



Ten Big News Items 2007

from the Institute for Geo-Resources
and Environment



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Our research focuses on three major areas central to ensuring the sustainable development of society: (1) utilization of the geosphere to establish a sustainable and stable energy cycle, (2) protection of the geosphere for the safety and health of all, and (3) procurement of a stable supply of natural resources for industrial activities and society at large. Ten Big News Items for 2007 were selected from projects carried out at our institute over the past year that have the most potential to contribute to the achievement of sustainable development, based on the following factors:

- Noteworthy research results
- Launch, continued implementation, or completion of an important project or joint research
- Contribution to society through the announcement of results or through technology transfer
- Creation of an important knowledge base or basic research results
- Events, awards, etc. that bring honor to the Institute
- Important initiatives taken by the Institute that lead to advances in its research

I sincerely hope that these news items will help you to appreciate the activities and contributions of our institute.

March 2008

Dr. Yusaku Yano, Director, Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology (AIST)

Ten Big News Items 2007

Title	Research Group·Researcher	
Development of a nuclear magnetic resonance (NMR) surface scanner	Exploration Geophysics RG Yoshito Nakashima	photo 1
Reproduction of environmental isotope fractionation between methane and water by coculture experiments	Geomicrobiology RG (Yoshioka, H., Sakata, S., Mochimaru, H.)	photo 2
Research for the development of advanced technology for the evaluation of coastal seawater/freshwater interfaces and faults	Groundwater RG, Exploration Geophysics RG	
Completion of <i>Atlas of Hydrothermal Systems in Japan</i>	Geothermal Resources RG	photo 3
Publication of technical report on carbon capture and storage	CO ₂ Geological Storage RG and many Concerned	
Development of geochemical information on subsurface soils, and risk assessment	Geo-Analysis RG (Hara, J., Kawabe, Y., Komai, T.)	photo 4
Investigation of rare earth content of apatite	Mineral Resources RG (Watanabe, Y., Murakami, H., Mori, T., Sanematsu, K.)	photo 5
Completion of nationwide survey of Japan's aggregate resources	Mineral Resources RG (Sudo, S., Fujihashi, Y., Watanabe, Y.)	photo 5
Exploration Geophysics Research Group leader Toshihiro Uchida receives Hohmann Award	Director Yusaku Yano	photo 6
New groups organization for the 3rd period	Director Yusaku Yano	photo 7



photo 1



photo 2



photo 3



photo 4



photo 5



photo 6
(T.Uchida Group Leader)



photo 7
(Group leaders of newly established research groups)



Development of a nuclear magnetic resonance (NMR) surface scanner

Yoshito Nakashima, Exploration Geophysics Research Group



[Outline]

We have developed a prototype scanner capable of nondestructive, in-situ measurement of water content in cracks in concrete structures.

[Details]

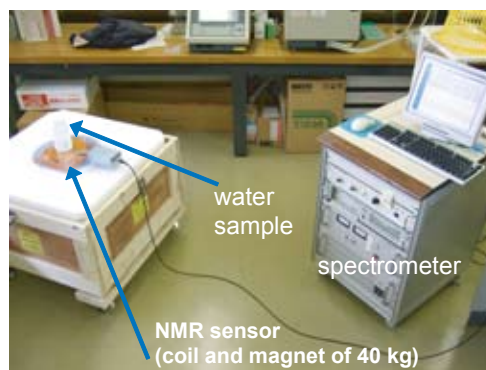
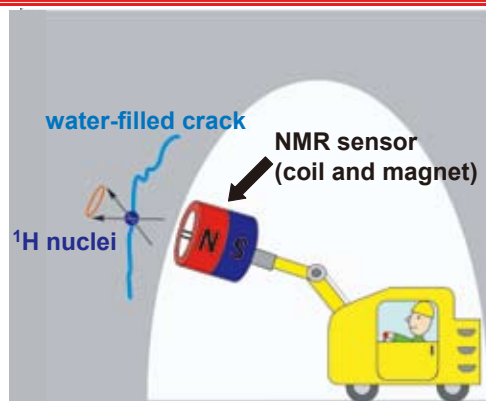
The need to maintain aging tunnels, dams, and other concrete structures to prevent geotechnical disasters calls for a means of nondestructive, in-situ measurement of cracks and other weaknesses that contain water. To address such needs, the Exploration Geophysics Research Group is developing a device that uses nuclear magnetic resonance (NMR) spectroscopy to target hydrogen nuclei, one of the few available geophysical exploration methods of measuring water quantity. A surface scanner based on the NMR principle has the potential to enable the non-destructive, in-situ, real-time measurement of the quantity of water in cracks within concrete structures or rock formations. The prototype developed by the Group is capable of detecting the NMR signal of a water sample separated by a distance of 5 cm from the sensor surface within about 5 minutes.

[Applications]

If the current prototype is developed through improving the configuration of the high-frequency coil and rare earth magnet and through making the device waterproof and dustproof, it could be put to practical use as a civil engineering geophysical exploration system.

[Joint researcher]

Shin Utsuzawa (New Mexico Resonance; Visiting researcher, AIST)



(top) Diagram showing how an NMR scanner might be used to inspect a tunnel for cracks
(bottom) The prototype NMR surface scanner

Contact: Yoshito Nakashima, e-mail: nakashima.yoshito@aist.go.jp, phone: +81-29-861-3960



Reproduction of environmental isotope fractionation between methane and water by coculture experiments

Yoshioka, H., Sakata, S., Mochimaru, H., Geomicrobiology Research Group



[Outline]

Through a coculture simulation of the natural environment, which is populated by many types of closely interacting microorganisms, we succeeded for the first time ever in reproducing the hydrogen isotope relationship (isotope fractionation) found in methane and water in environmental samples.

[Details]

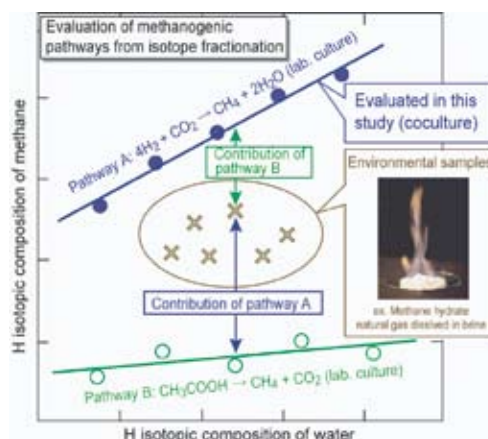
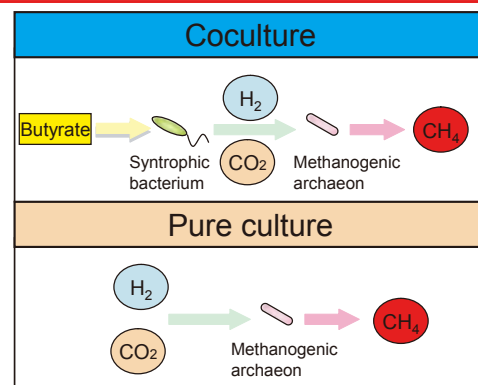
With the aim of simulating the material circulation processes mediated by subterranean microorganisms, an archaeon (found in a Niigata gas field) that produce methane from hydrogen and carbon dioxide was cocultured with a bacterium that produce hydrogen and carbon dioxide from butyric acid, and the hydrogen isotope fractionation between the methane and culture water was investigated. Results differed significantly from conventional pure cultures (monocultures of methanogenic archaea), and closely resembled the isotope fractionation between methane and water in samples taken from freshwater environments.

[Applications]

Knowledge of the processes by which subterranean microorganisms cause the decomposition of organic matter and the generation of methane is vital to elucidating the formation mechanisms of natural gas resources such as methane hydrate and natural gas dissolved in brine, and to developing technology for natural gas regeneration within oil-bearing strata and decontamination of oil-contaminated soil. The hydrogen isotope fractionation obtained from this research (co-culture) can be used as a benchmark for evaluating methane production pathways from the isotope data of environmental samples.

[Joint researcher]

Yoichi Kamagata, Research Institute of Genome-Based Biofactory, AIST



Contact: Hideyoshi Yoshioka, e-mail: hi-yoshioka@aist.go.jp, phone: +81-29-861-3810



Research for the development of advanced technology for the evaluation of coastal seawater/freshwater interfaces and faults

Groundwater Research Group and Exploration Geophysics Research Group



【Outline】

Research commissioned by Japan's Resources and Energy Agency has been launched in the town of Horonobe, Hokkaido, on the high precision elucidation of deep subsurface structure and hydrological environment, and exploration for permanent groundwater stable over ultra-long periods. This research is being conducted jointly by the Groundwater Research Group (deep groundwater survey and wide area groundwater flow analysis) and the Exploration Geophysics Research Group (electromagnetic and seismic exploration on land and shallow sea area).

【Details】

In 2007, the first year of this five-year project, we carried out land-based geophysical exploration research and wide area groundwater flow analysis. We also started drilling activities (photo) at the coastal experiment site for research from 2008 onwards. Once drilling is complete, we plan to conduct single- and cross-borehole tests and investigate test methods for improving the accuracy of outline survey tests. Also this year, we developed a new seafloor electromagnetic exploration tool for shallow sea area. We have high expectations for the full-scale research to be conducted from the second year.

【Applications】

The results of this research will be integrated with other research conducted by the Japan Atomic Energy Agency and the Central Research Institute of Electric Power Industry to serve as a synthesis of research related to coastal geological disposal.



(top) The research site at Hamasato, Horonobe. 1,000-meter-class observation and experiment boreholes will be drilled 200 meters inland for conducting deep groundwater experiments.

(right) Project leader Atsunao Marui addresses at the ceremony to mark the opening of AIST's Horonobe Office, explaining the outline of AIST's research to representatives from Horonobe Town Hall, Farmers Union, local businesses, and other organizations.



Contact: Atsunao Marui, email:marui.01@aist.go.jp, phone: +81-29-861-3684



Completion of *Atlas of Hydrothermal Systems in Japan*

Geothermal Resources Research Group



【Outline】

We compiled a nationwide hydrothermal database that enables comprehensive evaluation of Japan's hydrothermal systems, and published key data in the form of the Atlas of Hydrothermal Systems in Japan.

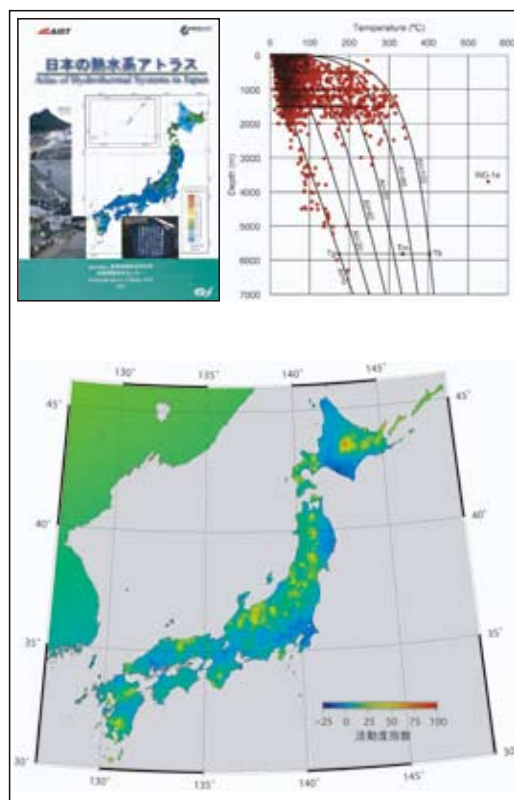
【Details】

We collected the data from chemical analyses of 7,203 hot springs and temperature data from 3,066 wells throughout Japan, and created Japan's first nationwide maps showing the regional characteristics of the chemical compositions of hydrothermal systems and the hydrothermal reservoir temperatures as measured by various types of geochemical thermometer. We also used this database to quantitatively elucidate the dependence of pH on depth, and we mapped the underground temperature structure extrapolated from standardized depth-temperature curves (right).

Muraoka, H., Sakaguchi, K., Tamanyu, S., Sasaki, M., Shigeno, H. and Mizugaki, K. (2007) Atlas of Hydrothermal Systems in Japan, Geological Survey of Japan, AIST, 110p.

【Applications】

This high spatial resolution data can be used for a wide variety of regional assessment purposes, including geothermal resource development, hot spring spa development, groundwater utilization, underground space utilization, and geological disposal. This publication also enables the immediate imaging of regional distribution of geothermal resources, and we are currently carrying out this research.



Atlas of Hydrothermal Systems in Japan and map of subsurface temperature structure

Contact: Hirofumi Muraoka, e-mail: hiro-muraoka@aist.go.jp, phone: +81-29-861-2403



Publication of technical report on carbon capture and storage

CO₂ Geological Storage Research Group and many concerned



【Outline】

Carbon dioxide Capture and Storage (CCS) is attracting an attention as a realistic solution to climate change probably caused by a rapid increase of greenhouse gas emission and Geological storage of CO₂ is a key technology in the process of CCS. In March 2008, we published a technical report reviewing our studies on the CCS technology development concerning to CO₂ storage in saline aquifer.

【Details】

CCS in many countries has been proposing to inject and storage CO₂ into depleted oil and gas fields. In Japan, however, there is limited storage potential in such fields due to different geological setting. CO₂ storage in open saline aquifers at a depth over 1,000m is considered to be an alternative option in the implementation of CCS in Japan. The technical report overviews our studies essential to the open aquifer CO₂ storage. The principal contents are as follows;

- Evaluation of regional flow of deep groundwater around the reservoir depth,
- Evaluation of seal integrity and fracture permeability through rock mechanical experiments,
- Modeling and analysis of CO₂ migration using seismic tomography technique,
- Basic studies on geochemical CO₂ trapping,
- CO₂ flux survey as a natural analogue of CO₂ geological storage.

【Outcome】

The global warming due to a rapid increase of atmospheric CO₂ is one of the serious problems that our society is facing. METI has presented a roadmap addressing the commercial basis CCS toward 2015. In the implementation of CCS in Japan, we have to take into account the peculiar geology of Japan. The technical report provides a scientific basis for the CCS in Japan incorporating saline aquifer storage, and will be used as fundamentals on the development of various techniques such as risk assessment, design for monitoring and so on in CCS, although there still remain several problems to be overcome.

Contact: Toshiyuki Tosha, email: toshi-tosha@aist.go.jp, phone: +81-29-861-3518



Provisional print of report and some research results



Development of geochemical information on subsurface soils, and risk assessment

Hara, J., Kawabe, Y., Komai, T., Geo-Analysis Research Group



【Outline】

We researched and organized information on the background levels of heavy metals occurring naturally in surface soil to determine levels of harmful heavy metals and their leaching properties, and assessed the risks they pose to human health. The Geological Survey of Japan compiled and published a geochemical and risk assessment map of subsurface soils for Miyagi Prefecture.

【Details】

For this project, we organized information through gathering existing data on surface soil, conducting field research, and analyzing data. We then used this data to conduct research as follows on assessment and analysis methods:

- Assessment of risks to humans and plants caused by natural origin heavy metals.
- Provenance analysis of heavy metals in subsurface soils using lead isotope ratios.
- Relationships between surface soil type and the heavy metal content and leaching properties.

These assessment and analysis methods are very useful for correctly interpreting soil contaminants.

【Applications】

To investigate heavy metal pollution, we need to decide whether it is from a natural or an anthropogenic source in order to devise countermeasures for the pollution. Even when the contamination is judged to be derived from natural origin heavy metals, the risks posed to human health and the ecosystem still need to be assessed and appropriate actions taken. This research yielded information useful to the analysis of origins of heavy metal contamination and implementation of appropriate land use, and we hope that it will prove useful to both local governments and private sector businesses involved in surface soil and groundwater contamination management in ensuring appropriate land use. We next plan to develop geochemical data from different regions.



Geochemical and risk assessment map of subsurface soils

Contact: Junko Hara, email: j.hara@aist.go.jp, phone: +81-29-861-8710



Investigation of rare earth content of apatite

Watanabe, Y., Murakami, H., Moriyama, T., Sanematsu, K., Mineral Resources Research Group



【Outline】

Our investigation of the rare earth content of apatite revealed that the yearly worldwide production of apatite contains around 170,000 tons of rare earths (oxide-converted).

【Details】

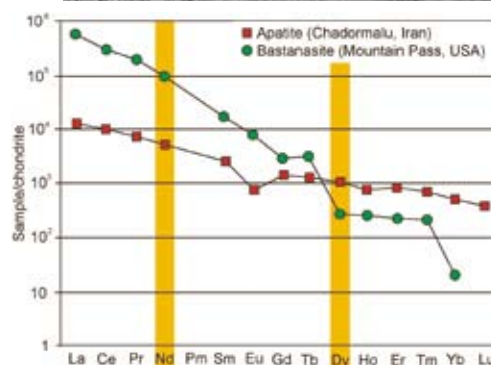
It has long been known that apatite of magma or hydrothermal origin contains rare earth elements. For this research, we collected samples from major apatite-containing deposits worldwide, and measured the quantity of rare earths they contained. Using these results and published data, we estimated that the yearly worldwide production of apatite contains around 170,000 tons of rare earths (oxide-converted). This amount exceeds the current annual production of rare earths (approximately 130,000 tons). We also discovered that apatite from certain deposits is rich in the heavy rare earth elements that are indispensable for the production of rare earth magnets. We expect that the growing demand for rare earths will in time likely require their extraction and production from apatite.

Watanabe, Y. (2008) To realize the stable supply of heavy rare earth elements. JEITA Review, v. 561, p. 2-7.

Ishihara, S., Hoshino, M. and Moriyama, T. (2007) Trace elements of apatites, particularly of REE, in the S- and I-type granites. Shigen-Chishitsu, v. 57, p. 115-125.

【Applications】

Production of apatite as a raw material for fertilizers continues to grow. The results of this research will be used to determine the most suitable deposits for producing rare earths as a by-product of apatite production, and as basic reference material when conducting experiments on rare earth extraction.



(top) Iron and apatite mine at Chadormalu, Iran
(bottom) A comparison of the rare earth content of Chadormalu ore compared with that of Mountain Pass Mine, USA, shows the Iranian apatite to contain less of the light rare earth elements (e.g. Nd), but more of the heavy rare earth elements (e.g. Dy).

Contact: Yasushi Watanabe, email: y-watanabe@aist.go.jp, phone: +81-29-861-3811



Completion of nationwide survey of Japan's aggregate resources

Sudo, S., Fujihashi, Y., Watanabe, Y., Mineral Resources Research Group



【Outline】

In 2007 we published a report on the aggregate resources of Hokkaido and the prefectures of the Tohoku region, completing our nationwide survey of aggregate resources.

【Details】

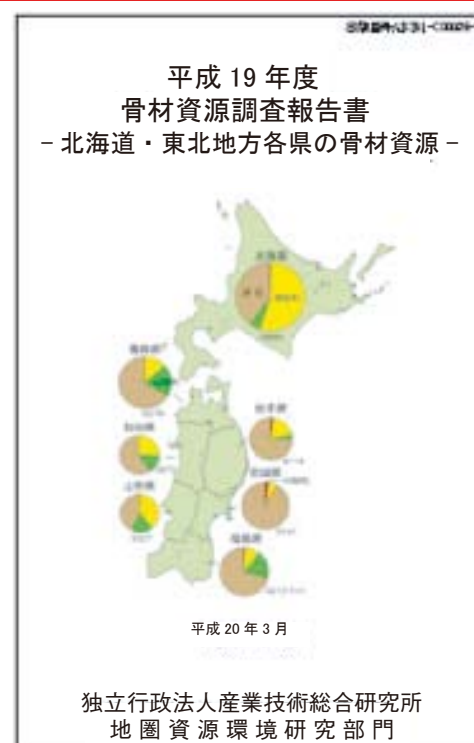
At the request of the Housing Industry, Ceramics and Construction Materials Division of the Ministry of Economy, Trade and Industry, the Mineral Resources Research Group has surveyed and prepared reports on the distribution and properties of aggregate resources throughout Japan. In 2007, we issued a report that provides an overview of the gravel and crushed stone resources of Hokkaido and the prefectures of the Tohoku region, together with information on aggregate production trends, distribution, and issues faced by individual localities. Hokkaido and Tohoku have rich aggregate resources, but gravel tends to be concentrated on the Japan Sea side, and crushed stone on the Pacific Ocean side. On the Pacific side, priority should be put on obtaining an accurate picture of the distribution and quality of crushed stone, land gravel, and pit gravel resources to ensure effective use. On the Japan Sea side, land gravel may contain porous rocks and some crushed stone is fragile as a result of alteration. This creates a need for the introduction of high quality crusher screenings from elsewhere. With the issue of this report, we have completed the five-year nationwide survey of aggregate resources that we embarked on in 2003.

Institute for Geo-Resources and Environment (2008) Report on the survey of rock aggregate resources in Hokkaido and Tohoku regions in the fiscal year Heisei 19. 43p.

【Applications】

The potential to supply aggregate differs significantly according to region. The survey results will be used as basic reference material for selecting sources of supply of aggregate and types of aggregate in each region.

Contact: Yasushi Watanabe, email: y-watanabe@aist.go.jp, phone: +81-29-861-3811



Aggregate Resources Survey Report 2007
Hokkaido and Tohoku Region Aggregate Resources



Exploration Geophysics Research Group leader Toshihiro Uchida receives Hohmann Award



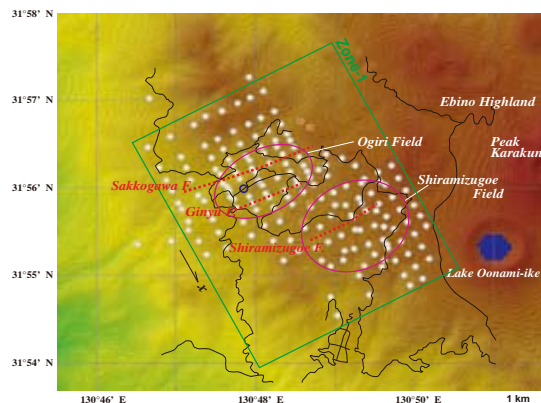
Yusaku Yano, Director

[Outline]

Exploration Geophysics Research Group leader Toshihiro Uchida was selected for the international Hohmann Award for Excellence in Applied Electrical Geophysics for 2006. The award ceremony was held in 2007. The Gerald W Hohmann Memorial Trust (USA) has awarded the Hohmann Award each year since 1997 to one or two researchers from throughout the world. The 2006 Award was presented to two researchers for outstanding application of electrical and electromagnetic methods to the study of geothermal resources.

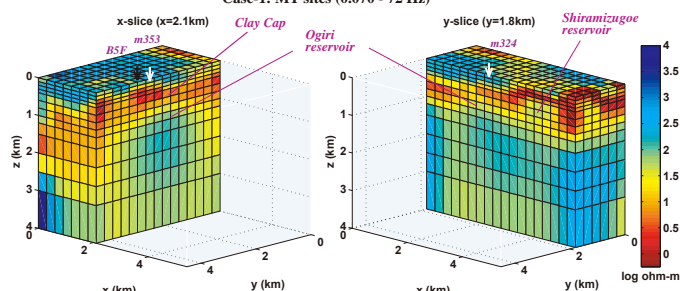
[Details]

Group leader Toshihiro Uchida has long worked on the development of modeling and inversion software for electrical and electromagnetic exploration data and on its application to the exploration of geothermal resources. He was selected for this award for (1) achievements in the interpretation of resistivity structure in geothermal fields; (2) development and popularization of 2D and 3D modeling and inversion software of magnetotellurics (MT) and DC resistivity data that contribute to geothermal exploration; and (3) cooperation in geothermal research and development in Japan and other countries (Indonesia, Philippines, South Korea, etc.). The award also pays recognition to Uchida's regular presentation of research findings at international meetings on electromagnetic exploration studies and contributions to international joint researches since 1990. The figures on the right represent one of Uchida's research achievements, showing an example of resistivity model at the Ogiri geothermal field in Kagoshima Prefecture (Uchida, 4th International Symposium on 3D Electromagnetics, 2007).



Location of MT survey stations at Ogiri geothermal field.

Case-1: MT sites (0.070 - 72 Hz)



3D resistivity model obtained from the MT data. Within the zone of geothermal reservoir, low-resistivity layer corresponds to cap layer in which clay alteration minerals are abundant, while the geothermal reservoir below the clay cap is relatively resistive.

Contact: Toshihiro Uchida, email: uchida-toshihiro@aist.go.jp, phone: +81-29-861-3840



New groups organization for the 3rd period



Yusaku Yano, Director

[Outline]

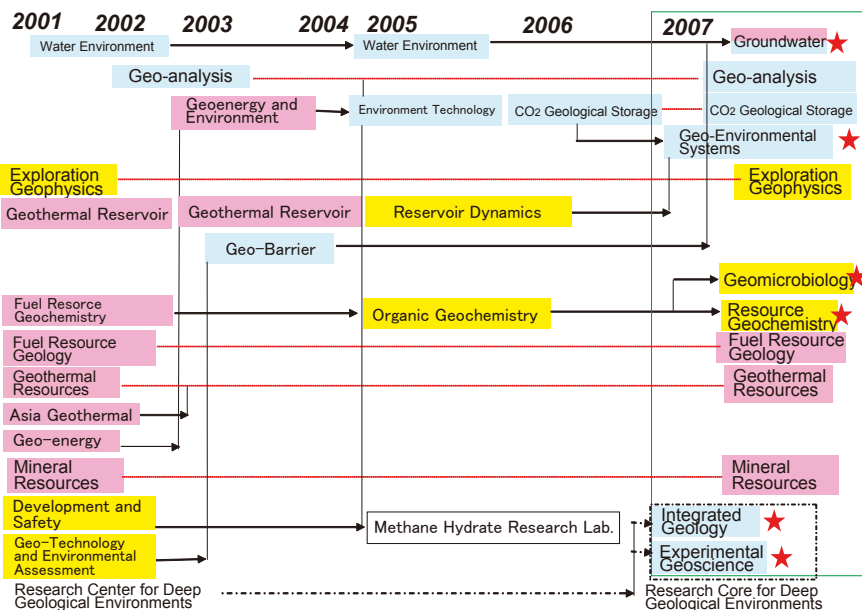
The Institute for Geo-Resources and Environment has conducted research both to address existing needs and to develop new potential under its key missions of geo-resource exploration and development and geosphere utilization and conservation. To address changing needs in society and make use of new research findings as AIST's 3rd period approaches, the Institute established six new research groups in 2007 (★ in the organization chart on the right).

[Details]

The groups involved in geological disposal safety research and groundwater environment, which are priority research areas, have been merged into a groundwater research group. Two groups from the Research Core for Deep Geological Environments that conduct research in the area of geological disposal safety regulations support have also joined the Institute. A new research group was established for subterranean microorganisms, a research field that is anticipated to grow dramatically. Two further new groups have also been established one to conduct research in the geophysical aspects of geological disposal and storage, and one for research in fuel resources and other aspects of geochemistry.

[Outlook]

We will do our utmost to realize the full potential of our research capabilities with the cooperation of other facilities.



Timeline of changes in the organization of our Institute

■ = resource-related, ■ = environment and utilization,
■ = shared technology research groups

Contact: Yusaku Yano, email: y.yano@aist.go.jp, phone: +81-29-861-2412

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Dr. Yusaku Yano, Director
Institute for Geo-Resources and Environment
National Institute of Advanced Industrial Science and Technology
AIST Tsukuba Central 7, Tsukuba, Ibaraki 305-8567, Japan, phone : +81-29-861-3633
AIST Tsukuba West, Tsukuba, Ibaraki 305-8569, Japan
<http://unit.aist.go.jp/georesenv/>



Research Group

- Groundwater Research Group
- Geo-Analysis Research Group
- CO₂ Geological Storage Research Group
- Geo-Environmental Systems Research Group
- Exploration Geophysics Research Group
- Geomicrobiology Research Group
- Resource Geochemistry Research Group
- Fuel Resource Geology Research Group
- Geothermal Resources Research Group
- Mineral Resources Research Group
- Integrated Geology Research Group
- Experimental Geoscience Research Group

Researches at the Institute for Geo-Resources and Environment are carried out at two locations: Tsukuba Central 7 and Tsukuba West.

