS ON THE PERFORMANCE OF THE TOTAL WASTE ISOLATION SYSTEM, INCLUDING WASTE PACKAGE RELEASE RATES, GROUNDWATER TRAVEL TIME, RETARDATION OF RADIONUCLIDES, AND THE INTEGRATED RELEASE OF RADIONUCLIDES TO THE ACCESSIBLE ENVIRC[illegible] A FUNCTION OF TIME

2.2.5 CALCULATED ESTIMATES OF AND BOUNDS ON THE RATES AND CONCENTRATIONS OF RADIONUCLIDE RELEASES FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT RESULTING FROM FUTURE CLIMATIC CONDITIONS AND TECTONISM

NNWSI PROJECT

TYPES OF DATA TO BE OBTAINED

Los Alamos

- THERMODYNAMIC DATA FOR ZEOLITE SOLID SOLUTIONS
- THERMODYNAMIC DATA FOR CLAY SOLID SOLUTIONS
- DATA ON THE EFFECTS OF Al/Si ORDERING ON THE THERMODYNAMICS OF ALKALI FELDSPARS
- KINETIC DATA ON MINERAL DISSOLUTION AND PRECIPITATION
- MINERALOGIC AND WATER COMPOSITION DATA FROM HOT SPRING DEPOSITS IN TUFF

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MODELS NEEDED

- EQ3/6
- KINETIC DISSOLUTION/PRECIPITATION MODELS
- COUPLED MASS TRANSPORT AND KINETIC MODELS

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WHAT CAN BE CALCULATED?

Los Alamos

EQ3/6

- EQUILIBRIUM MINERAL ASSEMBLAGES AND WATER COMPOSITIONS
- FUTURE VERSIONS MAY CONTAIN KINETICS

KINETIC DISSOLUTION/PRECIPITATION MODELS

- RATE OF CHANGE OF METASTABLE MINERAL ASSEMBLAGES AND WATER COMPOSITIONS

COUPLED MASS TRANSPORT AND KINETIC MODELS

- DISTRIBUTION OF METASTABLE MINERAL ASSEMBLAGES AND FLUID COMPOSITIONS
- RELATIONSHIP OF FLUID FLUX TO METASTABLE MINERAL DISTRIBUTION

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ARE THE MODELS CORRECT?

Los Alamos

- DO THEY EXPLAIN OBSERVATION IN YUCCA MOUNTAIN ?
- DO THEY EXPLAIN OBSERVATIONS IN HOT SPRING DEPOSITS IN TUFF ?
- DO THEY EXPLAIN LITERATURE DATA ON ALTERATION OF VITRIC TUFFS ?

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ESTIMATES OF AND BOUNDS ON RADIONUCLIDE RETARDATION

Los Alamos

BY SORPTION PROCESSES

- DEPENDENT ON MINERALOGY

BY PRECIPITATION PROCESSES

- DEPENDENT ON WATER CHEMISTRY
- DEPENDENT ON MINERALS THAT MAY BE PRECIPITATING

ESTIMATES OF AND BOUNDS ON HYDROLOGIC FLOW PATHS, FLUXES, WATER VELOCITIES, AND TRAVEL TIMES IN THE UNSATURATED ZONE

- WATER MOVEMENT THROUGH THE UNSATURATED ZONE, COUPLED WITH MINERAL AND GLASS DISSOLUTION AND PRECIPITATION RATES, DETERMINES THE DISTRIBUTION OF MINERALS

- MODELING THE DEVELOPMENT OF THE PRESENT MINERAL DISTRIBUTION CAN PROVIDE ESTIMATES OF THE FLOW PATHS, FLUXES, WATER VELOCITIES, AND TRAVEL TIMES

NNWSI PROJECT

STABILITY OF CLINOPTILOLITE

Los Alamos

- CLINOPTILOLITE IS A HIGHLY SORPTIVE MINERAL
- CLINOPTILOLITE → FELDSPAR + SiO_2
- FIELD EVIDENCE SUGGESTS THAT CLINOPTILOLITE IS NOT STABLE WHEN THE ACTIVITY OF SiO_2 IS IN EQUILIBRIUM WITH QUARTZ
- AS TEMPERATURE INCREASES, THE ACTIVITY OF SiO_2 MUST INCREASE RELATIVE TO QUARTZ SATURATION TO MAINTAIN CLINOPTILOLITE STABILITY

NNWSI PROJECT

Los Alamos

DISTRIBUTION OF SILICA POLYMORPHS

TRIDYMITE, CRISTOBALITE, AND QUARTZ ARE PRESENT IN YUCCA MOUNTAIN

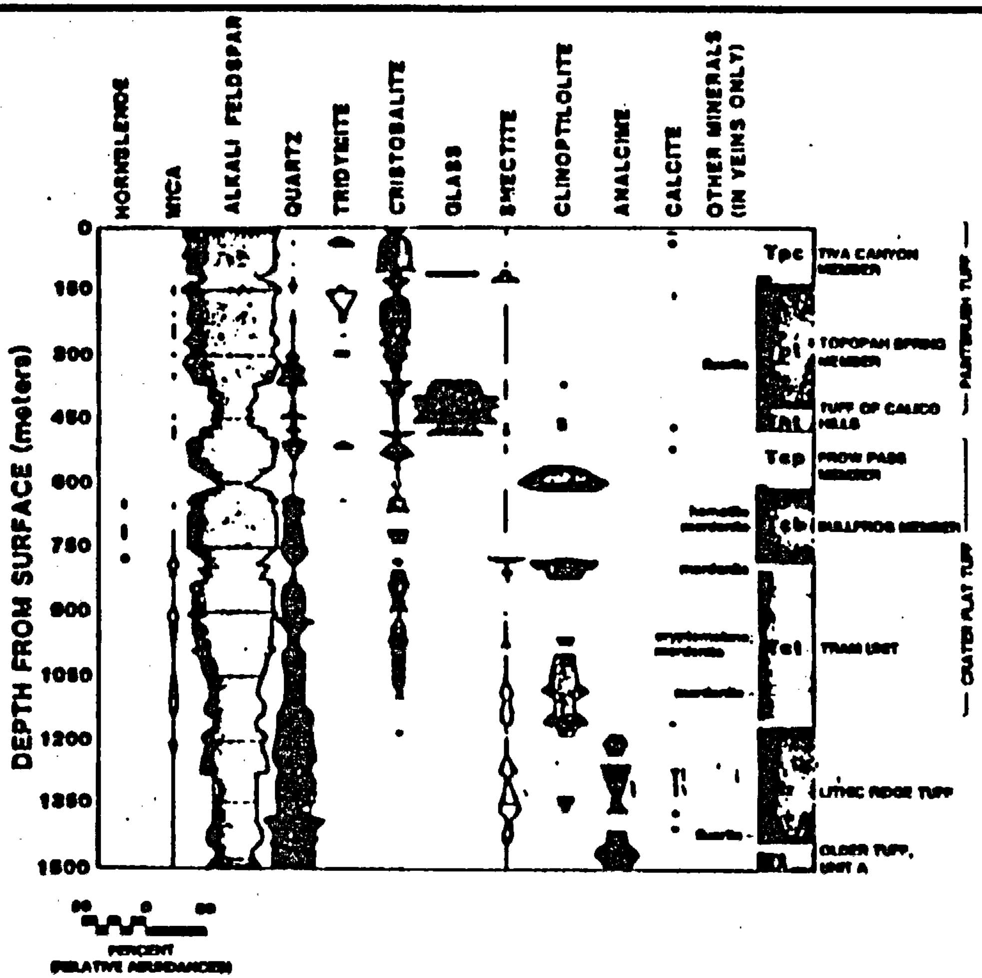
TRIDYMITE
- MOST SOLUBLE
- FOUND AT SHALLOW DEPTH
- GENERALLY ASSOCIATED WITH GLASS

CRISTOBALITE
- DECREASES WITH DEPTH
- ASSOCIATED WITH CLINOPTILOLITE BELOW THE STATIC WATER LEVEL

QUARTZ
- INCREASES WITH DEPTH

NNWSI PROJECT

Los Alamos



NNWSI PROJECT

Los Alamos

GROUNDWATER CHEMISTRY

WBS 2.3.4.1.1

A. E. OGARD

PLANNED ACHIEVEMENTS

FY 1985
- DETERMINE PARTICLE CONTENT OF YUCCA MOUNTAIN WATER
- DETERMINE POTENTIAL OF MICROBIOLOGICAL ACTIVITY TO ALTER GROUNDWATER COMPOSITION
- PLAN IN SITU DEMONSTRATION OF MATRIX DIFFUSION AND PARTICULATE TRANSPORT

FY 1986
- UPDATE THE GROUNDWATER COMPOSITIONAL MODEL TO INCLUDE PATHWAY TO THE ACCESSIBLE ENVIRONMENT
- CALCULATE POSSIBLE TRANSPORT OF WASTE ELEMENTS SORBED ON PARTICULATES
- ESTIMATE PALEOHYDROLOGICAL FLAWS THROUGH ZEOLITIZED ZONES ABOVE THE WATER TABLE AT YUCCA MOUNTAIN
- START IN SITU TRANSPORT DEMONSTRATION

FY 1987
- ESTIMATE TOTAL EFFECTS OF MICROBIOLOGICAL ACTIVITY ON GROUNDWATER COMPOSITION
- PRODUCE UPDATED MODEL OF Eh AND pH BUFFERING CAPACITY OF YUCCA MOUNTAIN TUFF/WATER/AIR SYSTEM

NNWSI PROJECT

Los Alamos

ACHIEVEMENTS

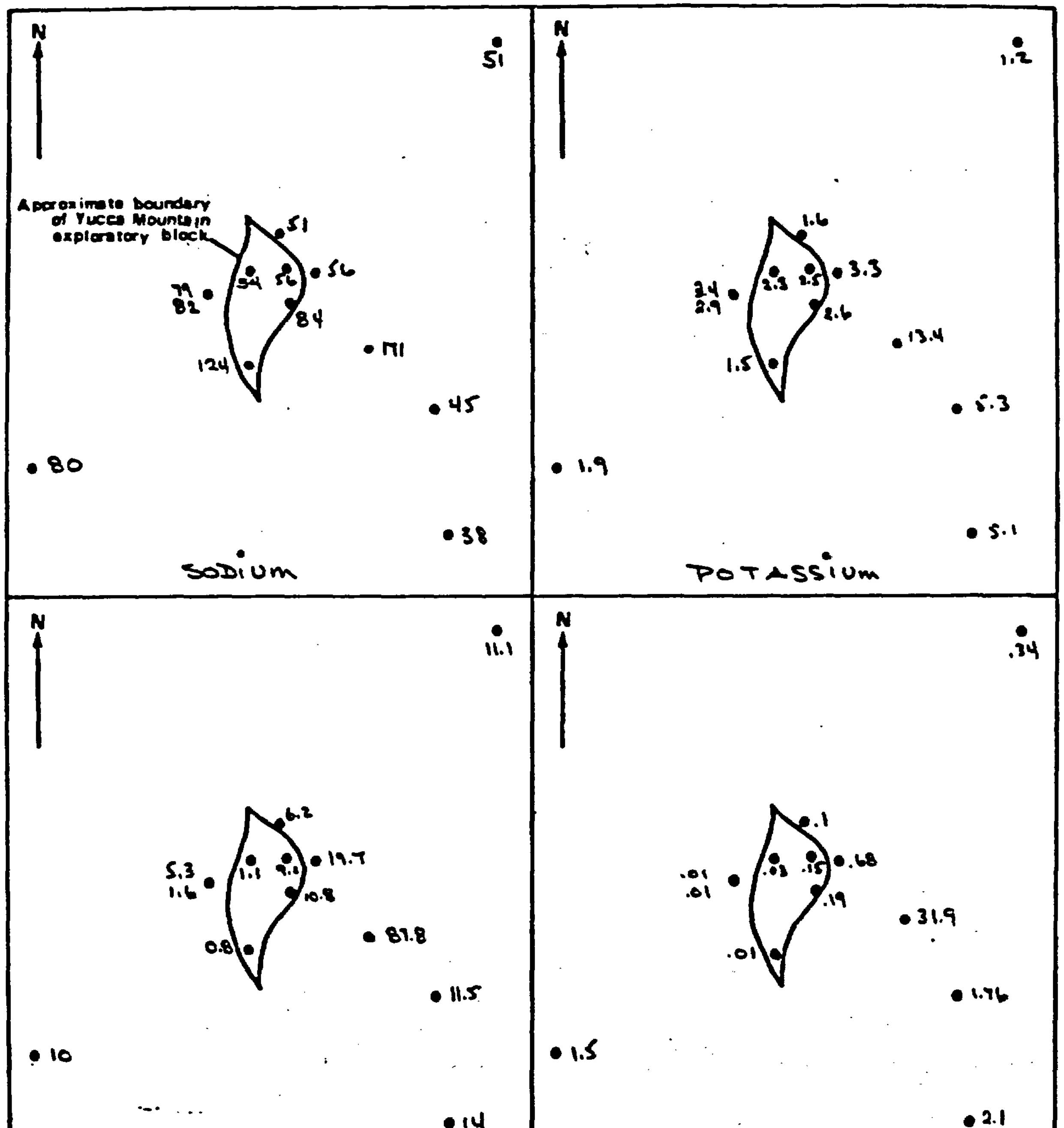
- ANALYSIS OF INTEGRAL SAMPLES FROM WELLS USW H-1, H-4, H-5, H-6, G-4, J-13, UE-29a#2, UE-25b#1, AND UE-25p#1
- ANALYSIS OF INDIVIDUAL ZONES FROM WELLS USW H-3, H-6, AND UE-25b#1
- PRELIMINARY MODEL OF GROUNDWATER ALONG PATHWAYS TO ACCESSIBLE ENVIRONMENT, LA-10188-MS
- PRELIMINARY MODEL OF Eh AND pH BUFFERING CAPACITY OF YUCCA MOUNTAIN AREA, LA-10188-MS

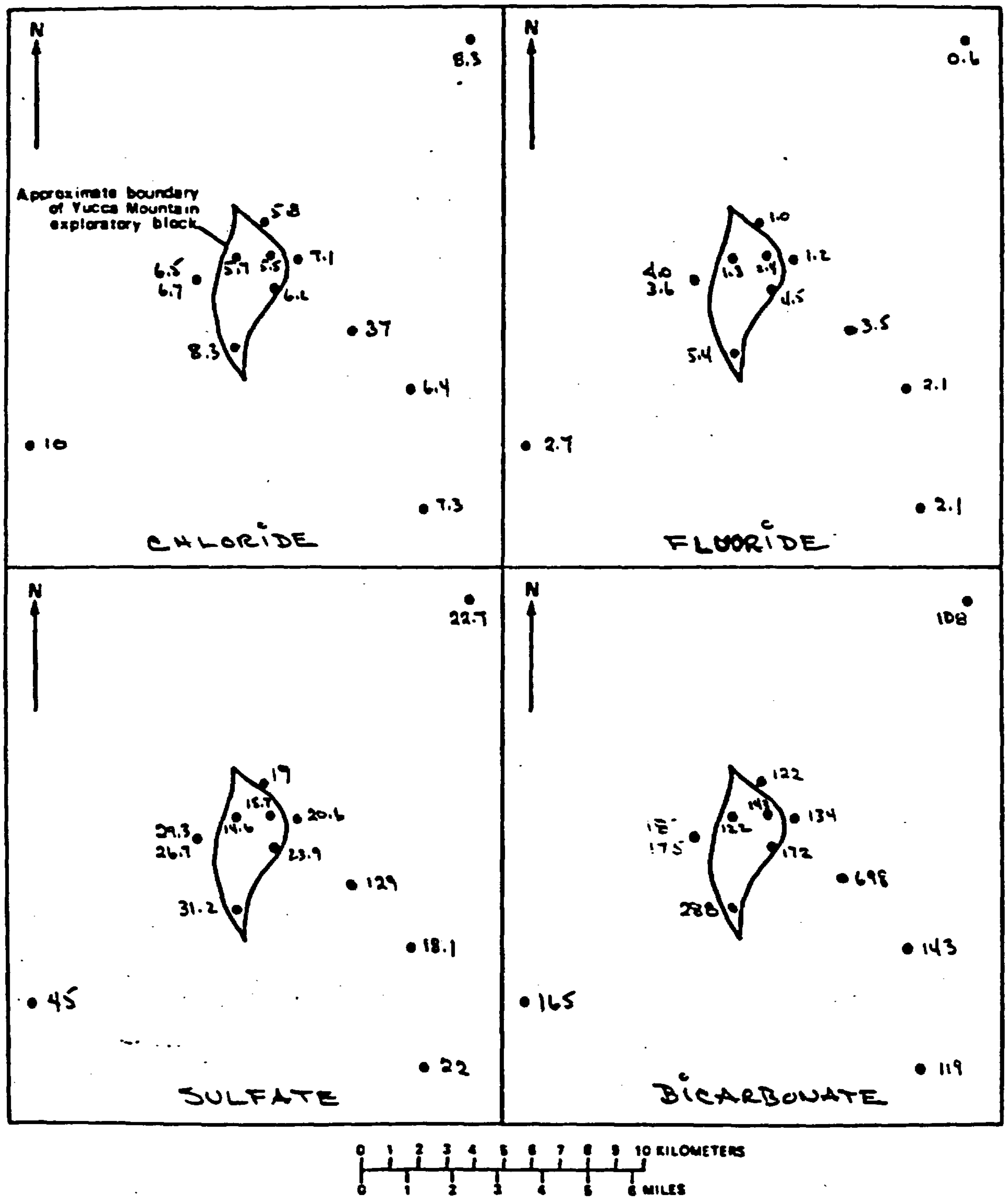
NNWSI PROJECT

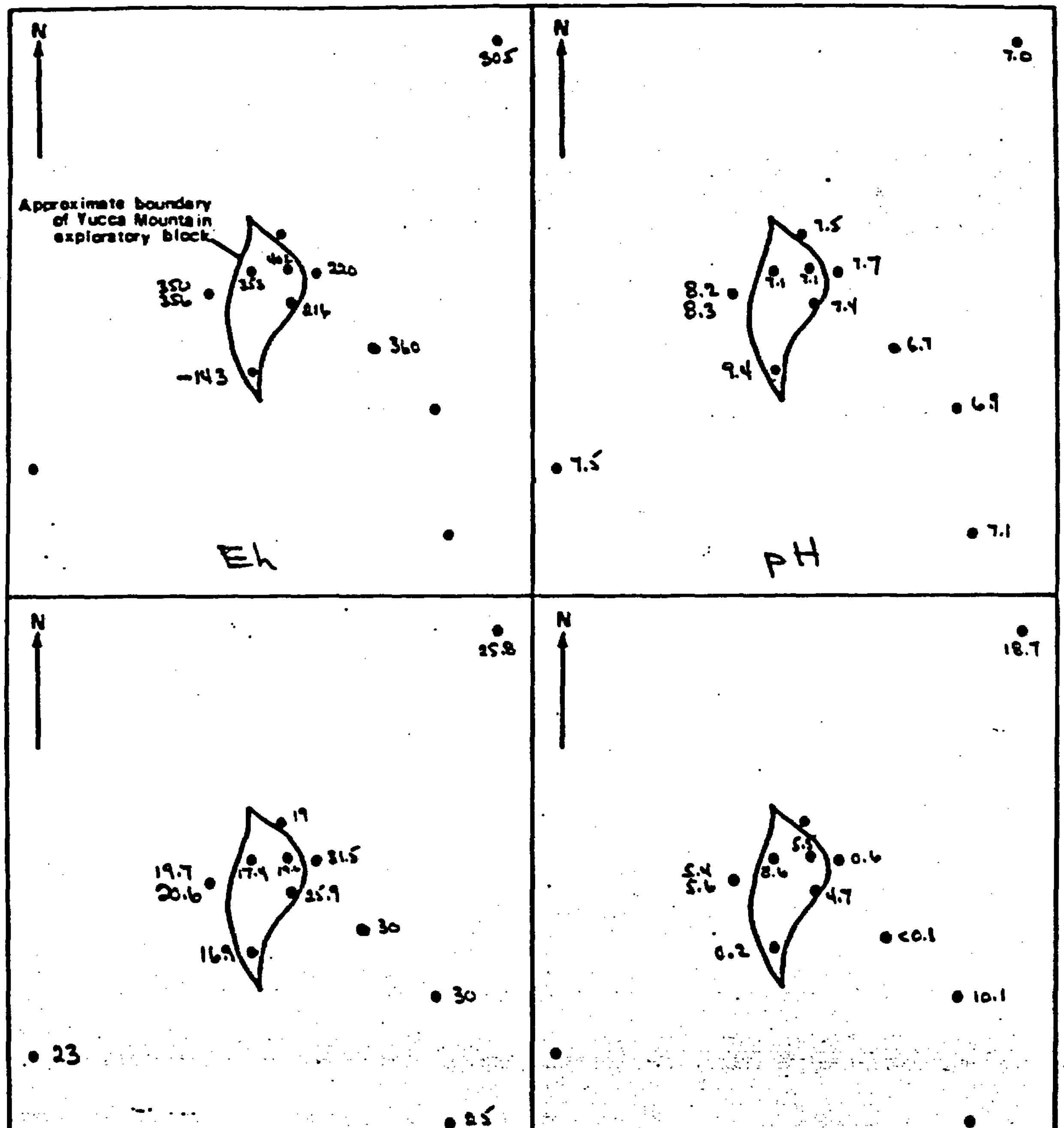
Los Alamos

SUBTASKS

- ANALYSIS OF GROUNDWATERS
- TUFF – GROUNDWATER INTERACTIONS
- ANALYSIS OF PARTICULATES
- POTENTIAL FOR MICROBIOLOGICAL ACTIVITY
- DEVELOP GROUNDWATER CHEMISTRY MODEL
- MODEL Eh AND pH CAPACITIES OF TUFF/WATER/AIR
- ESTIMATE EFFECTS OF PARTICULATE TRANSPORT
- IN SITU TRANSPORT TEST


N
51
Approximate boundary of Yucca Mountain exploratory block
51
56
54
56
79
82
84
171
124
45
80
38
SODIUM
N
1.2
1.6
3.3
2.4
2.9
2.3
2.5
2.6
13.4
1.5
1.9
5.1
POTASSIUM
N
11.1
6.2
19.7
5.3
1.6
10.8
81.8
0.8
11.5
10
14
N
.34
.1
.68
.01
.01
.15
.19
31.9
.01
1.76
1.5
2.1

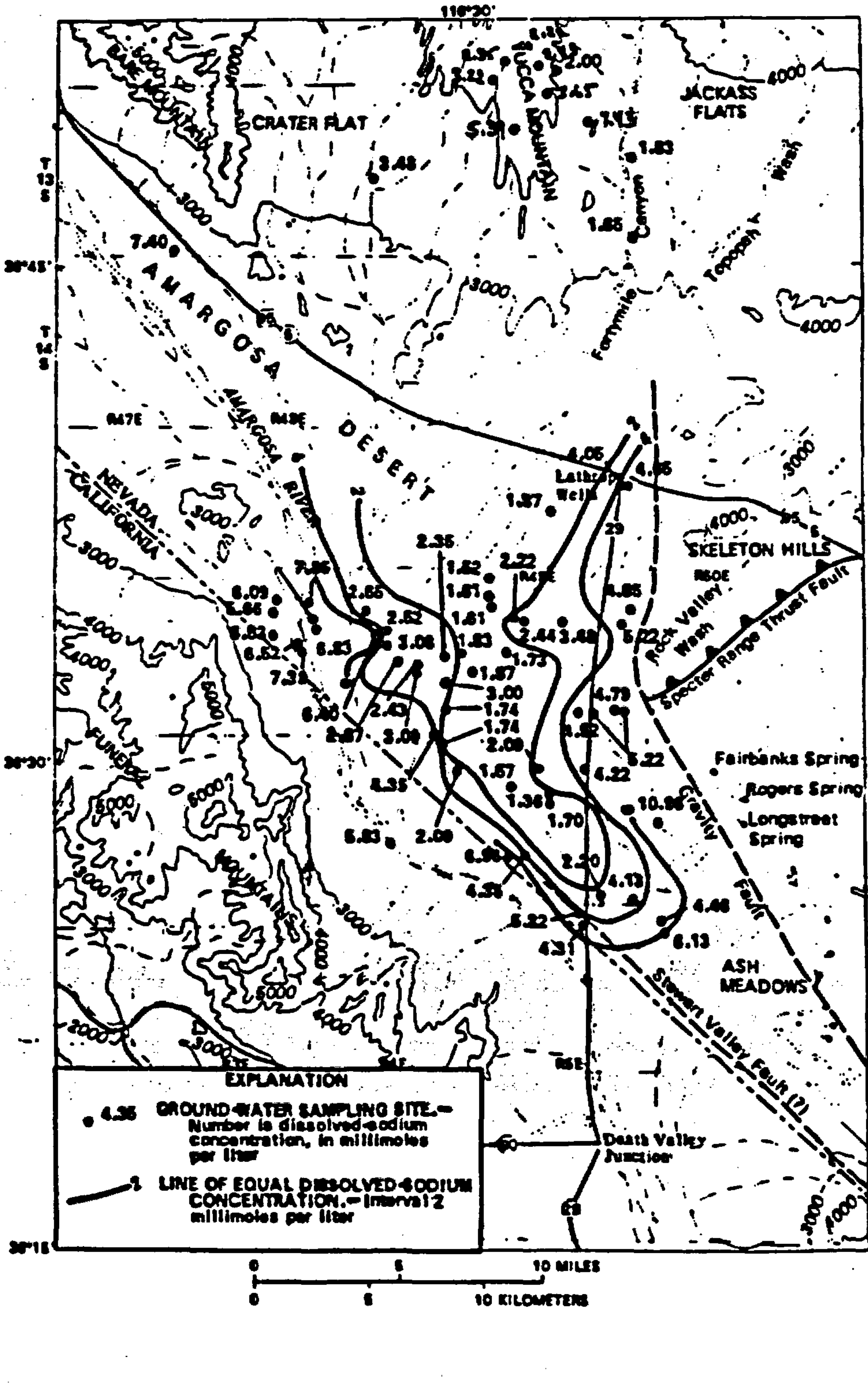

N
Approximate boundary of Yucca Mountain exploratory block
CHLORIDE
FLUORIDE
SULFATE
BICARBONATE
0 1 2 3 4 5 6 7 8 9 10 KILOMETERS
0 1 2 3 4 5 6 MILES


N
Approximate boundary of Yucca Mountain exploratory block
305
220
350
356
216
360
-143
Eh
N
7.0
7.5
7.7
8.2
8.3
7.4
6.7
9.4
6.9
7.5
7.1
pH
N
25.8
19
31.5
19.7
20.6
25.9
30
16.9
30
23
25
N
18.7
0.6
5.4
5.6
8.6
4.7
<0.1
0.2
10.1

NNWSI PROJECT

DISSOLVED SODIUM (Na^+) IN GROUNDWATER

Los Alamos



NNWSI PROJECT

WELL-TO-WELL PUMPING TESTS

Los Alamos

WELLS UE-25c#1,-2, AND -3

- MEASURE SCALE–SENSITIVE HYDROLOGY PARAMETERS SUCH AS DISPERSION (USGS)

- DEMONSTRATE RETARDATION IN SITU OF NON-SORBING WASTE ELEMENTS, COLLOIDS, AND PARTICULATES IN THE SATURATED ZONE

NNWSI PROJECT

WASTE-ELEMENT MIGRATORS

Los Alamos

- ^{95m}Tc $t_{1/2}$ = 61 DAYS
- ^{237}Pu $t_{1/2}$ = 45.6 DAYS
- NATURAL U AND Th ISOTOPES
- FLUORESCENT MICROSPHERES
- ACTINIDE OR RARE–EARTH COLLOIDS

- INTERNAL PLANNING AND REVIEW
- NRC REVIEW AND CONSENT
- COST AND TIMING OF ISOTOPE PRODUCTION
- RADIOLOGICAL HEALTH AND SAFETY

"ANALYSES AND MODELS THAT WILL BE USED TO PREDICT FUTURE CONDITIONS AND CHANGES IN THE GEOLOGIC SETTING SHALL BE SUPPORTED BY USING AN APPROPRIATE COMBINATION OF SUCH METHODS AS FIELD TESTS, IN SITU TESTS, LABORATORY TESTS WHICH ARE REPRESENTATIVE OF FIELD CONDITIONS, MONITORING DATA, AND NATURAL ANALOG STUDIES."

10CFR60, 60.21 (C) (I) (ii) (F)

NNWSI PROJECT

Los Alamos

NATURAL ISOTOPE CHEMISTRY

WBS 2.3.4.1.2

A. E. NORRIS

MEASUREMENTS OF YUCCA MOUNTAIN SAMPLES TO DETERMINE

- INFILTRATION FROM ^{36}Cl "BOMB PULSE" DATA
- ^{99}Tc TRANSPORT RELATIVE TO ^{36}Cl
- GROUNDWATER RETARDATION OF U, Th, AND Ra

NNWSI PROJECT

NATURAL ISOTOPE CHEMISTRY

^{36}Cl INFILTRATION

Los Alamos

PARAMETER TO BE MEASURED

- DEPTH OF ^{36}Cl BENEATH SURFACE

INFORMATION TO BE OBTAINED

- PRECIPITATION INFILTRATION DURING PAST 25 YEARS

NEED

- HYDROLOGIC MODEL OF YUCCA MOUNTAIN WATER MOVEMENT

NNWSI PROJECT

NATURAL ISOTOPE CHEMISTRY

^{36}Cl INFILTRATION

Los Alamos

FIELD TRIPS

- FEBRUARY 1984
  CHLORIDE CONCENTRATIONS IN YUCCA MOUNTAIN SOILS
- JUNE 1984
  SAMPLED TRENCH AT EXPLORATORY SHAFT SITE
  SELECTED FRACTURED TUFF SITE
- AUGUST 1984
  TRIED TO SAMPLE FRACTURED TUFF SITE

NNWSI PROJECT

NATURAL ISOTOPE CHEMISTRY

^{99}Tc TRANSPORT

Los Alamos

PARAMETER TO BE MEASURED

- ^{99}Tc DISTRIBUTION BENEATH SURFACE RELATIVE TO ^{36}Cl

INFORMATION TO BE OBTAINED

- ^{99}Tc TRANSPORT IN YUCCA MOUNTAIN SOIL RELATIVE TO ^{36}Cl

NEED

- ^{99}Tc TRANSPORT CALCULATIONS

NNWSI PROJECT

NATURAL ISOTOPE CHEMISTRY

Los Alamos

U, Th, AND Ra RETARDATION

PARAMETERS TO BE MEASURED

- DISTRIBUTIONS OF ^{238}U, ^{234}U, ^{234}Th, ^{232}Th, ^{230}Th, ^{228}Th, ^{228}Ra, ^{226}Ra, ^{224}Ra, AND ^{222}Rn IN YUCCA MOUNTAIN ROCK AND WATER SAMPLES

INFORMATION TO BE OBTAINED

- RETARDATION OF TRANSPORT OF LATER MEMBERS OF CHAINS RELATIVE TO EARLIER MEMBERS

NEED

- CALCULATION OF RADIOLOGICAL SAFETY IN THE FUTURE FOR THE YUCCA MOUNTAIN NUCLEAR WASTE REPOSITORY

N
N
W
S
I PROJECT

Los Alamos

SOLUBILITY DETERMINATION WBS 2.3.4.1.4

J. F. KERRISK

NNWSI PROJECT

OBJECTIVE OF SOLUBILITY DETERMINATION TASK — Los Alamos

DETERMINE SOLUBILITIES AND SPECIATION OF IMPORTANT WASTE ELEMENTS UNDER CONDITIONS THAT ARE CHARACTERISTIC OF THE REPOSITORY AND ALONG FLOW PATHS TO THE ENVIRONMENT

NNWSI PROJECT

ISSUES ADDRESSED BY SOLUBILITY AND SPECIATION DATA

Los Alamos

HOW WILL SOLUBILITY AND SPECIATION AFFECT RETARDATION?

- SOLUBILITY AND SPECIATION DATA ARE USED TO CALCULATE WASTE–ELEMENT CONCENTRATIONS:
  (1) AT THE WASTE AS AN ALTERNATE TO SOLID–WASTE DISSOLUTION RATES (SOURCE TERM)
  (2) ALONG FLOW PATHS IN RESPONSE TO CHANGING WATER CONDITIONS

- SPECIATION DATA ARE USED TO ESTIMATE HOW CHANGING WATER COMPOSITIONS INFLUENCE SORPTION

NNWSI PROJECT

REGULATORY BASIS FOR SOLUBILITY DETERMINATION

Los Alamos

- NRC DRAFT TECHNICAL POSITION ON SOLUBILITY – IF SOLUBILITIES ARE USED FOR PERFORMANCE ASSESSMENT, THEY SHOULD BE BASED ON SITE-SPECIFIC EXPERIMENTS UNDER EXPECTED REPOSITORY CONDITIONS

- NRC COMMENTS DURING GEOCHEMISTRY WORKSHOPS

NNWSI PROJECT

SOLUBILITY DETERMINATION APPROACH

Los Alamos

(1) DETERMINE IMPORTANT WASTE ELEMENTS AND REPOSITORY CONDITIONS

(2) MEASURE IMPORTANT WASTE–ELEMENT SOLUBILITIES

(3) MODEL SOLUBILITIES USING EXISTING SPECIATION DATA – IF MODEL IS INADEQUATE, IDENTIFY IMPORTANT AQUEOUS SPECIES AND MEASURE FORMATION CONSTANTS

SOLUBILITY DETERMINATION APPROACH (continued)

(4) IDENTIFY IMPORTANT WASTE ELEMENTS FORMING COLLOIDS IN SIGNIFICANT QUANTITIES – CHARACTERIZE PHYSICAL AND CHEMICAL NATURE OF COLLOIDS – MODEL, THERMODYNAMICALLY IF POSSIBLE

(5) CALCULATE WASTE ELEMENT SOLUBILITIES AND COLLOID CONCENTRATIONS AS NEEDED TO SUPPORT PERFORMANCE ASSESSMENT

NNWSI PROJECT

SOLUBILITY DETERMINATION SUBTASKS

Los Alamos

SUBTASK	DESCRIPTION	SCHEDULE
A	IDENTIFY RADIONUCLIDES	NOW - 9/85
B	DEFINE CONDITIONS	3/85 - 12/85
C	MEASURE SOLUBILITIES	9/85 - 3/89
D	MODEL SOLUBILITY AND SPECIATION	NOW - 9/89
E	MEASURE SPECIATION	NOW - 6/89
F	COLLOIDS	NOW - 3/87
G	FINAL SOLUBILITY CALCULATIONS	3/89 - 6/90
H	TASK MANAGEMENT	NOW - 9/90

NNWSI PROJECT

SOLUBILITY DETERMINATION SUBTASKS C AND E BREAKDOWN

Los Alamos

SUBTASK	DESCRIPTION	SCHEDULE
C	MEASURE SOLUBILITIES	9/85 - 3/89
	Pu, Am, Np	9/85 - 6/88
	U, Th	3/86 - 3/89
	Ra, Ni, Zr	9/86 - 9/88
	OTHER WASTE ELEMENTS	9/86 - 3/89
E	MEASURE SPECIATION	NOW - 6/89
	Am (III) - CARBONATE	NOW - 3/86
	Pu (IV) - CARBONATE	NOW - 9/86
	OTHER WASTE ELEMENTS	9/86 - 6/89

NNWSI PROJECT

Los Alamos

PAST CONTRIBUTIONS

- THERMODYNAMIC DATA – ZEOLITES AND WASTE ELEMENTS
- WASTE-ELEMENT SOLUBILITY MEASUREMENTS AND CALCULATIONS
- SOLUBILITY-LIMITED DISSOLUTION MODEL FOR WASTE
- PRELIMINARY ASSESSMENT OF KEY RADIO-NUCLIDES

NNWSI PROJECT

Los Alamos

SORPTION AND PRECIPITATION WBS 2.3.4.1.5

K. W. THOMAS

OBJECTIVE

TO PROVIDE NECESSARY DATA (SORPTION COEFFICIENTS) FOR PREDICTION OF RADIONUCLIDE MOVEMENT FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT

ISSUES ADDRESSED

- 1.3.1 ESTIMATES OF AND BOUNDS ON RADIONUCLIDE RETARDATION BY SORPTION PROCESSES
- 1.3.3 BOUNDS ON EFFECTIVE RETARDATION IN DISPERSIVE/DIFFUSIVE/ADVECTIVE TRANSPORT
- 1.3.4 CALCULATED ESTIMATES OF AND BOUNDS ON RADIONUCLIDE RETARDATION ALONG THE HYDROLOGIC FLOW PATHS WITHIN THE REPOSITORY AND BETWEEN THE REPOSITORY AND THE ACCESSIBLE ENVIRONMENT
- 1.4.2 CALCULATED ESTIMATES OF AND BOUNDS ON THE PERFORMANCE OF THE TOTAL WASTE ISOLATION SYSTEM, INCLUDING WASTE PACKAGE RELEASE RATES, GROUNDWATER TRAVEL TIME, RETARDATION OF RADIONUCLIDES, AND THE INTEGRATED RELEASE OF RADIONUCLIDES TO THE ACCESSIBLE ENVIRONMENT AS A FUNCTION OF TIME
- 2.2.4 CALCULATED ESTIMATES OF AND BOUNDS ON THE EFFECTS OF TECTONIC AND CLIMATIC CONDITIONS THAT HAVE REASONABLE POTENTIAL OF OCCURING ON HYDROLOGIC FLOW PATHS, HYDRAULIC PROPERTIES, AND RETARDATION POTENTIAL WITHIN THE REPOSITORY BLOCK AND BETWEEN THE REPOSITORY AND THE ACCESSIBLE ENVIRONMENT
- 2.2.5 CALCULATED ESTIMATES OF AND BOUNDS ON THE RATES AND CONCENTRATIONS OF RADIONUCLIDE RELEASES FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT RESULTING FROM FUTURE CLIMATIC CONDITIONS AND TECTONISM

NNWSI PROJECT

Los Alamos

METHOD

(1) MEASURE SORPTION COEFFICIENTS AS A FUNCTION OF
- MINERALOGY
- WATER COMPOSITION
- TEMPERATURE
- TIME
- ATMOSPHERE
- WASTE–ELEMENT CONCENTRATION
- WASTE ELEMENT SPECIATION
- PRESENCE OF DRILLING FLUIDS
- MICROBIAL ACTIVITY
- PRESENCE OF PARTICULATES AND COLLOIDS

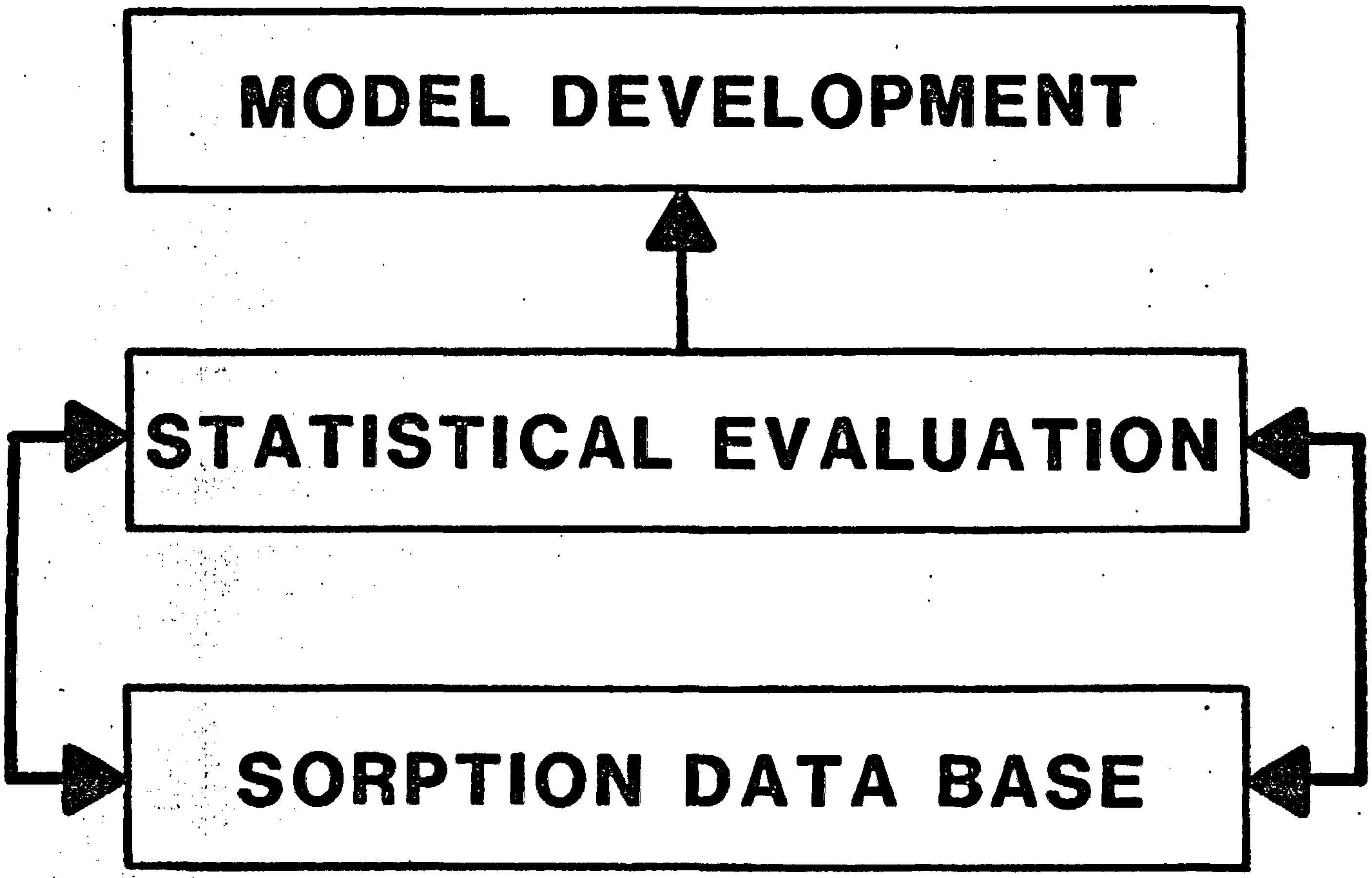
(2) EVALUATE DATA USING VARIOUS STATISTICAL METHODS TO CHARACTERIZE SORPTION BEHAVIOR AND TO IDENTIFY ANY IMPORTANT GAPS IN THE DATA BASE

(3) USING THE KNOWLEDGE GAINED ABOVE, DEVELOP A MODEL TO PREDICT SORPTION AT YUCCA MOUNTAIN

NNWSI PROJECT

Los Alamos

METHOD



NNWSI PROJECT

Los Alamos

MODEL DEVELOPMENT

GOAL IS TO PREDICT SORPTION OF RADIONUCLIDES ALONG THE FLOW PATH FROM THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT

- MAY HAVE TO BE AN EMPIRICAL MODEL
- MAY ACTUALLY BE COMPOSED OF SEVERAL DIFFERENT MODELS DEPENDING UPON INDIVIDUAL ELEMENT CHEMISTRIES

NNWSI PROJECT

STATISTICAL EVALUATION

Los Alamos

- WORK IN CONJUNCTION WITH THE STATISTICS GROUP IN THE ANALYSIS OF OUR SORPTION DATA BASE

- LOOKING FOR:

  (1) CORRELATION WITH MINERALOGY, SORPTION TIME, ELEMENT CHEMISTRY, etc

  (2) OBVIOUS GAPS IN DATA

  (3) IDENTIFICATION, IF POSSIBLE, OF MOST IMPORTANT VARIABLES

Los Alamos

MINERALOGY

TO DATE

- DATA BASE INCLUDES STUDIES OF MORE THAN 50 TUFF SAMPLES FROM 9 DIFFERENT UNITS OF YUCCA MOUNTAIN
- ZEOLITES HAVE BEEN IDENTIFIED AS PRIMARY SORPTIVE MINERALS FOR SIMPLE CATIONS

FUTURE

- NEED TO EXAMINE PURE MINERALS TO HELP IDENTIFY SORBING SPECIES AND SORPTION SITES
- BASED ON PURE MINERAL RESULTS, MAKE PREDICTIONS OF SORPTION FOR VARYING TUFF COMPOSITIONS

NNWSI PROJECT

Los Alamos

WATER COMPOSITION

TO DATE

- WELL J-13 WATER HAS BEEN USED AS "REPRESENTATIVE" WATER FROM YUCCA MOUNTAIN. EXTENSIVE DATA BASE EXISTS
- WELL UE-25p#1 WATER IS BEING INVESTIGATED AS AN EXAMPLE OF HIGH SALT CONTENT YUCCA MOUNTAIN WATER
- WELL H-3 WATER IS BEING INVESTIGATED AS AN EXAMPLE OF HIGH pH YUCCA MOUNTAIN WATER
- DEIONIZED WATER HAS BEEN INVESTIGATED ON NUMEROUS SAMPLES AND GIVES SIMILAR RESULTS AS J-13 WATER

FUTURE

- STUDIES OF VADOSE WATER MUST WAIT UNTIL THE EXPLORATORY SHAFT IS COMPLETE AND SAMPLES CAN BE TAKEN

IMPORTANT COMPOSITIONAL VARIABLES OF WATER FROM WELLS J-13, UE-25p#1 (1298 TO 1792 m), AND H-3

Component[a]	Well J-13	Well UE-25p#1 (1293 to 1792 m)	Well H-3
pH	7	6.7	9.1
Total carbonate, mol/ℓ	2.8×10^{-3}	1.61×10^{-2}	$\sim 10^{-3}$
$SO_4^{=}$	18.1	129	32
Cl^-	6.4	37	9.1
F^-	2.1	3.5	5.4
Na^+	45.2	110	126
K^+	5.47	13.4	1.73
Ca^{2+}	11.5	87.8	0.79
Mg^{2+}	1.73	31.9	0.015
SiO_2(aq)	64.2	37.2	36

[a]Listed in units of mg/ℓ unless otherwise noted.

NNWSI PROJECT

SORPTION RATIOS IN UE-25p#1, J-13, AND DEIONIZED WATERS

Los Alamos

CORE	ELEMENT	SORPTION RATIOS (ml/g) UE-25p#1	J-13
GU3-1301	Sr	10(2)	32(8)
	Cs	45(5)	160(35)
	Ba	82(18)	570(60)
	Eu	>17 000	75(12)

CORE	ELEMENT	SORPTION RATIOS (ml/g) UE-25p#1	J-13	DEIONIZED
G1-2233	Sr	2 000(330)	48 000(3 000)	>56 000
	Cs	7 500(1 100)	13 500(800)	13 000(1 600)
	Ba	41 000(6 300)	250 000(30 000)	55 000(5 300)
	Eu	>5 600	900(200)	810(100)

NNWSI PROJECT

COMPARISON OF TIN SORPTION RATIOS IN J-13 AND UE-25p#1[a] GROUNDWATERS

Los Alamos

CORE	SORPTION RATIOS (ml/g)		DESORPTION RATIOS (ml/g)	
	J-13	UE-25#1	J-13	UE-25#1
G1-2840	283	20000	780	18400
GU3-1301	168	4000	1280	6750
G4-1502	215	800	500	300
G1-2901	22000	35800	38000	52500

[a]WATER FROM DEPTH 1298–1792m.

NNWSI PROJECT

WASTE-ELEMENT CONCENTRATION

Los Alamos

- PAST STUDIES FOR SEVERAL ELEMENTS ON YUCCA MOUNTAIN TUFF SAMPLES INDICATE, ON A GROSS SCALE, THAT THE SORPTION COEFFICIENTS CHANGE LITTLE OVER 7-8 ORDERS OF MAGNITUDE IN ELEMENT CONCENTRATION

  <u>HOWEVER</u>: THEY GIVE NO INFORMATION ON THE SORBING SPECIES OR SORPTION SITES

- FUTURE STUDIES WILL BE PERFORMED ON PURE MINERALS AT VARYING pH VALUES TO DETERMINE WHAT SITES ON THE MINERALS (SURFACE OR INTERSTITIAL) ARE RESPONSIBLE FOR SORPTION AND WHICH SPECIES OF THE ELEMENT IN QUESTION ARE ACTUALLY SORBING

Np ISOTHERM SORPTION RATIOS UNDER CO_2 – CONTROLLED ATMOSPHERIC CONDITIONS

Np CONC (M)	SORPTION RATIO (mℓ/g)
6×10^{-4}	2.4
3×10^{-4}	0.94
7×10^{-5}	3.4
3×10^{-5}	3.3
8×10^{-6}	4.9
3×10^{-6}	5.0
7×10^{-7}	5.0
4×10^{-7}	5.2
2×10^{-11}	5.4

NNWSI PROJECT

WASTE-ELEMENT SPECIATION

Los Alamos

MULTIVALENT ACTINIDES PRESENT PARTICULARLY DIFFICULT PROBLEMS

- SEVERAL SPECIES MAY BE PRESENT AT NEUTRAL pH
- CONCENTRATION OF THE VARIOUS SPECIES MAY NOT BE CONSTANT AT NEUTRAL pH
- CONCENTRATION LEVELS OF THE SPECIES BEING STUDIED ARE BELOW DETECTION LIMITS
- WHICH SPECIES WILL BE MOST IMPORTANT WILL BE DETERMINED BY WASTE FORM, CANISTER MATERIAL, BACKFILL MATERIAL, GROUND-WATER CHEMISTRY, etc, MOST OF WHICH ARE CURRENTLY UNDEFINED. THEREFORE, WE MUST CONCENTRATE OUR STUDIES ON THE MOST "PROBABLE" CANDIDATES AS DETERMINED BY CALCULATIONS

NNWSI PROJECT

Los Alamos

MICROBIAL ACTIVITY

- BACTERIA HAVE BEEN ISOLATED FROM YUCCA MOUNTAIN THAT ACTIVELY GROW USING DRILLING POLYMER AS THEIR ONLY FOOD SOURCE

- THESE SAME BACTERIA HAVE BEEN SHOWN TO "SORB" PLUTONIUM FROM WELL J-13 WATER IN THE PRESENCE AND ABSENCE OF YUCCA MOUNTAIN TUFF

- QUESTIONS INCLUDE

  (1) CAN THE BACTERIA TRANSPORT THE PLUTONIUM UNDERGROUND ?
  (2) DO BACTERIAL DECAY PRODUCTS ALSO COMPLEX PLUTONIUM ?
  (3) WHAT ROLE DO ANAEROBIC BACTERIA PLAY ?

NNWSI PROJECT

Los Alamos

SEALING MATERIALS EVALUATION

WBS 2.4.2.3.2

C. J. DUFFY

OBJECTIVE

DEVELOP SEALING MATERIALS FOR FRACTURES, BOREHOLES, AND ACCESS SHAFTS AND DRIFTS AND ASSESS THEIR CHEMICAL STABILITY AND POSSIBLE EFFECTS UPON WATER CHEMISTRY

ISSUES

1.4.2 CALCULATED ESTIMATES OF AND BOUNDS ON THE PERFORMANCE OF THE TOTAL WASTE ISOLATION SYSTEM, INCLUDING WASTE PACKAGE RELEASE RATES, GROUNDWATER TRAVEL TIME, RETARD-ATION OF RADIONUCLIDES, AND THE INTEGRATED RELEASE OF RADIONUCLIDES TO ACCESSIBLE ENVIRONMENT AS A FUNCTION OF TIME

3.4.6 DEFINITIONS OF THE METHOD OF BACKFILLING AND SEALING BOREHOLES, DRIFTS, AND SHAFTS

NNWSI PROJECT

Los Alamos

CONCERNS

- WILL THE EFFECTIVENESS OF THE SEALS IN INHIBITING WATER FLOW DECREASE WITH TIME DUE TO MINERALOGIC CHANGES IN THE SEAL OR THE ADJACENT TUFF ?

- WILL INTERACTIONS BETWEEN THE SEALING MATERIAL AND WATER INCREASE THE ABILITY OF THE WATER TO CARRY WASTE ELEMENTS ?

Los Alamos

WATER CHEMISTRY

- IS EMPLACEMENT OF A SEAL LIKELY TO CHANGE THE pH OF THE GROUNDWATER ?

- IMPORTANT BECAUSE SOLUBILITY OF THE WASTE IS pH DEPENDENT

NNWSI PROJECT

Los Alamos

WATER CHEMISTRY

- WILL ALTERATION OF THE SEALING MATERIAL ADD COMPLEXING AGENTS TO THE WATER THAT WOULD INCREASE WASTE SOLUBILITY ?

- SULFATE MINERALS ARE USED AS EXPANSIVE AGENTS IN SEALING MATERIALS

- WOULD LIBERATION OF THIS SULFATE APPRECIABLY INCREASE WASTE TRANSPORT ?

NNWSI PROJECT

MECHANICAL PROPERTIES

Los Alamos

- PRIMARY PROPERTY OF CONCERN IN SEAL IS PERMEABILITY
- MECHANICAL STRENGTH OF THE SEAL MAY BE OF SECONDARY CONCERN

NNWSI PROJECT

Los Alamos

MINERAL ALTERATION

- IMPORTANT IN SEAL MATERIAL AND ADJACENT TUFF
- MINERAL ALTERATION WILL OCCUR BECAUSE THE TUFF AND SEAL ARE NOT IN EQUILIBRIUM AT THE TIME OF EMPLACEMENT
- MINERAL ALTERATION WILL ALSO OCCUR BE-CAUSE OF CHANGES IN TEMPERATURE DURING REPOSITORY HEATING

DISEQUILIBRIUM BETWEEN SEAL MATERIAL AND TUFF

- POSSIBLE SEALING MATERIAL COMPOSITION HAS BEEN ADJUSTED TO MAKE IT APPROACH EQUILIBRIUM WITH TUFF

- ACCOMPLISHED PRIMARILY BY ADDITION OF SILICA

NNWSI PROJECT

TEMPERATURE EFFECTS UPON FAULT AND FRACTURE SEALS

Los Alamos

- IMPORTANT LOW-TEMPERATURE PHASES ARE CALCIUM SILICATE HYDRATE AND THE EXPANSIVE AGENT ETTRINGITE

- AT 100° TO 150° C

  CALCIUM SILICATE HYDRATE → TOBERMORITE

  ETTRINGITE → ANHYDRITE ?

- ABOUT 200° C

  TOBERMORITE → TRUSCOTTITE

NNWSI PROJECT

Los Alamos

MINERAL ALTERATION

- WHY IS IT IMPORTANT?
- CHANGES IN MINERALOGY MAY AFFECT SOLUBILITY
- VOLUME CHANGES MAY ACCOMPANY MINERALOGIC CHANGES AND INCREASE THE PERMEABILITY OF THE SEAL
- CHANGES IN MINERALOGY MAY AFFECT THE CEMENTITIOUS QUALITIES OF THE SEAL MATERIAL AND CHANGE ITS STRENGTH

NNWSI PROJECT

SEAL-WATER INTERACTION

Los Alamos

- WATER COMING INTO CONTACT WITH THE SEAL WILL NOT BE IN EQUILIBRIUM WITH IT
- DISSOLUTION AND/OR PRECIPITATION MAY OCCUR
- IS SUFFICIENT DISSOLUTION POSSIBLE TO CAUSE FAILURE OF THE SEAL ?

NNWSI PROJECT

DISSOLUTION OF FAULT SEALS

Los Alamos

PRELIMINARY DISSOLUTION MODEL FOR FAULT SEALS INDICATES THAT FAULT SEAL DISSOLUTION IS LIKELY TO BE IMPORTANT ONLY IF

- THE BULK PERMEABILITY OF THE SEAL IS GREATLY INCREASED

- THERE IS SHRINKAGE OF THE FAULT SEAL

NNWSI PROJECT

Los Alamos

FUTURE WORK

- FURTHER DEFINE MINERALOGIC CHANGES DUE TO INCREASED TEMPERATURE

- DETERMINE PHYSICAL PROPERTIES FOR ALTERED SEALING MATERIALS
  - BULK PERMEABILITY
  - INTERFACE PERMEABILITY
  - VOLUME CHANGE DUE TO MINERAL ALTERATION
  - BOND STRENGTHS

- REFINE FAULT SEAL DISSOLUTION MODEL

NNWSI PROJECT

Los Alamos

DYNAMIC TRANSPORT PROCESS

WBS 2.3.4.1.6

R. S. RUNDBERG

NNWSI PROJECT

DYNAMIC TRANSPORT PROCESS

Los Alamos

1. CRUSHED ROCK COLUMNS –
   SPECIATION, KINETICS
2. FRACTURED TUFF COLUMNS –
   MATRIX DIFFUSION, CAPILLARY SUCTION
3. SOLID TUFF COLUMNS –
   SPECIATION, KINETICS, FILTRATION OF PARTICULATES, AND CHEMICAL-FLOW COUPLING
4. VAPOR PHASE TRANSPORT
5. AUXILIARY EXPERIMENTS
   a. DIFFUSION IN THE ABSENCE OF FLOW
   b. PARTICLE SIZE ANALYSES
   c. SORPTION KINETICS

NNWSI PROJECT

Los Alamos

CRUSHED TUFF COLUMNS

PAST ACHIEVEMENTS

- SIMPLE CATIONS Sr^{++}, Cs^{+}, AND Ba^{++} SHOWN TO AGREE WITH BATCH SORPTION MEASUREMENT (PROVIDED PARTICLE SIZE FRACTIONATION WAS CONTROLLED)

RECENT ACHIEVEMENTS

- PLUTONIUM AND AMERICIUM FOUND TO HAVE A SMALL FRACTION WHICH ELUTES EARLIER THAN HTO (PRELIMINARY RESULTS INDICATE HYDRODYNAMIC CHROMATOGRAPHY)

- 76% Tc 95-m FOUND TO ELUTE AS AN ANION, TcO_4^-, ELUTING EARLIER THAN HTO. 24% ADSORBED

NNWSI PROJECT

Los Alamos

CRUSHED TUFF COLUMNS (cont)

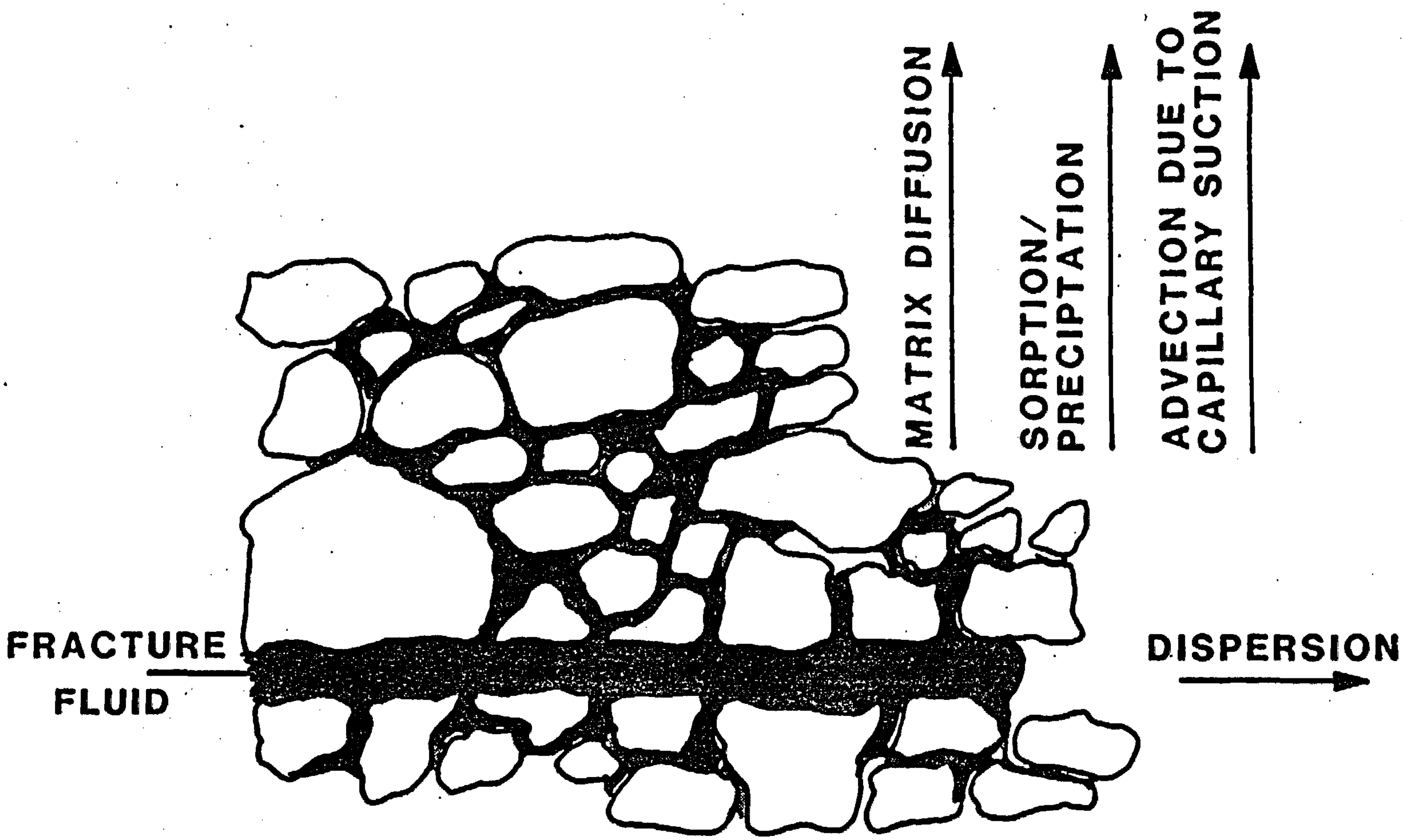
FUTURE WORK

- DETERMINE THE IDENTITY OF THE ACTINIDE FRACTION WHICH ELUTES EARLY
  - COMPARE WITH ANIONS
  - COMPARE WITH COLLOID STANDARDS
  - STUDY DEFINED ACTINIDE SPECIES
- DETERMINE THE MECHANISM RESPONSIBLE FOR Tc 95-m ADSORPTION
  - IDENTIFY SPECIES CHARGE
  - STUDY Tc 99 (POSSIBLE AUTORADIOLYSIS)

NNWSI PROJECT

FRACTURE FLOW IN UNSATURATED TUFF

Los Alamos



NNWSI PROJECT

FRACTURED TUFF COLUMNS

Los Alamos

PAST ACHIEVEMENTS

- NONSORBING TRACER SHOWN TO FIT MATRIX DIFFUSION MODEL
- CONSTRICTIVITY/TORTUOSITY FACTORS OF 0.01 – 0.1
- PRELIMINARY EVIDENCE INDICATES THAT SORPTION IS EFFECTIVELY DECREASED MORE THAN AN ORDER OF MAGNITUDE

NNWSI PROJECT

FRACTURED TUFF COLUMNS (cont)

Los Alamos

FUTURE WORK

- DETERMINE CAUSE OF SORPTION DECREASE
  - UNEVEN DISTRIBUTION OF SORBING MINERALS?
  - CHANNELING?
- PERFORM EXPERIMENTS WITH UNSATURATED COLUMNS
- EXAMINE PARTICULATE TRANSPORT IN FRACTURES
- TEST FLOW TRACERS

NNWSI PROJECT

Los Alamos

SOLID TUFF COLUMNS

PAST ACHIEVEMENTS

- Sr SHOWN TO BE IN GOOD AGREEMENT WITH BATCH AND CRUSHED TUFF COLUMN FOR TOPOPAH SPRING TUFF SAMPLE

FUTURE WORK

- UNSATURATED FLOW
- FILTRATION OF COLLOIDS
- GEOCHEMICAL – FLOW COUPLING
- CATIONS CONTINUED

DIFFUSION IN ABSENCE OF FLOW

Los Alamos

PAST ACHIEVEMENTS

- EARLY RESULTS FROM TUFF WAFERS INDICATE CONSTRICTIVITY/TORTUOSITY FACTOR FROM 0.1 TO ~1.0

FUTURE WORK

- DETERMINE IF DIFFUSION COEFFICIENTS ARE SUBJECT TO SCALING EFFECTS
- DETERMINE DIFFUSIVITIES IN TUFF FOR IMPORTANT WASTE ELEMENTS
- DETERMINE DIFFUSIVITY AS A FUNCTION OF SATURATION

NNWSI PROJECT

Los Alamos

PARTICLE SIZE ANALYSIS

ACCOMPLISHMENTS

- DEVELOPMENT OF A "STATE-OF-THE-ART" AUTO-CORRELATOR SPECTROMETER
- DETERMINED THE SIZE DISTRIBUTION BY APS OF PLUTONIUM POLYMER IN pH 8 WATER

FUTURE WORK

- DETERMINE THE RESOLUTION LIMITS OF APS
- DETERMINE ACTINIDE SIZE DISTRIBUTIONS, FOR ACTINIDE COLLOIDS UNDER VARIOUS CONDITIONS
- DEVELOP NONINTERACTING COLLOID TRACERS

SORPTION KINETICS

NNWSI PROJECT

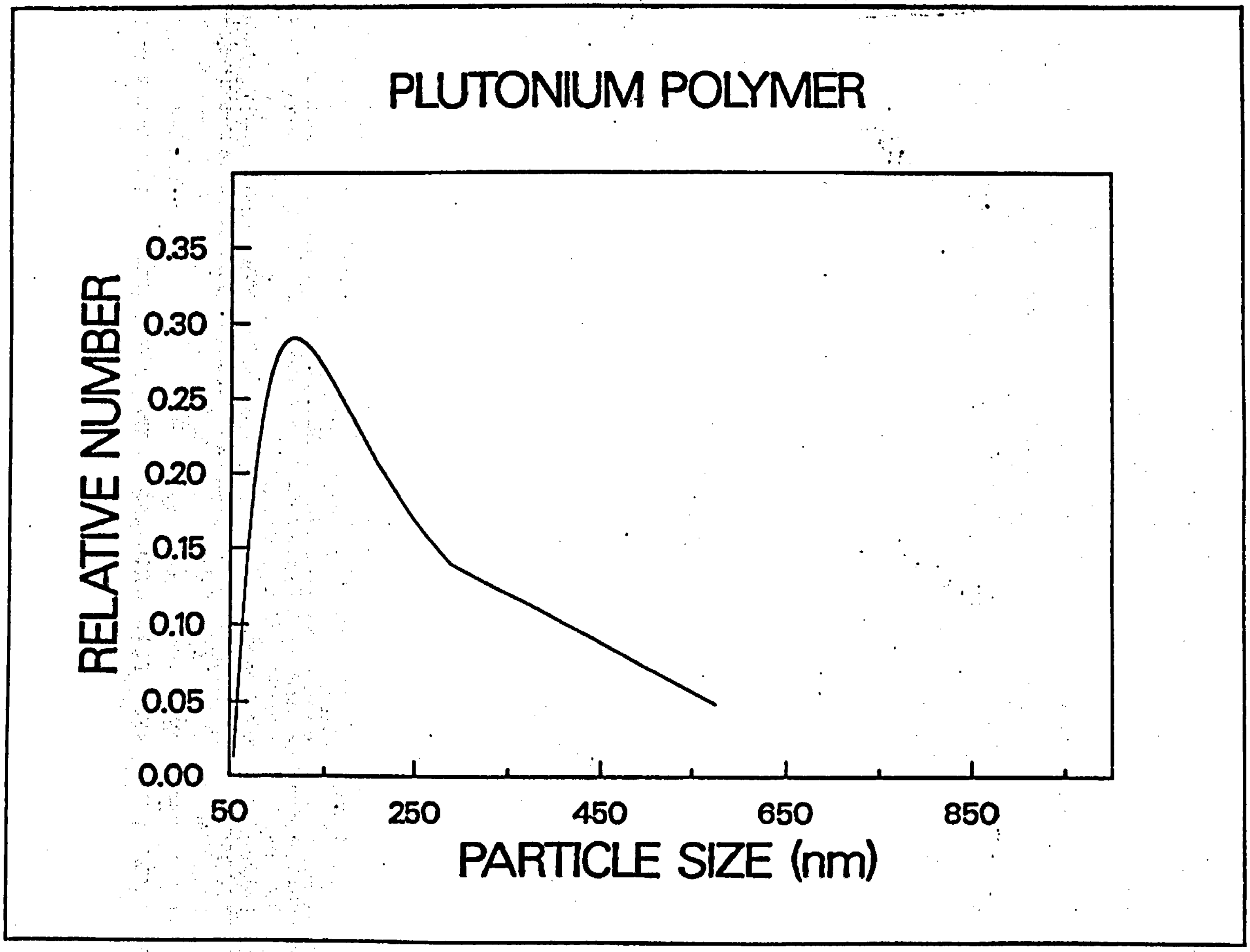
Los Alamos

ACCOMPLISHMENTS

- ION EXCHANGE OF SIMPLE CATIONS IN TUFF SHOWN TO BE DIFFUSION LIMITED (2 STEP DIFFUSION)

FUTURE WORK

- KINETICS OF SORPTION OF THE ACTINIDES


PLUTONIUM POLYMER
RELATIVE NUMBER
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
50
250
450
650
850
PARTICLE SIZE (nm)

NNWSI PROJECT

Los Alamos

RETARDATION SENSITIVITY ANALYSIS WBS 2.3.4.1.7

B. J. TRAVIS

NNWSI PROJECT

Los Alamos

SCHEDULE

SUBTASK A: BENCHMARKING
COMMENCE: IN PROGRESS
COMPLETE: SEPTEMBER 1986

SUBTASK B: DIFFUSION CALCULATIONS
COMMENCE: IN PROGRESS
COMPLETE: APRIL 1985

SUBTASK C: COUPLED PHENOMENA
COMMENCE: IN PROGRESS
COMPLETE: APRIL 1985

SUBTASK D: FRACTURE-FLOW EXPERIMENT
COMMENCE: IN PROGRESS
COMPLETE: MARCH 1985

SUBTASK E: GEOCHEMICAL TRANSPORT CALCULATIONS
COMMENCE: IN PROGRESS
COMPLETE: SEPTEMBER 1985

SUBTASK F: ALTERNATE NUMERICAL METHODS
COMMENCE: IN PROGRESS
COMPLETE: SEPTEMBER 1985

SUBTASK G: PARTICULATE TRANSPORT
COMMENCE: IN PROGRESS
COMPLETE: SEPTEMBER 1986

SUBTASK H: HEAT-LOAD EFFECTS
COMMENCE: IN PROGRESS
COMPLETE: SEPTEMBER 1985

SUBTASK I: STOCHASTIC METHODOLOGY
COMMENCE: JANUARY 1985
COMPLETE: JANUARY 1986

SUBTASK J: SENSITIVITY ANALYSIS
COMMENCE: MARCH 1985
COMPLETE: JUNE 1987

SUBTASK K: DATA INTEGRATION
COMMENCE: IN PROGRESS
COMPLETE: MARCH 1990

NNWSI PROJECT

UNSATURATED HYDROTHERMAL FLOW AND TRANSPORT MODELS LOS ALAMOS

Los Alamos

CAPABILITIES

WAFE – UNSATURATED HYDROTHERMAL FLOW, VAPOR AND LIQUID
TRACR3D – UNSATURATED FLOW, TRANSPORT OF PARTICULATES, SOLUBILITY LIMITS, KINETICS
TRANQL – FLOW WITH TRUE GEOCHEMISTRY

DEVELOPMENTS

TRANQL – ADDITION OF PRECIPITATION/SOLUBILITY CHEMISTRY
WAFE/TRACR3D – COUPLING WITH EQ3/6
INVADJC – SENSITIVITY CALCULATIONS

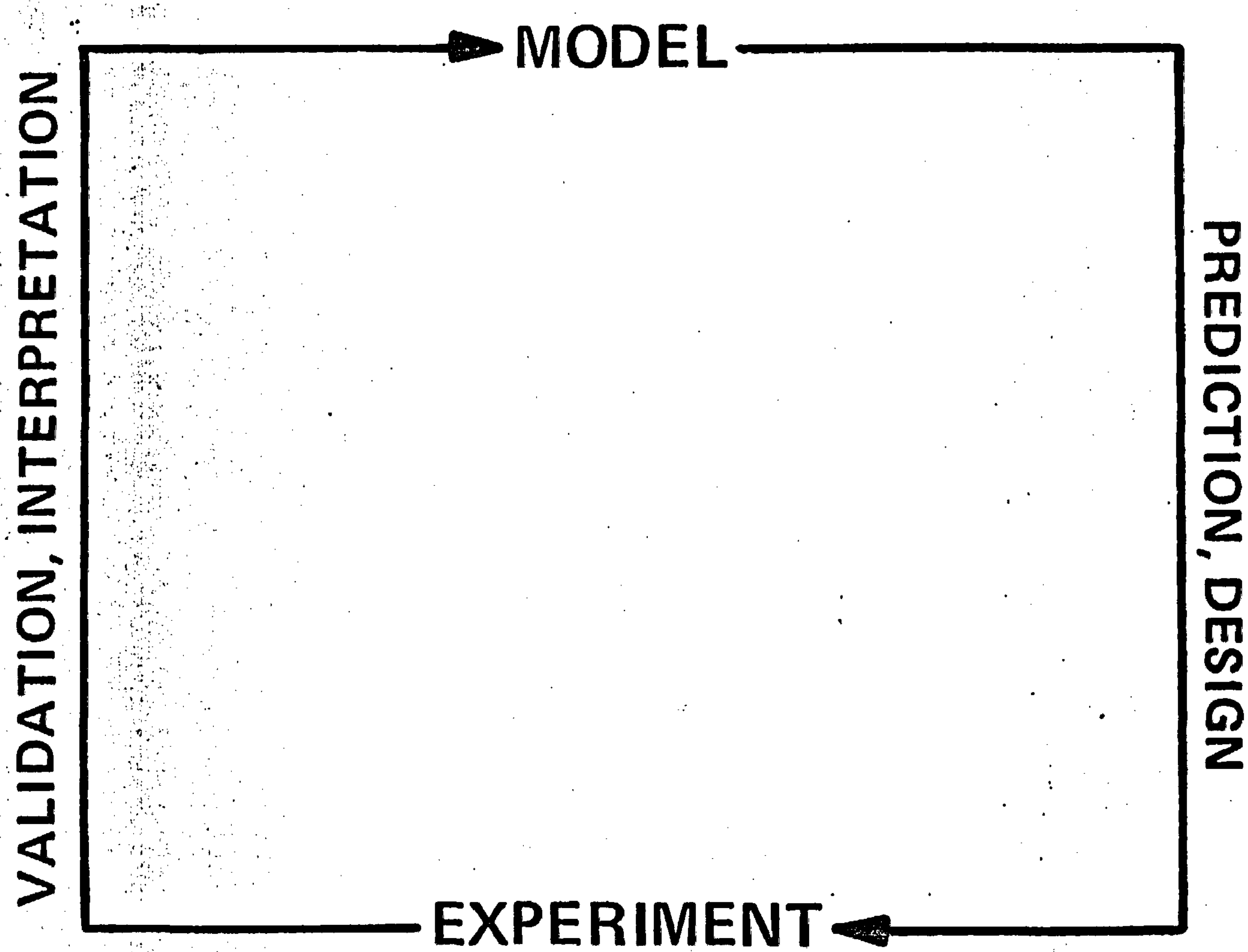
APPLICATIONS

- TRANSPORT IN "COATED" FRACTURES
- PARTICULATE/COLLOID TRANSPORT
- HYDROTHERMAL CIRCULATION
- COUPLED PHENOMENA
- SENSITIVITY/UNCERTAINTY ANALYSIS
- COMPARISON OF GEOCHEMICAL vs K_d TRANSPORT
- EXPERIMENTAL DESIGN

NNWSI PROJECT

INTERACTION BETWEEN MODELS AND EXPERIMENTS

Los Alamos



NNWSI PROJECT

MATHEMATICAL CHARACTERIZATION

Los Alamos

DETERMINISTIC

- FORWARD – REQUIRES SPECIFICATION OF SPATIAL DISTRIBUTION OF PROPERTIES, b.c.s., i.c.s.
- INVERSE – TWEAKING – NO JUSTIFICATION OF SOLUTION
  FORMAL – CAN ACCOUNT FOR MEASUREMENT ERRORS, GIVES DEGREE OF RESOLUTION

STOCHASTIC

- FORWARD – REQUIRES SPECIFICATION OF CORRELATION FUNCTIONS
  – MORE REALISTIC, ALLOWS FOR UNCERTAINTIES
  – ASSOCIATES ERROR BAR WITH SOLUTIONS
- INVERSE – GENERATES CORRELATION FUNCTIONS
  – ASSOCIATES PROBABILITY TO SOLUTION

SOME AREAS OF UNCERTAINTY IN MODELING

- CHEMISTRY IN UNSATURATED SOIL/ROCK
  - VAPOR-ROCK INTERACTIONS (HYDRO-THERMO-CHEMICAL)
- FRACTURE FLOW – IS IT IMPORTANT IN UNSATURATED ROCK ?
- COLLOID MIGRATION
  - PRECIPITATES
  - PARTICULATES
- STOCHASTIC BEHAVIOR
  - NEED MEAN $c = c(x_1, x_2, \ldots, x_n)$
    AND VARIANCE $c = f(x_1, \ldots, x_n, \sigma_1, \ldots, \sigma_n)$
    WHERE x_i = VARIABLE, σ_i = UNCERTAINTY IN x_i
- COUPLED PROCESSES
  - FLUX $J_i = \sum_J L_{ij} F_j$ WHERE F_j ARE DRIVING FORCES
    WHAT ARE L_{ij} ?, ESPECIALLY WHAT ARE L_{ij}, $i \neq j$?

NNWSI PROJECT

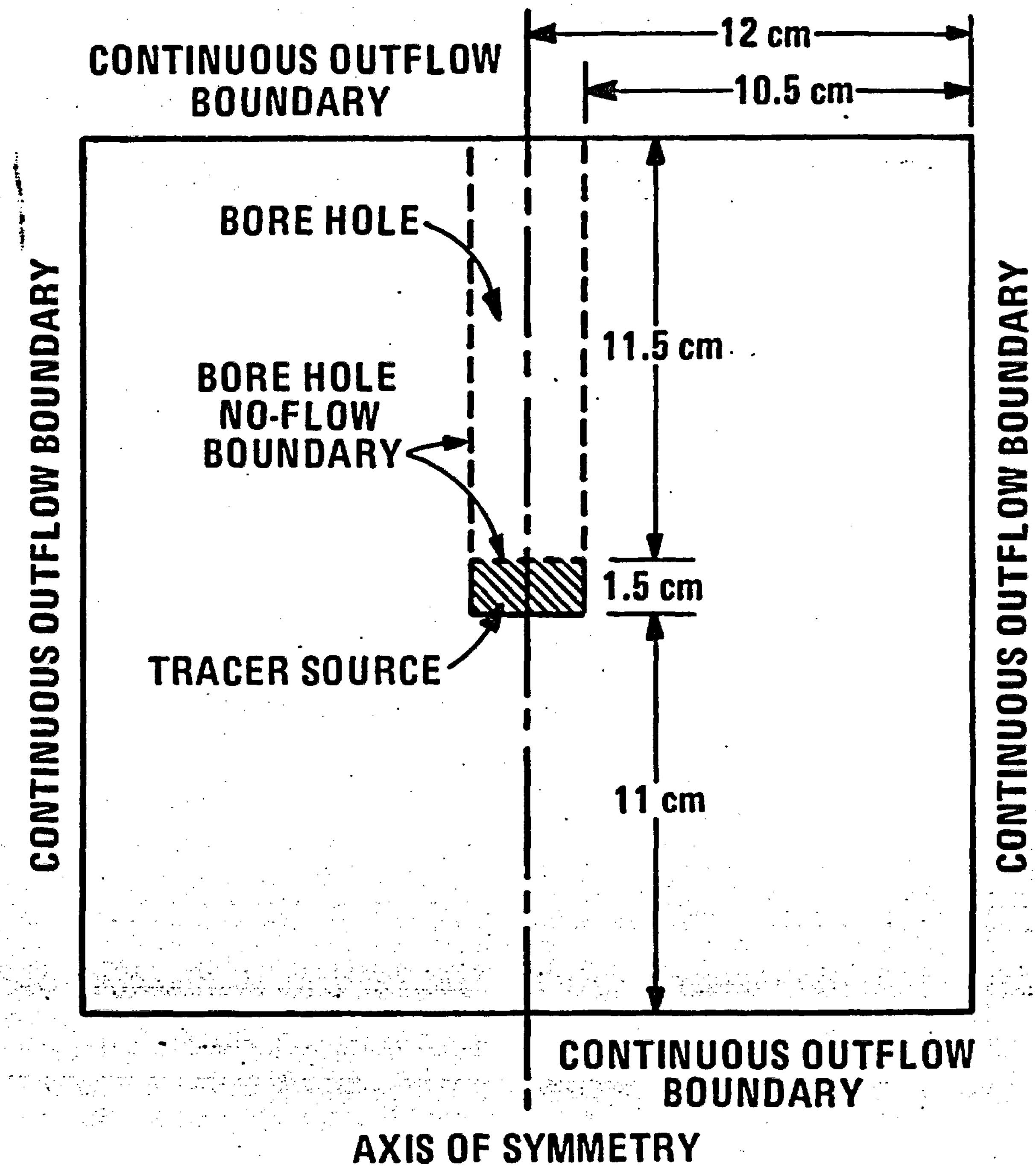
Los Alamos

RESULTS OF TRACR3D CALCULATIONS FOR EXPLORATORY SHAFT DIFFUSION TESTS

NNWSI PROJECT

SCHEMATIC OF BORE HOLE AND SURROUNDING MATRIX

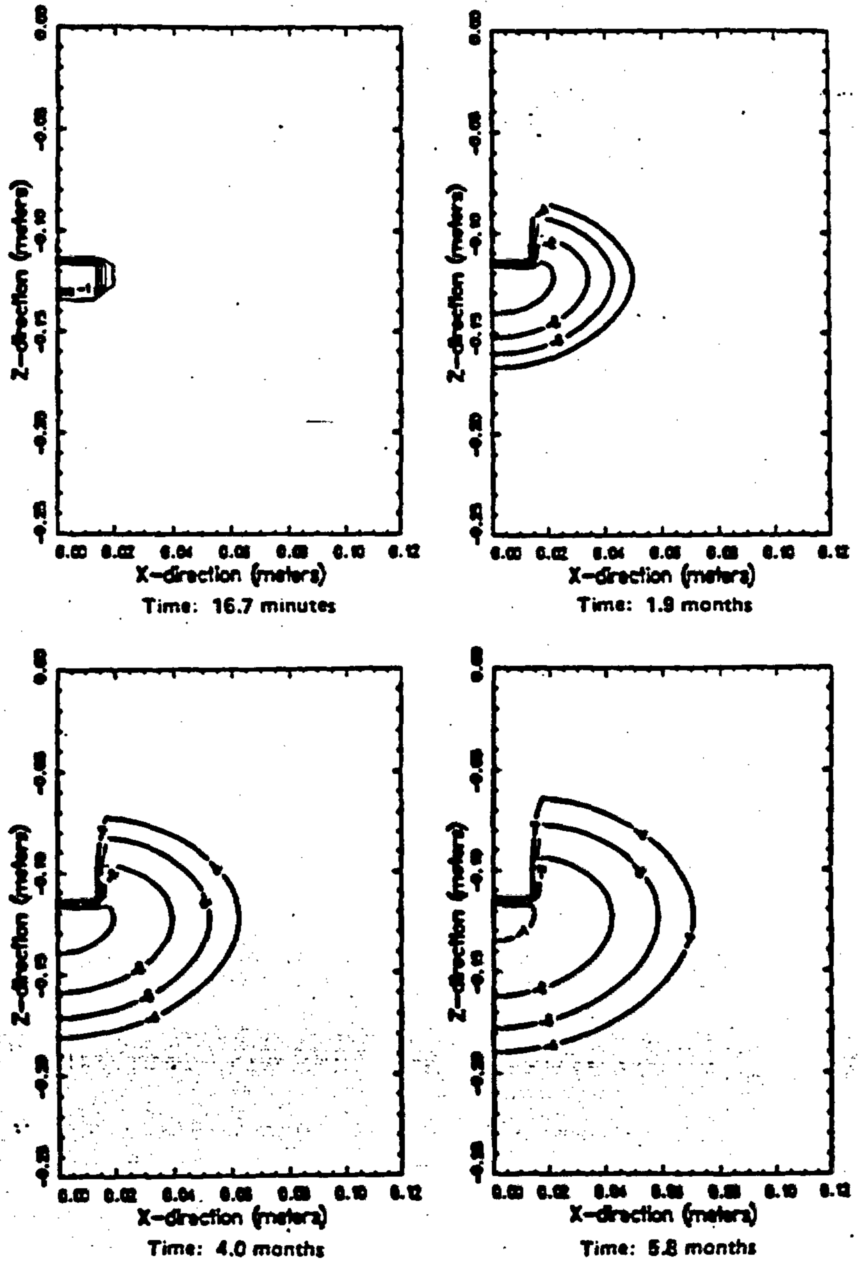
Los Alamos



NNWSI PROJECT

PURE DIFFUSION

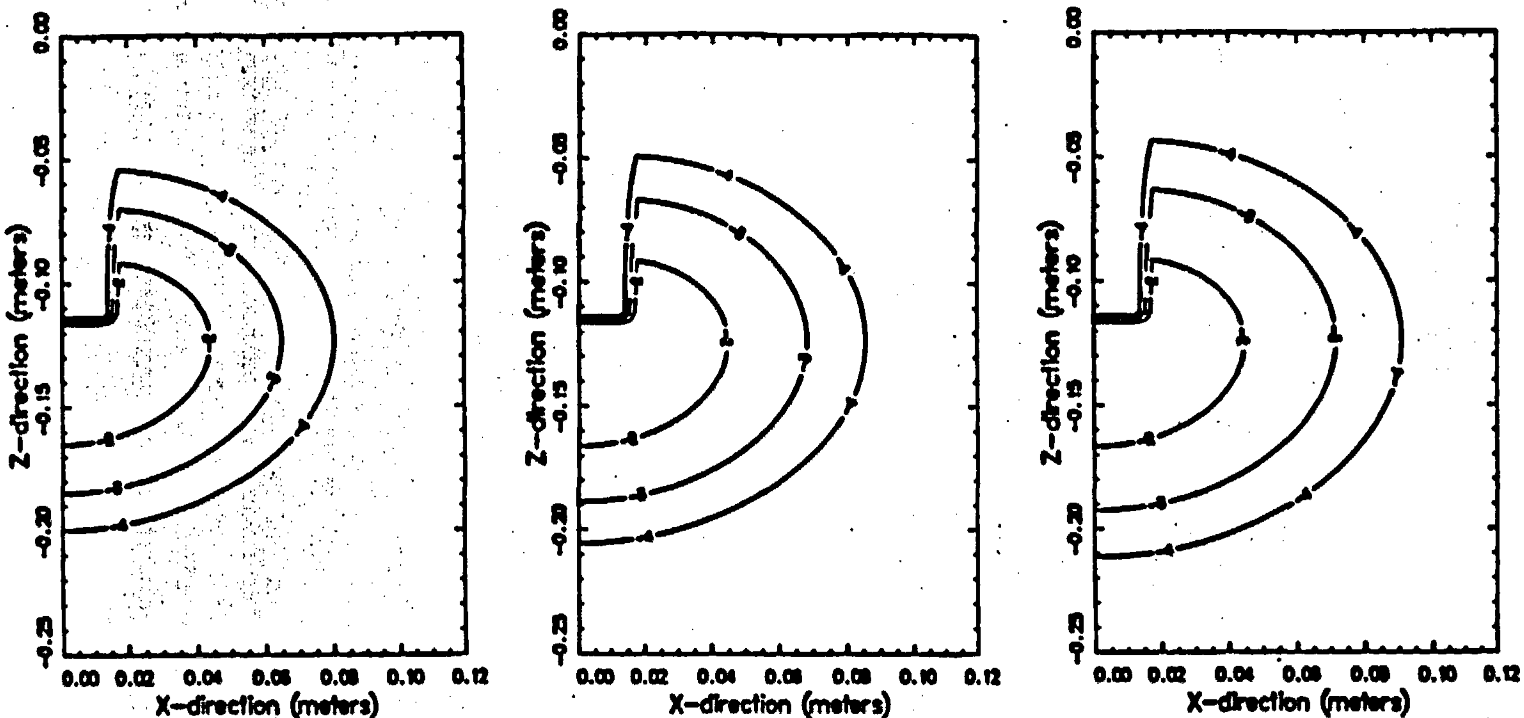
Los Alamos



NNWSI PROJECT

PURE DIFFUSION (continued)

Los Alamos

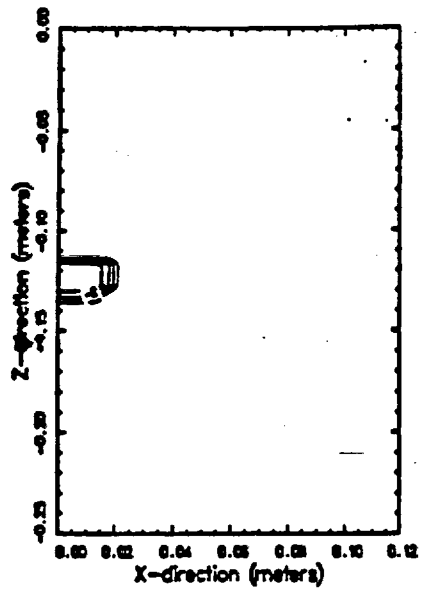


Time: 8.3 months

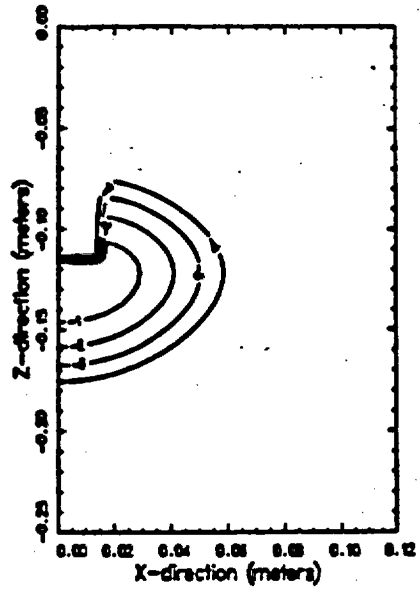
Time: 10.0 months

Time: 1.0 year

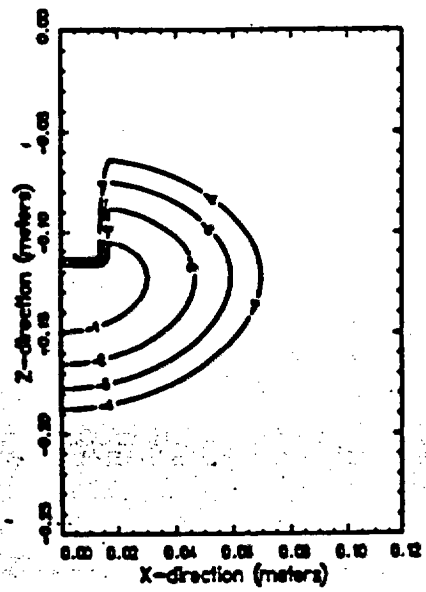
WATER REDISTRIBUTION PLUS TRACER DIFFUSION



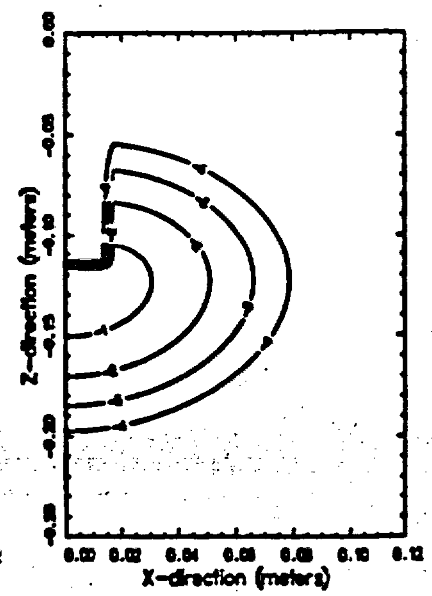
Time: 16.7 minutes



Time: 1.9 months



Time: 3.8 months

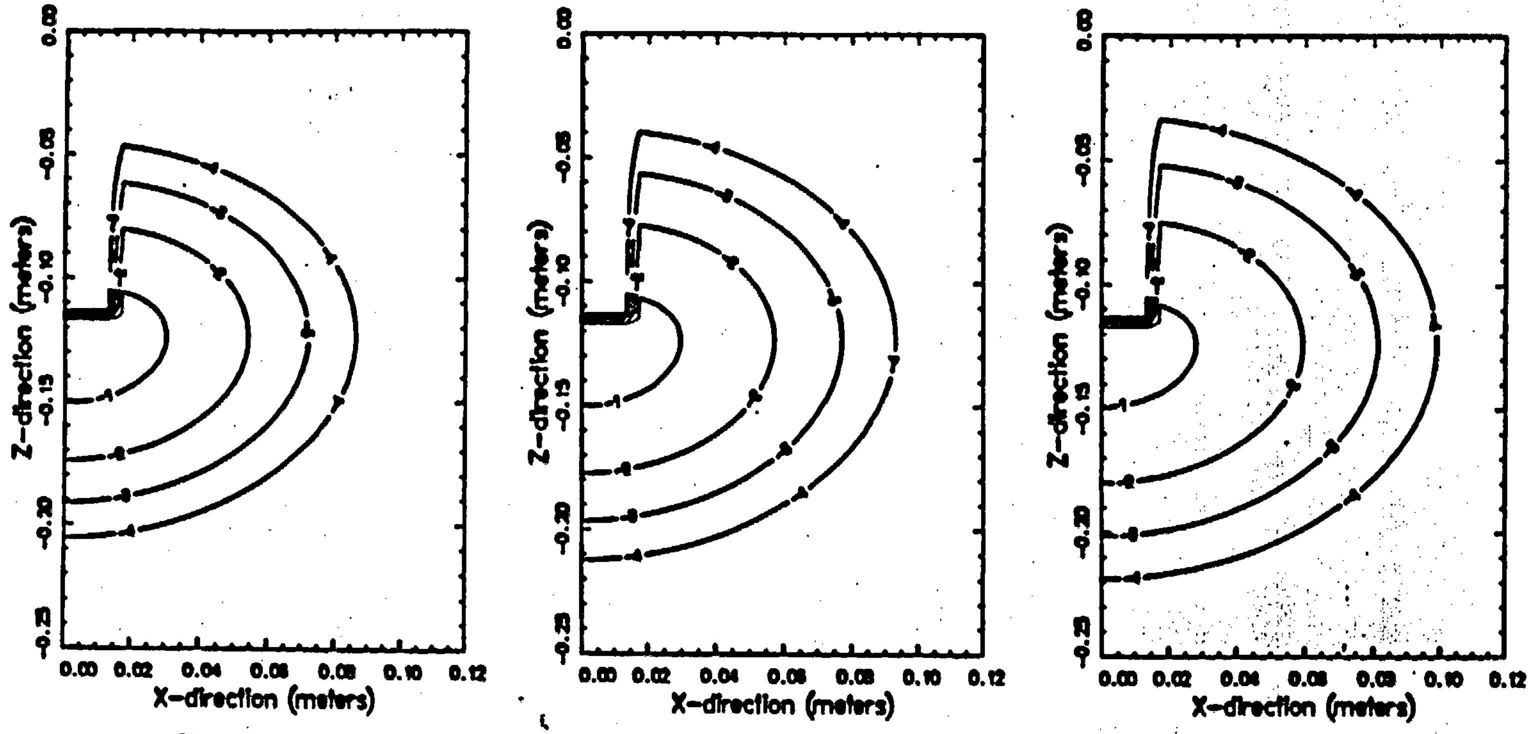


Time: 5.7 months

WATER REDISTRIBUTION PLUS TRACER DIFFUSION (continued)

NNWSI PROJECT

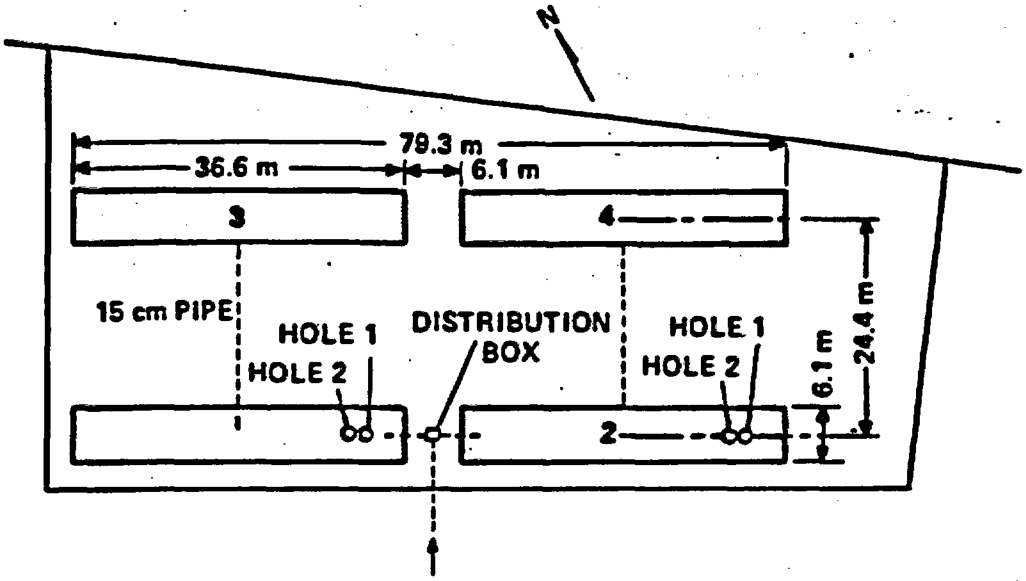
Los Alamos

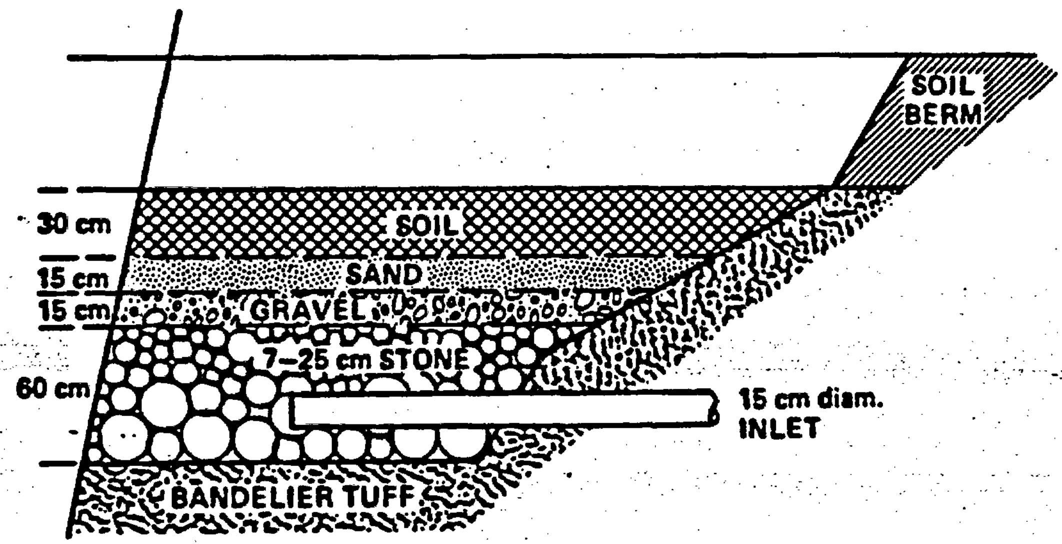


Time: 7.6 months

Time: 9.5 months

Time: 11.4 Months

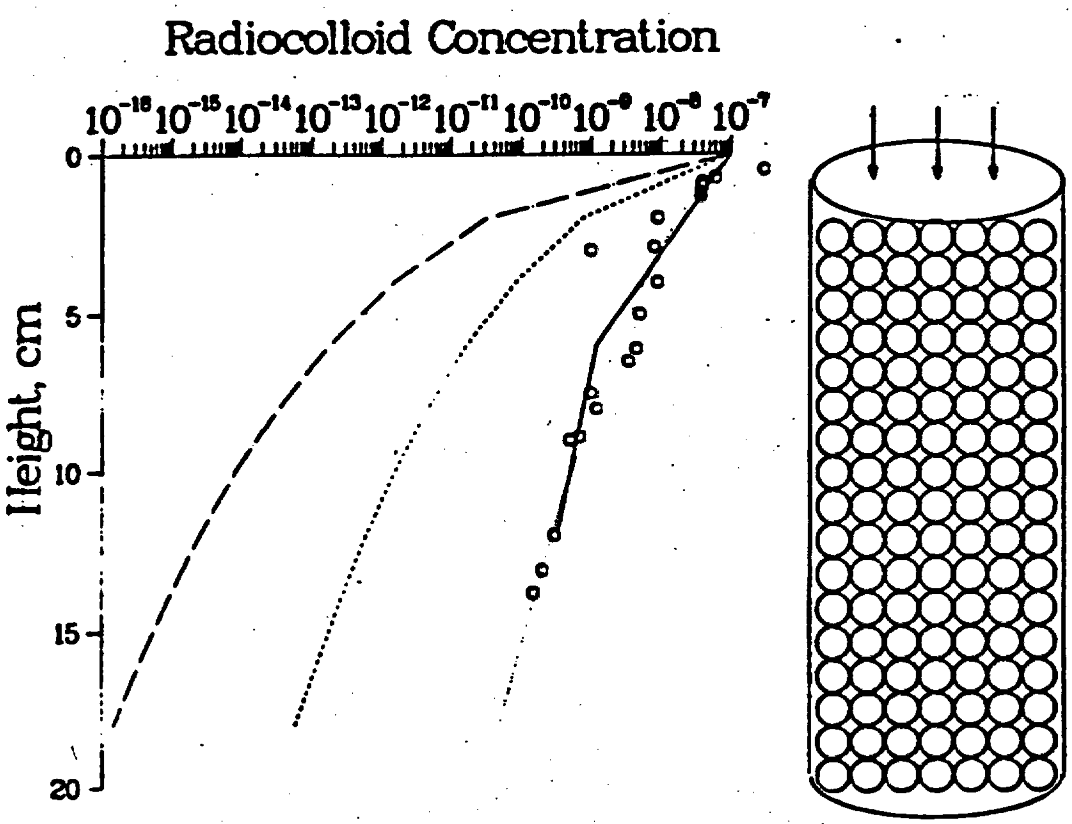

N
79.3 m
36.6 m
6.1 m
3
4
15 cm PIPE
HOLE 1
HOLE 2
DISTRIBUTION
BOX
HOLE 1
HOLE 2
2
6.1 m
24.4 m
FROM WASTE TREATMENT PLANT


SOIL
BERM
30 cm
SOIL
15 cm
SAND
15 cm
GRAVEL
7–25 cm STONE
60 cm
15 cm diam.
INLET
BANDELIER TUFF

NNWSI PROJECT

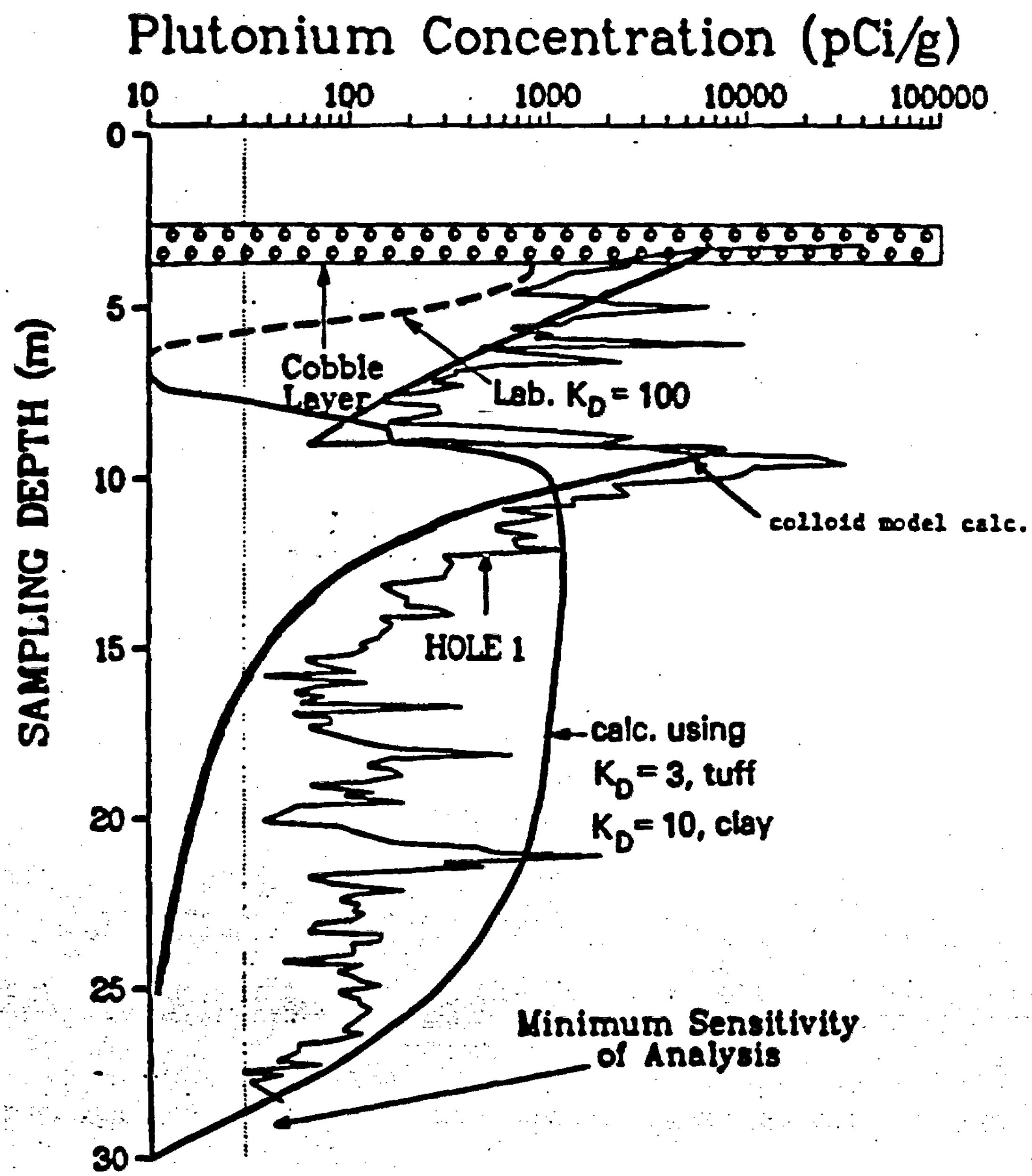
COLUMN EXPERIMENT

Los Alamos



LEGEND FOR COLUMN EXPERIMENT

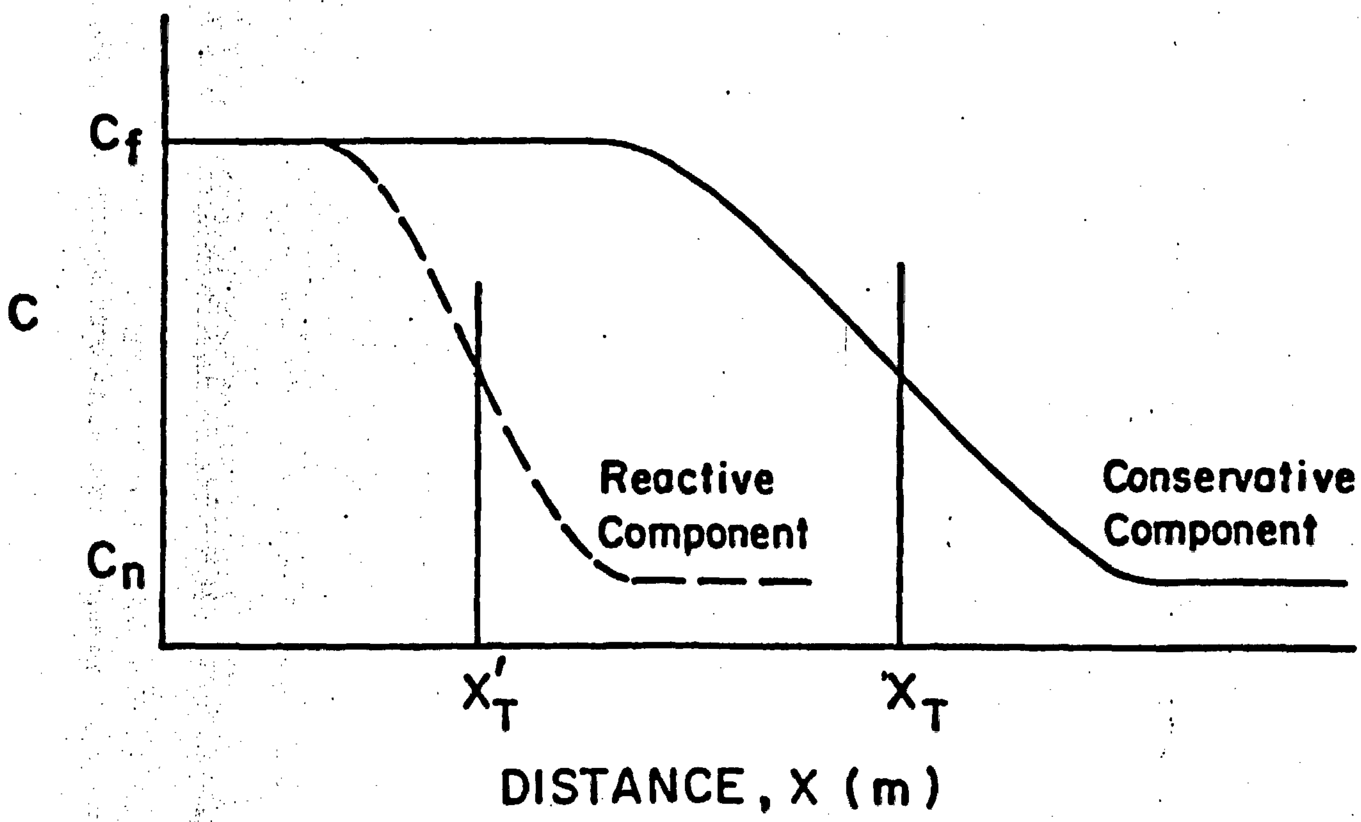
——·—·—	$\bar{\lambda} = 1.0\ cm^{-1}$	$\sigma = 2.0$
————	$\bar{\lambda} = 2.0\ cm^{-1}$	$\sigma = 2.0$
— — —	$\bar{\lambda} = 3.0\ cm^{-1}$	$\sigma = 1.5$
▬▬▬	Model result	
••••••••	Experimental data	

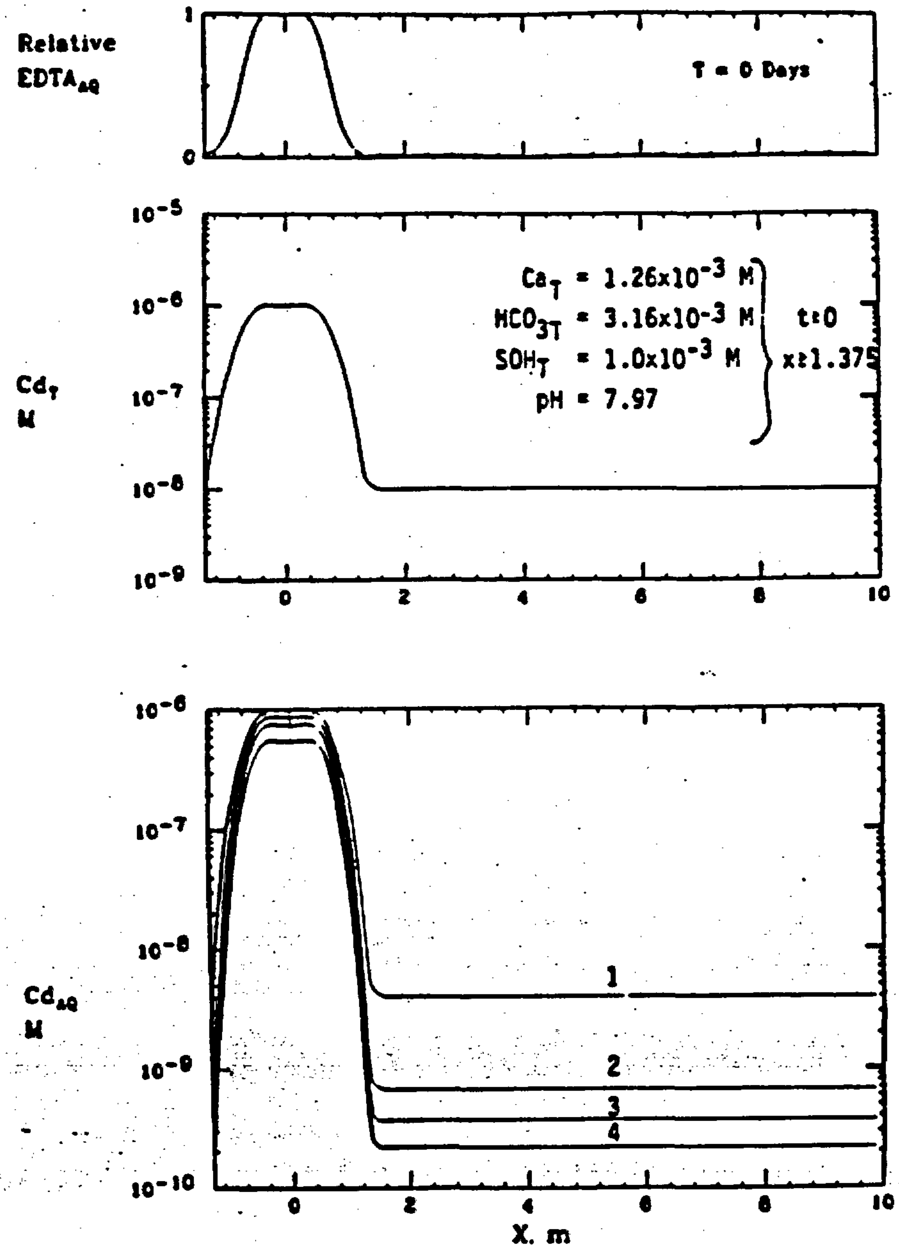

Plutonium Concentration (pCi/g)
10
100
1000
10000
100000
0
5
10
15
20
25
30
SAMPLING DEPTH (m)
Cobble Layer
Lab. K_D = 100
colloid model calc.
HOLE 1
calc. using
K_D = 3, tuff
K_D = 10, clay
Minimum Sensitivity of Analysis

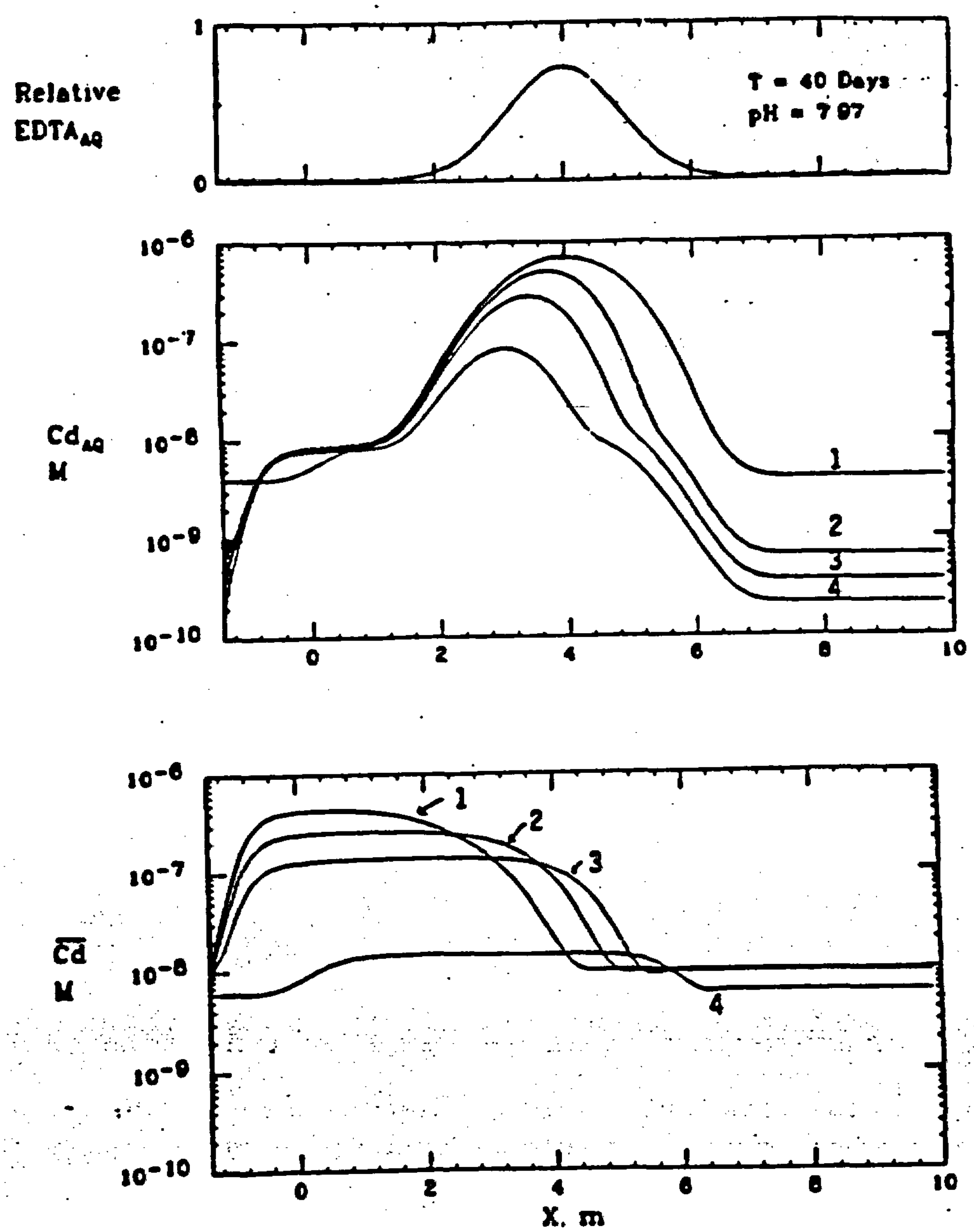
TRANQL MODEL

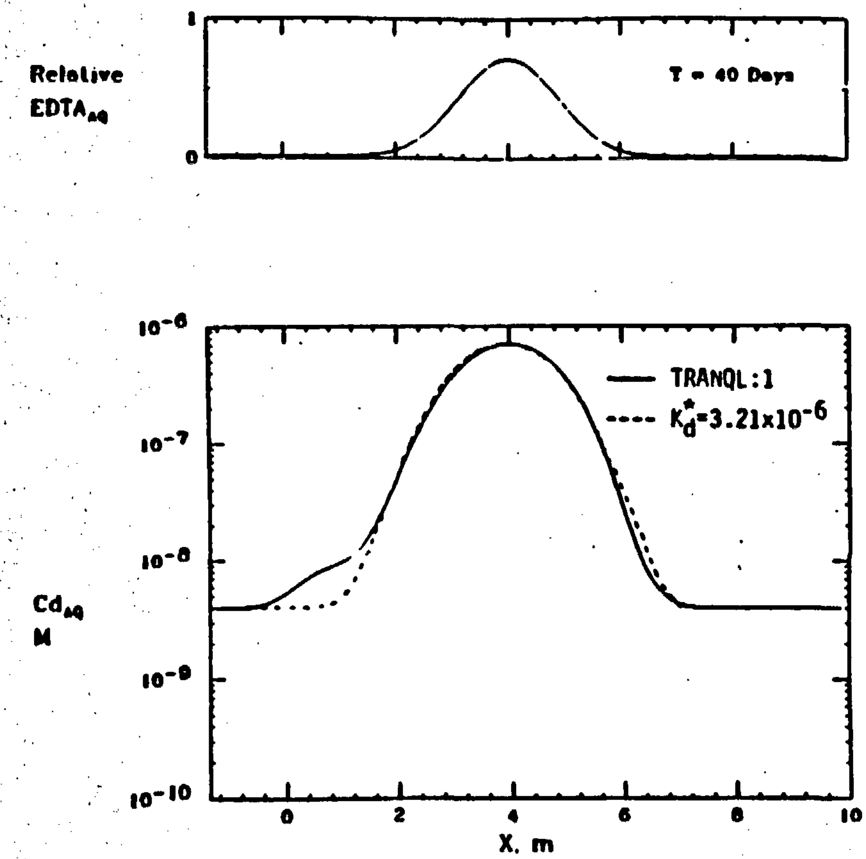
RESULTS FROM (TRANQL) THAT COMPUTES TRUE GEOCHEMICAL TRANSPORT AS OPPOSED TO K_d MODELING

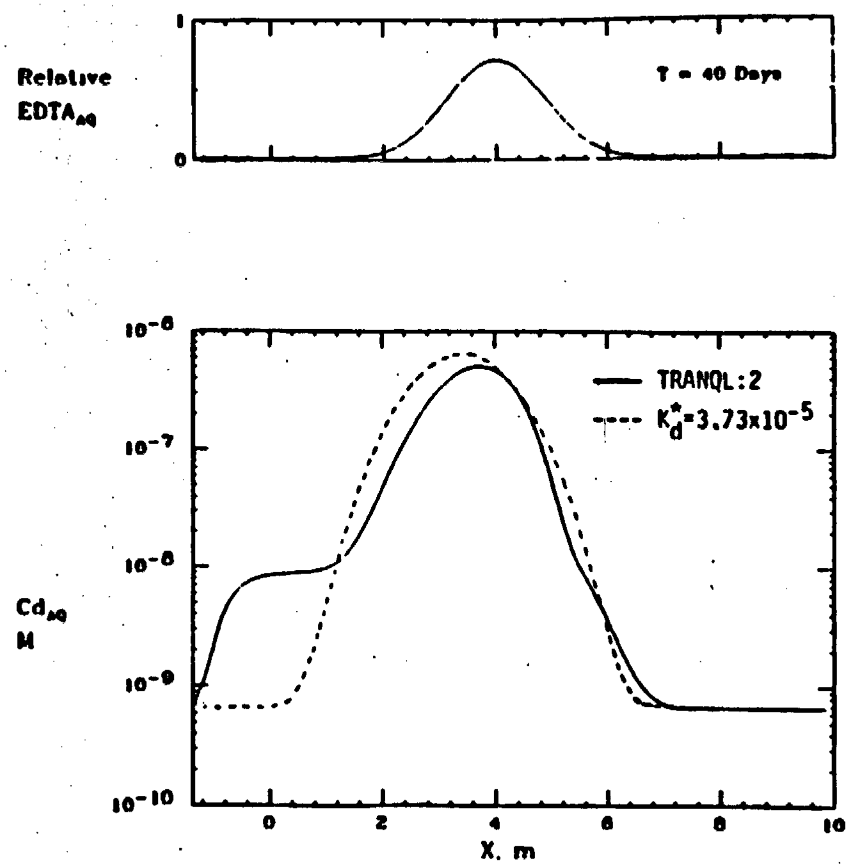
THIS MODEL IS BEING ADAPTED TO HANDLE GEOCHEMISTRY APPROPRIATE FOR YUCCA MOUNTAIN

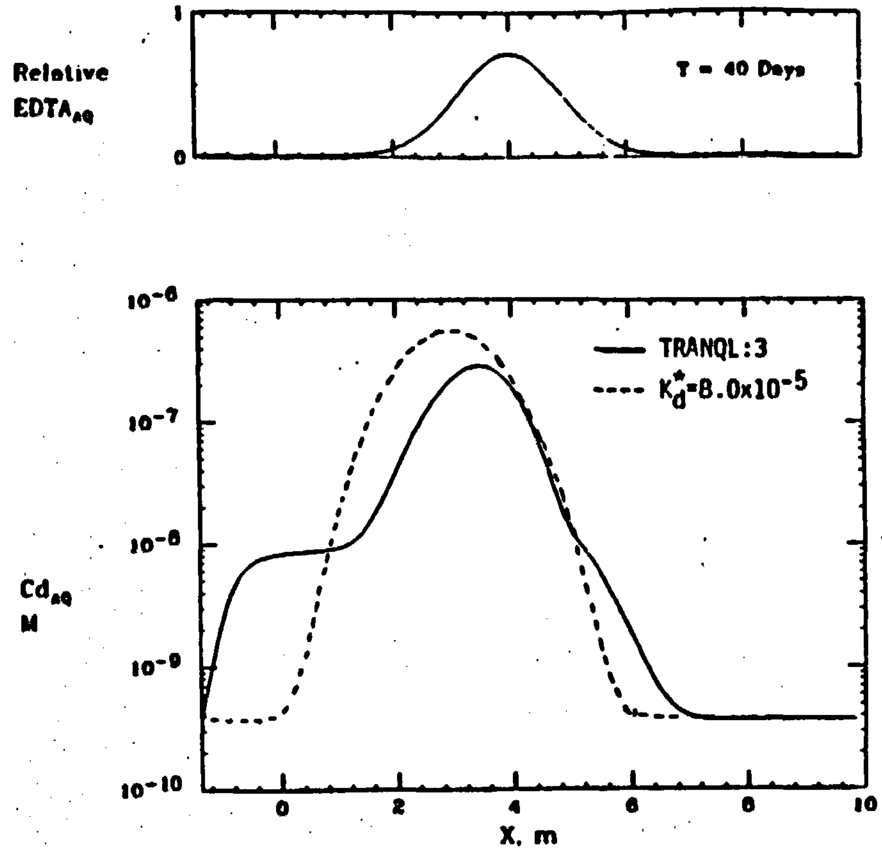

C_f
C
C_n
Reactive Component
Conservative Component
X'_T
X_T
DISTANCE, X (m)

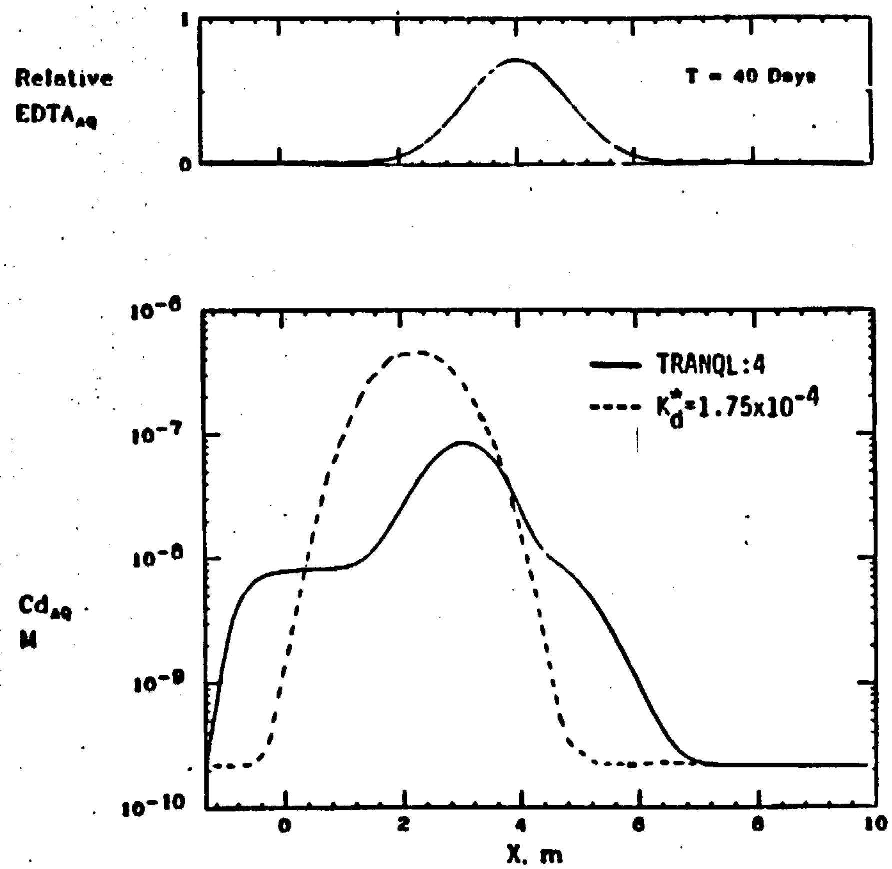

Relative
EDTA$_{AQ}$
T = 0 Days
1
0
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
Cd$_T$
M
Ca_T = 1.26×10^{-3} M
HCO_{3T} = 3.16×10^{-3} M
SOH_T = 1.0×10^{-3} M
pH = 7.97
t≥0
x≥1.375
0
2
4
6
8
10
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
Cd$_{AQ}$
M
1
2
3
4
X, m

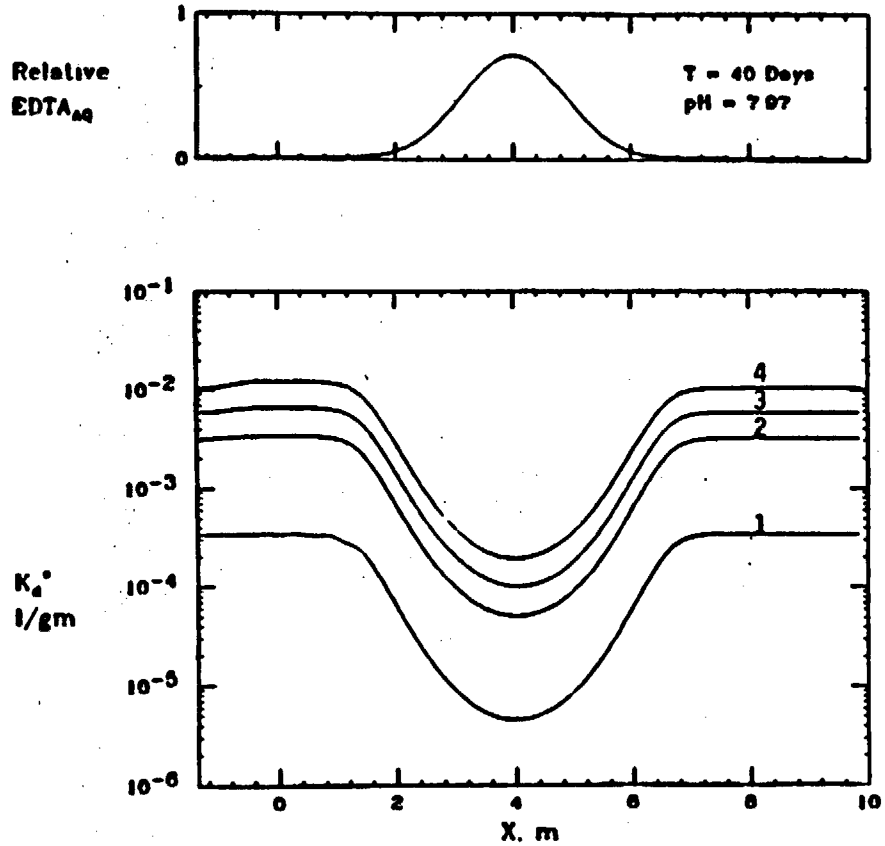

Relative EDTA$_{AQ}$
T = 40 Days
pH = 7.97
Cd_{AQ} M
$\overline{Cd}$ M
1
2
3
4
X, m


Relative
EDTA$_{AQ}$
1
0
T = 40 Days
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
Cd$_{AQ}$
M
TRANQL:1
$K_d^* = 3.21 \times 10^{-6}$
0
2
4
6
8
10
X, m


Relative
EDTA$_{AQ}$
1
0
T = 40 Days
Cd_{AQ}
M
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
TRANQL:2
$K_d^* = 3.73 \times 10^{-5}$
0
2
4
6
8
10
X, m


Relative
EDTA$_{AQ}$
T = 40 Days
1
0
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
TRANQL:3
K_d^*=8.0x10^{-5}
Cd$_{AQ}$
M
0
2
4
6
8
10
X, m


Relative
EDTA_AQ
T = 40 Days
1
0
TRANQL:4
K*d=1.75x10-4
Cd_AQ
M
10-6
10-7
10-8
10-9
10-10
0
2
4
6
8
10
X, m


1
0
Relative
EDTA$_{AQ}$
T = 40 Days
pH = 7.97
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
K_d^*
l/gm
4
3
2
1
0
2
4
6
8
10
X, m

NNWSI PROJECT

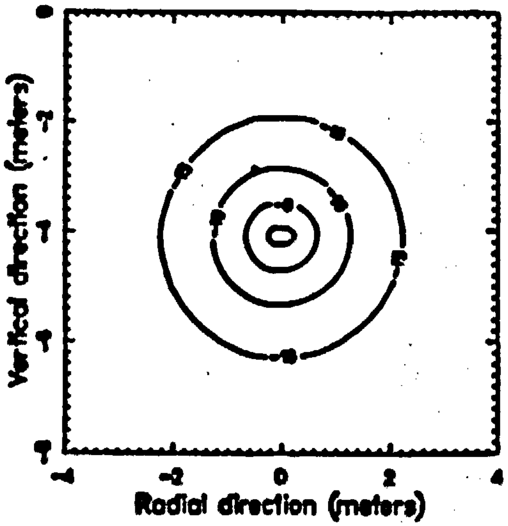
Los Alamos

RESULTS OF TRACR3D CAL-CULATIONS IN SUPPORT OF FRACTURE FLOW EXPERIMENTS

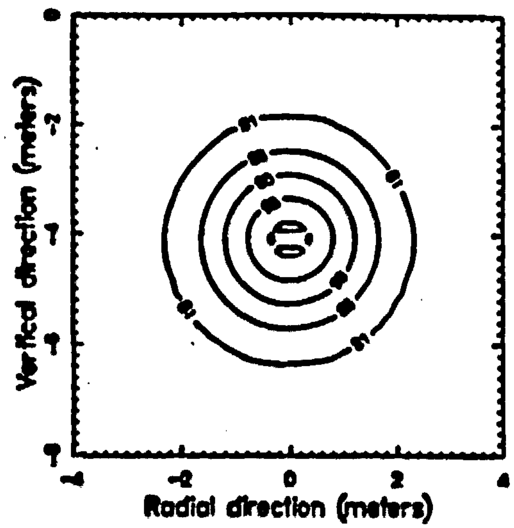
NNWSI PROJECT

NUMERICAL RESULTS OF PRESSURE-DRIVEN FRACTURE-FLOW EXPERIMENT WHEN NO PRESSURE IS APPLIED TO SOURCE REGION

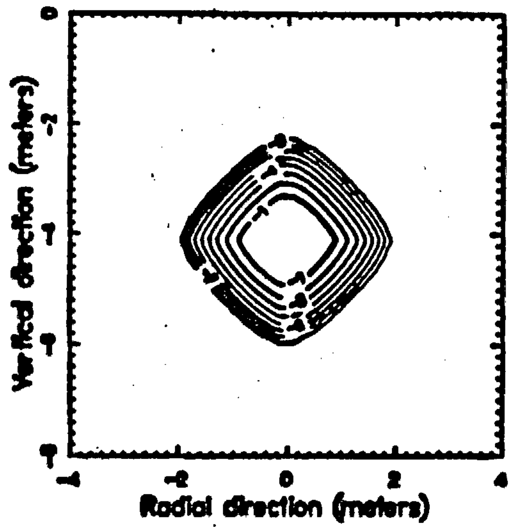
Los Alamos



Liquid Pressure Curves



Liquid Saturation Curves

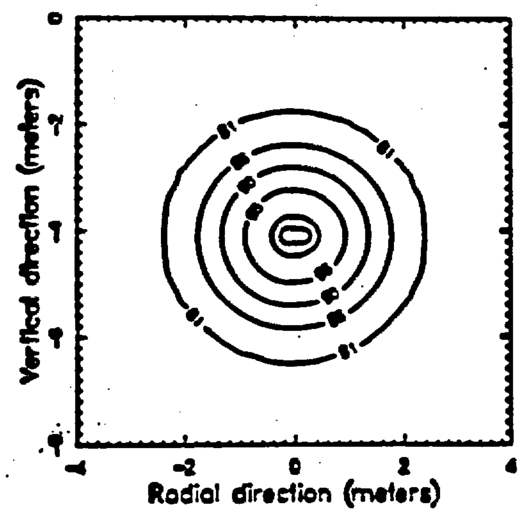


Tracer Concentration Curves

NNWSI PROJECT

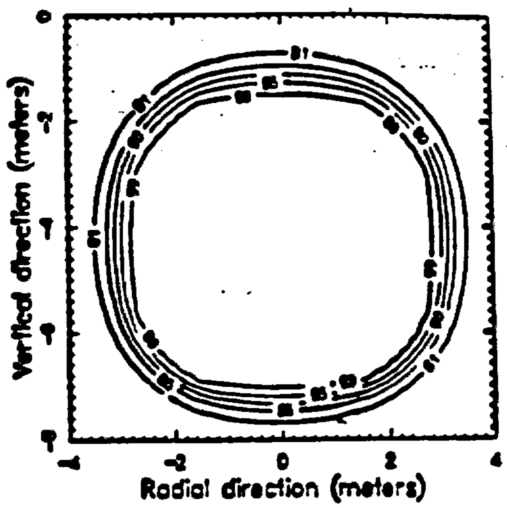
PRESSURE-DRIVEN FRACTURE-FLOW TRACER EXPERIMENT IN WELDED TOPOPAH SPRINGS MEMBER

Los Alamos



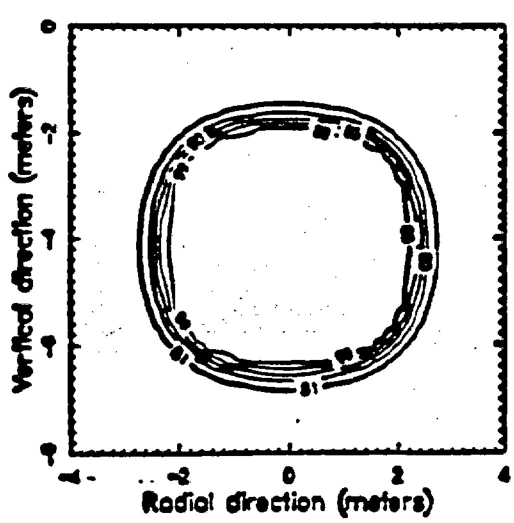
Source Pressure. 1 bar gauge

Time: 1.0 year



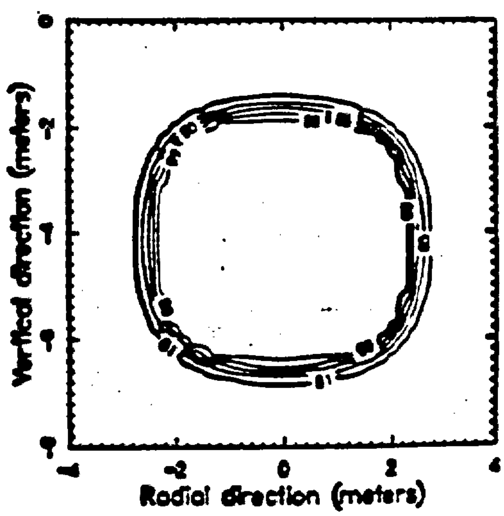
Source Pressure: 2 bars gauge

Time: 10.6 months



Source Pressure: 3 bars gauge

Time: 5.0 months



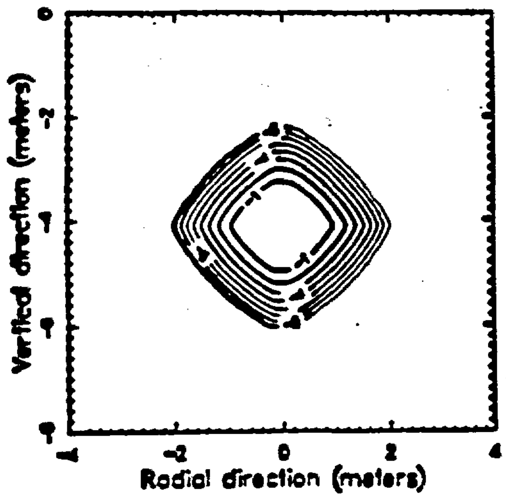
Source Pressure: 5 bars gauge

Time: 4.0 months

NNWSI PROJECT

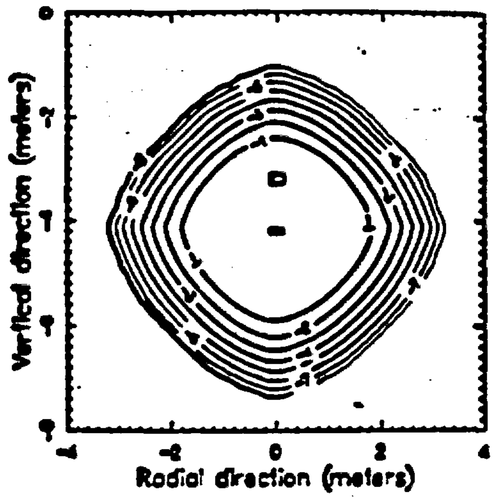
PRESSURE-DRIVEN FRACTURE-FLOW TRACER EXPERIMENT IN WELDED TOPOPAH SPRINGS MEMBER

Los Alamos



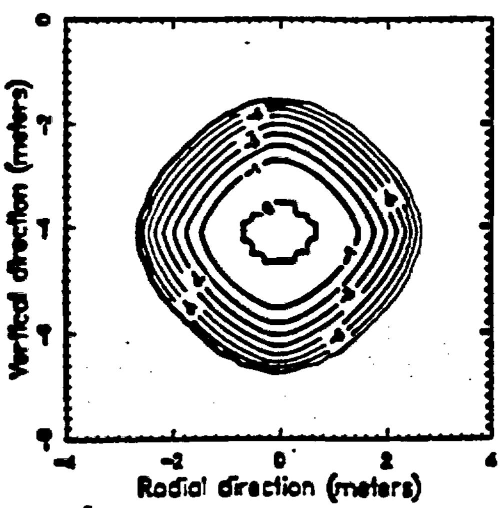
Source Pressure: 1 bar gauge

Time: 1.0 year



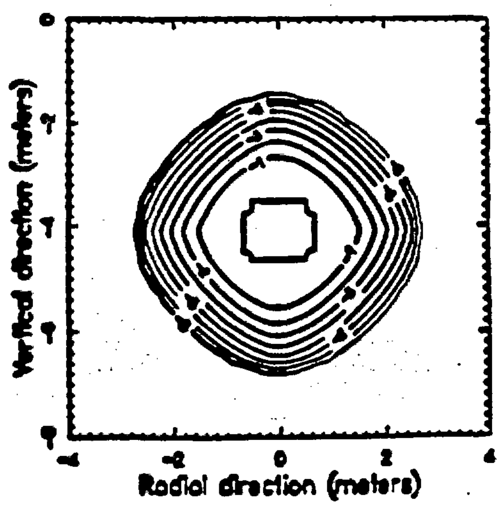
Source Pressure: 2 bars gauge

Time: 10.6 months



Source Pressure: 3 bars gauge

Time: 5.0 months



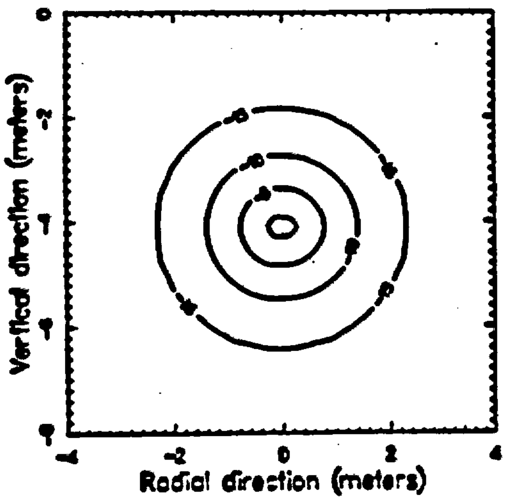
Source Pressure: 5 bars gauge

Time: 4.0 months

NNWSI PROJECT

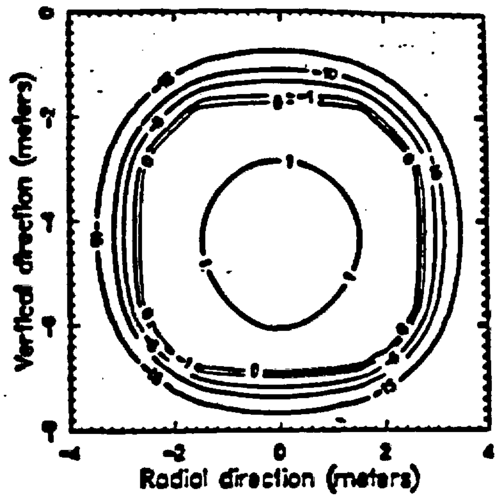
PRESSURE-DRIVEN FRACTURE-FLOW TRACER EXPERIMENT IN WELDED TOPOPAH SPRINGS MEMBER

Los Alamos



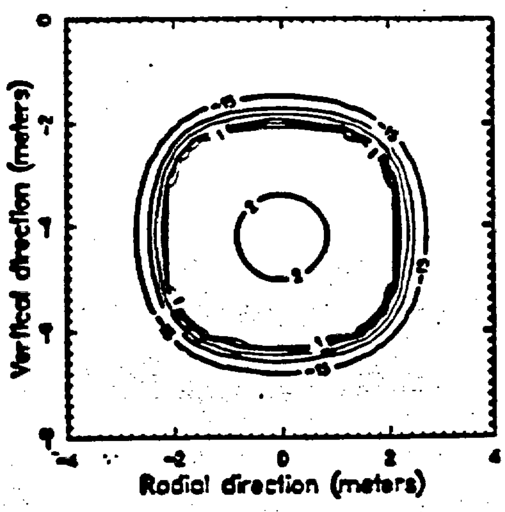
Source Pressure: 1 bar gauge

Time: 1.0 year



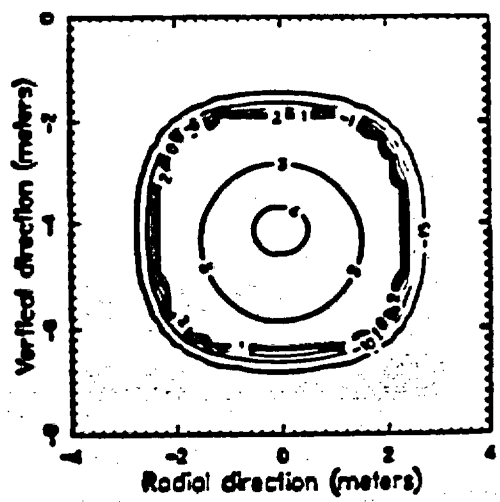
Source Pressure: 2 bars gauge

Time: 10.6 months



Source Pressure: 3 bars gauge

Time: 5.0 months

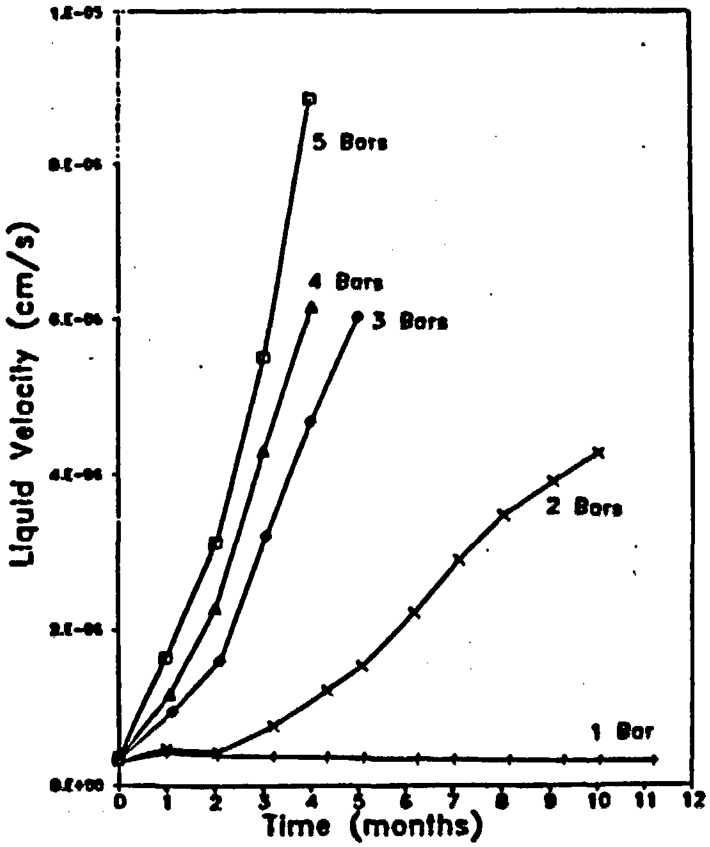


Source Pressure: 5 bars gauge

Time: 4.0 months

NNWSI PROJECT

FRACTURE-FLOW EXPERIMENT – Los Alamos IN WELDED TOPOPAH SPRINGS MEMBER



NNWSI PROJECT

TYPICAL WAFE CALCULATION

Los Alamos

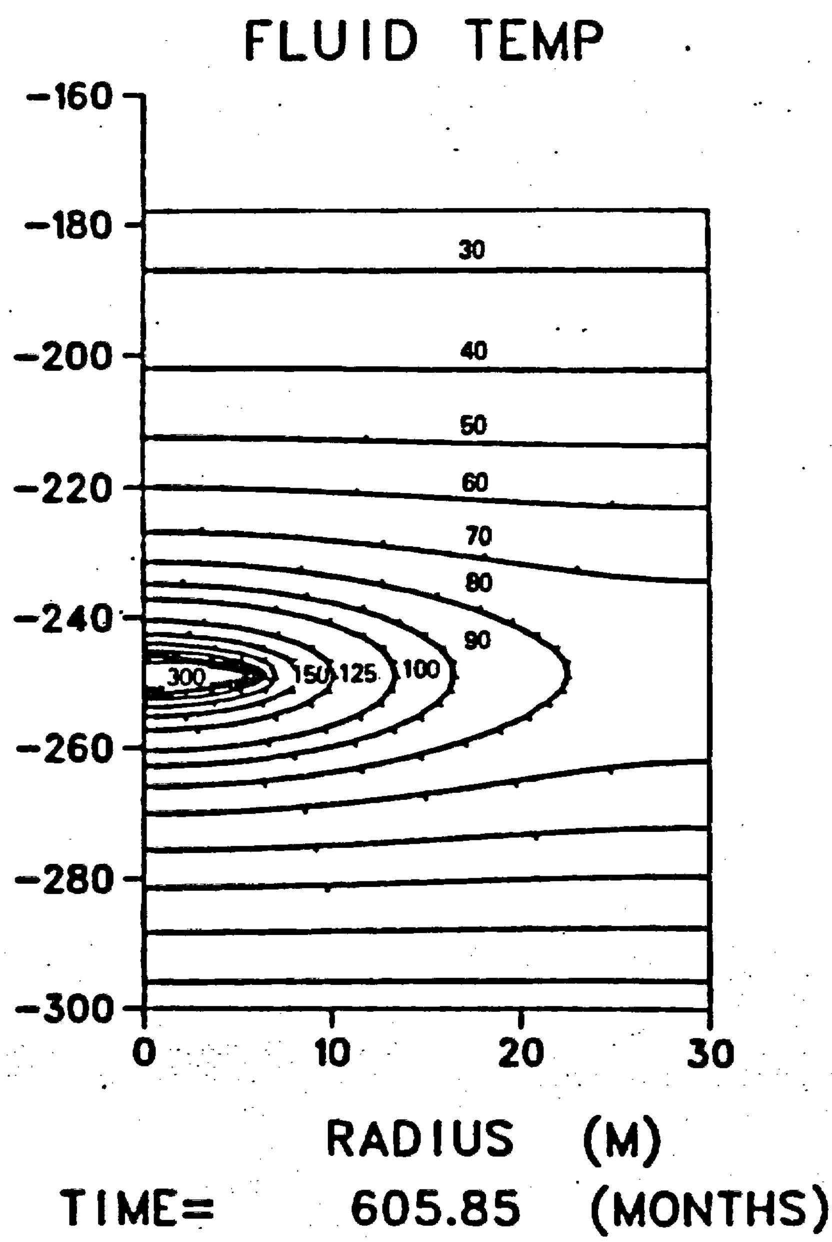
THIS IS A SIMULATION OF

HEAT LOAD EFFECTS ON

FLOW IN YUCCA MOUNTAIN

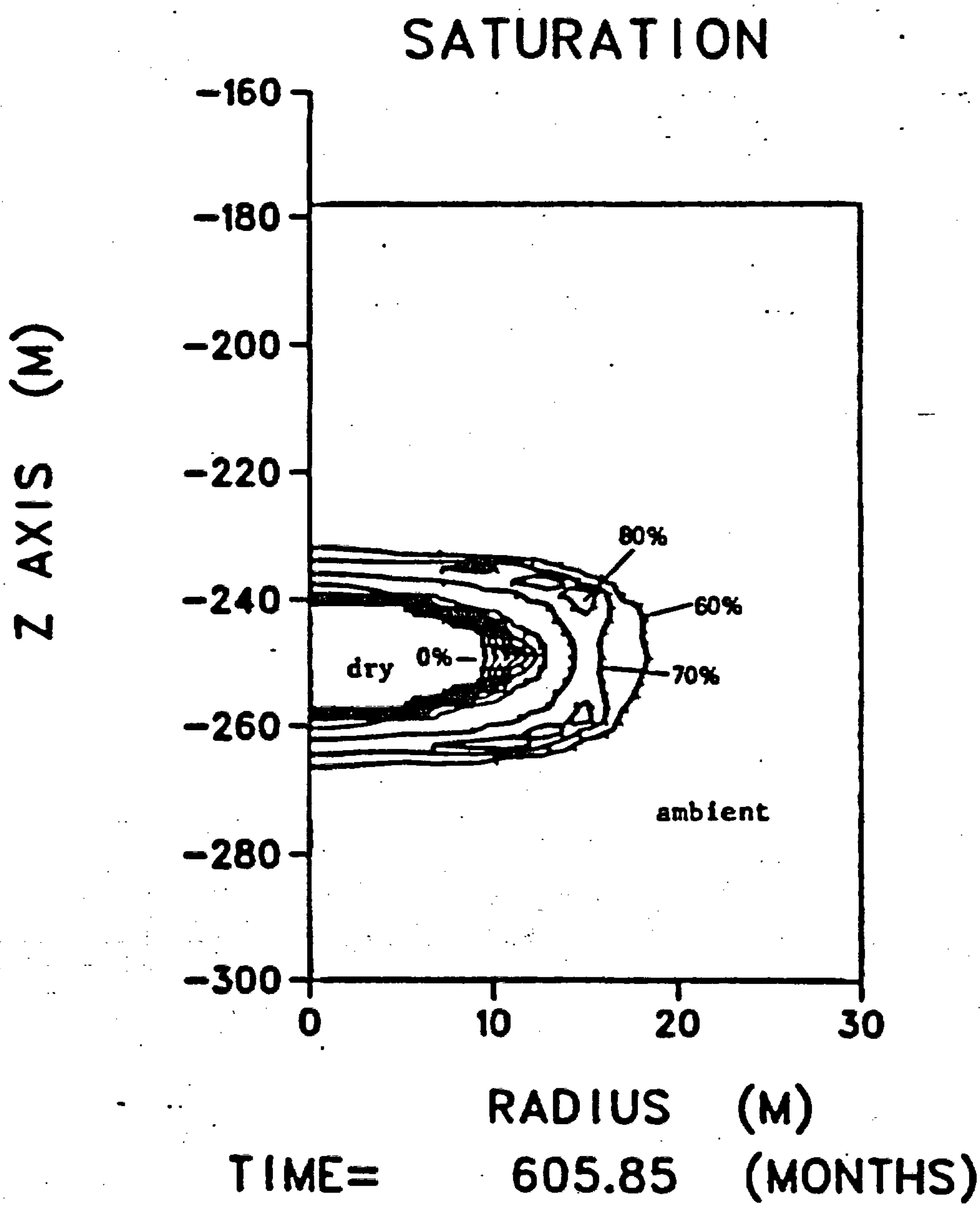
NNWSI PROJECT

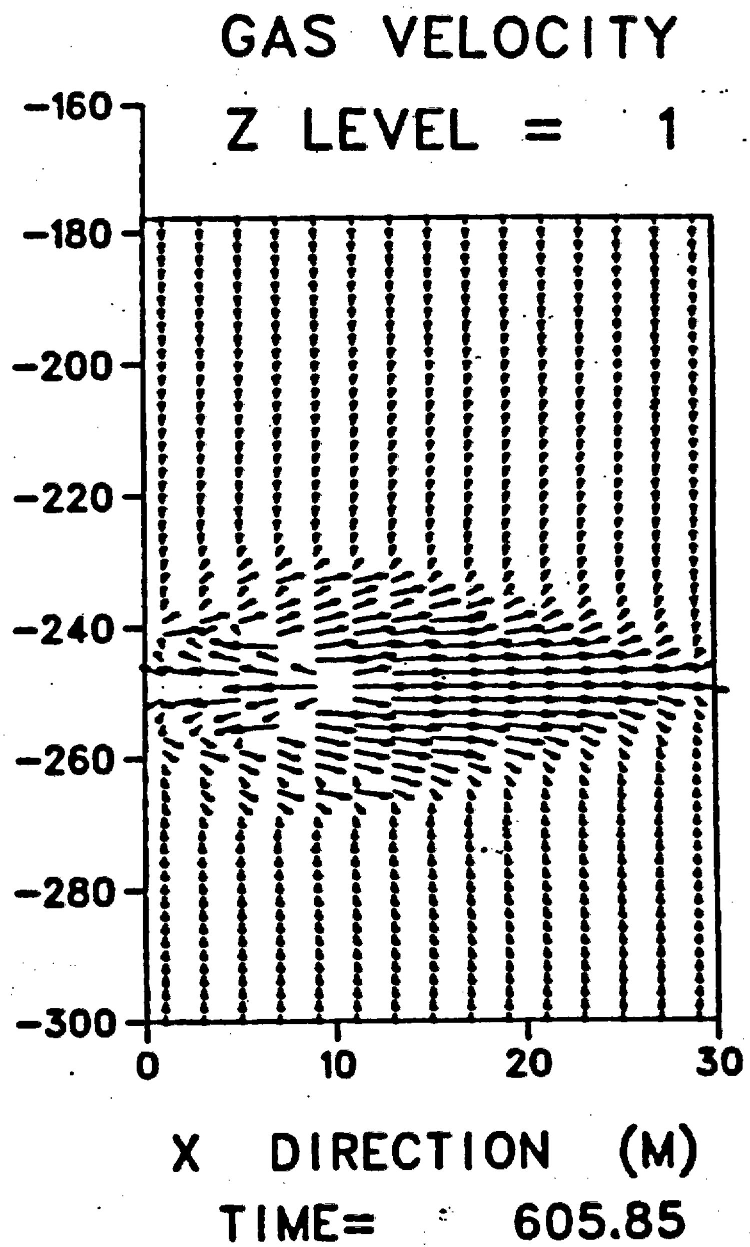
Los Alamos

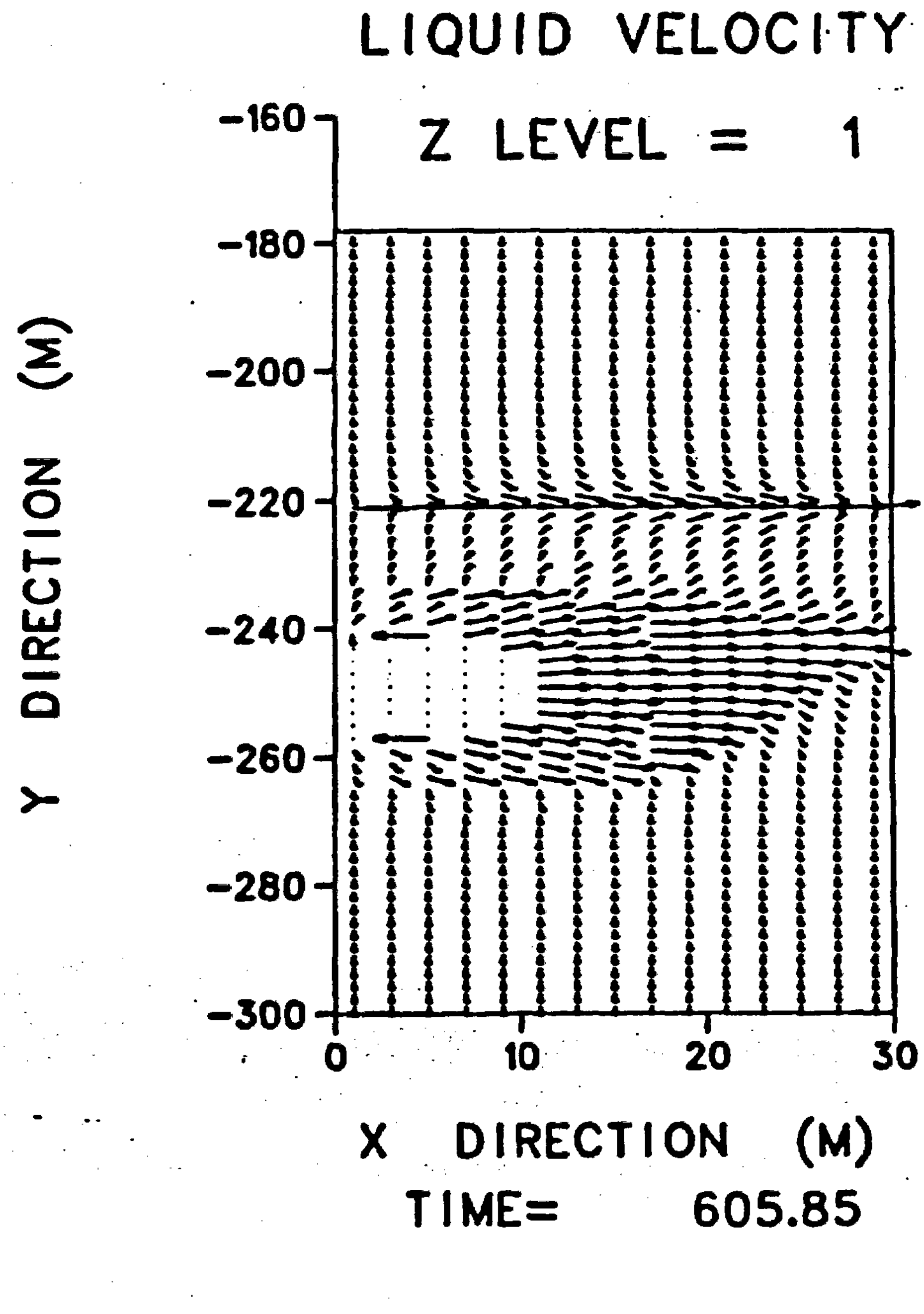


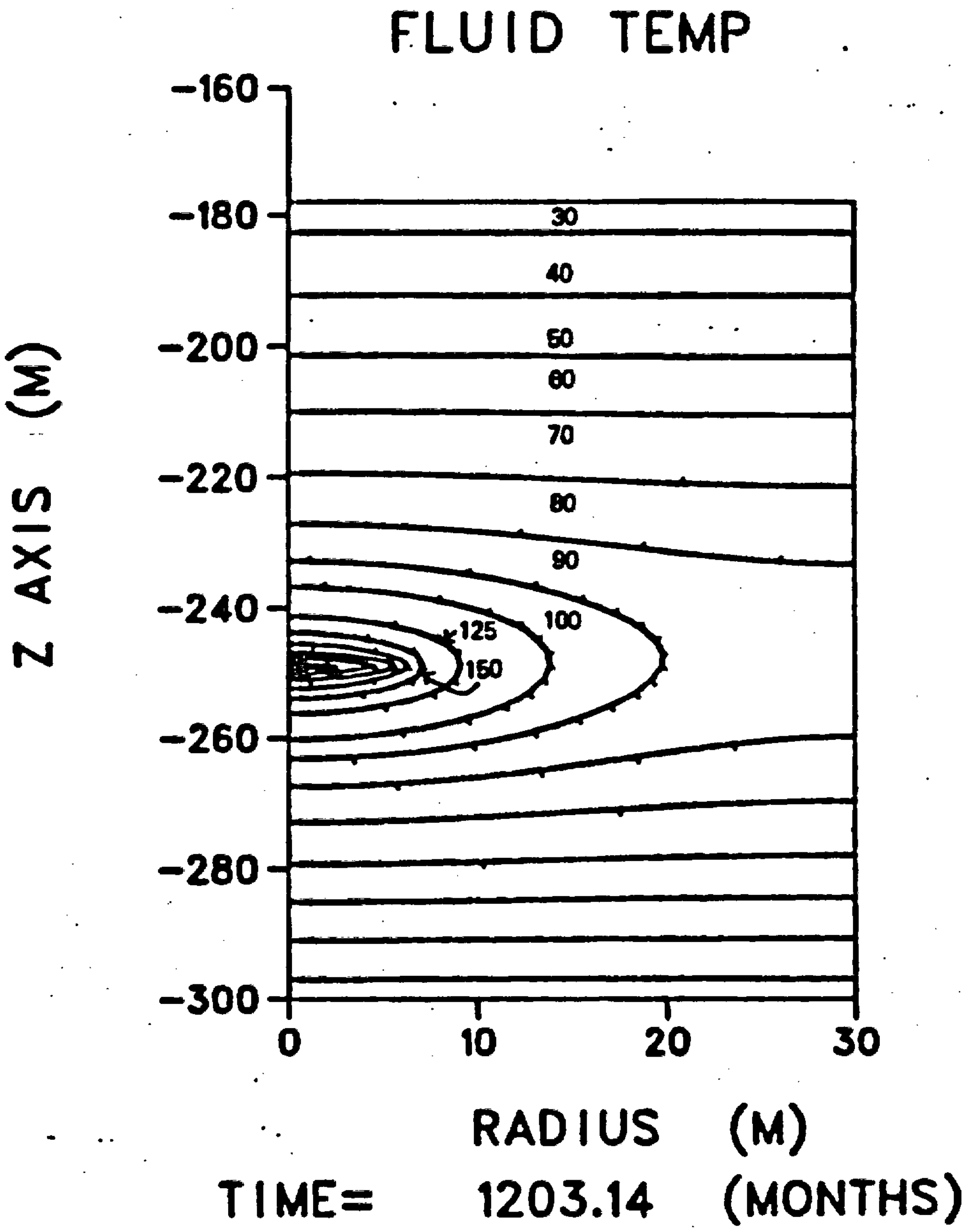
NNWSI PROJECT

Los Alamos

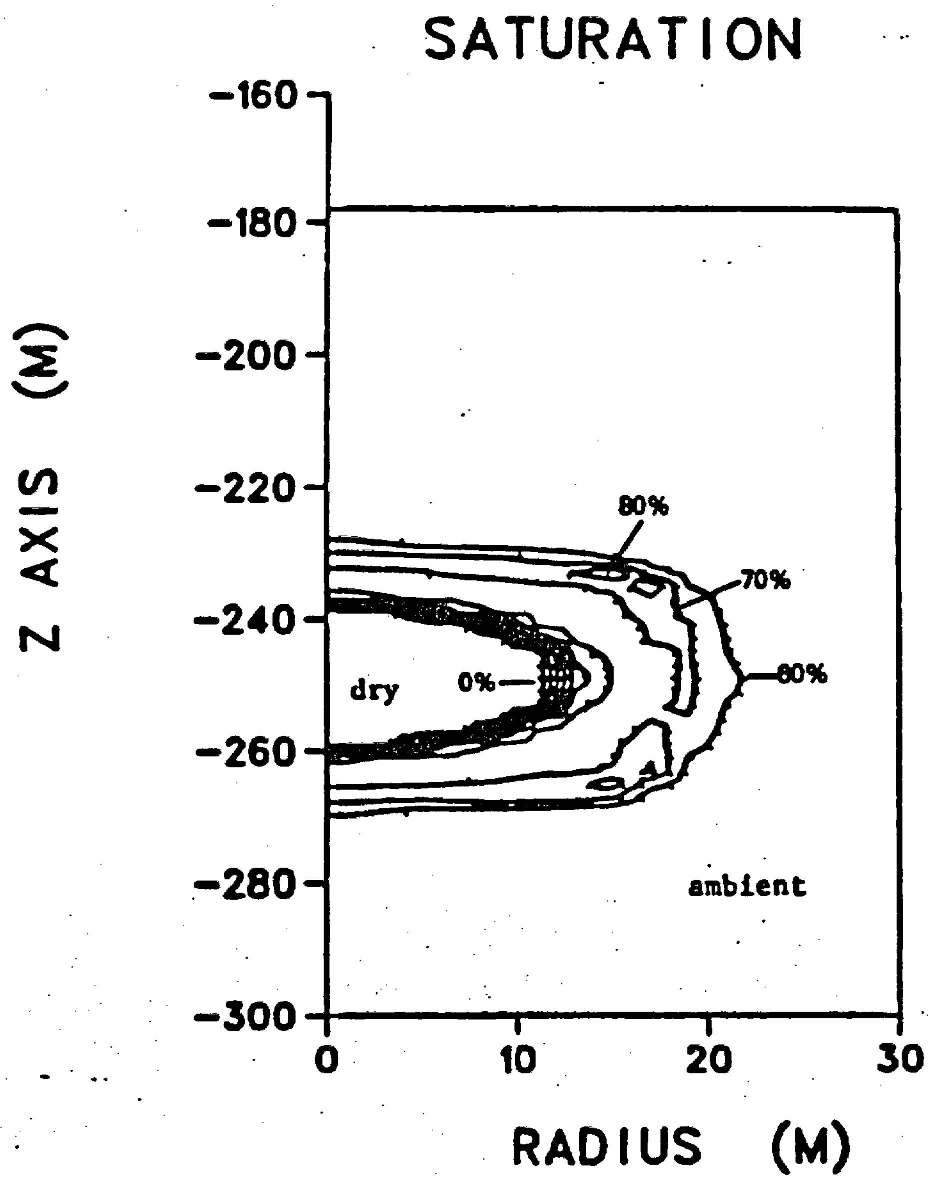



GAS VELOCITY
Z LEVEL = 1
-160
-180
-200
-220
-240
-260
-280
-300
Y DIRECTION (M)
0
10
20
30
X DIRECTION (M)
TIME= 605.85

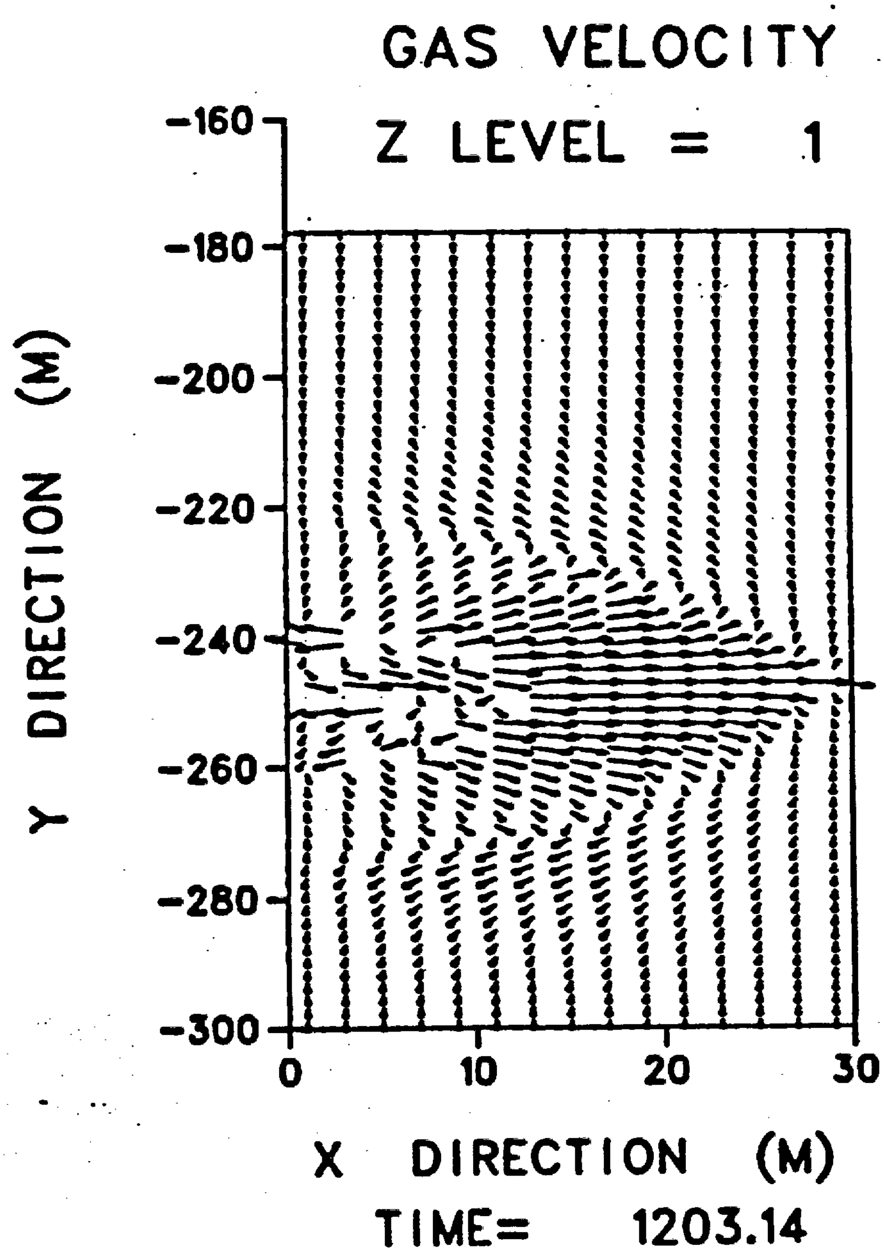

LIQUID VELOCITY
Z LEVEL = 1
-160
-180
-200
-220
-240
-260
-280
-300
0
10
20
30
Y DIRECTION (M)
X DIRECTION (M)
TIME= 605.85

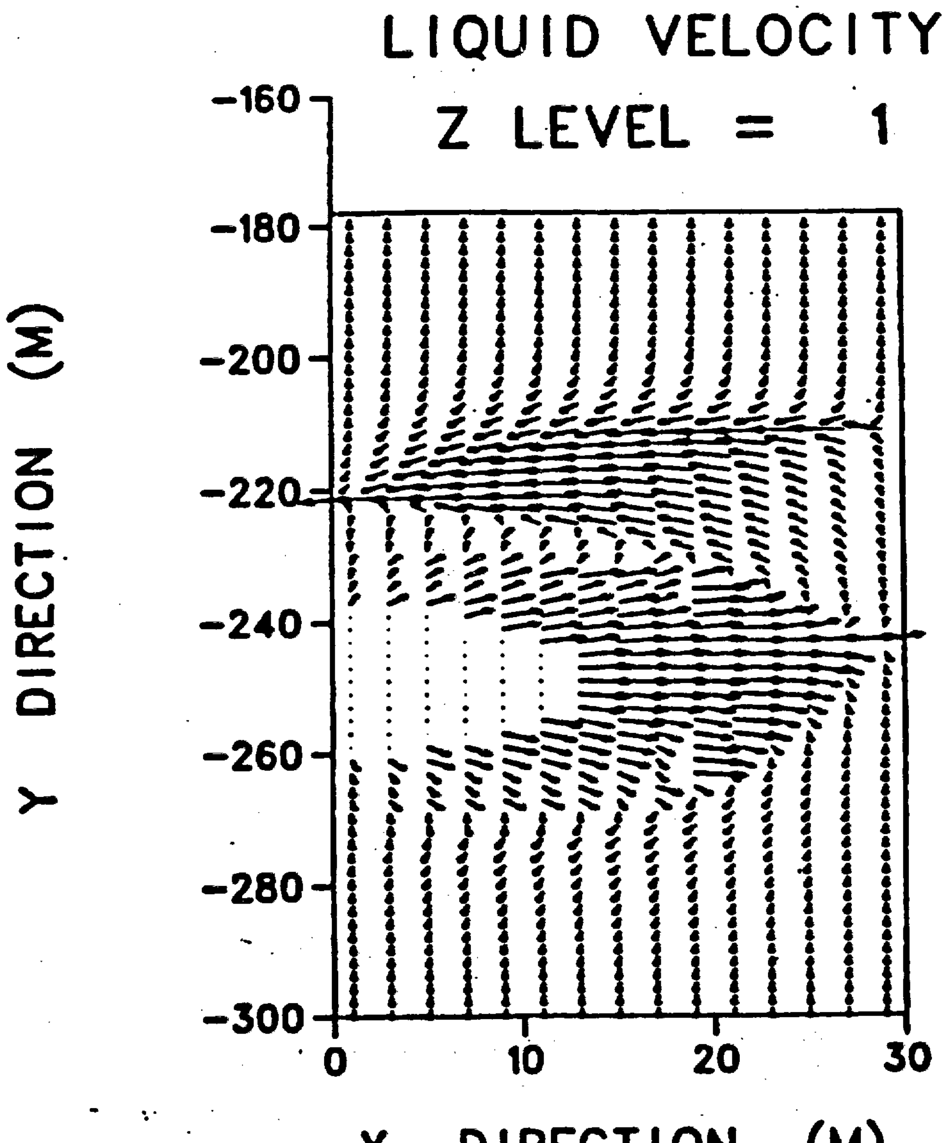

FLUID TEMP
-160
-180
-200
-220
-240
-260
-280
-300
30
40
50
60
70
80
90
100
125
150
0
10
20
30
Z AXIS (M)
RADIUS (M)
TIME= 1203.14 (MONTHS)

Los Alamos



TIME= 1203.14 (MONTHS)


GAS VELOCITY
Z LEVEL = 1
-160
-180
-200
-220
-240
-260
-280
-300
Y DIRECTION (M)
0
10
20
30
X DIRECTION (M)
TIME= 1203.14


LIQUID VELOCITY
Z LEVEL = 1
-160
-180
-200
-220
-240
-260
-280
-300
Y DIRECTION (M)
0
10
20
30