THE BELGIAN WASTE DISPOSAL CONCEPT

US Nuclear Waste
Technical Review Board
J. VAN MIEGROET - 12.10.1994

BELGIUM

- the country

- the nuclear facilities

- the nuclear wastes

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THE COUNTRY (fig. 1)

Belgium is a small (30,000 km²), heavily populated (10,000,000 inhabitants) country of North-Western Europe, best known for its capital, Brussels, also the capital of the European Union.

THE NUCLEAR FACILITIES (fig. 1)

Belgium does not have a military nuclear programme ; all nuclear facilities are civilian.

Most belong to the nuclear fuel cycle i.e.

- Seven power plants with a total power of 5,500 MW(e) :
  four plants at Doel, on the Scheldt river : 2,700 MW(e)
  three plants at Tihange, on the Meuse river : 2,800 MW(e)
- Two fuel fabrication facilities at Mol-Dessel, one for uranium fuel, one for plutonium (i.e. MOX) fuel.
- One - now shut-down - pilot reprocessing plant (called EUROCHEMIC in its prime time) at Mol-Dessel.

Besides

- nuclear research centre (at Mol)
- isotope production facility (IRE)
- many small waste producers (hospitals, universities, labs, ...)

THE NUCLEAR WASTES

Three categories

A	short-lived / low activity	150,000 m^{3*}
B	long-lived / low ... medium activity	25,000 m^{3*}
C	heat-emitting / long-lived / very high activity	5,000 m^{3*}

Shallow land disposal is the favored route for A-waste, deep underground disposal for B+C waste.

* estimates up to 2050 / includes decommissioning waste

UNDERGROUND DISPOSAL

- geological medium
- facility conceptual design
- R+D programme
- major (as yet) unresolved problems
- project timing

GEOLOGICAL MEDIUM (fig. 2)

- The "European Catalogue of geological formations having suitable characteristics for the disposal of solidified HLW and/or long-lived radioactive waste"* identified five formations in the belgian underground
  - three hardened rocks : shale layers
  - two plastic rocks : Ypresian and Boom clays.

- Boom clay was present in the underground of the Mol Research Centre at adequate depth, with a number of attractive features unequaled by the other media : low permeability, homogeneity, self-healing properties, low migration velocities for most nuclides.

- Performance analyses carried-out in 1986-88 (PAGIS)** with realistic datas, on a number of major scenarios confirmed the medium potentialities. They also quantified the critical importance of several clay properties, mostly effective thickness, diffusion coefficient and retardation factor for dose limitation. They also identified that "the very efficient confinement (... provided by the clay layer ...) masks the contributions of the engineered barriers in the systems performance evaluations".

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* EUR report 6891, 1980

** EUR report 11776, 1988

FACILITY CONCEPTUAL DESIGN (fig. 3 and 4)

In line with the PAGIS findings, the basic features of the disposal facility were thus selected to

- maximize the thickness of the clay barrier available for nuclide retardation i.e. "keep the mined repository as flat as possible" ;
- minimize the amount and severity of the perturbations imposed to the natural barrier while constructing and operating the repository.

This has led to a number of design criteria

- the waste will be disposed of in horizontal galleries*
- the disposal gallery diameter will be kept at a minimum
- the heat-emitting waste (vitrified canisters and spent fuel) will only be disposed of several decades after fuel unloading from the reactor, when residual heat generation will be down to a small percentage of its initial value
- minimizing the volume of oxydable material associated with the waste will restrict gas production and pressure build-up to levels acceptable for the clay layer.
- the backfill will primarily aim at reducing the disruptions to the clay layer by
    - minimizing the residual void percentage inside the galleries
    - developing a high degree of chemical compatibility with the geological environment
    - providing counter-pressure to the gallery wall, thus significantly postponing lining collapse and preventing water vaporisation in the backfill.

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* inside horizontal shrouds installed along the gallery centerline.

Additional efforts are being made to develop tunneling techniques that would limit the disposal gallery diameter to little more than the waste canister diameter, reducing even more the geomechanical and hydraulic disruptions of the clay layer.

Several important criteria unrelated to the protection of the natural barrier, have also been developed :

- distributing the global repository into (at least) two areas sheltering respectively the heat producing and the non-heat producing waste
- completing the gallery network (including installation of the central shroud and backfill) before initiating the waste installation phase, thus totally separating the active and non-active operational phases
- maximizing the thermal conductivity of the backfill
- providing the disposed waste with some degree of retrievability.

R+D PROGRAMME

The R+D programme is focussing on
- the long term safety demonstration
- the technical feasibility demonstration

of the part of the repository that is to host the heat-emitting waste.

- ***long term safety demonstration***
  . quantification of the clay material properties relevant to the nuclides migration process : small scale permeability, diffusion, retention, complexation, redox potential, pH, ... (lab + in-situ experiments) ; mathematical modelling.
  . detailed mapping, using sismic techniques and confirmation boreholes, of the local geology (tertiary layers) in search of the inhomogeneities that might affect the global permeability of the clay.
  . corrosion experiments (lab and in-situ) for structural and waste materials in contact with the clay medium ; mathematical modelling.
  . investigation, mapping and modelling of the regional hydrogeology affecting the clay and the nearby aquiferous layers.
  . assessment of gas production, pressure build-up and pressure release mechanisms (o.a. pore water displacement).
  . development / demonstration of backfill additives for trapping hard-to-catch nuclides.
  . identification / development of FEP's and scenarios for performance analysis.

- development / calibration of the mathematical models used for deterministic and stochastic performance analyses. Completion of a number of important analyses.
- exploration of natural analogues potentialities in a clay environment.

- ***technical feasibility demonstration***

The actual repository is not to be constructed before several decades (see "project timing"). It is thus likely to take advantage of presently unheard-of-technological developments. However, demonstrating the technical feasibility with to-day techniques of several key aspects of its construction and operation, particularly those dealing with unusual equipments or unusual uses of existing equipments, is a necessary step when attempting to build now a realistic and convincing safety case.

Most important among those "key aspects" :

- selection, fabrication, testing, installation procedure, mathematical modelling and performance assessment of the precompacted bentonite-based material that will backfill the annular region around the waste.
- design, construction and testing of a prototype machine that will transport, handle and emplace the waste canisters (and spent fuel subassemblies) at their disposal location.
- design, construction and testing of a special micro-tunneling machine that would essentially limit the tunnel excavation to the diameter of the waste-hosting shroud.

MAJOR (AS YET) UNRESOLVED PROBLEMS

- inadequate retention performance of the clay barrier for some nuclides (most notably I-129)

- large scale permeability of the clay layer

- backfilling / obturation, with the needed effectiveness, of the shafts and main galleries (post-operational phase)

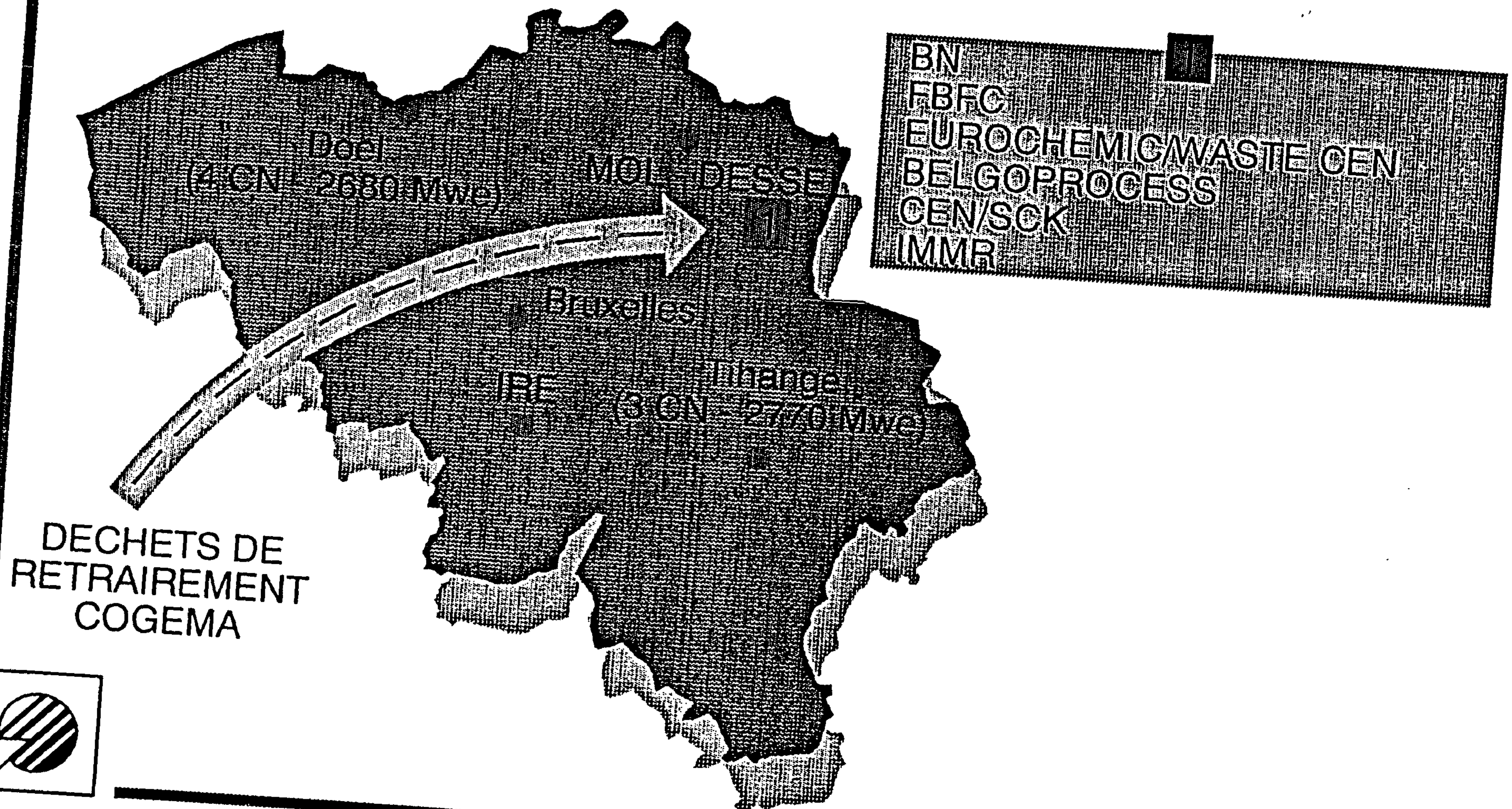
- build-up and release of gas pressure inside the geological medium

- potentially harmful consequences for the repository of the next major glaciation periode

PROJECT TIMING

2015	Detailed study of disposal facility
2020	Start of construction (underground facility)
2035	First disposal of non heat-emitting waste
2050	First disposal of heat-emitting waste
2070-2080	Site closure

Fig. 1


Doel
(4 CN - 2680 Mwe)
MOL DESSE
Bruxelles
IRE
Tihange
(3 CN - 2770 Mwe)
BN
FBFC
EUROCHEMIC/WASTE CEN
BELGOPROCESS
CEN/SCK
IMMR
DECHETS DE
RETRAIREMENT
COGEMA

UNDERGROUND EXPERIMENTAL FACILITY

Fig. 2

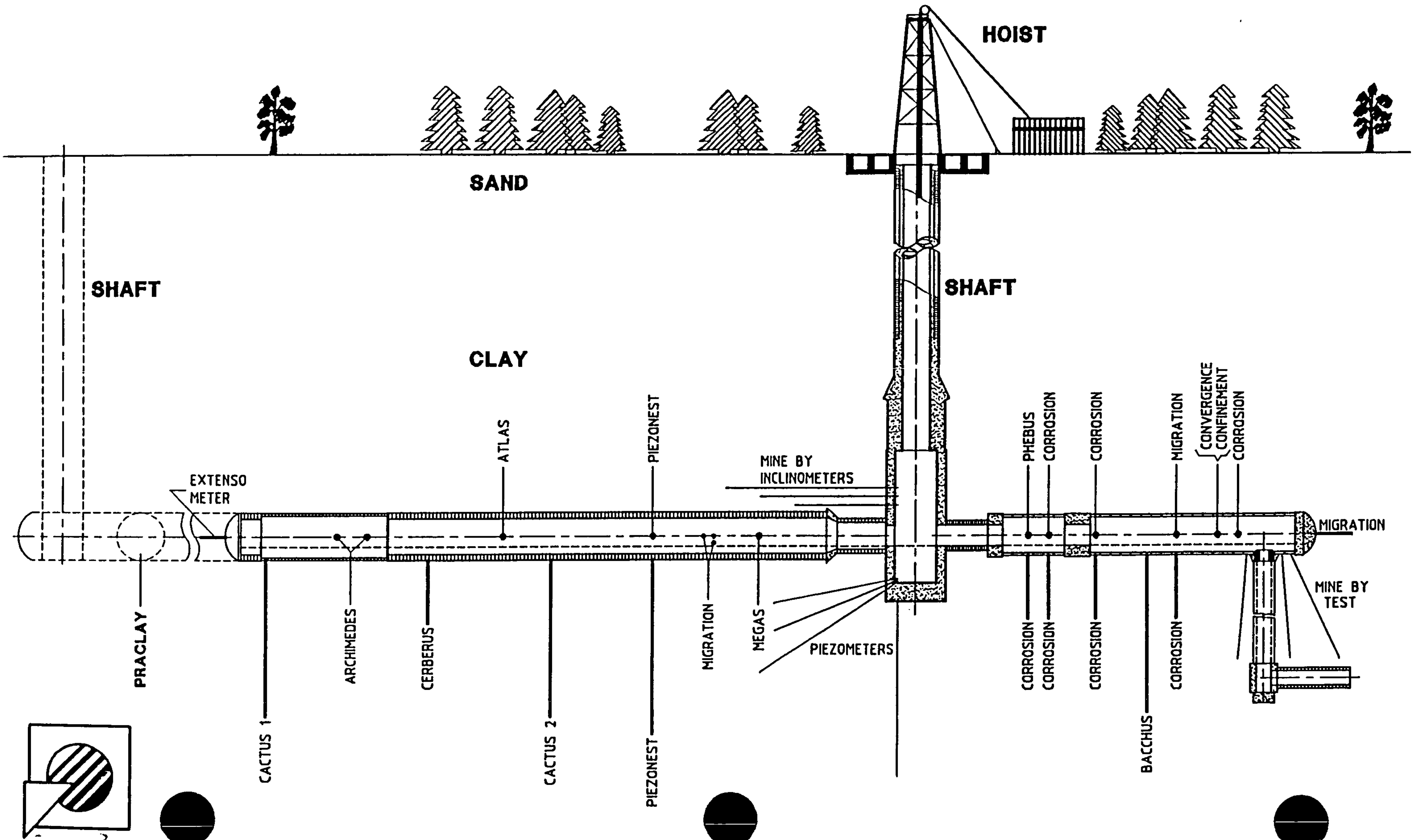
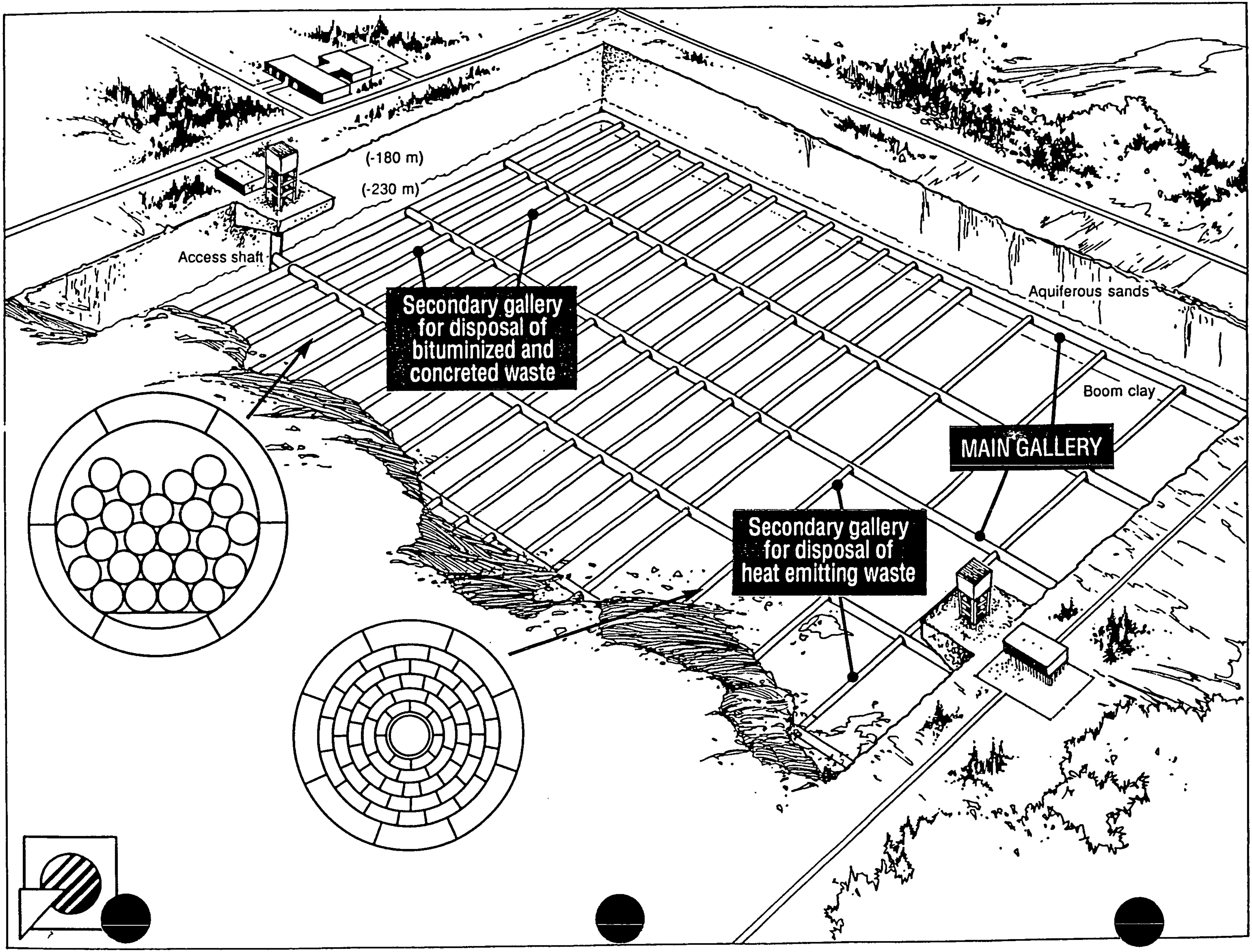


Fig. 3



(-180 m)
(-230 m)
Access shaft
Secondary gallery for disposal of bituminized and concreted waste
Aquiferous sands
Boom clay
MAIN GALLERY
Secondary gallery for disposal of heat emitting waste

FINAL ARRANGEMENT OF DISPOSAL GALLERY (CROSS-SECTION)

Fig. 4