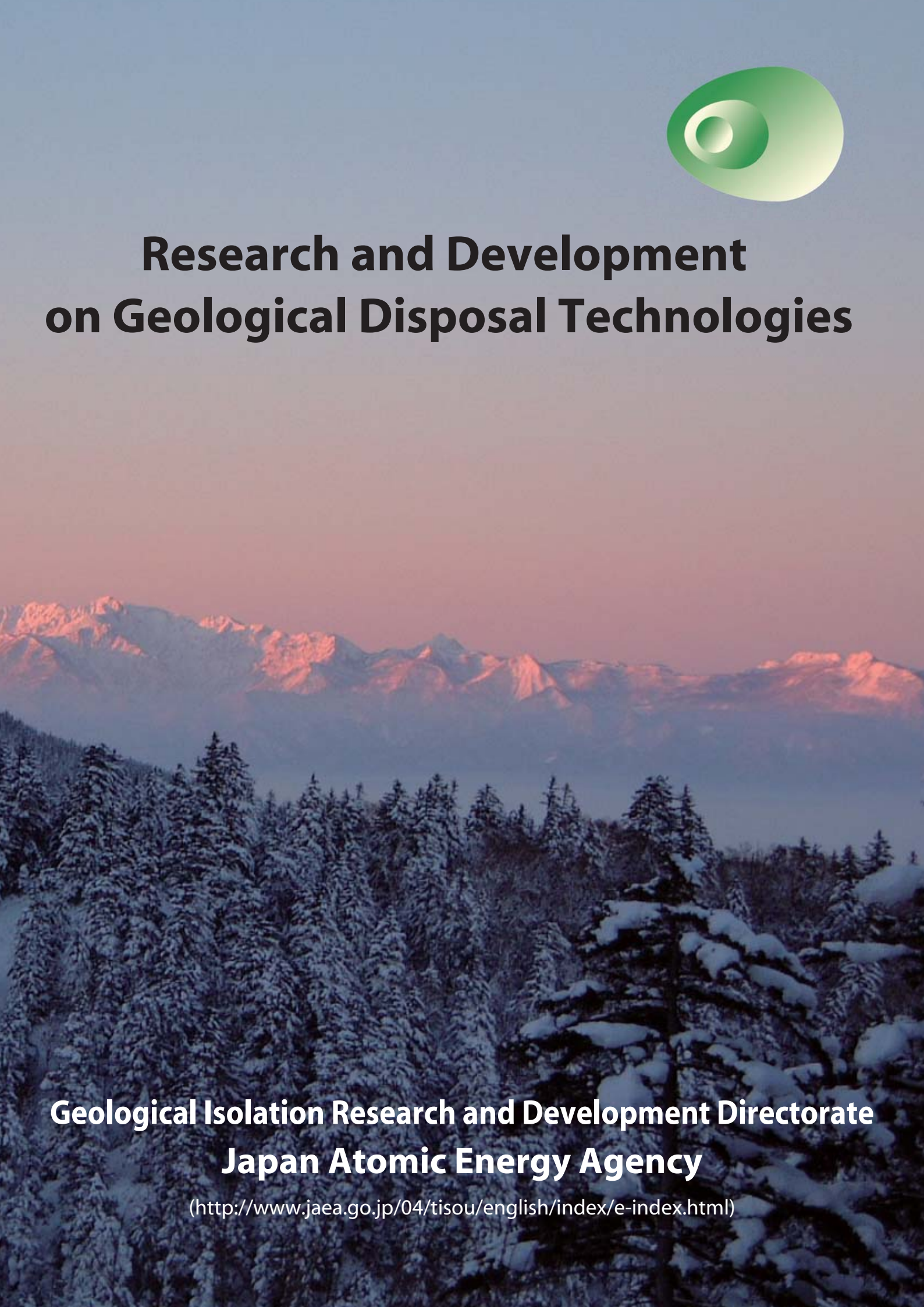


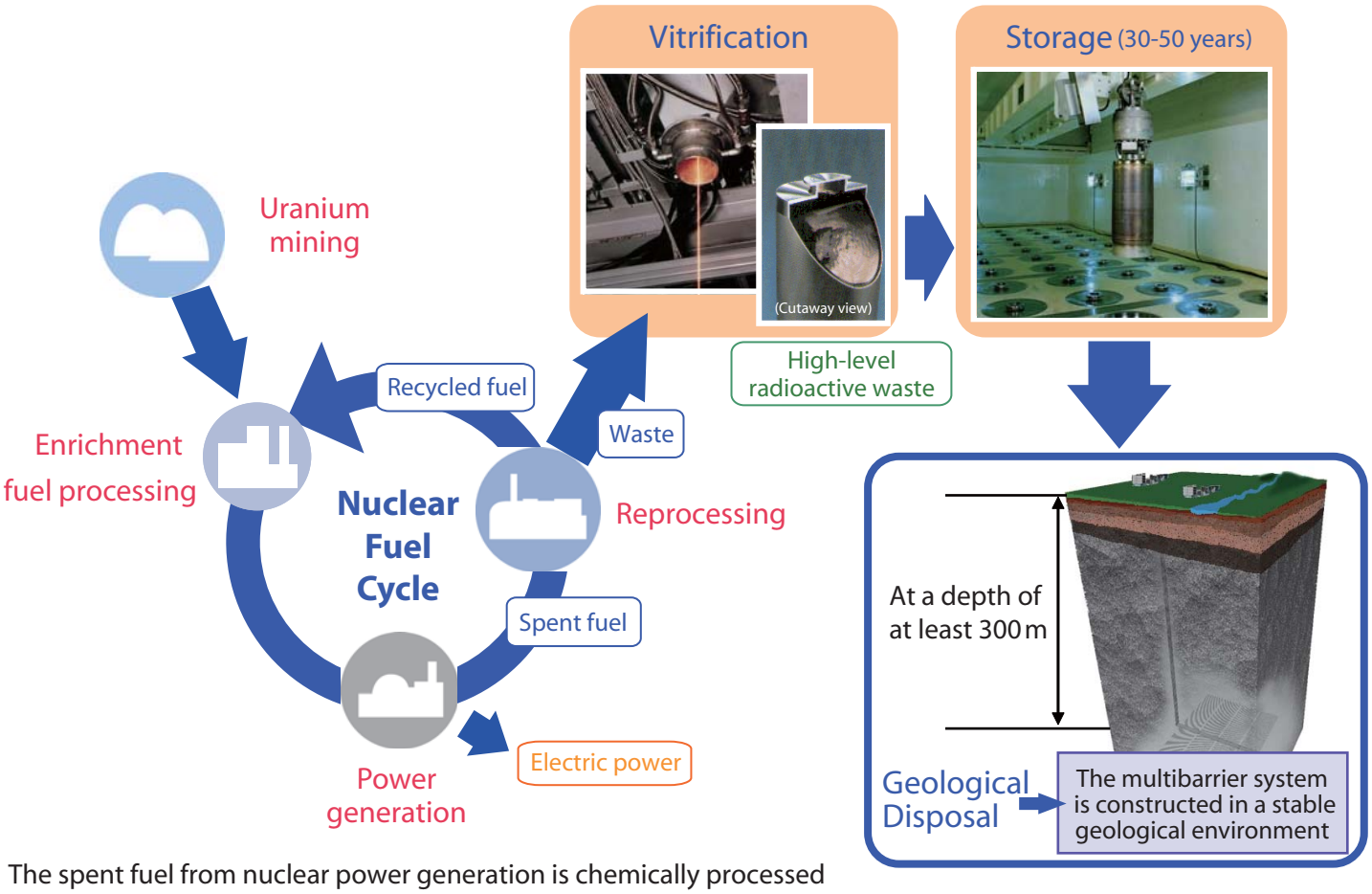
Research and Development on Geological Disposal Technologies

Geological Isolation Research and Development Directorate

Japan Atomic Energy Agency

(http://www.jaea.go.jp/04/tisou/english/index/e-index.html)

Nuclear Fuel Cycle and Geological Disposal

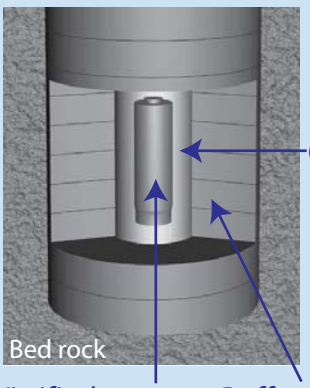


The spent fuel from nuclear power generation is chemically processed at a fuel reprocessing plant for use as new fuel. The recovered uranium and plutonium can be recycled as fuel for the generation of electricity. Establishment of the "Nuclear Fuel Cycle" is the fundamental policy for nuclear energy development and utilization in Japan.

After reprocessing spent fuel and recovery of the uranium and plutonium, the resultant high-level radioactive liquid waste is mixed with glass material and melted at high temperature. The waste is then vitrified into a solid glass form to ensure good physical and chemical stability.
The vitrified waste is encapsulated in stainless steel containers and placed into temporary storage for 30 to 50 years to cool. It will subsequently be placed in a deep underground, geological disposal repository, at a depth of at least 300 m. This outline of geological disposal is defined by the "Specified Radioactive Waste Final Disposal Act (Final Act)".

The concept of geological disposal relies on a multiple barrier approach, incorporating the natural geological barrier and multiple engineered barriers to keep the waste safely away from the human environment for the long term.

Engineered barriers



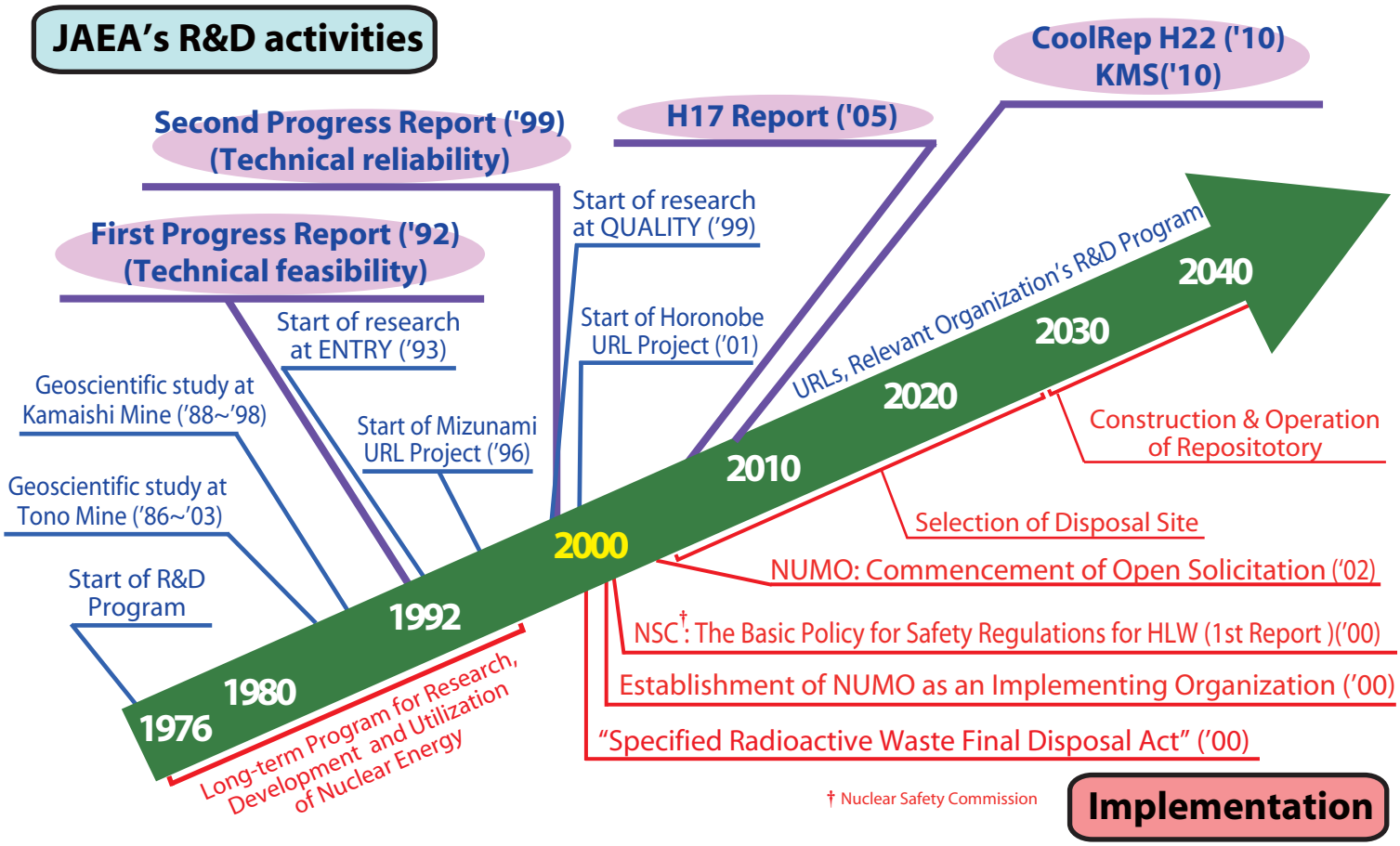
Engineered barrier is a generic term for vitrified waste, overpack and buffer material

Overpack:
Containers to encapsulate the Vitrified waste and isolate it from contact with groundwater

Vitrified waste:
Immobilized HLW in a borosilicate glass material

Buffer material:
Filling between the Overpack and bed rock to restrict the groundwater flow and the migration of radionuclides

Milestones in the HLW Disposal Program



Research and Development on geological disposal technology has been conducted in Japan since 1976. JAEA compiled its R&D achievements in two progress reports in 1992 and 1999. These reports presented the technical feasibility and reliability of geological disposal in Japan.

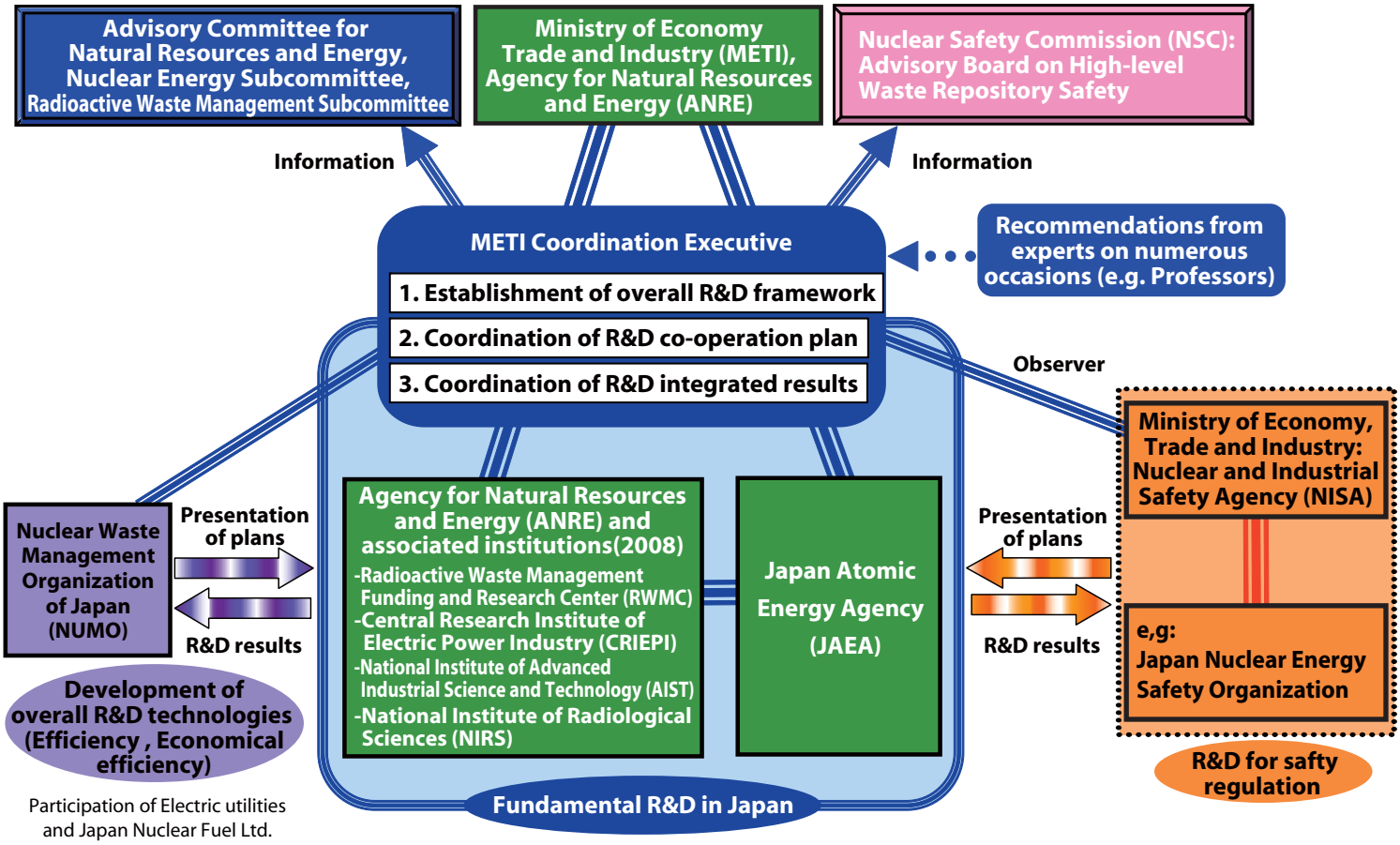
In particular, based on the second progress report "H12: Project to Establish the Scientific and Technical Basis for HLW Disposal in Japan" (JNC, 2000), the "Specified Radioactive Waste Final Disposal Act " was promulgated in 2000 and the Nuclear Waste Management Organization of Japan (NUMO) was established. With the establishment of the Act, the Japanese program for geological disposal began to move into the implementation phase. In 2000, the Nuclear Safety Commission issued "The Basic Policy for Safety Regulations for High-Level Radioactive Wastes (1st Report)" . Then, in December, 2002, NUMO began an open solicitation process to invite municipalities to volunteer for preliminary investigation areas.

During the implementation phase of the Disposal Program, continued R&D will be required to increase the reliability of geological disposal technology and to enhance the technical basis of geological disposal.

First Progress Report
(Technical feasibility)

Second Progress Report
(Technical reliability)

Organizations and Roles in the HLW Disposal Program in Japan



Revised from R&D program for the geological disposal of HLW (Jul, 2009)

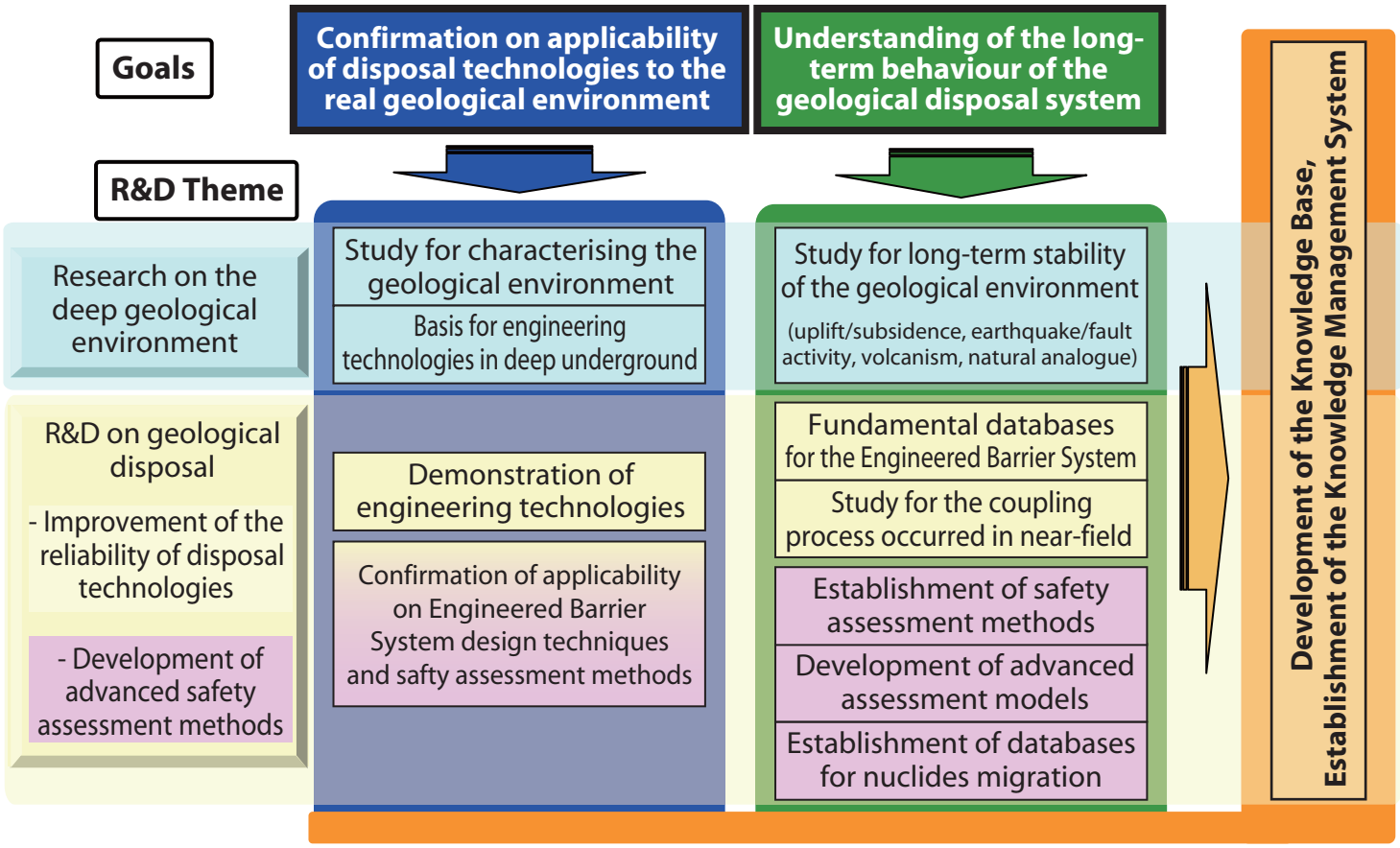
Fundamental R&D on geological disposal in Japan, has been conducted by the Japan Atomic Energy Agency (JAEA), and the Agency for Natural Resources and Energy (ANRE) and associated institutions. In a very general categorization of R&D roles, JAEA's R&D has mainly concentrated on the scientific and systematic aspects of disposal and ANRE associated institutions have concentrated on engineering aspects. The results obtained from all R&D are reflected in the geological disposal project and for safety regulations.

METI Coordination Executive

ANRE regards the wide range of R&D carried out by JAEA and ANRE-associated institutions as fundamental R&D for final disposal in Japan. In July 2005, ANRE established the "METI Coordination Executive" to efficiently enhance cooperation and integration of R&D results between JAEA and other related research institutions.

In the METI Coordination Executive, the members have been respecting the requirements from NUMO and regulatory organizations, and also been developing a co-operation plan to integrate the R&D results and the roadmap for R&D.

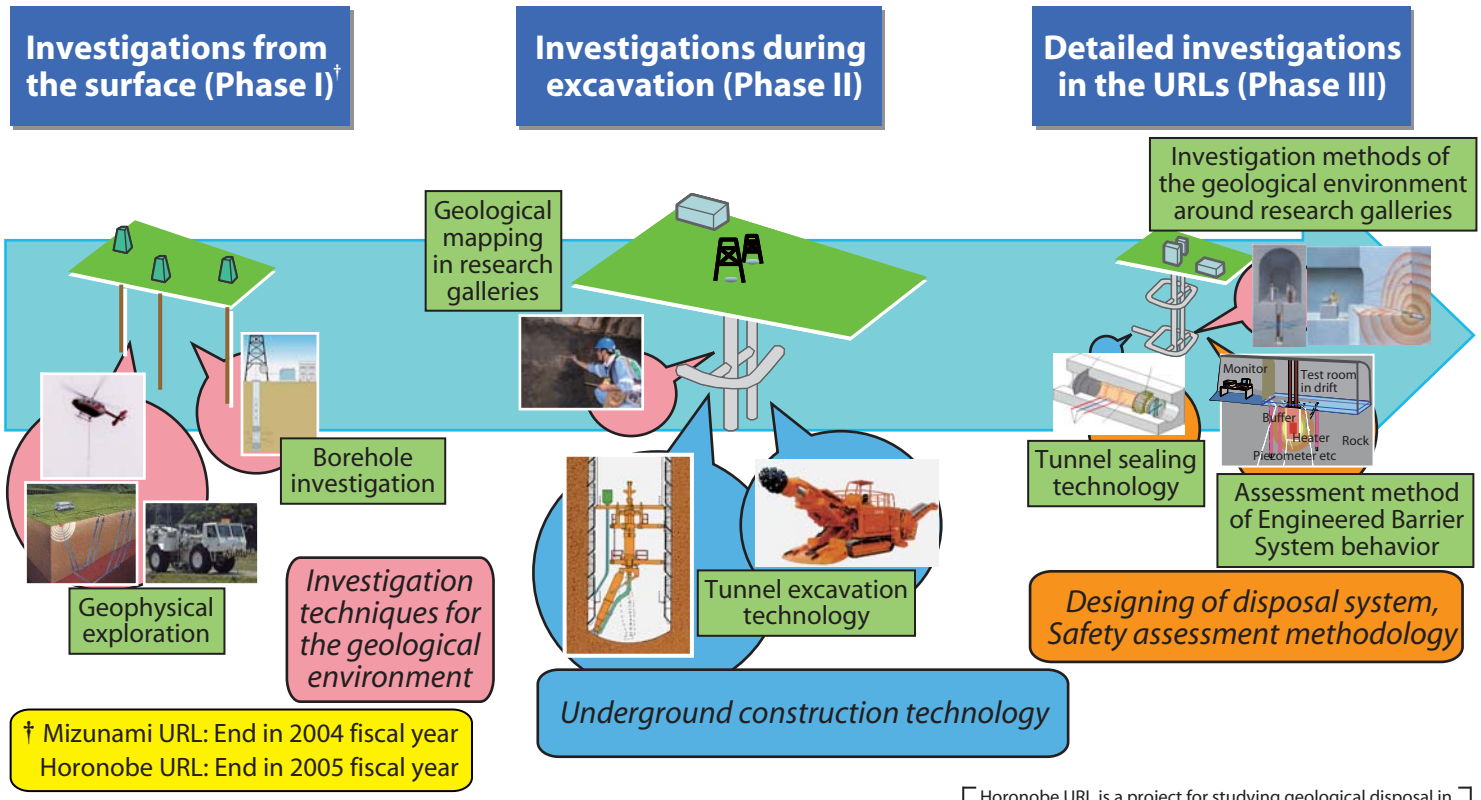
Goals and Tasks for R&D on HLW Geological Disposal in JAEA



With respect to improvement of the reliability of geological disposal technology, JAEA has conducted the requisite R&D, with two key goals; confirmation of the applicability of disposal technologies to the real geological environment and understanding the long-term behavior of the geological disposal system. The goals are addressed under these research themes; research on the deep geological environment and R&D on geological disposal. The latter R&D on geological disposal is aimed at improvement of the reliability of disposal technologies and development of advanced safety assessment methods. Research on the deep geological environment establishes the basis of the R&D on disposal technologies and safety assessment methods.

To achieve the above goals, JAEA establish the requisite R&D tasks under the following fields; “Research on the deep geological environment”, “Improvement of the reliability of disposal technologies” and “Development of advanced safety assessment methods”. These have been carried out in collaboration with the R&D Program. The results obtained from the R&D activities are being systematically organized and synthesized in a “knowledge base” for information relating to safety, and are being used for safety assessment for geological disposal technologies.

Confirmation of applicability of disposal technologies to the real geological environment

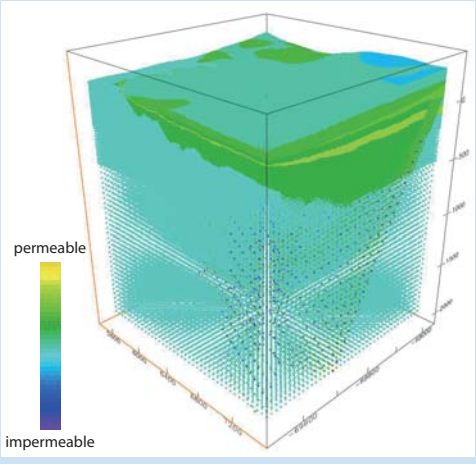


Horonobe URL is a project for studying geological disposal in sedimentary rocks as well as for conducting general research of the deep underground environment. R&D for geological disposal in crystalline is being carried out at overseas URLs. (Graphics show conceptual sketches)

To achieve the first goal of the R&D for HLW Geological Disposal in JAEA, "Confirmation on applicability of disposal technologies to the real geological environment", field research has been carried out using surface and underground facilities. "Research on the deep underground environment" at the Underground Research Laboratory project, is planned in Phases: Surface based investigations (Phase I); Investigations during excavation (Phase II) and Investigations in research galleries (Phase III). In the phases, the investigation technologies developed for geological disposal have been and will be applied and improved in the actual geological environment and, based on this R&D, JAEA will then be able to confirm the applicability of the disposal technologies.

Phase I have been completed and investigations have been carried out to characterize the underground geological environment. For example, in Phase I, the bedrock and groundwater flow conditions were described and then predictions of expected geology and hydrogeology in the subsurface were made. The predictions made during Phase I are being evaluated during excavation of shafts and horizontal galleries in Phase II, investigations during excavation. Moreover, in Phase III, detailed investigations of the geological environment, around research galleries will be performed to evaluate the feasibility of disposal system design and safety assesment methodologies.

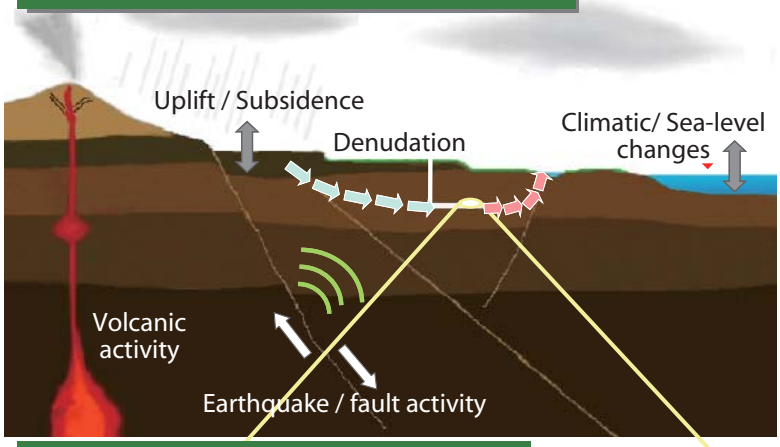
3D Hydrogeological Model



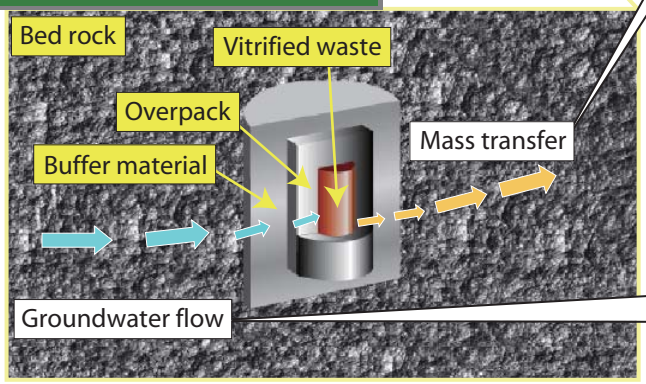
3D hydrogeological model (hydraulic conductivity field) used to simulate ground-water flow at, around, the Mizunami URL

Understanding the long-term behavior of the geological disposal system

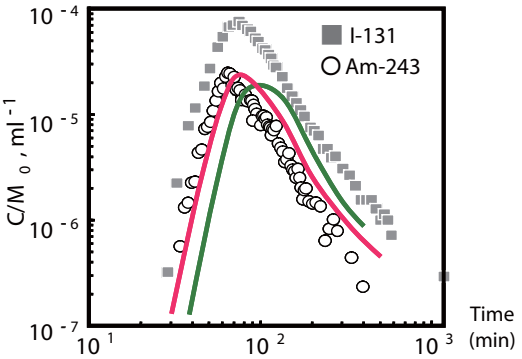
Understanding of long-term changes of geological environment



Improvement of model based on the understanding of phenomena

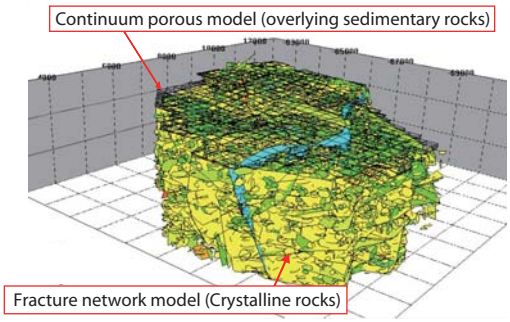


Colloid formation and migration



Result of Nagra/JAEA in situ radionuclide migration experiment at Grimsel test site: Activity Migration Model (red) matched to the experimental results

Groundwater flow model



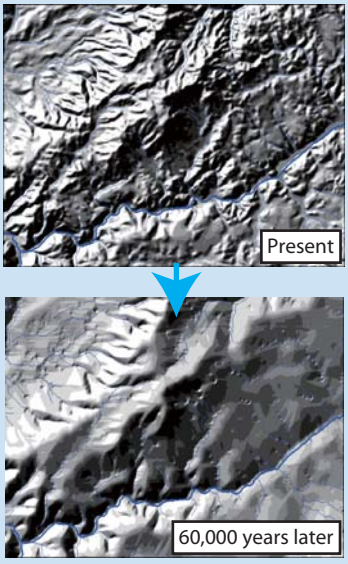
Fracture network model showing water conducting fractures

To achieve the second goal of the R&D for HLW Geological Disposal, "Understanding the long-term behavior of the geological disposal system", JAEA has worked to develop an improved understanding of deep underground conditions and changes that can occur in the long-term. In order to simulate processes that can occur in and around engineered barriers and in the rock mass, JAEA has developed models based on realistic data. This work is intended to enhance the understanding of processes relevant to the geological disposal system and results in increased reliability of the performance assessment methodology.

It is predicted that, in the long-term, radioactive materials immobilized in the vitrified solid waste form, will come into contact with ground-water and eventually migrate in groundwater moving through the bed rock. In order to evaluate such long-term processes, development of advanced performance assessment methods have been pursued, for example, by incorporating models of groundwater flow in fractured bed rock and mass transport behavior in groundwater.

Furthermore, natural analogues can be used to support long-term predictions of the geological disposal system; supplemented by studies of seismicity, active volcanoes and tectonics. At the same time, development of investigation methods and simulation technologies has been carrying out.

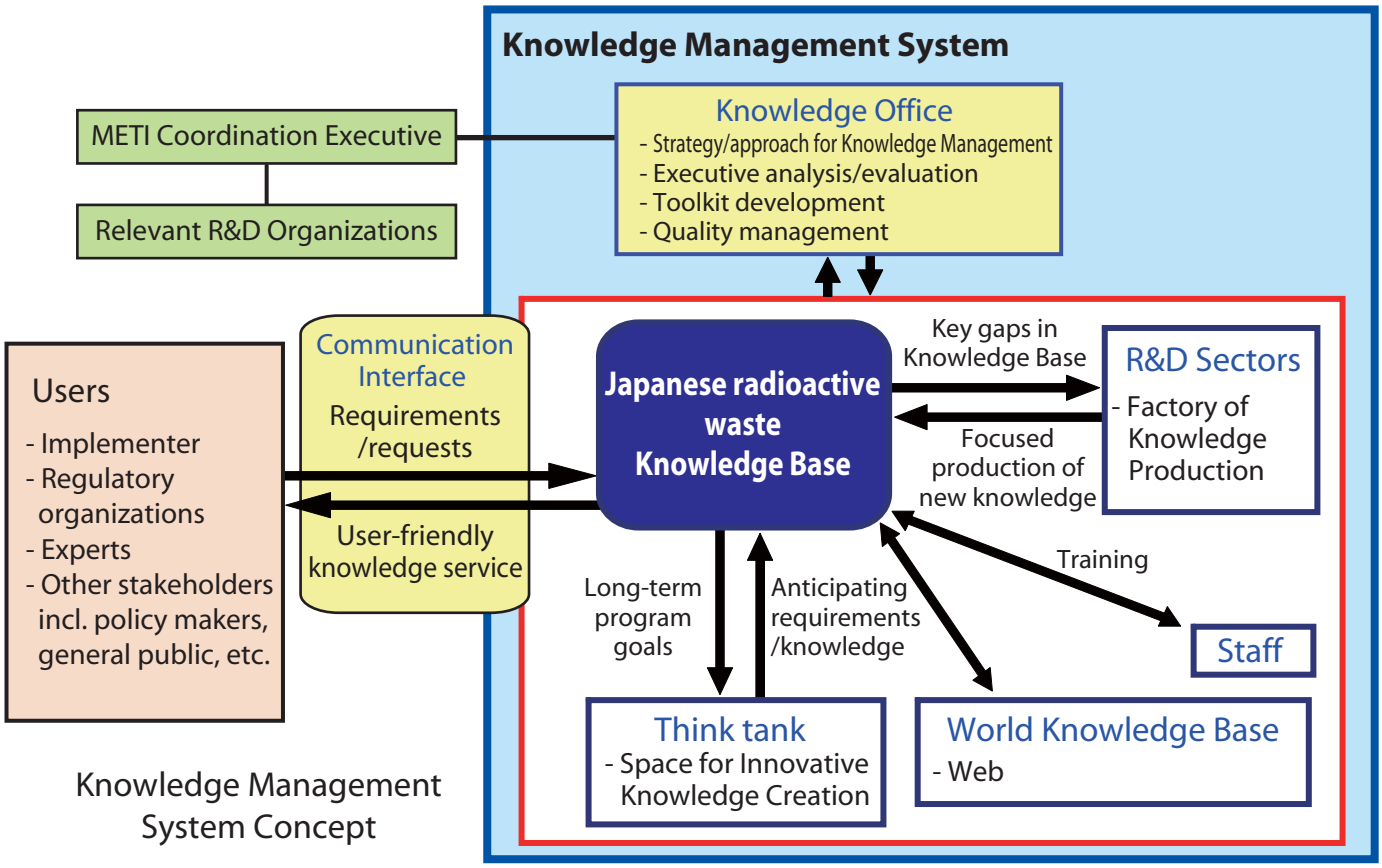
Simulation of long-term topographic change



3D simulation of topographic change

This simulation is useful to investigate the effects on groundwater flow caused by long-term topographic change

Knowledge Management System



Knowledge Management System Concept

The geological disposal project is taking a stepwise approach to selecting a candidate disposal site and, to theapproval and licensing, construction, operation and closure of a repository. It is a long-term project anticipated to require approximately 100 years.
To support the progress of this long-term project and to enhance the technical basis, it is required to improve interdisciplinary R&D in the various disciplines and organizations using underground and surface facilities, such as laboratories and facilities licensed for processing of radioactive material. It is essential that the requisite information, including the existing information should be well organized and available whenever they are required. Therefore it is also required that "Knowledge", should be managed systematically so that all results, information and experience from the R&D project are useful and not simply archived in investigation reports.

JAEA has been developing an integrated system, the "Knowledge Management System", to manage in a comprehensive manner, the vast quantities of data, information, relevant experience and understanding arising from various sources, primarily the geological disposal programs in Japan and internationally. JAEA is successfully developing and integrating the knowledge obtained and will be a technical resource for the communication of the knowledge to various end users on the Japanese Disposal Project.

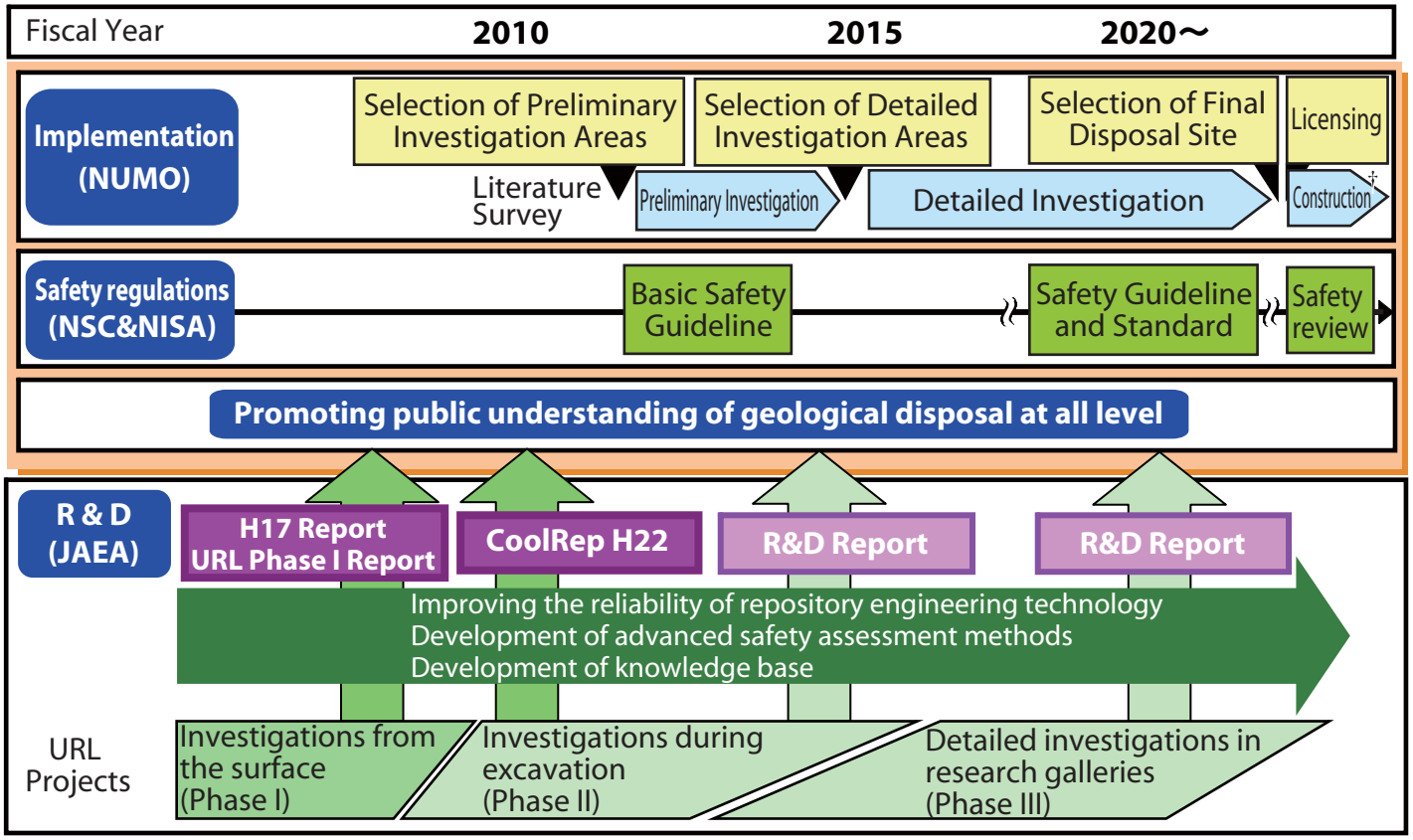
Knowledge Management System (KMS)

Prototype of the KMS has been opened to public since March, 2010.
It is available at http://www.jaea.go.jp/04/tisou/toppage/top.html

-Systematization for accumulating basic data, experience and information concerning underground research

-Accumulation of knowledge required for the implementers and the safety case

Contribution of R&D to Implementation and Safety Regulation



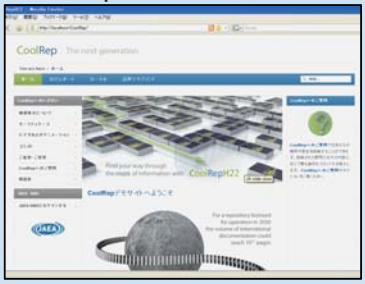
† to be followed by operation and closure

To ensure the results obtained from the R&D are available as the technical basis of the geological disposal project, JAEA has been developing a "knowledge base" taking into consideration the requirements and schedule of the disposal project and for making the safety case. And, JAEA has been proceeded with these results stepwise to organize the results.

In September 2005, "The H17 Report on the development and management of the technical knowledge base for the geological disposal of HLW" was released. It presents a status review of R&D carried out during the 5 year R&D program since the H12 report was released in 1999. By March 2007, the Phase I technical report, an overview of Phase I (Surface-based investigations), had been written. Furthermore, the results of the R&D activities have been summarized as an unconventional web-based report (CoolRep H22), and it has been made available on JAEA's public website since March 2010. JAEA will continue to perform R&D as a preliminary activity in the stepwise development of the geological disposal project and for safety regulation and will be documenting the results in the knowledge base.

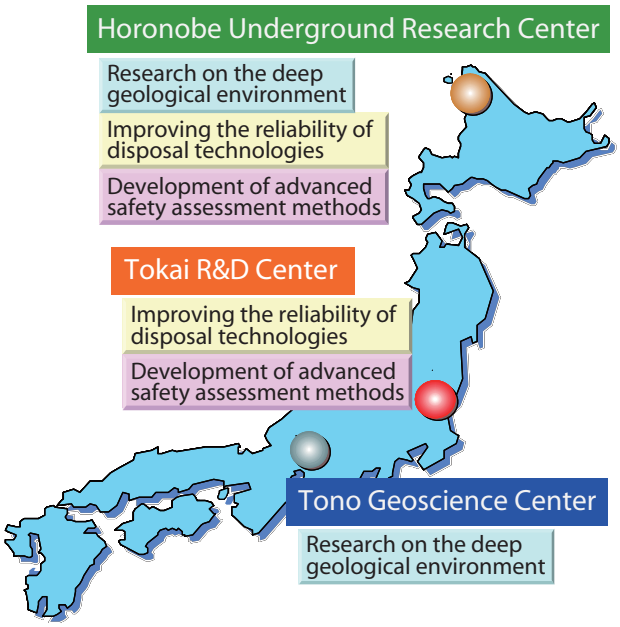
H17 Report
(Development and management of the technical knowledge base on the geological disposal of HLW)

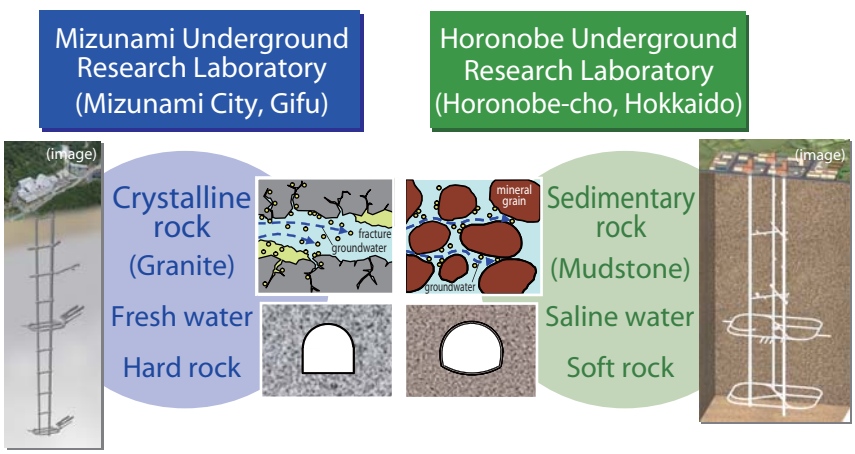
CoolRep H22
(web-based report linked to JAEA-KMS)



It is available at http://www.jaea.go.jp/04/tisou/toppage/top.html

Research and Development Facilities





Tokai R&D Center

ENTRY: ENgineering scale Test and Research facilitY, QUALITY: QUantitative Assessment radionuclide migration experimental faciLITY

EDAS: Exploratory Data Acquisition System, apparatus for studying of chemical interactions among rock minerals, engineered barrier materials and groundwater under anaerobic condition

COUPLE: apparatus for studying coupled thermo-hydro-mechanical-chemical process, NETBLOCK: apparatus for studying groundwater flow in fractued rock

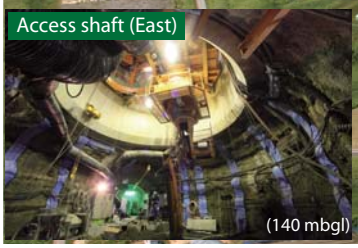
Horonobe Underground Research Center

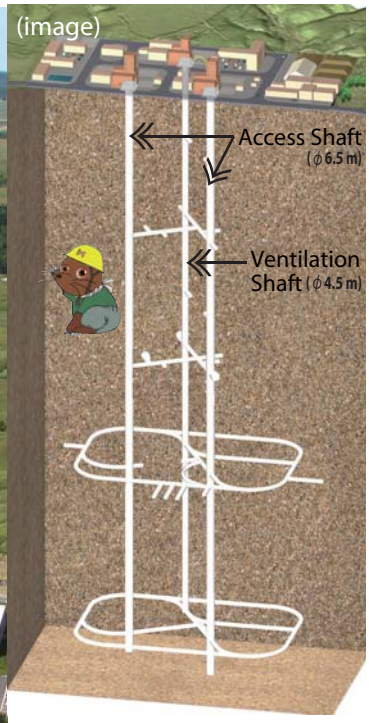

Research and administration facility and Test facility


Public information house
(Yume Chisoukan)


Construction site


In-situ test on excavation disturbed zone of the drift
(140mbgl Sub stage)


Access shaft (East)
(140 mbgl)



Horonobe Underground Research Laboratory (sedimentary rock)

Tono Geoscience Center

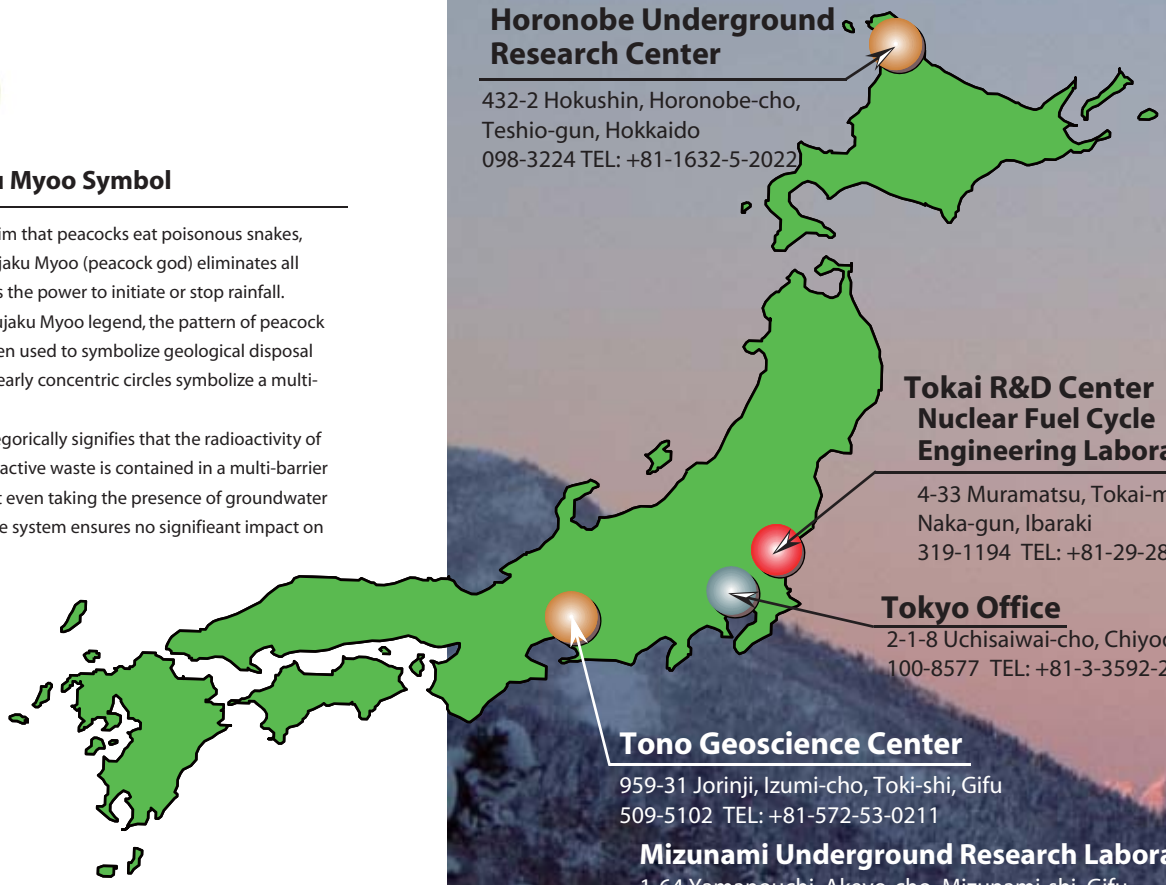
Mizunami Underground Research Laboratory (crystalline rock)

mbgl: meter below ground level

Geological Isolation Research and Development Directorate Sites

The Kujaku Myoo Symbol

Old legends claim that peacocks eat poisonous snakes, and that the Kujaku Myoo (peacock god) eliminates all poisons and has the power to initiate or stop rainfall. Based on the Kujaku Myoo legend, the pattern of peacock feathers has been used to symbolize geological disposal of waste. The nearly concentric circles symbolize a multi-barrier system.
This symbol allegorically signifies that the radioactivity of high-level radioactive waste is contained in a multi-barrier system and that even taking the presence of groundwater into account, the system ensures no signifieant impact on the biosphere.



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432-2 Hokushin, Horonobe-cho,
Teshio-gun, Hokkaido
098-3224 TEL: +81-1632-5-2022

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4-33 Muramatsu, Tokai-mura,
Naka-gun, Ibaraki
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Tokyo Office
2-1-8 Uchisaiwai-cho, Chiyoda-ku, Tokyo
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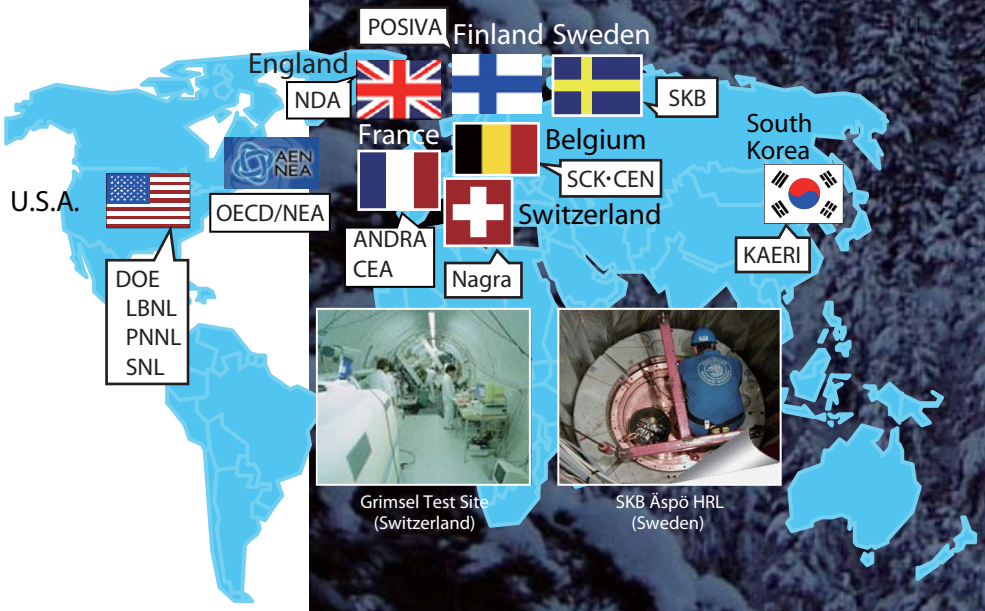
Tono Geoscience Center
959-31 Jorinji, Izumi-cho, Toki-shi, Gifu
509-5102 TEL: +81-572-53-0211

Mizunami Underground Research Laboratory
1-64 Yamanouchi, Akeyo-cho, Mizunami-shi, Gifu
509-6132 TEL: +81-572-66-2244

International Collaborations



Grimsel Test Site (Switzerland)

SKB Äspö HRL (Sweden)

http://www.jaea.go.jp/04/tisou/english/index/e-index.html

Japan Atomic Energy Agency
Geological Isolation Research and Development Directorate (Apr. , 2010)

Photo: Ikuro Hirose