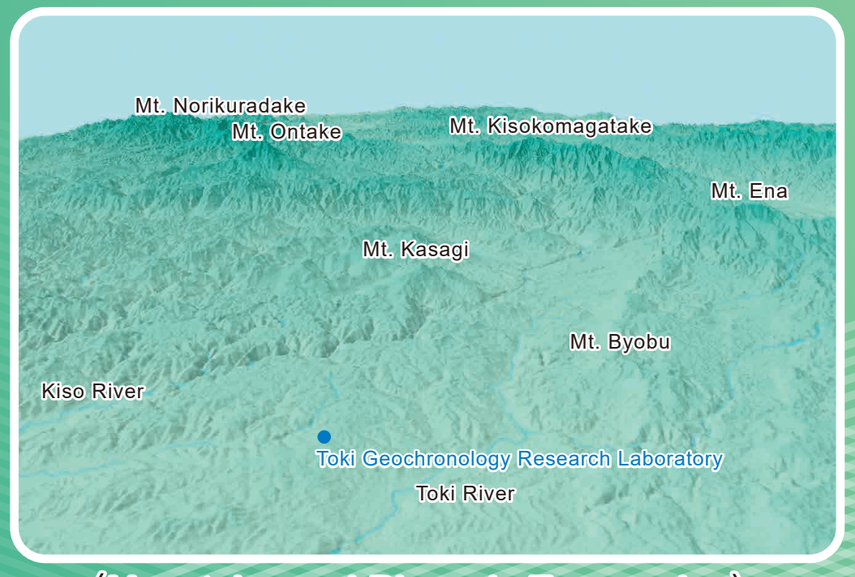
# *Tono Geoscience Center*




〈Mountains and Rivers in Tono region〉

Japan Atomic Energy Agency
Tono Geoscience Center
Sector of Nuclear Fuel, Decommissioning and
Waste Management Technology Development
https://www.jaea.go.jp/04/tono/index.html

# Facilities of Tono Geoscience Center

| | |
|---|---|
| ①Research building | ◆Development of investigation technologies for the long-term stability of the geological environment, and geological models for long-term estimation and effective assessment<br>◆Development of dating methods using high-precision mass spectrometers |
| ②Instrumental analysis building | ◆Development of dating methods, such as optically stimulated luminescence/thermoluminescence (OSL/TL)<br>◆Quantitative analysis of the main and trace elements in volcanic glasses and minerals |
| ③AMS building | ◆Development of dating methods using accelerator mass spectrometer (AMS) |
| ④Administration building | ◆Analysis of metallic elements and anions in rocks and water<br>◆Sample preparation |

① Research building

② Instrumental analysis building

③ AMS building

④ Administration building

## Toki Geochronology Research Laboratory





Mizunami Site



Mizunami Geoscience Academy

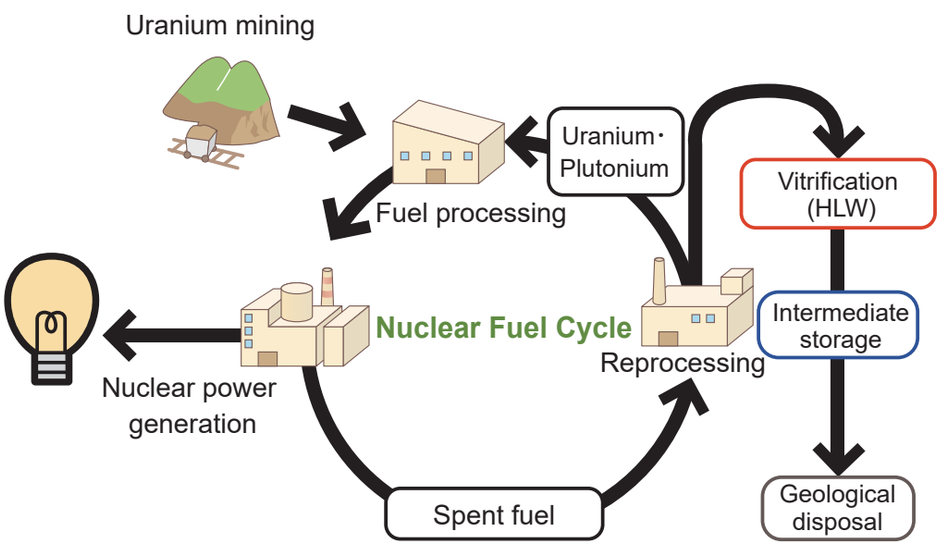
2023.2

# Tono Geoscience Center is pursuing Geoscience Research

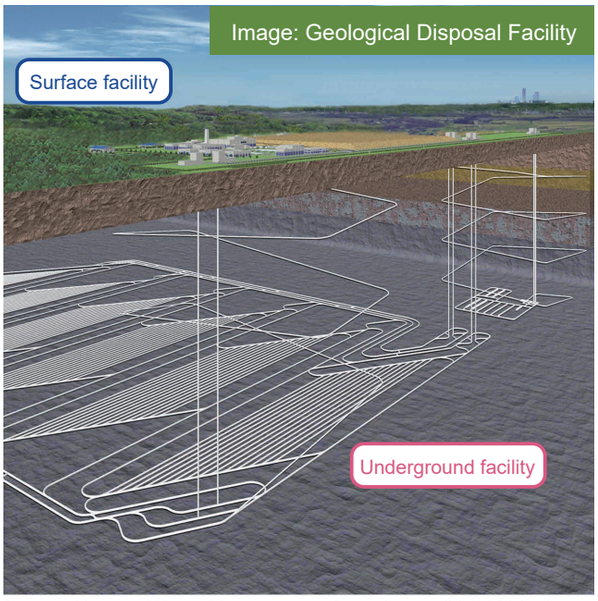
The Tono Geoscience Center has been conducting scientific research on the deep underground environment, and this is called "geoscience research". This research focuses on understanding the features and long-term stability of the deep underground environment as a part of research and development (R&D) related to the geological disposal of high-level radioactive waste(HLW) produced by nuclear power generation process.

## What is the geological disposal?

In Japan, the spent fuel from nuclear power generation is reprocessed and separated into reusable uranium and plutonium and HLW. Uranium and plutonium are recovered and recycled as fuel to generate electricity. This cycle of efficient nuclear fuel use is called "nuclear fuel cycle".




HLW is highly radioactive. Although its radioactivity decays with time, HLW continues to release radiation for a long time. Therefore, it is necessary to isolate and dispose HLW from the human environment. Various methods of HLW disposal have been considered worldwide. However, geological disposal is universally recognized as the most promising method because of its technical feasibility. In Japan, the HLW is to be disposed of at over 300 m depth below surface.




Source: Nuclear Waste Management Organization(NUMO) in Japan

## Concept of Safety Assurance of Geological Disposal

To ensure the safety performance of geological disposal, research from various perspectives related to deep underground has been conducted.

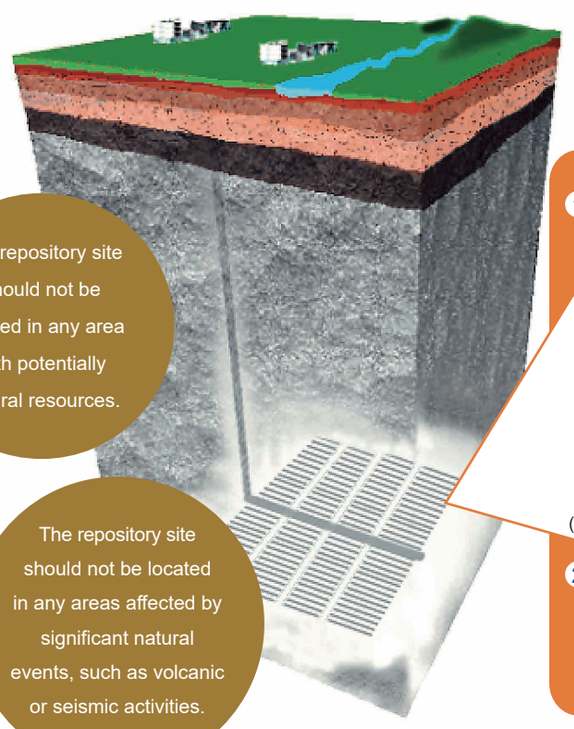
Could the radioactive waste leak into groundwater and migrate to the environment?

Could humans disturb radioactive waste while mining coal and oil?

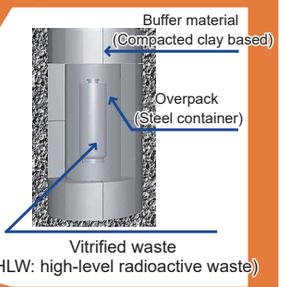
The repository site should not be located in any area with potentially natural resources.

Could the radioactive waste be uplifted to the surface by volcanic and seismic activities?

The repository site should not be located in any areas affected by significant natural events, such as volcanic or seismic activities.

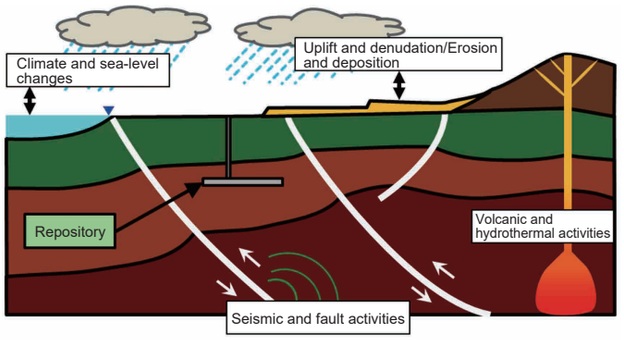


1 Engineered barrier system




2 Natural geological barrier: keeps the radioactive waste isolated

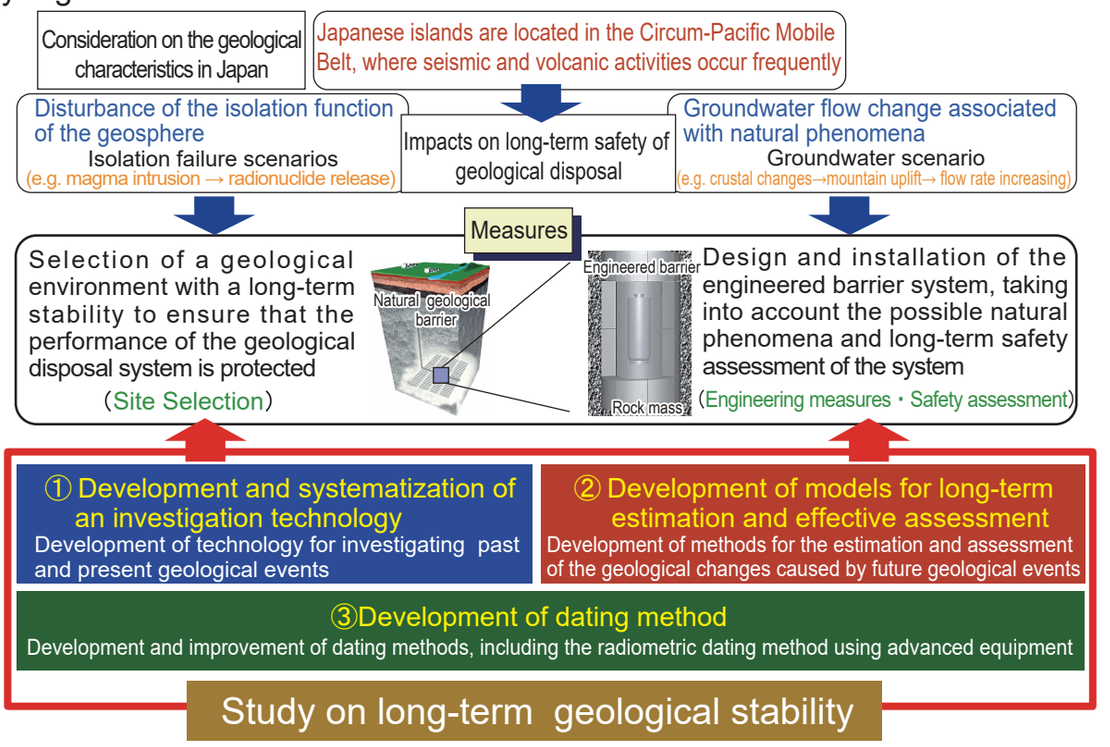
Study on long-term stability of geological environment




Geoscience research being pursued at Tono Geoscience Center

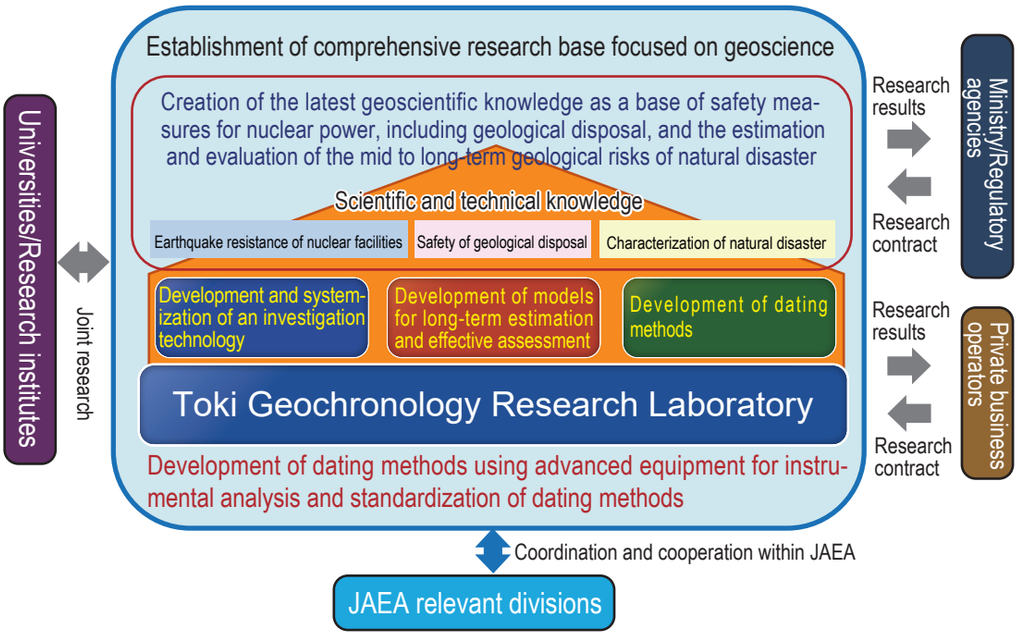
# Toki Geochronology Research Laboratory

The Toki Geochronology Research Laboratory has been conducting a “Study on the long-term stability of the geological environment” to provide scientific knowledge and the investigation and evaluation technology required for the geological disposal project and national safety regulations




## 《Role of Toki Geochronology Research Laboratory》

With the aim of further improving the safety measures of the nuclear facility, including geological disposal, the Toki Geochronology Research Laboratory has been conducting research on the creation of new scientific knowledge and the estimation, and evaluation of the mid-to long-term risks of natural disasters.




2023.2

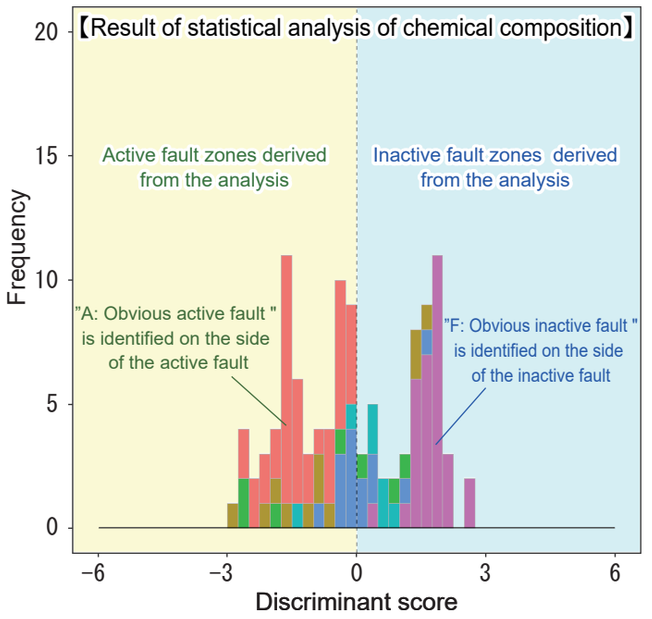
# Study on Long-term Stability of Geological Environment

## ① Development and systemization of investigation technology

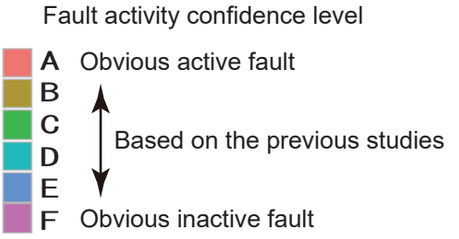
Development and systemization of an investigation technology with the aim of developing the technical basis to acquire data necessary for site selection.
Technology is being developed to understand the rates and ranges of geological change caused by natural events, such as seismic and fault activities, volcanic and igneous activities, and uplift and erosion.

### ○ Investigation technology for evaluation of fault activities

（Development of discriminant technology for active and inactive faults based on chemical composition of fault filling minerals.）




The results of the statistical analysis of the chemical composition of the fault filling minerals agreed with the results obtained in previous studies, indicating that this method is one effective method for discriminating between active and inactive faulting.



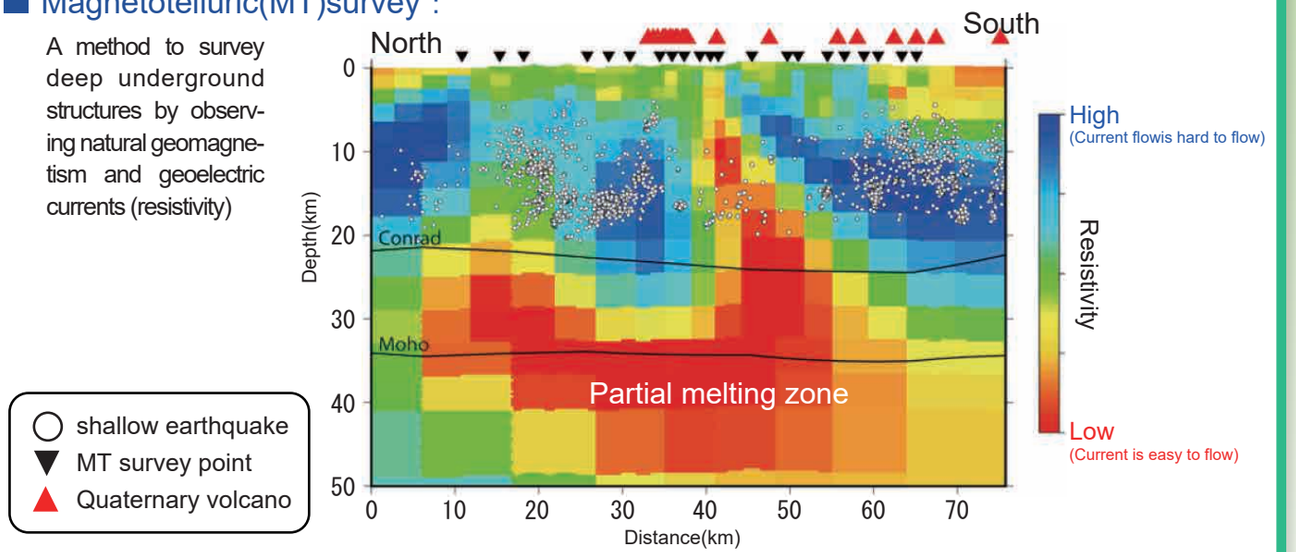

(JAEA・CRIEPI (2022))

### ○ Investigation technology for high-resolution imaging of crustal heterogeneity

（Development of technology for detecting underground structure, magma, and geofluids）

#### ■ Magnetotelluric(MT)survey :

A method to survey deep underground structures by observing natural geomagnetism and geoelectric currents (resistivity)




Two-dimensional (2D) resistivity structure beneath the Aonoyama monogenetic volcano group (Shimane - Yamaguchi Prefecture) estimated by MT survey

(JAEA・CRIEPI (2020))

2023.2

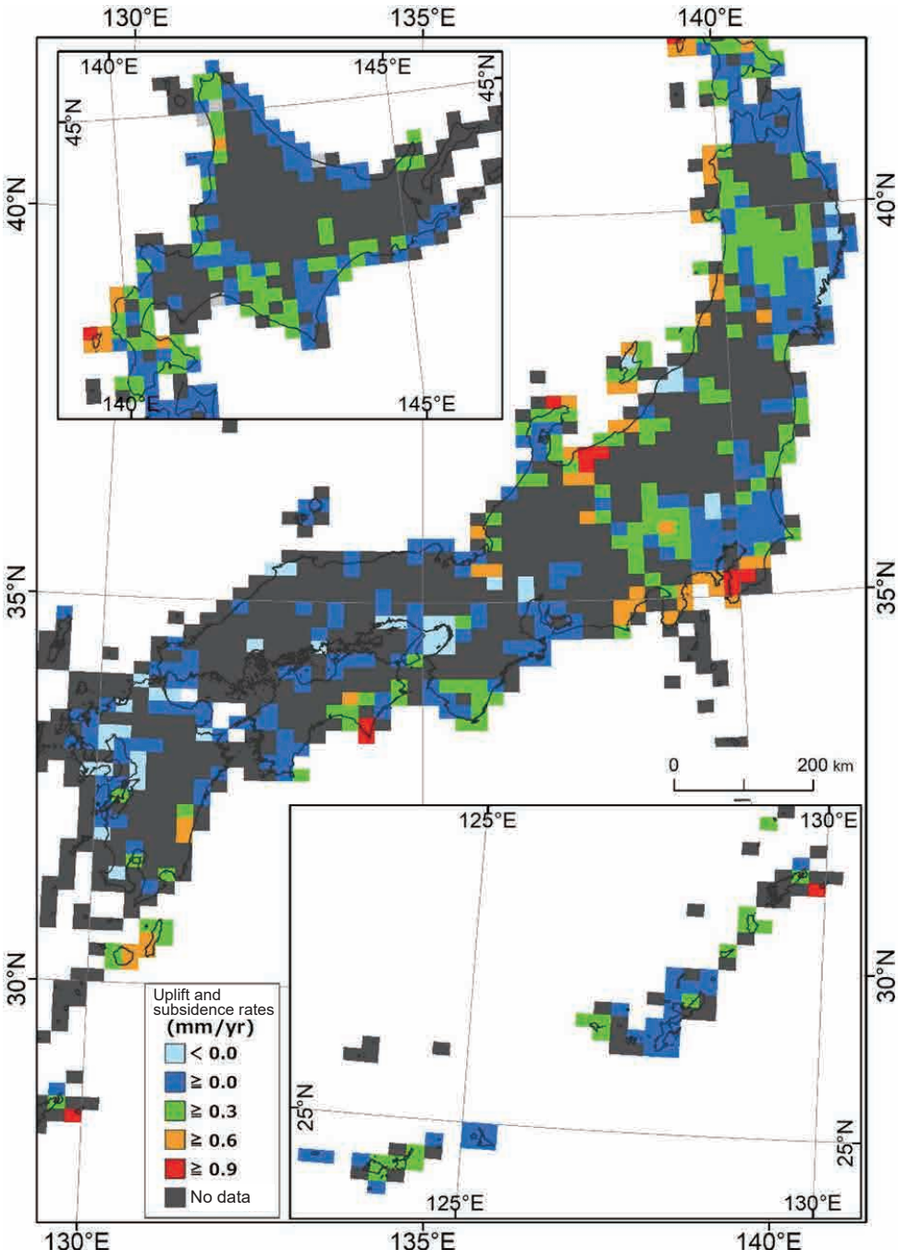
# Study on Long-term Stability of Geological Environment

## ② Development of models for long-term estimation and effective assessment

To evaluate the long-term safety of geological disposal for the next tens of thousands of years, scenarios of potential impacts on the geological environment due to natural events should be considered.
The development of models for long-term estimation and effective assessment aims to produce methods showing the probability of occurrence of the scenario and ranges of change in the geological environment, including uncertainties in the estimation results.

○ Technology for understanding geo-environment changes depending on timescale

(Improvement of investigation and evaluation techniques of uplift and erosion based on topographical and geological information)




Distribution of uplift and subsidence rates over hundreds of thousands of years

(JAEA・CRIEPI (2021))

# Study on Long-term Stability of Geological Environment

## ③Development of dating methods

The technical development for chronological studies is being performed using various equipment, including mass spectrometers, to understand geological events, such as fault activity and volcanic and igneous activities that are subjected to “study on the long-term stability of the geological environment" and estimate the wide range of geological ages.

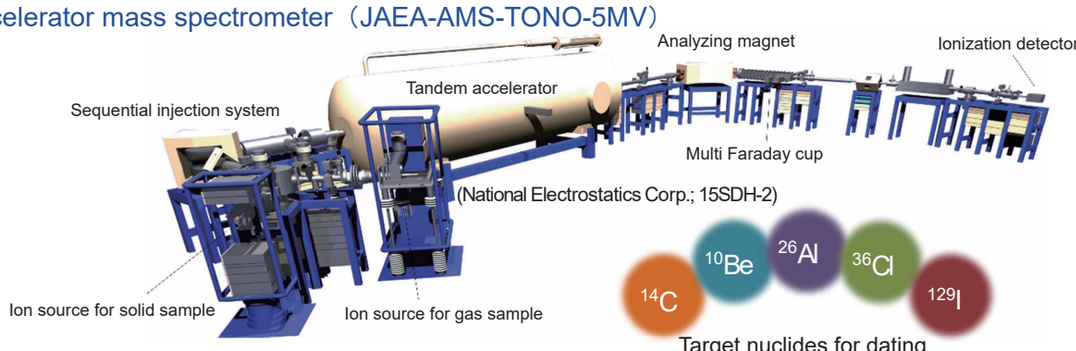
For example, the depositional ages of sediments can be determined by measuring carbon isotopes ($^{12}C$, $^{13}C$ and $^{14}C$: same elements with different mass numbers [neutrons]) extracted from plant fragments in sediments using an accelerator mass spectrometer (AMS). In addition, the cooling process of magma can be revealed, and hinterland, where sediments originate, can be estimated by dating minerals in igneous rocks, such as zircon, using laser ablation inductively coupled plasma mass spectrometer (e.g., U–Pb method).

〈R&D Status of dating methods〉

Target measurement range

| Equipment | Dating method | Measurable dating period (year) $10^9$ $10^8$ $10^7$ $10^6$ $10^5$ $10^4$ $10^3$ | Reflected in | Target material | Present status |
|---|---|---|---|---|---|
| Accelerator mass spectrometer (AMS) | $^{14}C$ | | Fault activity | Groundwater, Organic | Practical use |
| | $^{10}Be$ | | Erosion rate | Quartz | Practical use |
| | $^{26}Al$ | | Erosion rate | Quartz | Practical use |
| | $^{36}Cl$ | | Groundwater age | Groundwater | Under development |
| | $^{129}I$ | | Groundwater age | Groundwater | Practical use |
| Noble gas mass spectrometer | K-Ar | | Fault activity | Authigenic clay mineral (Mica) | Practical use |
| Quadrupole mass spectrometer | (U-Th)/He | | Erosion rate | Apatite, Zircon | Practical use |
| Optically stimulated luminescence measurement device | OSL | | Fault activity | Quartz | Practical use |
| | | | Uplift rate | Feldspar | Practical use |
| Electron spin resonance device | ESR | | Fault activity | Quartz, Carbonate | Under development |
| High precision noble gas mass spectrometer | Noble gas | | Groundwater age | Groundwater | Practical use |
| Electron probe micro analyzer | CHIME | | Provenance analysis | Monazite, Zircon | Practical use |
| Laser ablation inductively coupled plasma mass spectrometer | U-Pb | | Provenance analysis | Zircon | Practical use |
| | | | Fault activity | Carbonate | Practical use |
| Fission track automatic counting system | FT | | Erosion rate | Apatite, Zircon | Practical use |

### Accelerator mass spectrometer（JAEA-AMS-TONO-5MV）







Target nuclides for dating

### Laser ablation inductively coupled plasma mass spectrometer

Laser ablation system
(Photon-machines; AnalyteG2)

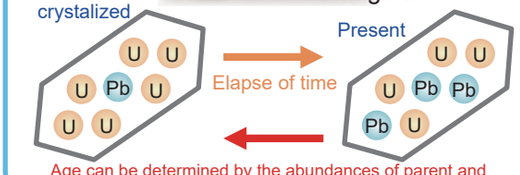
Inductively-coupled plasma mass spectrometer
(Thermo Scientific; Neptune-Plus)

Mass spectrometry of rock and mineral samples fine grained(aerosolized) by laser ablation

### Uranium (U)-lead (Pb) dating method

Method based on uranium decay to lead with time

Zircon crystallized in magma

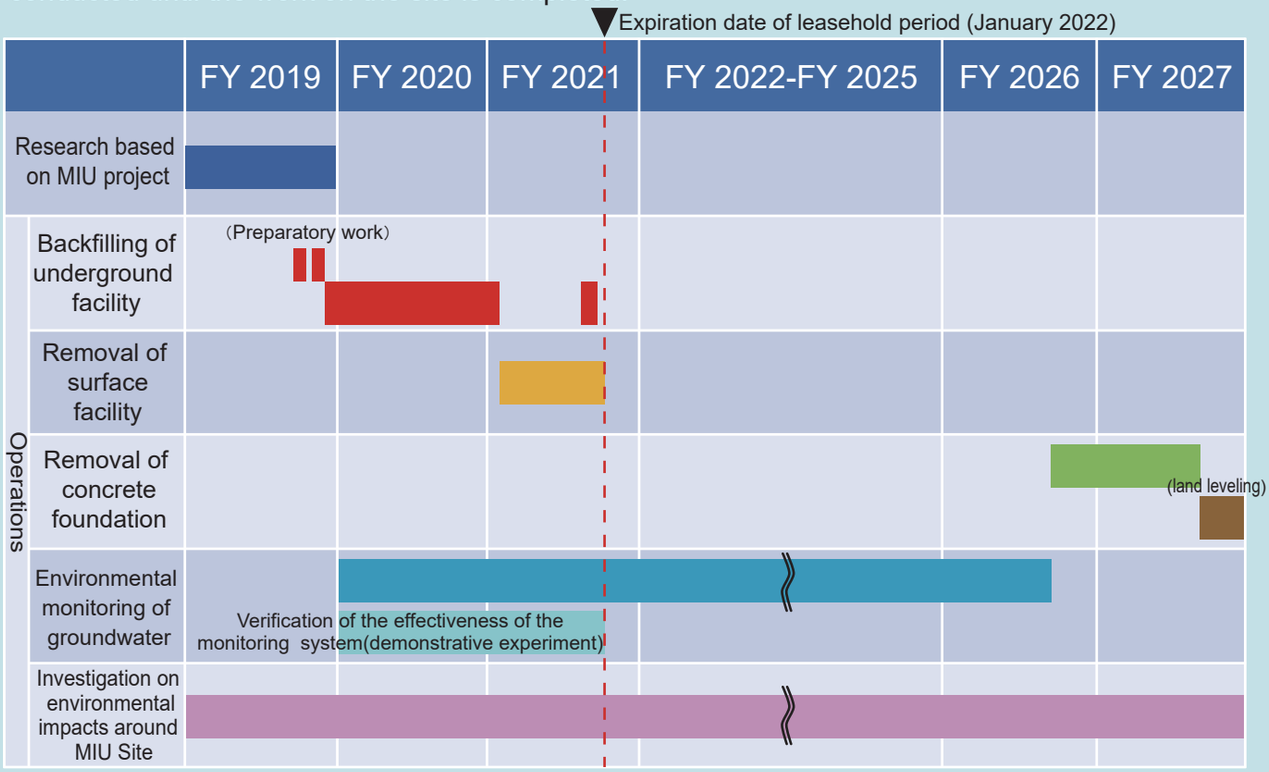



Age can be determined by the abundances of parent and daughter isotopes in zircon

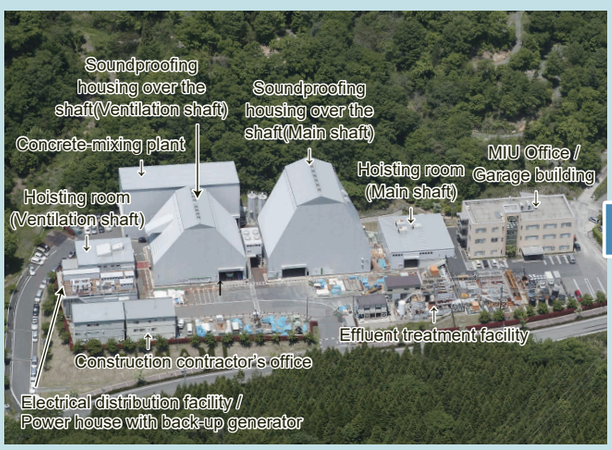
2023.2

# Mizunami Underground Research Laboratory Project

Research and development at the Mizunami Underground Research Laboratory (MIU) was started in FY2002 and had been pursued with a focus on the important issues from FY2015. Since the MIU Project has achieved satisfactory research results, research and development on the MIU project was completed in FY2019. Backfilling of underground facility and removal of surface facilities at the MIU Construction Site have been completed by the end of the land lease period (January 16, 2022). After January 17, 2020, based on the "Mizunami Underground Research Laboratory Project from 2020 onward," environmental monitoring surveys is being conducted to check groundwater conditions at the land (Mizunami Site)newly leased from Mizunami City for about five years, and then removal of the foundations of the surface facilities and land leveling are scheduled to be completed by the end of FY2027. Chemical analysis of river water and noise and vibration measurements around the site, which have been performed since the beginning of the R&D, will continuously be conducted until the work on the site is completed.




※Groundwater pressure monitoring and water sampling have been performed with surface boreholes since the establishment of the MIU.




MIU Before demolition of surface facilities (May, 2009)


After demolition of the surface facilities (February, 2022)

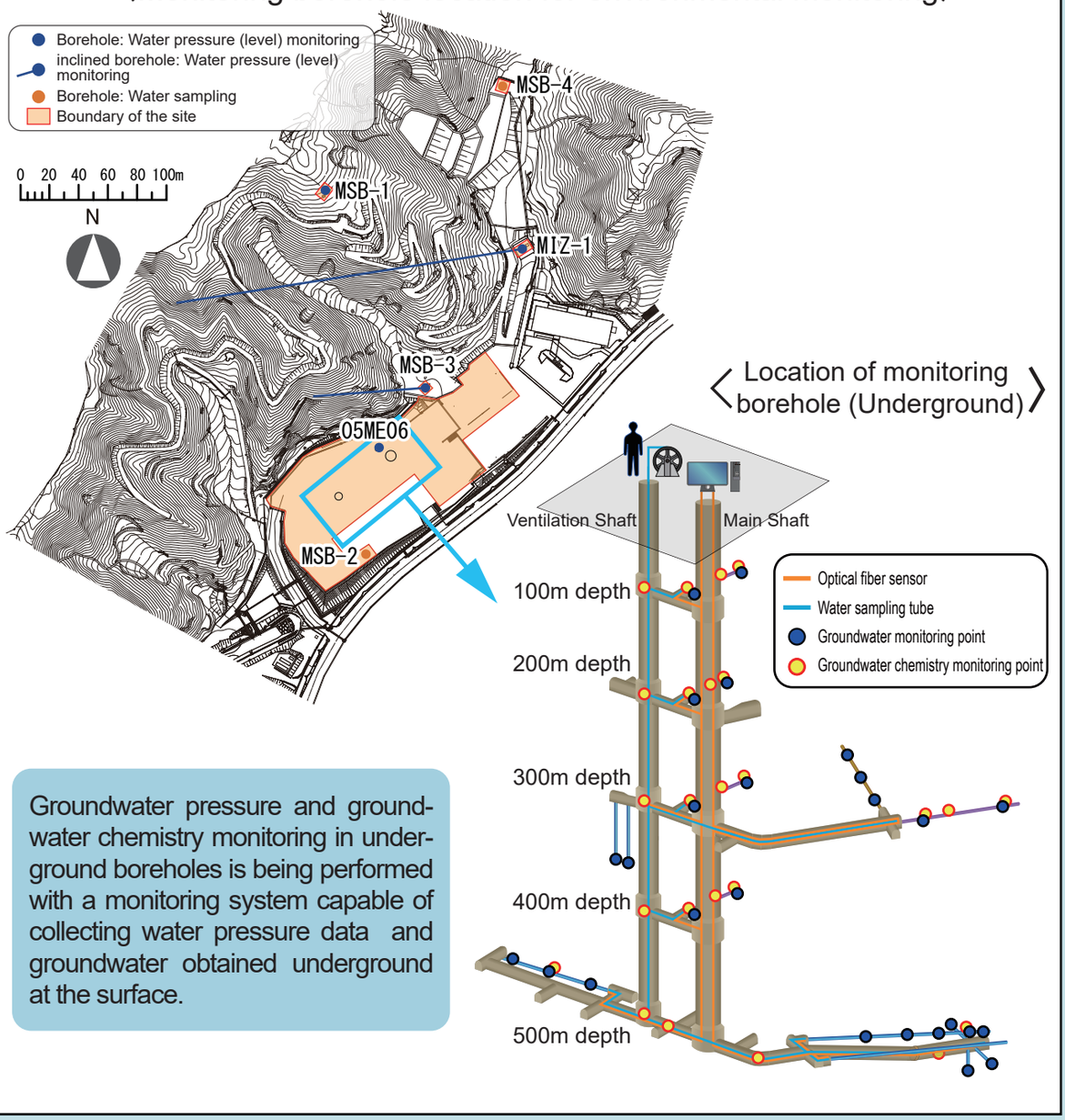
2023.3

# Mizunami Site

## Environmental monitoring of groundwater in surface and underground boreholes

To understand the recovery of groundwater associated with backfilling of the underground facility and environmental impact after the backfilling, environmental monitoring survey of groundwater is being conducted. The environmental monitoring survey has been conducted since the backfilling period, and the monitoring of groundwater pressure and groundwater chemistry in surface and underground boreholes will continue for approximately 5 years after the completion of the backfilling.

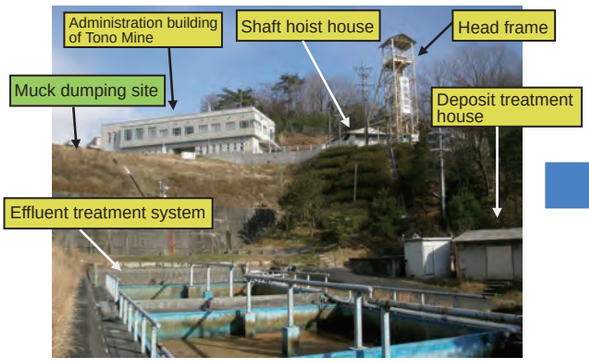
〈Monitoring borehole location for environmental monitoring〉




Groundwater pressure and groundwater chemistry monitoring in underground boreholes is being performed with a monitoring system capable of collecting water pressure data and groundwater obtained underground at the surface.

# Tono Mine

The Tono Mine excavation began in 1972 with the purpose of characterizing uranium deposits. Geoscience research, including the study on the solute transport in rock mass focused on sedimentary rock, was conducted from 1986.
The examination on the closure activities of the Tono Mine was started in FY 2004 and the closure activities were actually initiated in FY 2010. The backfilling of mine drifts, including three shafts, was completed in FY 2014, and as the final activities, in FY2015 and 2016, main surface facilities were removed, and land levelling was conducted leaving the muck dumping site. Voluntary environment monitoring around the mine besides that required by law, which was conducted for five years after the backfilling of the drifts, was also completed with confirmation from an outside expert as it verified that there were no abnormalities in 2019. Currently, measures for the effective utilization of ores other than those from Tono Mine stored at the site is being considered.



<Before facility removal>

<After facility removal>

# Information Transmission and Public Outreach Activities

## Information transmission


Publication of JAEA research reports
Paper submission to academic journals


Research facility tour(AMS building)

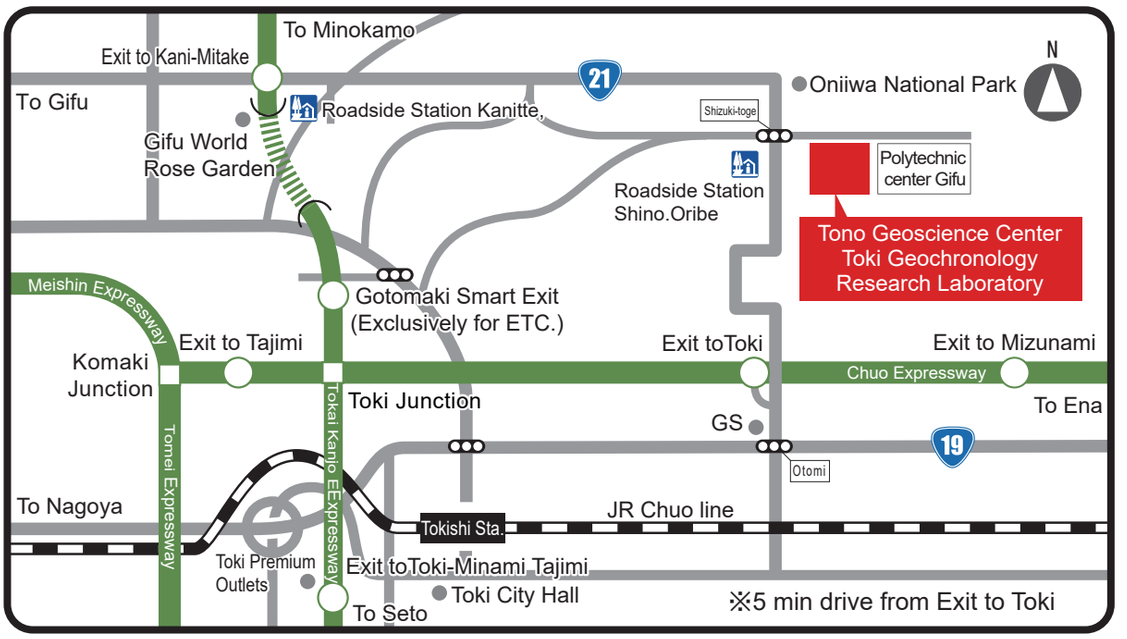
## Public outreach activities


Participating in local events


Organizing science cafes

2023.2

# Access to Tono Geoscience Center




## ■Access

By public transportation:

JR Tokishi Sta. ⇒ Community bus “Minoyaki-danchi Line” (15 min) ⇒ ”Shizuki-toge” bus stop ⇒ (5 min walk) ⇒ Toki Geochronology Research Laboratory

By Car:

Toki I.C., Chuo Expressway ⇒ Turn left at the Exit ⇒ On Route 21 towards Minokamo (5 min)

## ■Contact:


Toki Geochronology Research Laboratory
Tono Geoscience Center
Sector of Nuclear Fuel, Decommissioning and Waste Management Technology Development
Japan Atomic Energy Agency
959-31, Jorinji, Izumi-cho, Toki-shi, Gifu-ken 509-5102
Tel: +81-572-53-0211


2023.2