

Ten Big News Items



AIST
Institute for Geo-Resources and Environment
Ten Big News Items 2010



Ten Big News Items from the Institute for Geo-Resources and Environment

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 the nation, and (3) procurement of a stable supply of natural resources for industrial activities and society at large. Ten Big News Items for 2010 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 publication of research 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 this brochure will help you in understanding the activities and contributions of our institute.

March 2011

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

Ten Big News Items 2010

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Development and application of technologies for <i>in situ</i> remediation of polluted soils and groundwater	M. Zhang, M. Yoshikawa, J. Hara, T. Komai, Geo-environment Risk RG; M. Takeuchi, Geomicrobiology RG; Y. Imoto, Geo-analysis RG; M. Hoshino, Mineral Resources RG	I
Development of an on-site measurement method for oil-contaminated soil core samples by nuclear magnetic resonance	Y. Nakashima, Exploration Geophysics RG	J



A



B



C



D



E



F



G



H



I



J

Development of a shallow-seafloor magnetotelluric survey system and its application at the Horonobe coastal area

T. Uchida, Y. Mitsuhashi, T. Ueda, Exploration Geophysics RG; A. Marui, Groundwater RG

【Outline】

We have developed a new seafloor magnetotelluric (MT) survey system that can reduce interference caused by wave motion and can be applied to measurements under a shallow sea. High-quality data were successfully obtained for the first time in a field survey at the Horonobe coastal area, Hokkaido, Japan.

【Details】

We have been conducting research on geophysical technology (the MT method) for seamlessly evaluating geological structures that extend from land to sea, under a nuclear waste depository research project funded by the Ministry of Economy, Trade and Industry. Application of the MT method in shallow seas is extremely difficult because sea waves sway magnetic sensors and generate strong electromagnetic noise. We have developed a new seafloor MT instrument that is short in height to reduce the motion caused by sea waves. The first MT survey using this instrument was conducted in Horonobe in 2010, and high-quality MT data were successfully obtained. Our institute also drilled to 1,000 m on land near the coastline and obtained detailed geological information for the area. A 2-D resistivity model calculated by the inversion of both land and seafloor MT data clearly indicates that a Quaternary high-resistivity sedimentary layer of a few hundred meters in thickness, which was determined to be a freshwater layer by the drilling, extends a distance of several kilometers under the sea.

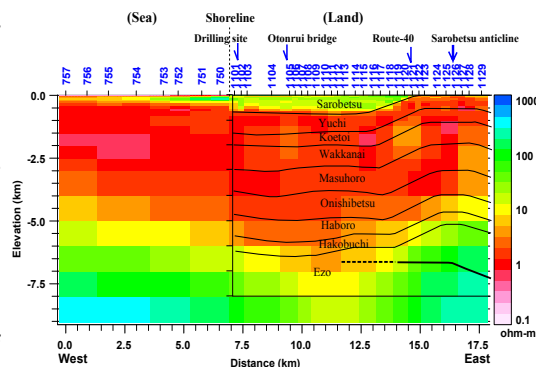
【Application of research results】

The results of this research will be applied to geological characterization for future nuclear waste depository projects. Other possible uses include geological evaluation for CO₂ geological sequestration and active fault surveys over coastal zones.

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A new seafloor MT instrument



2-D electrical resistivity model for the Horonobe coastal area obtained by inversion of land and seafloor MT data (color section). Layer boundaries estimated from an existing seismic reflection survey on land are overlaid (black lines).

Study into the rational redevelopment of groundwater resources for industrial use

Groundwater RG; Exploration Geophysics RG; Geo-environment Risk RG

【Outline】

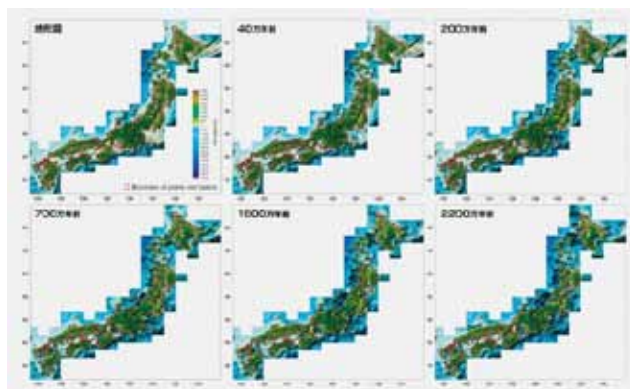
Research by the Institute for Geo-Resources and Environment verified a 13-trillion ton groundwater resource in 61 groundwater basins in the Japanese Islands. A geochemical database and map were created on the basis of research by the Institute of Geology and Geoinformation, and the Energy Technology Research Institute studied a heat pump system that uses geothermal energy. These studies were integrated to develop a new system for groundwater use as a resource and in geothermal energy.

【Details】

AIST has a history of over 40 years of research into groundwater with the goal of sustaining industrial groundwater resources. AIST has completed a simulation of the groundwater system including 61 groundwater basins (plains and basins) in the Japanese Islands, and has identified the volume of groundwater resources and rate of groundwater flow. The new, layer-separated analysis revealed that there are many unknown (unused) groundwater resources in the islands. Local regulation and/or excessive solicitude are the reasons preventing the groundwater use. We hope that our research will provide scientific data for evaluating the groundwater environment and help Japanese industries alleviate the concerns of society regarding groundwater use.

【Application of research results】

The research techniques, method of analysis and database will be used to provide a service to stimulate industrial development and plan future industrial expansion. The results will also be useful for developing geothermal energy for domestic use, especially in cold and hot latitudes.



Sedimentary layers model of the Japanese Islands. We estimated the groundwater resources in the Islands by showing the structure of aquifers in the 3-D model of sedimentary layers of Neogene and Quaternary age.



Dr. Clifford Voss of the U.S. Geological Survey (USGS) lectures about groundwater modeling at the AIST research meeting in February 2011.

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Development of a map showing the potential for ground-coupled heat-pump systems

M. Yoshioka, Groundwater RG

【Outline】

We developed a map of ground-coupled heat-pump (GCHP) system potential for the Fukui area reflecting groundwater and geological conditions and devised an approach using GIS for evaluating the area suitable for GCHP systems.

【Details】

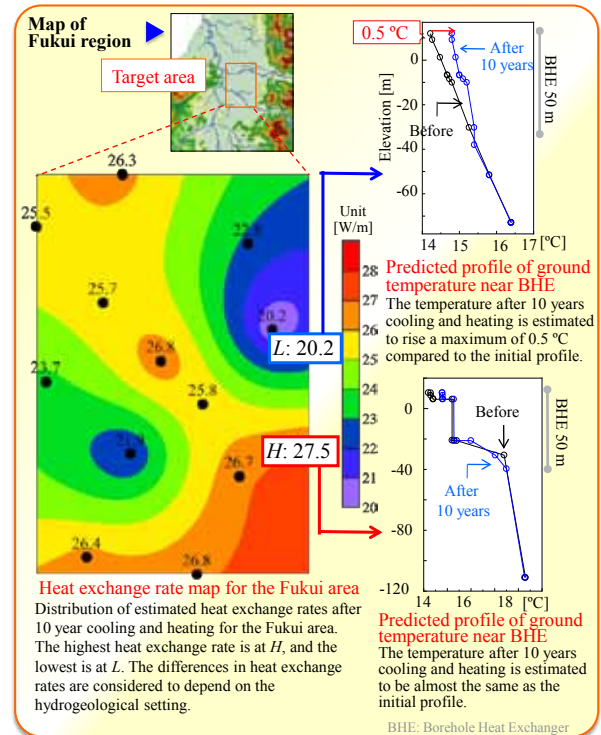
GCHP systems use shallow geothermal energy and are considered to be one of the most energy-efficient systems for air-conditioning or snow-melting. The promotion of these systems in Japan requires a map of GCHP system potential. In this study, we developed a heat-exchange rate map, which is the same as a map of GCHP system potential, reflecting subsurface hydrothermal conditions, such as groundwater potentials and subsurface temperatures, estimated by wide-scale groundwater flow and heat transport modeling in collaboration with Kyushu University and Fukui Prefecture. By comparing the potential maps with hydrological and geological conditions, we evaluated the potential for GCHP systems based on the subsurface environments.

Yoshioka et al. (2010) Journal of the Geothermal Research Society of Japan, 32, 241-251 (in Japanese).

Uchida et al. (2010) Journal of the Geothermal Research Society of Japan, 32, 229-239 (in Japanese).

【Application of research results】

We expect the approach used in this study for evaluating the potential for GCHP systems to be applied in other areas where GCHP systems are being considered, providing basic information about suitable GCHP system designs and area-specific operation. The preparation of maps for GCHP system potential in major plains and basins will contribute to the furtherance of these systems in Japan.



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Launch of two research projects aimed at the harmonious development of geothermal power generation and hot springs

Geothermal Resources RG, etc.

【Outline】

Our Institute started two 3-year research projects, supported by the competitive research fund of the Ministry of Environment, to promote harmonious development between geothermal power generation and hot springs: (1) "Experimental study of the development of an advanced geothermal reservoir management system for the harmonious development of hot spring resources", and (2) "Development and demonstration of a small-grid power generation system using a hot spring heat source".

【Details】

The goal of project 1 is to develop a geothermal reservoir management system for development and operation of geothermal power plants without causing damage to surrounding hot springs. Geothermal system modeling, various kinds of monitoring, and reservoir simulation will be conducted on Hachijo Island and at other test sites. We will investigate effective combinations of modeling, monitoring and simulation for both geothermal power plants and surrounding hot springs. Project 2 involves testing a demonstration power plant that uses a Kalina-cycle power generation system with hot spring water at Matsunoyama Spa, Niigata Prefecture. To optimize this demonstration plant we will also model hot spring systems and study methods for controlling scaling.

【Application of research results】

Project 1 will give reassurance on development of geothermal power plant to the owners of surrounding hot springs, and lead to promotion of geothermal power plants. Project 2 will lead the way toward utilizing the thermal energy of high-temperature hot springs as a local energy source and be an example of local CO₂-reducing activities.

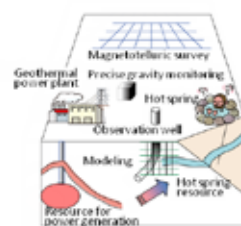
Collaborators

Project 1: AIST (leader), Hirosaki University, Tokyo Electric Power Services Co., Ltd., Nittetsu Mining Consultants Co., Ltd., Hachijo Town

Project 2: Geothermal Energy Research & Development Co., Ltd. (leader), AIST, Hirosaki University

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Development of Advanced Geothermal Reservoir Management System



The key for harmonious development between geothermal power plant and hot springs is **balancing heat and water budgets.**

Overview of "Experimental study of development of an advanced geothermal reservoir management system for harmonized development with hot spring resources" project.

International critical-metal research activities

T. Takagi, H. Murakami, K. Sanematsu, M. Hoshino, Y. Kon, Mineral Resources RG;
Y. Watanabe, Principal Research Scientist

【Outline】

To address the recent serious rare-earth-element (REE) shortage for Japanese industries, which is mainly attributed to China's export limit, a Memorandum of Understanding regarding mineral exploration was concluded between AIST, the Japan Oil, Gas, and Metals National Corporation (JOGMEC), and the Mongolian Government, in accordance with the resource diversification policy of Japan. These three parties have started a joint geological survey in Mongolia beginning this year.

The Mineral Resources Research Group organized a session on critical-metal research at the 2010 Annual Meeting of the Geological Society of America (GSA) held in Denver, Colorado (USA) and has taken the initiative in the critical-metal researches.

【Details】

To ensure the REE supply from sources other than China, we conducted a preliminary field survey in the southern Gobi Desert to estimate the REE resource potential of the area. In FY 2010, we surveyed deposits at Lugin Gol, Mushgai Khudag, and Hanbogd and determined that prospects at the first two occur closely with alkaline igneous rocks, and at the third with granite pegmatite.

At GSA 2010, Dr. Yasushi Watanabe organized technical session number 132 on critical-metal research with Prof. Murray Hitzman (Colorado School of Mines); 13 oral presentations (including six by AIST members) were given at the session. The advanced research results, e.g., critical-metal supply-demand structure, the genesis of ore deposits, and the laser-ablation analytical technique, attracted the attention of researchers worldwide.

【Application of research results】

- Cooperation with Mongolia is an important national strategy for ensuring REE suppliers other than China and a stable supply of critical metals.
- Advanced research and the exchange of information with world specialists enable us to develop more practical mineral exploration guidelines.

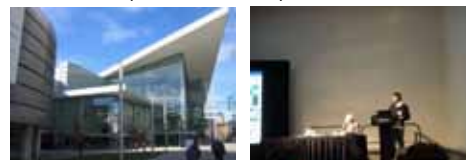
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(Left) Discussion between the delegations of Japan side (AIST and JOGMEC) and the Mineral Resources Authority of Mongolia (MRAM). (Right) Representatives of MRAM, Dr. Yano (GREEN Director) and Mr. Moriawaki (JOGMEC Trustee) signed the specific agreement.



Field survey in the southern Gobi Desert (October 2010).



Dr. Yasushi Watanabe (right) presenting a talk at the GSA 2010 annual meeting in the Colorado Convention Center (left).

Promotion of research on CO₂ geological storage, including initial collaboration with national institutes in the United States

CO₂ Geological Storage RG, etc.

【Outline】

To provide technical support for the practical use of CO₂ geological storage, we have launched joint research projects on safety evaluation with national research institutes under the U.S. Department of Energy, and the Ministry of Economy, Trade and Industry (METI) has been engaged in a large-scale demonstration project aimed at implementing CO₂ geological storage.

【Details】

- We have started the following METI-commissioned research works,
- Development of cost-effective geophysical monitoring tools (with Los Alamos National Laboratory, USA)
- Development of fault modeling techniques including geomechanical processes (with Lawrence Berkeley National Laboratory, USA)

The objectives of these joint research projects with U.S. institutes are to develop cost-effective and multilateral monitoring tools that can be used to complement seismic surveys, and also to develop modeling techniques to incorporate geological deformation and geomechanical processes into a numerical simulation model for predicting long-term CO₂ behavior.

In addition, we have promoted technology exchanges and the dissemination of our research and development results. For example, a poster entitled "The long-term safety assessment technology of CO₂ geological storage" was displayed by Masao Sorai and others at the AIST "Open Lab" event in October 2010 and won the "Excellent Poster Presentation Award". The 3rd joint workshop with the Korea Institute of Geosciences and Mineral Resources (KIGAM) was held at AIST (Tsukuba) in December 2010.

【Application of research results】

Putting CO₂ geological storage into practical use requires the development of effective monitoring technology and assessment of the safety of stored CO₂. We expect to provide basic technologies and information that contributes to this end.

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A candidate field for a demonstration project in the USA.



The 3rd joint workshop with KIGAM.

Methanogenic pathway in a petroleum reservoir

D. Mayumi, H. Yoshioka, M. Takeuchi, S. Sakata, Geomicrobiology RG

[Outline]

We demonstrated that the methanogenic pathway in a deep subsurface petroleum reservoir is syntrophic acetate oxidation coupled with hydrogenotrophic methanogenesis (Fig. 1).

[Details]

We performed high-temperature and high-pressure incubation experiments using production water and crude oil from the Yabase oil field (Akita Prefecture, Japan), mimicking the *in situ* reservoir conditions. The experiments showed methane production with a decrease of acetate originally in production water (Fig. 2). Furthermore, radioisotope tracer experiments showed that the rates of hydrogenotrophic methanogenesis were higher than those of acetoclastic methanogenesis in production water after incubation (Table 1). Microbial community analyses based on the 16S rRNA gene revealed the dominance of syntrophic acetate-oxidizing bacteria and hydrogenotrophic methanogens (Fig. 3).

Mayumi et al. (2011) Evidence for syntrophic acetate oxidation coupled to hydrogenotrophic methanogenesis in the high-temperature petroleum reservoir of Yabase oil field (Japan), Environmental Microbiology (in press).

[Application of research results]

This study provides important data useful for stimulating methanogenesis that normally proceeds slowly in petroleum reservoirs. The data can be used for development of new technology for recovering fuel energy as methane from depleted oil fields.

[Collaborative research scientists]

H. Maeda, Y. Miyagawa, M. Ikarashi (INPEX Corporation),
H. Mochimaru (International Patent Organism Depository),
Y. Kamagata (Bioproduction Research Institute, AIST).

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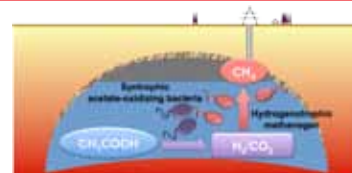


Fig. 1: Methanogenic pathway in a petroleum reservoir.

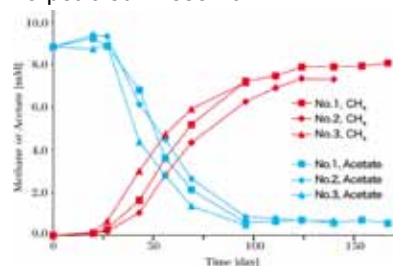


Fig. 2: Methane production during three replicate high-temperature and high-pressure incubations.

Table 1: Methanogenic rates estimated by radioisotope tracer.

Methane production phase (day)	Residual substrate concentration (mM)		Rate of methanogenesis (mmol l ⁻¹ day ⁻¹)	
	HCO ₃ ⁻	CH ₃ COO ⁻	Hydrogenotrophic	Acetoclastic
Early stationary phase (day 96)	44.2	0.48	112.3	1.63



Fig. 3: Microscopic image of incubated production water: (green) syntrophic acetate-oxidizing bacteria and (red) hydrogenotrophic methanogens.

AIST President Award: Development of Geo-environment Risk Assessment System and Its Contribution to Society

T. Komai, Y. Kawabe, J. Hara, Y. Sakamoto, Geo-environment Risk RG; H. Sugita, Geo-analysis RG

[Outline]

Our group developed the Geo-environment Risk Assessment System, GERAS, which can assess human risks due to soil contamination. GERAS greatly contributes to industry and society for risk management and communication.

[Details]

The development of three types of modules - comprehensive, site-specific and detailed models - in GERAS has been accomplished for soil contamination assessment R&D during the AIST Second Midterm Plan.

The contribution to industry and society is a typical success of this project as a *Full Research*, in which we finally completed a product of GERAS by means of an integrated process of geosciences, environmental sciences and risk sciences. GERAS has been distributed to more than 1000 factories and laboratories to become a standard assessment tool in the Japanese government.

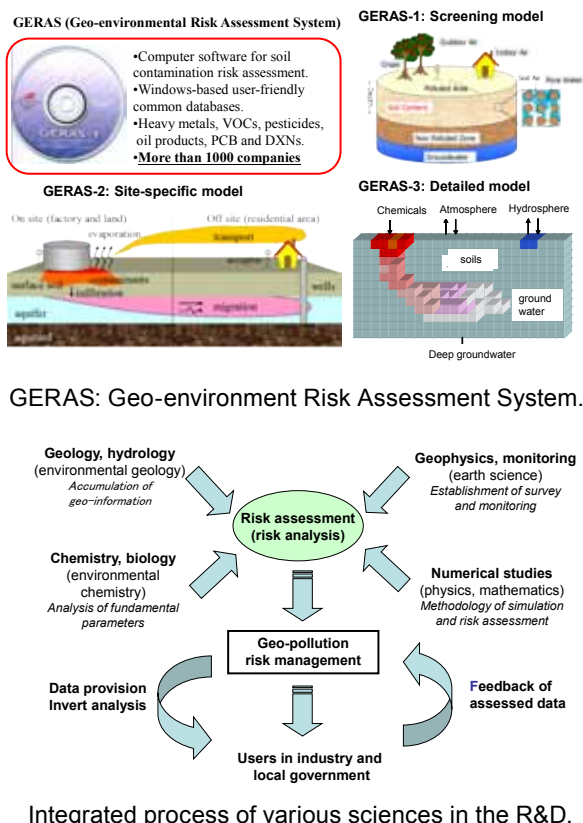
[Application of research results]

The following examples show practical applications of GERAS in industry and society:

- Site assessment tool for contaminated lands.
- Assessment method for risk mitigation and economical risk reduction.
- Introduction of risk assessment system into legal and social systems.

* The AIST President Award is given to an AIST researcher (or a research team) who has achieved the most prominent research result in the year.

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Integrated process of various sciences in the R&D.

Development and application of technologies for *in situ* remediation of polluted soils and groundwater

M. Zhang, M. Yoshikawa (Collaborative research scientist), J. Hara, T. Komai, Geo-environment Risk RG; M. Takeuchi, Geomicrobiology RG; Y. Imoto, Geo-analysis RG; M. Hoshino, Mineral Resources RG

【Outline】

R&D toward practical application of the technologies associated with *in situ* remediation of polluted soils and groundwater was promoted through technology integration and collaborative research.

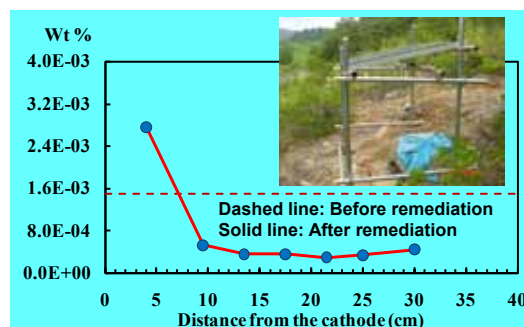
【Details】

We have developed an approach for on-site characterization of heavy-metal pollution and successfully performed a pilot test using solar energy to remove heavy metals such as cadmium from a polluted site. Current studies are focused on how to increase cost efficiency and reduce environmental impacts for practical application of the electro-kinetic remediation technology.

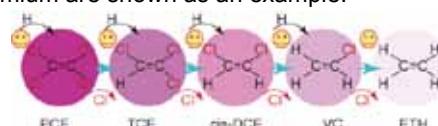
In addition, we have been developing technologies for *in situ* bioremediation of volatile organic compounds (VOCs), especially chlorinated ethenes. We have identified fundamental environmental conditions for the survival of *Dehalococcoides* bacteria, the only known bacteria that can completely degrade perchloroethylene (PCE) and trichloroethylene (TCE) to ethene. Studies continue on how to decrease the effects of factors limiting the efficiency of biodegradation for the effective design and practical implementation of bioremediation.

【Application of research results】

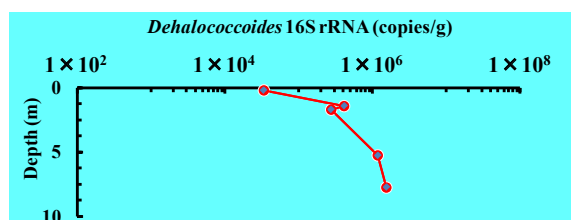
More than 400,000 sites in Japan are polluted by heavy metals and/or VOCs. Technologies developed in this study can be used to clean up contaminated sites with low cost and low environmental impact, and can facilitate risk management.



A pilot test using solar energy for electro-kinetic remediation of heavy metals *in situ*. Data for cadmium are shown as an example.



A pathway of reductive biodegradation.



Distribution of 16S rRNA of *Dehalococcoides* spp. at a contaminated site.

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Development of an on-site measurement method for oil-contaminated soil core samples by nuclear magnetic resonance

Y. Nakashima, Exploration Geophysics RG

【Outline】

Non-destructive on-site measurement methods for contaminated soil cores are needed to quickly evaluate the degree of contamination. To meet this need, we applied proton nuclear magnetic resonance (NMR) relaxometry to oil-contaminated soil cores and successfully detected the contaminated core portions and quantified the heavy oil component in the cores.

【Details】

We measured the NMR transverse relaxation of soil core samples from an oil-contaminated site using a low-field NMR system (Fig. 1). The proton transverse relaxation time and initial signal amplitude were plotted for each sample (Fig. 2). Through calibration, the signal amplitude for clean and oil-contaminated samples can be converted into the water volume fraction and oil weight fraction, respectively. Data points for the oil-contaminated core portions are clearly distinguished from those for the clean portions (Fig. 2). This is a consequence of the simple and robust physics that the relaxation time of viscous heavy oil molecules is shorter than that of the less viscous water molecules.

Nakashima et al. (2011) Water Air & Soil Pollution, 214, 681-698.

This study was financially supported by the Ministry of the Environment, Government of Japan.

【Application of research results】

The system shown in Fig. 1 is portable, and this method is useful for the non-destructive, quick, on-site measurement of cores before the time-consuming, destructive measurements in laboratories far from the site.



Fig. 1: NMR apparatus with a soil core. About 4 minutes were needed to measure each core portion.

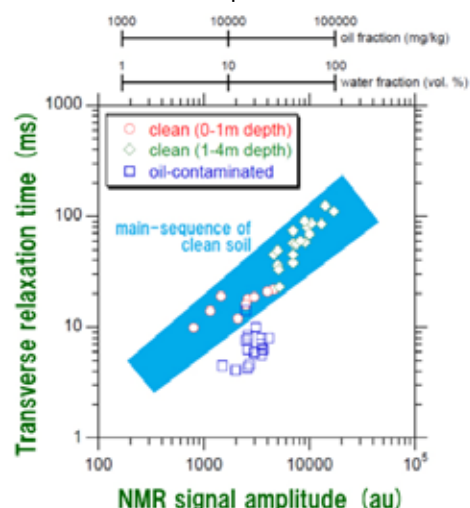


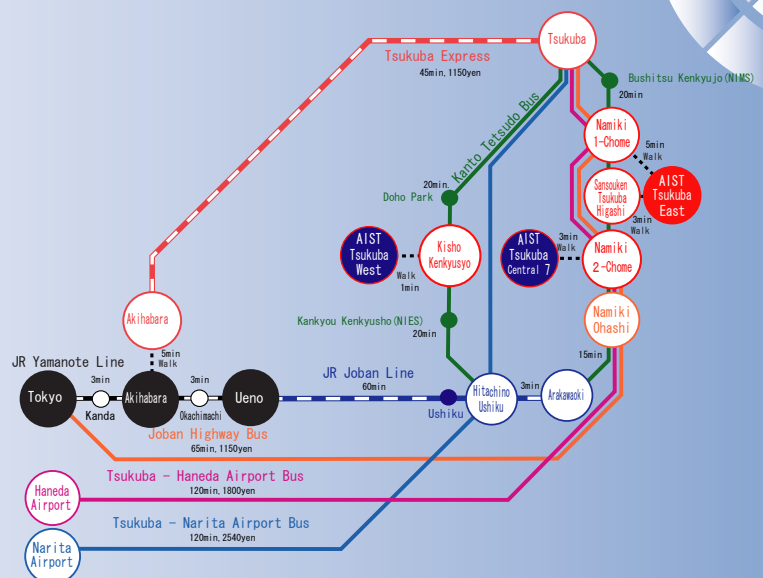
Fig. 2: Plot of 44 NMR data points. The clean sample data points are divided into two groups on the basis of the sampling depth.

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Research Groups

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

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



Ten Big News Items