C9

SCK·CEN

STUDIECENTRUM VOOR KERNENERGIE
CENTRE D'ÉTUDE DE L'ÉNERGIE NUCLÉAIRE

Working Group
Hot Laboratories and Remote Handling

Mol, June 14 and 15, 1994

C.9 In-situ Tests in the Underground Research Laboratory for Rad Waste Disposal

B. Neerdael (B-Mol)

HADES

TWO MAIN OBJECTIVES

- Demonstration of the technical feasibility
- Demonstration of the long term safety and performance

R & D AND DT & E PROGRAMME: FROM BASIC RESEARCH UP TO TECHNOLOGICAL DEVELOPMENTS

- SCALE: Small - Pilot - 1/1
- APPROACH: Individual/Integrated Experiments
  Local (Mol/Dessel)/Regional investigations

CONTENTS:

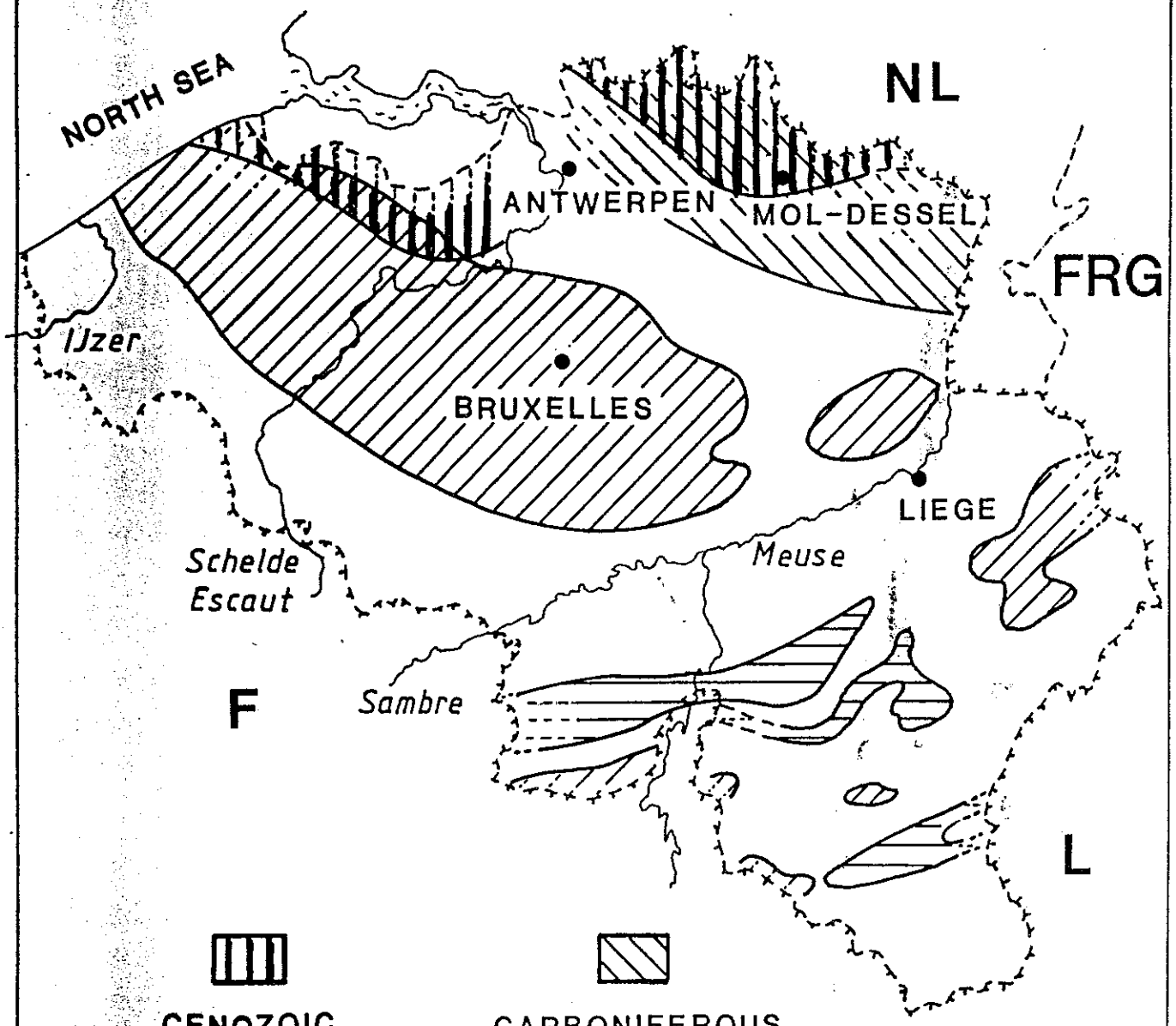
- HISTORICAL OVERVIEW (20 years)

- IN SITU TESTING

  * Waste Packages
  * Natural Host Rock (Boom Clay)
  * Engineered Barriers (Backfill)
  * Near Field Aspects
  * Surrounding Geologies

(01)

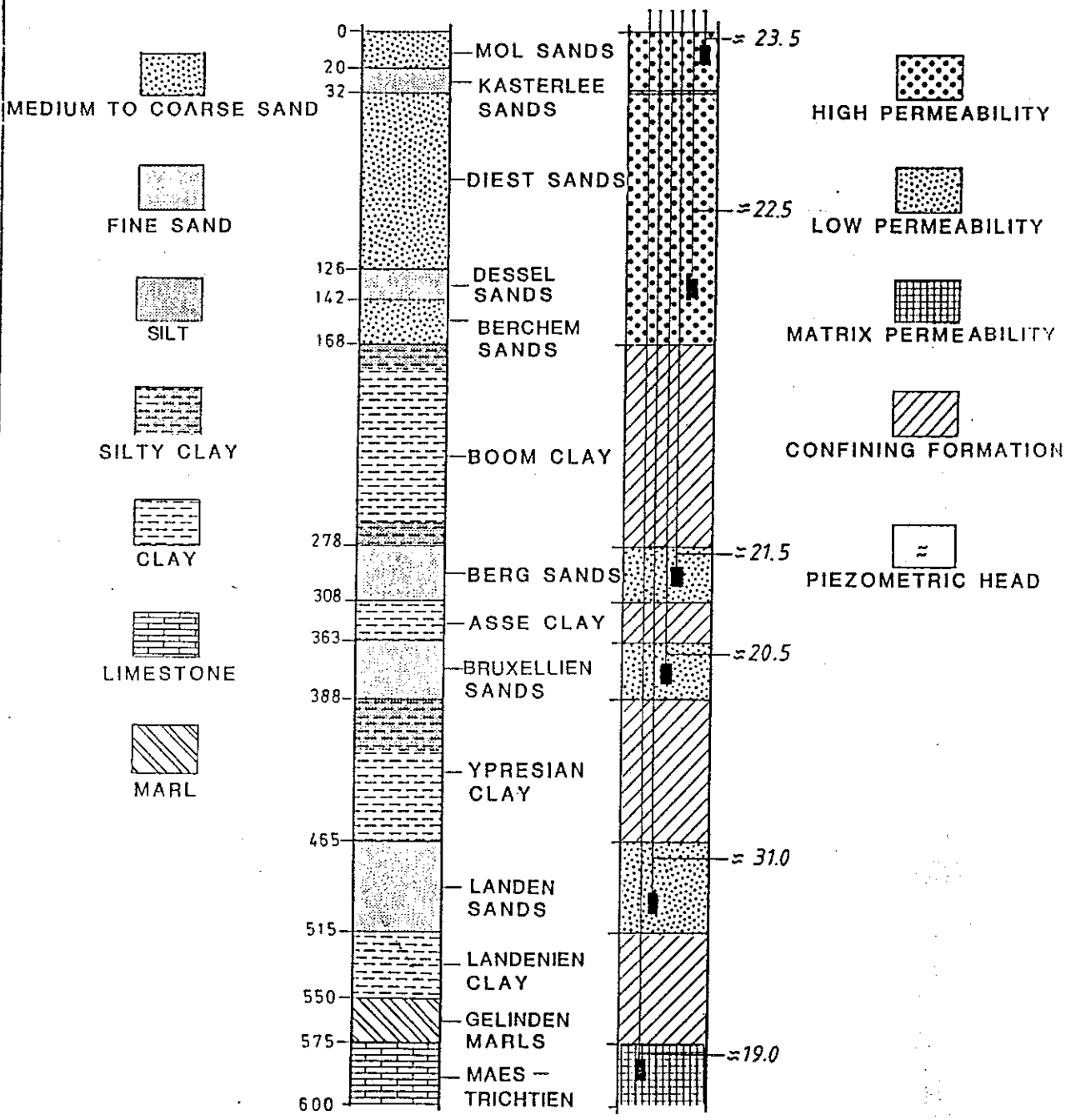
Ge/002/83



MAP OF BELGIUM WITH POTENTIAL GEOLOGIC FORMATIONS FOR SHL AND α WASTE DISPOSAL

SCK/CEN

Ge/003 / 83



LITHOSTATIC & HYDROLOGIC CUTS OF THE MOL SITE (1975 BORING)

SCK / CEN

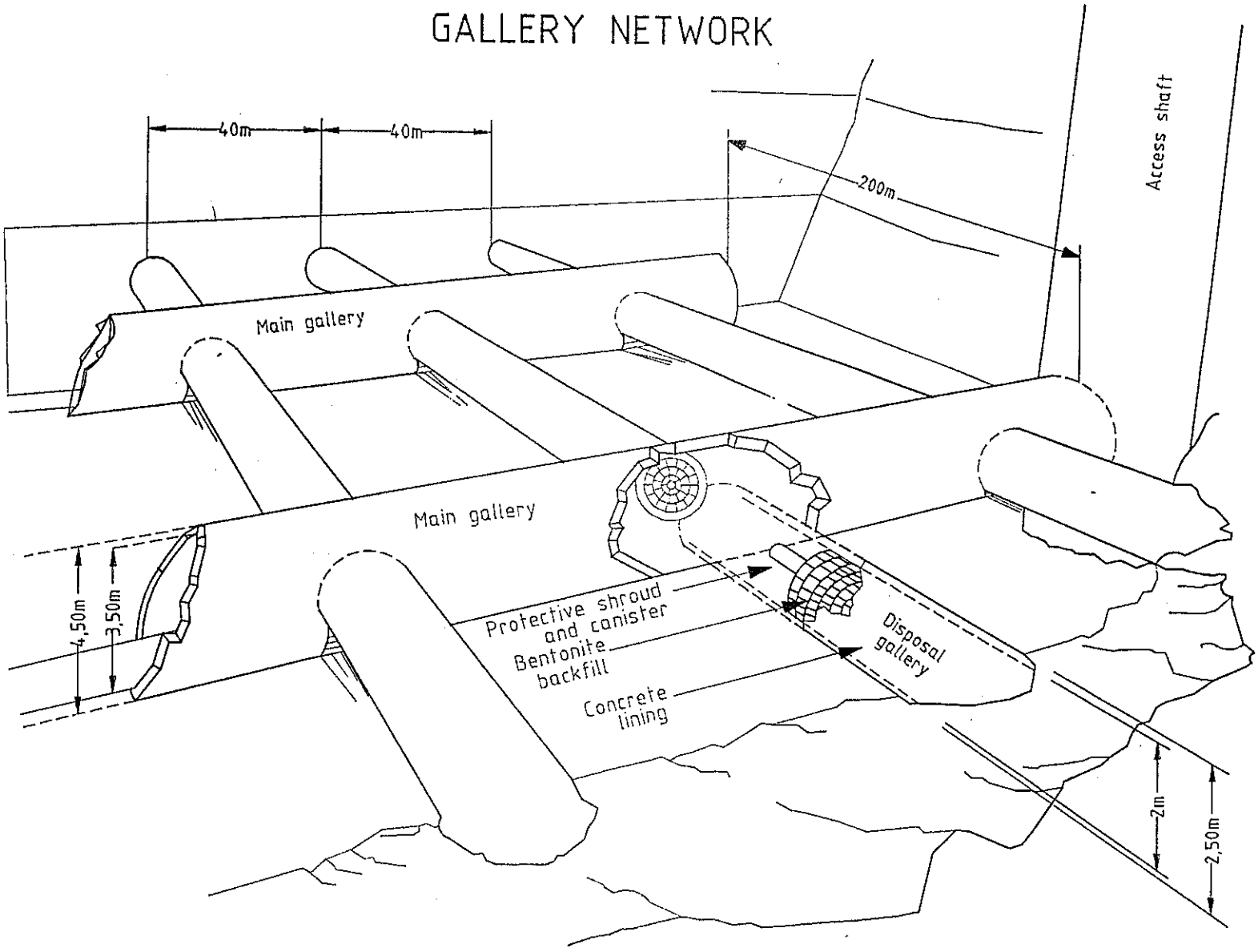
OVERVIEW 73/83 (I)

- Rather limited choice for potential Host Rocks (BGS)
- Favourable argillaceous Formations Underneath CEN/SCK

ARE THE CHARACTERISTICS AND PROPERTIES OF THE BOOM CLAY FORMATION REALLY PROMISING FOR HOSTING A HLW REPOSITORY ?

ACTIONS:

- Core Drilling (Geol., Geomech., Physico-chem.)
- Hydrogeological studies
- Preliminary Repository Design
- Risk Analysis



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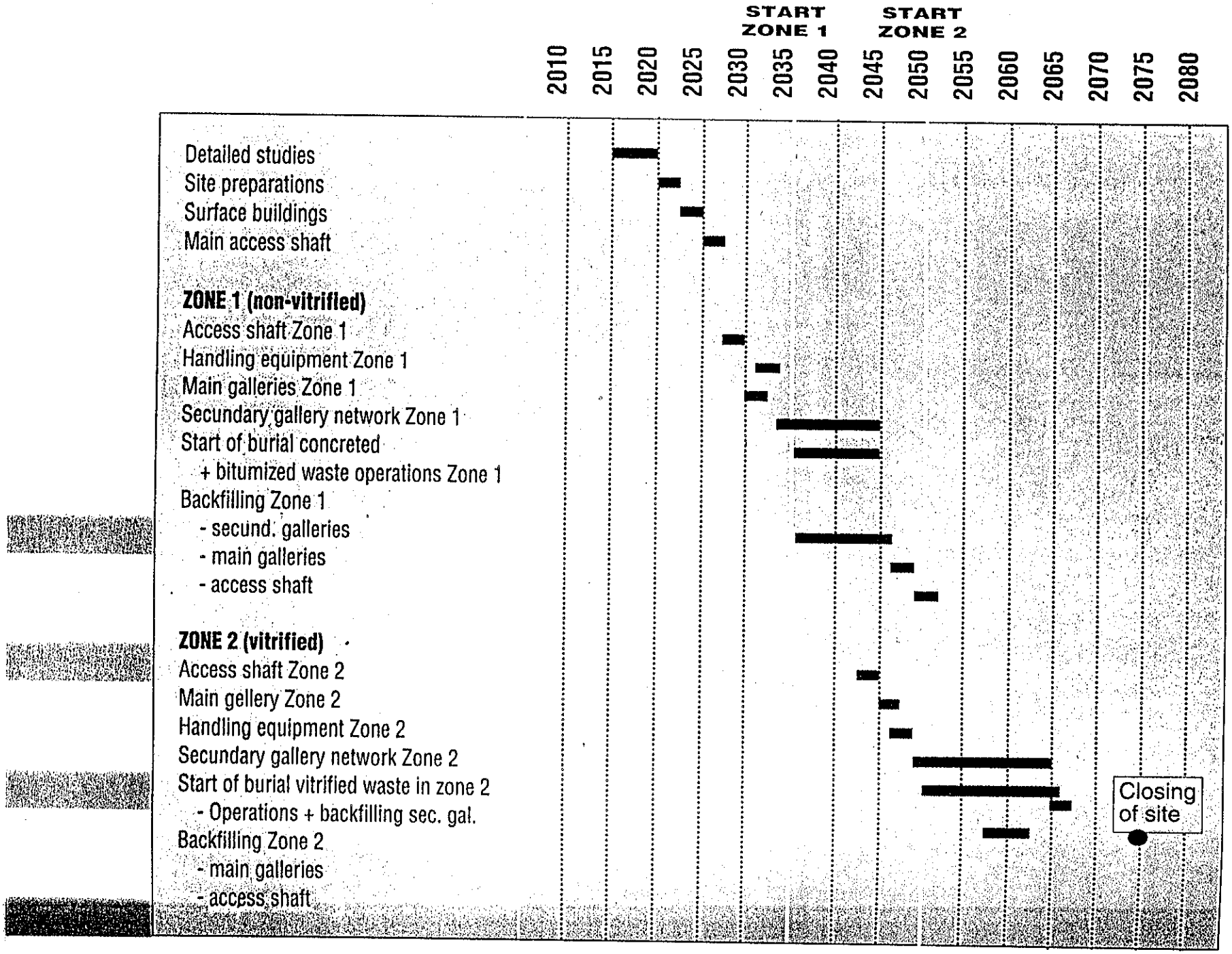
NATIONAL WASTE MANAGEMENT PROGRAMME

WASTE TYPE	CAT.	VOLUME (m^3)	MAIN PRODUCERS / ORIGIN
Low-level beta, gamma and non-alpha waste	A	150.000	Operation of power stations and reprocessing, research facilities and dismantling all facilities
Low- or medium-level waste with significant amount of alpha	B	25.000	Reprocessing (Fuel power stations and former Eurochemic plant). Dismantling Research Facilities.
High-level waste	C	5.000	Reprocessing (Fuel power stations and former Eurochemic plant).

Approximate quantities of radioactive waste expected to be generated in Belgium until the year 2050

schedule


START ZONE 1
START ZONE 2
2010
2015
2020
2025
2030
2035
2040
2045
2050
2055
2060
2065
2070
2075
2080
Detailed studies
Site preparations
Surface buildings
Main access shaft
ZONE 1 (non-vitrified)
Access shaft Zone 1
Handling equipment Zone 1
Main galleries Zone 1
Secundary gallery network Zone 1
Start of burial concreted
+ bitumized waste operations Zone 1
Backfilling Zone 1
- secund. galleries
- main galleries
- access shaft
ZONE 2 (vitrified)
Access shaft Zone 2
Main gellery Zone 2
Handling equipment Zone 2
Secundary gallery network Zone 2
Start of burial vitrified waste in zone 2
- Operations + backfilling sec. gal.
Backfilling Zone 2
- main galleries
- access shaft
Closing of site

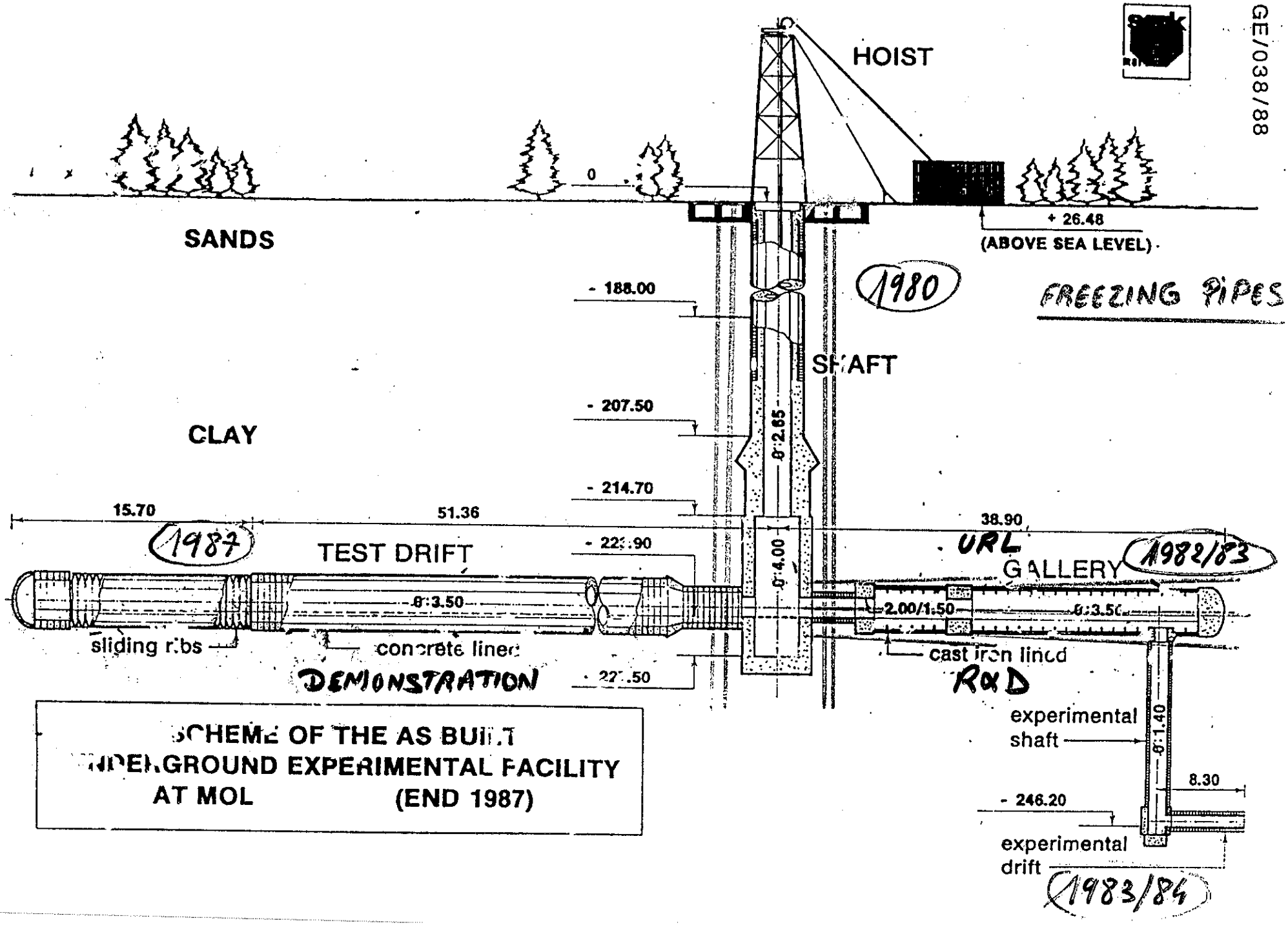
OVERVIEW 73/83 (2)

RESULTS: (labo / open clay pit / field)

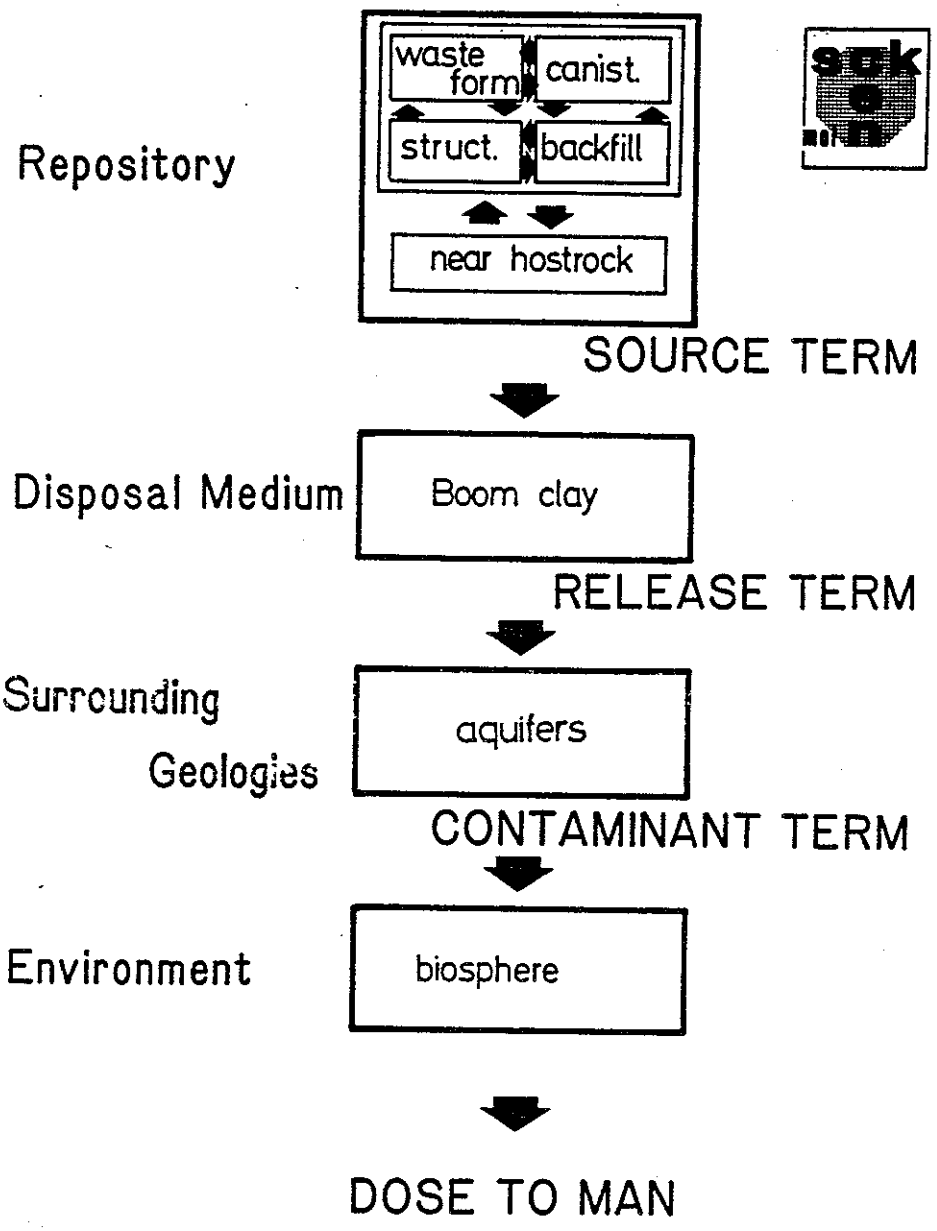
- Good sorption characteristics,
- Chem-mineral. stability,
- Sufficient heat conduction
- Low permeability
- Self healing behaviour (*)

(*) WHAT ABOUT MINING CAPABILITIES ?

1980 : Decision to build an URL (-223 m) for the Characterisation of Boom Clay under in situ conditions



SCHEME OF THE AS BUILT
UNDERGROUND EXPERIMENTAL FACILITY
AT MOL (END 1987)



SIMPLIFIED CLAY REPOSITORY EVOLUTION SYSTEM

OVERVIEW 83/93

FORMATION AND SITE SPECIFIC APPROACH

: URL completed; collaboration with ANDRA (Geomech.)
Investigations in corrosion, migration, heat transfer, hydraulics

: Extension of the URL to a URF. (TEST DRIFT)
Demonstration of tunnelling in clay
New generation of integrated tests
Participation in validation and extensive performance assessment exercises

: Safir Report
Further studies on the main repository system components

BOOM CLAY AT DEPTH

STIFF OVERCONSOLIDATED CLAY OF HIGH PLASTICITY
OCR= 2.4 (preconsolidation stress: 6 MPa)

MOISTURE CONTENT:	19 to 26	%
BULK (DRY) UNIT WEIGHT:	20 (16.5)	kN/m3
POROSITY:	35 to 39	%
LIQUID LIMIT:	64 to 68	%
PLASTIC LIMIT:	19 to 25	%
MEAN PLASTICITY INDEX:	+/- 47	%
HYDRAULIC CONDUCTIVITY:	3.5 E-12	m/s
COEF. OF CONSOLIDATION:	0.6 to 0.8	m2/y
UNDR. SHEAR STRENGTH:	0.8 to 1.2	MPa
UNDR. YOUNG'S MODULUS:	200 to 350	MPa

3.2. HYDRAULIC CONDUCTIVITY (K)

- VERY LOW (~ picometer / sec)
- ANISOTROPY

Values	K_H (10^{-12} m s^{-1})	K_V (10^{-12} m s^{-1})	K_H / K_V	S° (10^{-5} m^{-1})
In situ	4,1	2,2	1,9	1,3
Laboratory	3,8	1,6	2,4	/
Proposed (PA)	4,1	1,7	2,4	1,3

CHEMICAL CHARACTERISTICS OF THE BOOM CLAY

• STRONGLY REDUCING MEDIUM

— FeS_2 (pyrite) (± 1%) = pool of Fe^{2+} and S_2^{2-}

— Sorbed Fe (II)

— Organic Material (OM) (2 – 3 %) :

– Humic Acids (HA):high MW (less mobile)

– Fulvic Acids (FA): low MW (mobile: < 0,05 %)

• SLIGHTLY ALKALINE MEDIUM

— $CaCO_3$ (calcite + *Septaria*) (± 1%)

— $FeCO_3$ (siderite)

• INTERSTITIAL BOOM CLAY WATER

— pH = 8,5

— Eh = -265 mV

— HCO_3^- (0,01 N)

— soluble organics (less than 0,05 % of the total OM)

IN SITU TESTS

- WASTE PACKAGES: CORROSION
- ENGINEERED BARRIERS: BACCHUS 2
- HOST ROCK: GEOMECHANICS, MIGRATION, MEGAS
- NEAR FIELD: MINE-BY, ATLAS, CERBERUS

  CACTUS (ANDRA)
- SURROUNDING GEOLOGIES: HYDROGEOLOGY

  ARCHIMEDES & PHEBUS (ANDRA)

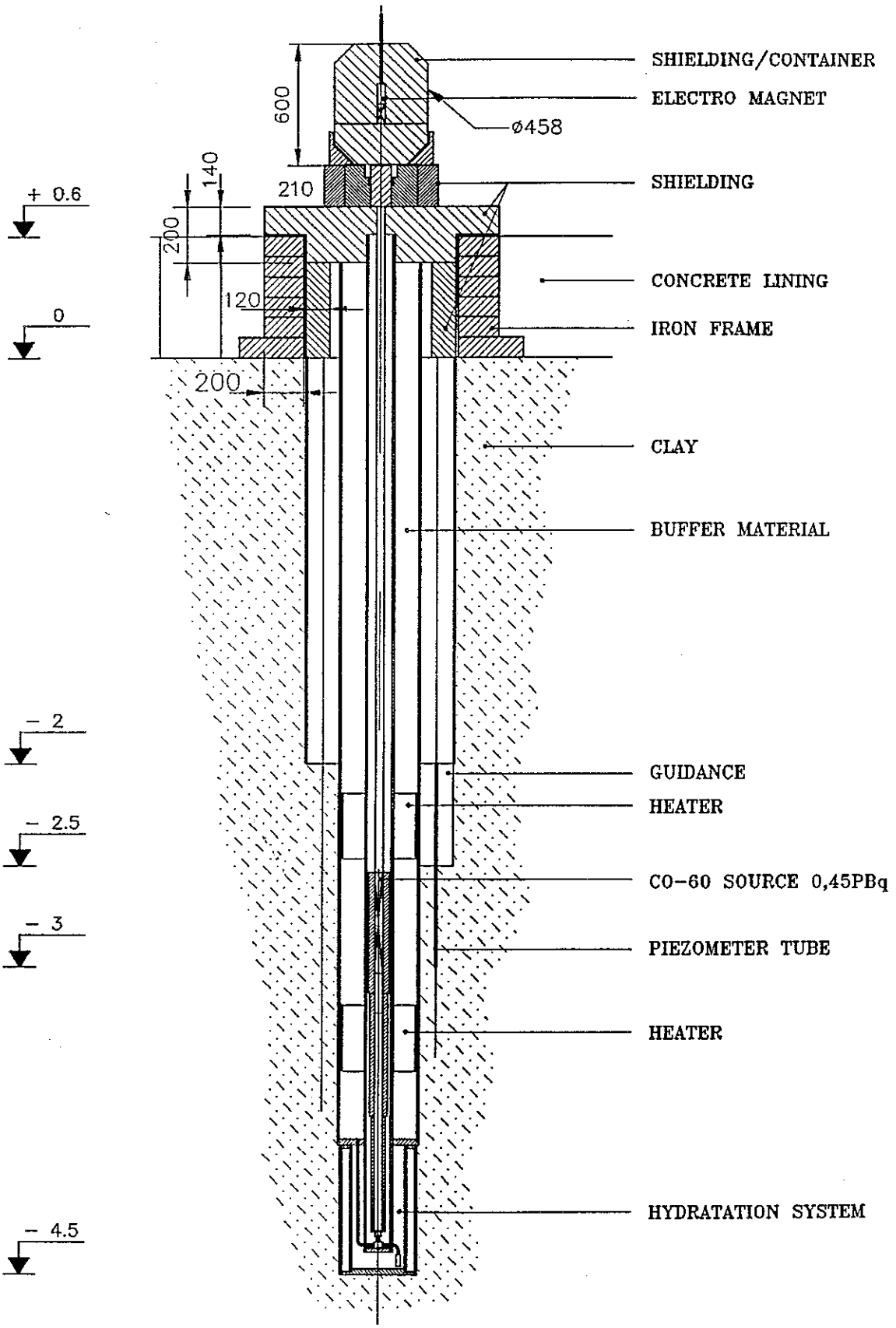
CERBERUS (1)

OBJECTIVE:

DIRECT DEMONSTRATION OF COMBINED EFFECTS OF RADIATION, HEAT AND DRILLING (NEAR-FIELD).

DESCRIPTION:

COMBINED SOURCE: 444 TBq Co-60 AND TWO ELECTRICAL HEATERS OF 362 W EACH, 2,5 M IN FLOOR OF TEST DRIFT.
PARAMETERS: DOSE RATE, TEMPERATURE, WATER SAMPLING, TOTAL AND PORE WATER PRESSURE.
INTEGRATED EXPERIMENT FOR: MIGRATION, CORROSION, HYDRATION OF BACKFILL MATERIAL -TEST MATERIAL IS RETRIEVABLE-


SHIELDING/CONTAINER
ELECTRO MAGNET
ø458
SHIELDING
CONCRETE LINING
IRON FRAME
CLAY
BUFFER MATERIAL
GUIDANCE
HEATER
CO-60 SOURCE 0,45PBq
PIEZOMETER TUBE
HEATER
HYDRATATION SYSTEM
600
140
210
200
120
200
+ 0.6
0
- 2
- 2.5
- 3
- 4.5

CERBERUS (2)

TIMING:

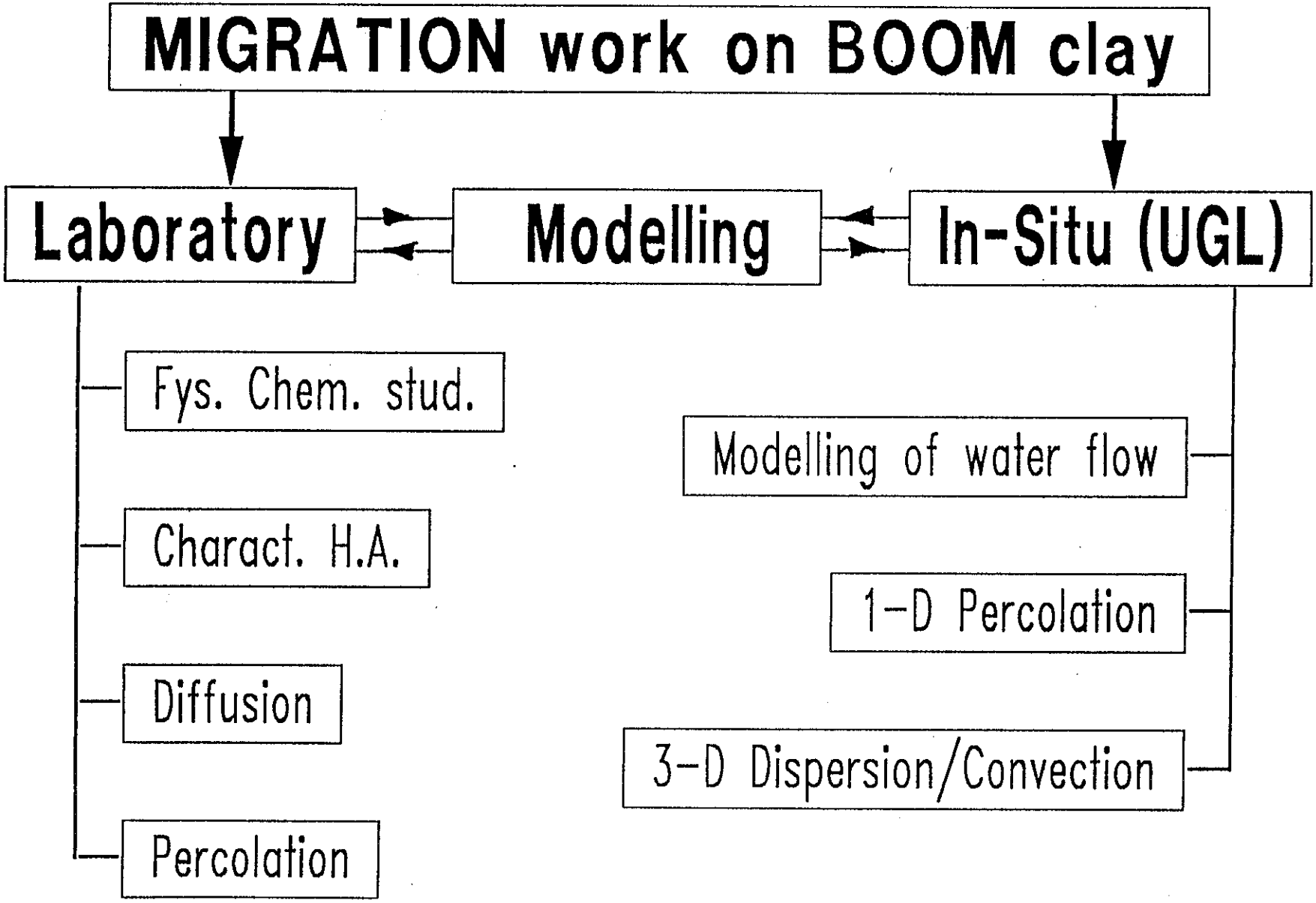
INSTALLATION: END 1988
RADIATION SOURCE LOADED: EARLY 1989
SHUT-DOWN HEATING AND RETRIEVAL: END 1994
HYDRATION: EARLY 1995 UNTIL MID 1996
RECOVERY AND ANALYSES FROM MID 1996 ON.

STATUS:

FULL OPERATION PRESENTLY.

ACHIEVEMENTS:

IMPACT ON LOCAL CHEMISTRY AND HYDRAULIC PROPERTIES PUT IN EVIDENCE (interpretation is ongoing).



MIGDOC1/mp/91

MIGRATION

OBJECTIVE:

DIRECT DEMONSTRATION OF MIGRATION BEHAVIOUR OF RADIONUCLIDES IN THE BOOM CLAY

DESCRIPTION:

TRACER PERCOLATION THROUGH CLAY CORE

Sr-85 (3.7 E6 Bq, URL): start 1987, end 1987
Eu-152/54 (1.8 E6 Bq,URL): start 1985, end 1987
Am-241 (Cerberus): start 1990, end 1994
Cs-134 (3 MBq, URL): start 1987, end 1995

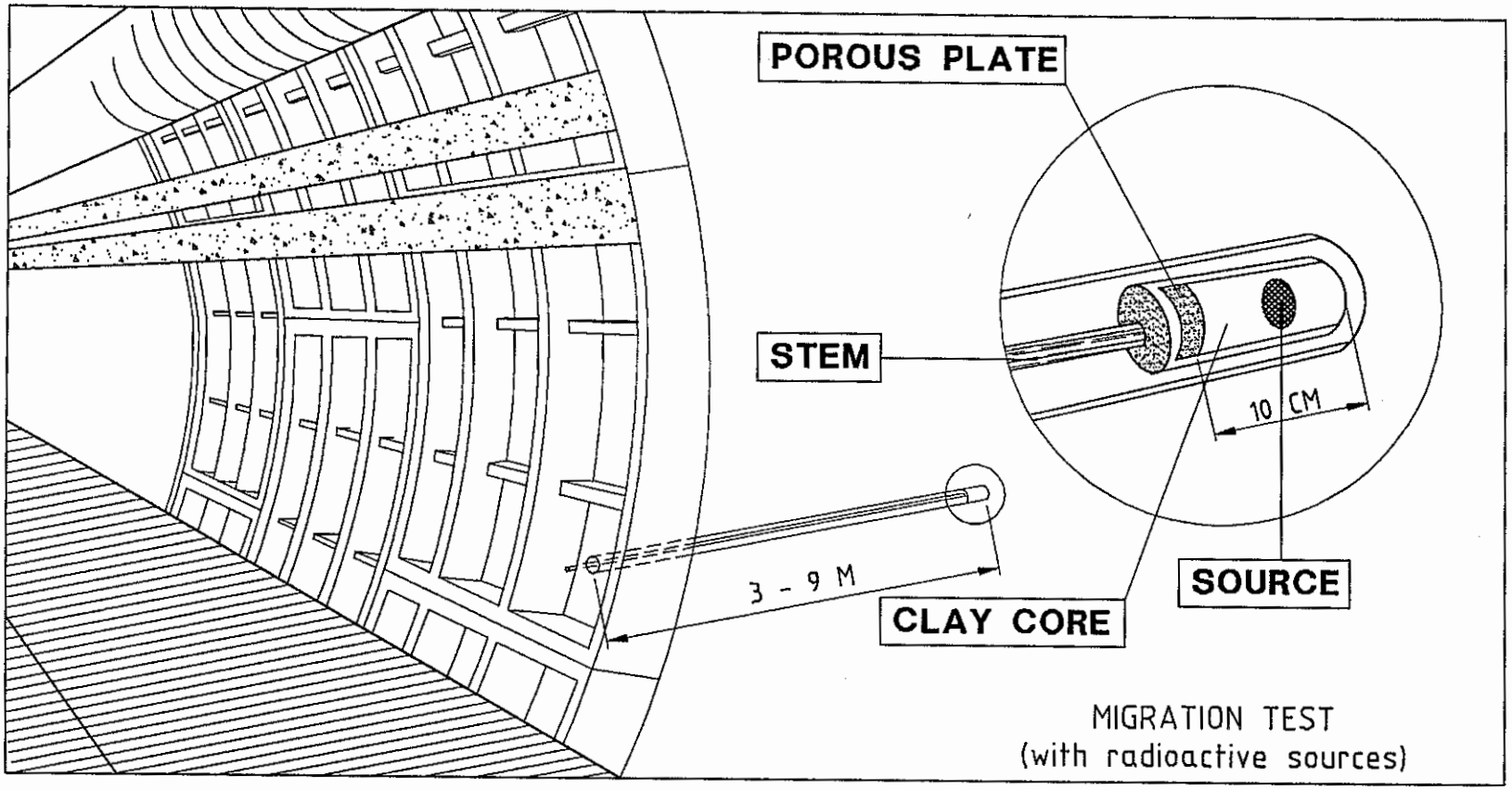
LARGE SCALE IN-SITU INJECTION OF NON SORBED TRACER

I-125 (0.25 GBq, TD): start 1992, end open
HTO (1.25 GBq, URL): start 1988, end open
HTO (1 GBq, TD): start 1993, end open

ACHIEVEMENTS:

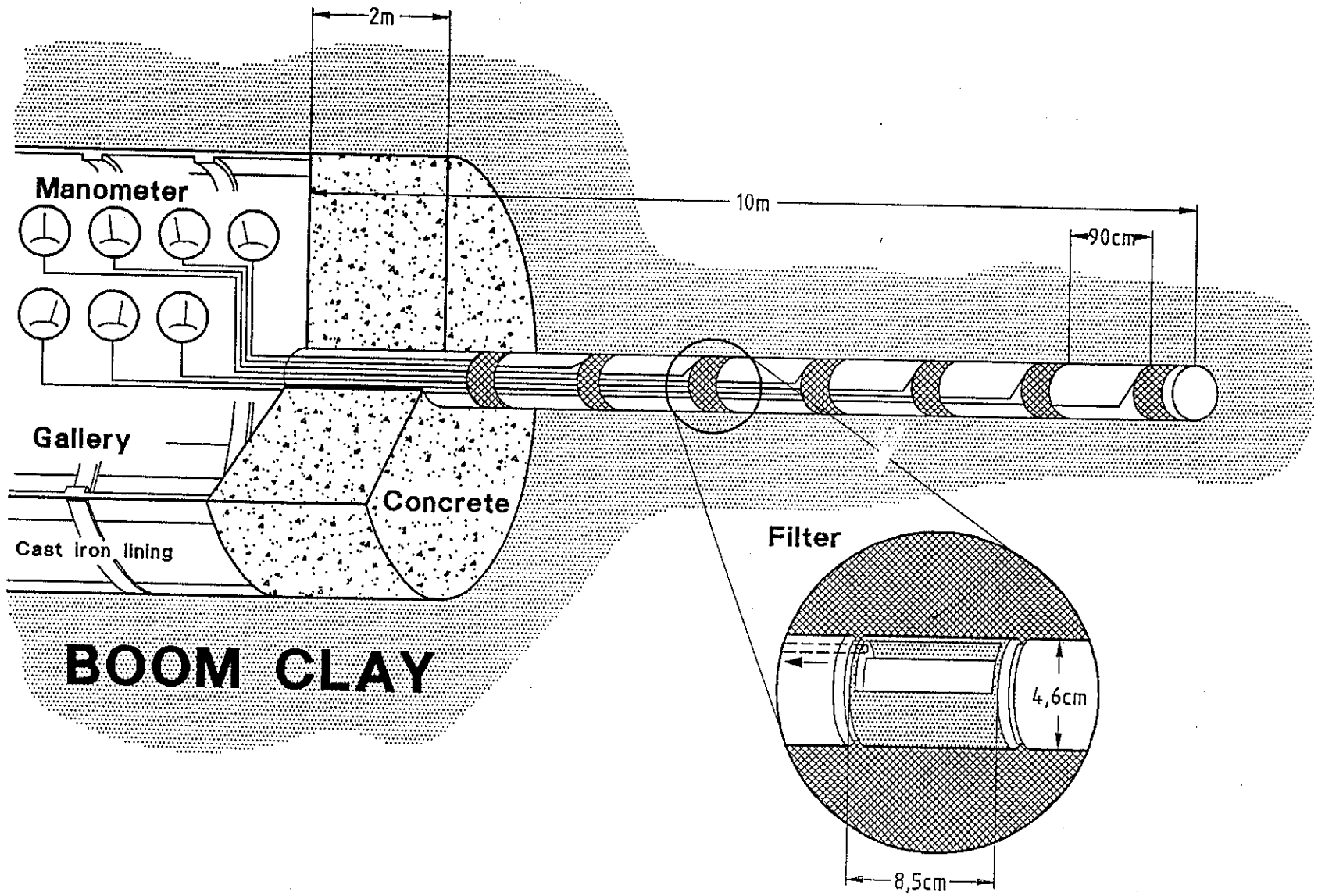
EXPERIMENT WITH HTO INCLUDED IN INTRAVAL VALIDATION EXERCISE. GOOD AGREEMENT BETWEEN SIMULATED (MICOF) AND MEASURED CONCENTRATION DISTRIBUTION.

MIGRATION TEST

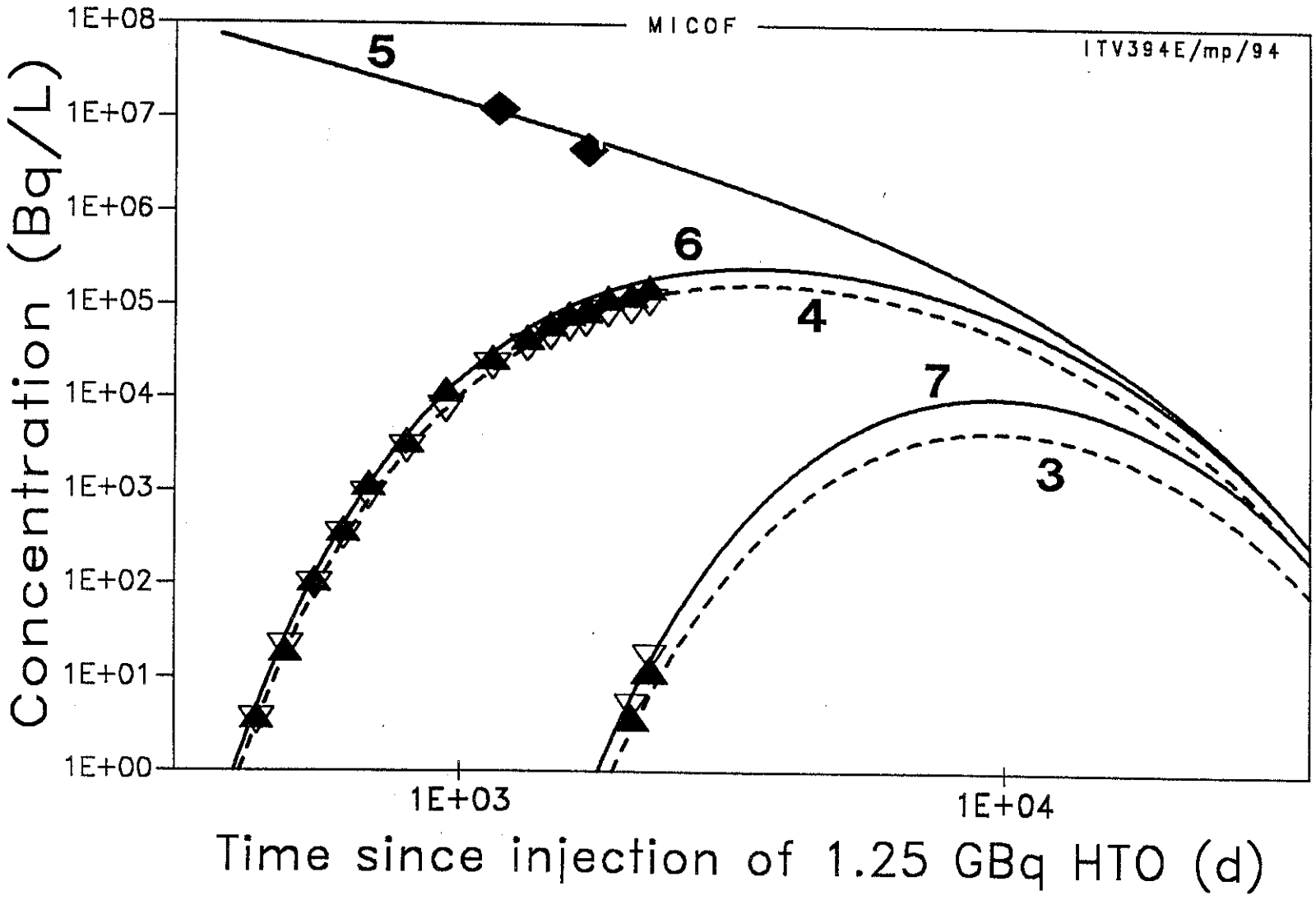


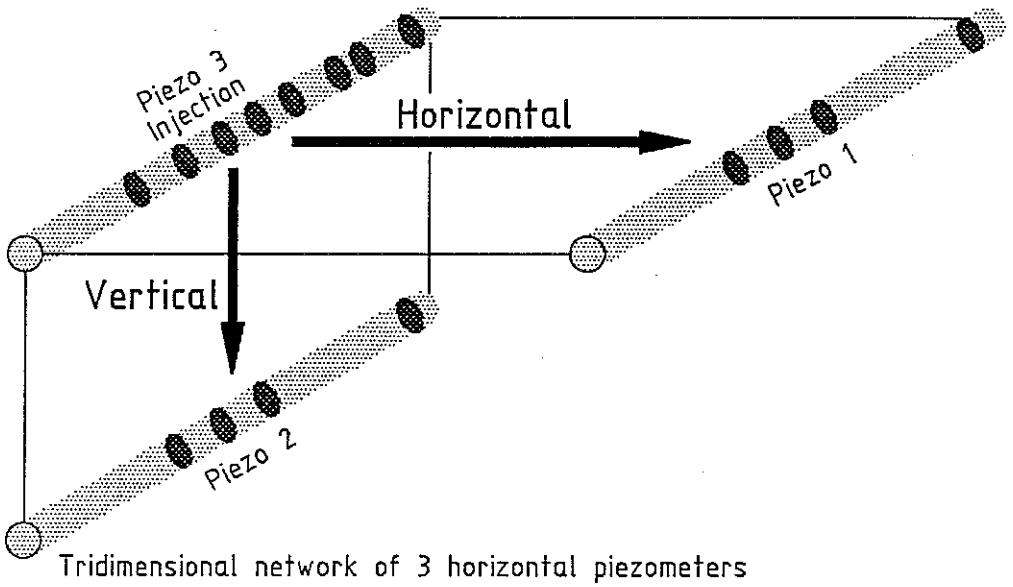
Clay cores and tracers

Ø filter paper C	radio-isotope	activity Bq	Emplacement date
31	152+154 Eu	1.78 E+6	15.10.85
31	152+154 Eu	1.78 E+6	16.10.85
28	Sr-85	3.7 E+6	12.08.87
28	Cs-134	3.0 E+6	03.07.87
28	U-233	3.5 E+6	24.11.87

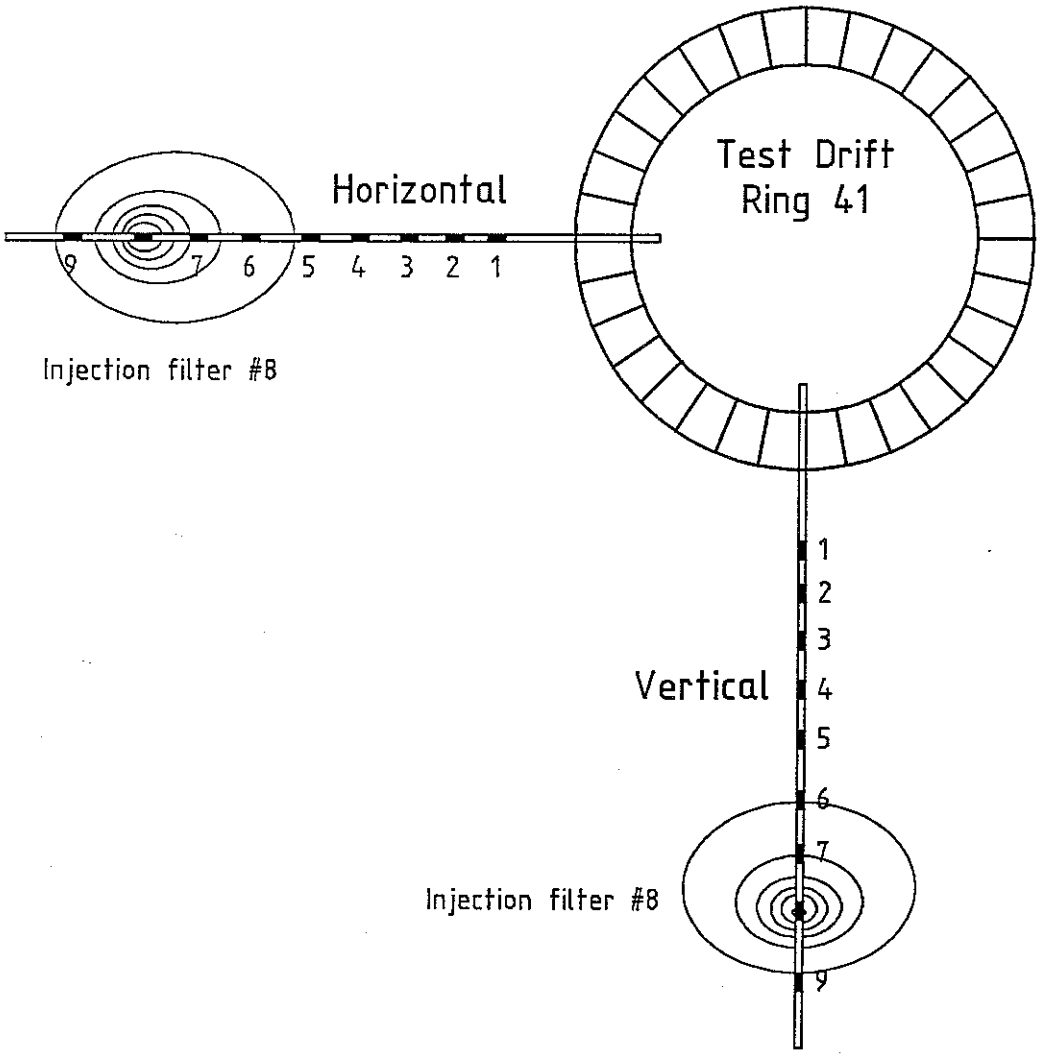


Conceptual view of the horizontal piezometernest, for the in-situ injection experiment with tritiated water, showing the arrangement and the dimensions of the filters.
Purpose : Validation of flow and transport model of radionuclides in Boom clay.

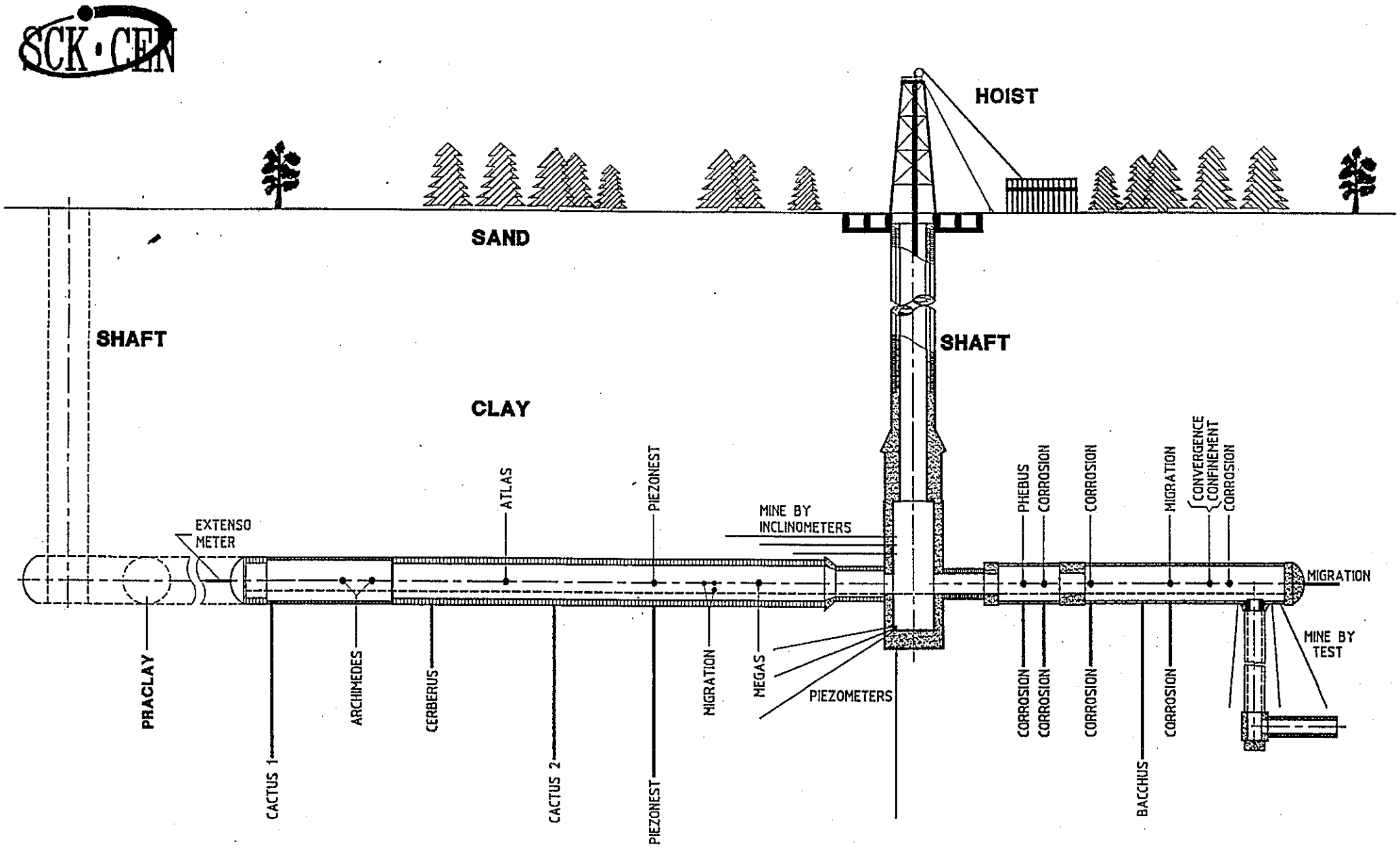

MICOF
ITV394E/mp/94
Concentration (Bq/L)
1E+08
1E+07
1E+06
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E+03
1E+04
Time since injection of 1.25 GBq HTO (d)
5
6
4
7
3



Tridimensional network of 3 horizontal piezometers
nearly installed at the ring 32 (east) in the Test Drift



Vertical and horizontal piezometers installed in the ring 41
of the Test Drift



IN SITU TEST PROGRAMME HADES

12-11-92 F0156