International Research Institute of Disaster Science, Tohoku University
災害科学国際研究所 IRIDeS

Knowledge of disaster science for a secure and prosperous future

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Feature Articles

Breaking News

Story
Towards the Tohoku of the Future

On-site investigation by IRIDeS emergency survey team

In July 2013 torrential rain fell on Yamagata Prefecture. The area of Kaoyoshiotsu in Oe Town, Nishimurayama District, suffered damage including failure of embankments and destruction of farmland. The destruction is believed to have resulted from upstream waters collecting in a narrow area of the Tsukinuno River where it flows through a meandering valley, resulting in scouring of the embankments. In this special issue, we describe the torrential rain disaster of Akita and Iwate Prefectures of August 2013 and the emergency investigation that followed.

Photo and text: Daisuke Sugawara, Jeremy Bricker (International Research Institute of Disaster Science, Hazard and Risk Evaluation Research Division) (Photo taken: July 22, 2013)

Feature Article 1

Disasters exceeding previous experience and forecasts: Interdisciplinary research teams confront challenges through investigations and research

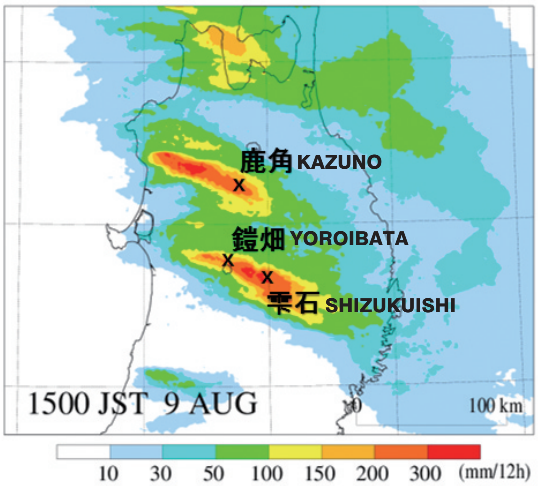
- Akita/Iwate Torrential Rain, August 2013: Emergency Investigation -

(Photo 1) August 12: Akita Shinkansen running at reduced speed, following emergency repairs (Photo courtesy of Shizukuishi Town)

Disaster due to unprecedented torrential rain: IRIDeS emergency survey team dispatched

Meteorological phenomena including heat waves, heavy rain and drought were continuously in the news this past summer. The torrential rain in the Tohoku region (Map 1) on August 9 caused loss of life and great damage to property, agriculture and forests, as well as public infrastructure.

Torrential rain is known to occur when local conditions combine with continental-scale atmospheric circulation in a very complicated process. In addition to rainfall amount and intensity, flooding is influenced by river basin terrain, geological features and vegetation, and also by human activity (how land was used in the past). To mitigate damage due to heavy rain, it is necessary to clarify the causes of damage and to take multifaceted disaster mitigation and reduction measures.



▲(Fig. 1) Rainfall distribution in Akita/Iwate on August 9, 2013 (courtesy of the Meteorological Research Institute, Japan Meteorological Agency). Due to the water temperature of the Japan Sea being about 1～2℃ higher than normal, unusually moist air blew into Akita and Iwate, bringing local downpours.

Confronting complex disasters caused by unprecedented rainfall requires a broad interdisciplinary initiative encompassing various fields of expertise. The International Research Institute of Disaster Science (IRIDeS) at Tohoku University dispatched an emergency disaster survey team immediately after the torrential rain to the prefectures of Yamagata, Iwate and Akita. The team comprised experts from the fields of disaster mitigation, water engineering, geotechnical engineering, geology, meteorology, disaster medical care, and conducted the survey on August 14 and 15. An account of their findings is given here.

Living close to the river banks of class B rivers, tributaries, and mountain streams: flood damage on a local scale.

When Shizukuishi, Iwate Prefecture, was hit by a cascade-like downpour of 78 mm/hour (the highest ever recorded), bridge damage (photos 2 and 3), road erosion and slope collapse of agricultural land and forest roads occurred, temporarily isolating many villages.

The torrential rain in Tohoku on this occasion brought widespread damage to many areas simultaneously. Much of the damage occurred at a local level: class B rivers and tributaries, waterways and mountain streams and slopes, and roads and railways. Nationwide, there are countless places like these, too many for the state to build protective measures for. Thus, there is a need to grasp the extent of vulnerable areas and to make priorities for damage limitation and protection.

▶(Photo 2) Collapsed pier at Yabitsu Bridge (Shizukuishi, Iwate Prefecture). Analysis after the survey indicated a river flow speed of over 5m/s at the time of collapse.

▲(Photo 3) The Ryu River (Shizukuishi, Iwate Prefecture), normally known for mountain stream fishing. Trees and driftwood caught on bridge girders illustrate the intensity of the flood.

▶(Photo 4) After a large-scale collapse of the upper slope, the landslide entrained topsoil and trees, reaching as far as an area occupied by houses.

No disasters have occurred in designated mudslide hazard areas in recent years. Has this fact influenced evacuation behavior?

The fatalities caused by the Akita/Iwate torrential rain (6 victims in Akita, 2 in Iwate) were principally due to landslides.

In Kuyōbutsu Tazawako Tazawa, Senboku City, Akita, there was a large-scale slope failure (photo 4). The mudslide dragged trees (mainly cedar) into the flow, spilling out over a wide area. The escarpment height differential was about 100m and the angle of the slope was about 20-30°. From the form of the mudflow, it was estimated that the soil was very fluid when wet. It is also thought that a road located above the village (at the base of the slide) guided the direction of the mudflow.

The collapsed portion and spill-out area is located in a basin (valley-like terrain where not only surface water but also ground water collects easily), and the area was designated as a potential mudslide location in a hazard map produced by Senboku City. However, although flood damage has frequently occurred in this area, according to Tazawako Office, Senboku City Hall, there had recently been almost no damage due to landslides and this may have negatively affected the evacuation behavior of residents.

Torrential rain disasters are becoming more frequent. Risk awareness must be improved and preparations made in advance.

The following summarizes knowledge gained in the mudslide disaster survey after the Akita/Iwate torrential rain, together with lessons learned and issues remaining.

Damage may exceed past disaster experiences

Landslide disasters have the characteristic of repeatedly occurring in the same places, so it is important to gain knowledge of past disasters that will be useful in the future. However, with localized torrential rain, past experience may have only limited usefulness. In particular, in a watershed where precipitation differs from normal, the possibility of a landslide disaster must always be considered.

How to alert residents into taking "life-preserving action"?

In general, during localized torrential rain the risk of landslide increases, and a significant correlation is observed between precipitation distribution and landslide locations. However, at a local level, on a scale smaller than that of municipalities, it has become difficult to accurately predict where and how much rain will fall.

With floods, evacuating upwards to higher ground is effective, but with landslides it is necessary to get away from a hazard area. However, there may be situations where such evacuation may not be feasible due to heavy rain and flooded roads. In order to alert people to take life-preserving action, it is important to communicate measures considering the normal state of rivers and slopes, and experience of past disasters with heavy rain. Attention must be paid to warnings regarding river flooding and landslides during torrential rains, and to actions including taking refuge at a community level at an early stage. Consequently, specialist knowledge and technology must be integrated in future research.

Influence of 2011 Tohoku-oki Earthquake

In Hanamaki City, Iwate Prefecture, in neighborhoods where slope collapse occurred during the rainstorm, residents confirmed that there had been ground displacement such as small fissures at the time of the Tohoku-oki Earthquake of March 11, 2011. These scars of the quake weakened the ground, suggesting that they may be present in various regions, and making it urgent to establish methods for landslide disaster evaluation giving consideration to post-quake long-term effects.

Coincidently, while drafting this article in mid-October 2013, a massive typhoon No. 26 struck Japan, bringing record rainfall to many areas and causing a large-scale mudslide in Oshima Town on the island of Oshima, south of Tokyo. The large number of typhoons this year and the torrential rain of Akita/Iwate were both mainly due to the sea temperature being higher than normal. Careful investigation is needed to decide whether this rise in sea temperature is due to global warming, but there is no doubt that the latter is an important factor in the unusual weather.

Living on this planet inevitably means an engagement with nature, including natural disasters. The investigation of calamities from a composed scientific perspective must be a source of encouragement for humanity. In this regard, the International Research Institute of Disaster Science (IRIDeS) at Tohoku University continues to offer its wisdom and zeal in advancing disaster mitigation and reduction.

Disaster survey team members:
Fumihiko Imamura (Professor; Deputy Director, International Research Institute of Disaster Science),
Jeremy Bricker (Associate Professor), Kentaro Imai (Assistant Professor), Daisuke Sugawara (Assistant Professor), Shuichi Kure (Assistant Professor), Hiroyuki Kimura (Research Associate) (all belonging to the Hazard and Risk Evaluation Research Division);
Shuji Moriguchi (Associate Professor), Carine Yi (Assistant Professor) (both belonging to the Regional and Urban Reconstruction Research Division);
Yugo Ashino (Associate Professor) (Disaster Medical Science Division), Miwa Kuri (lecturer, Disaster Information Management and Public Collaboration Division)

Acknowledgement: Special thanks for their understanding and support are extended to the Disaster Task Force, Senboku City, Akita Prefecture, and to the Regional Development Construction Division, Kazuno City, Akita Prefecture.

Breaking News

Typhoon No. 30 (Typhoon Haiyan) IRIDeS secondary on-site survey report

(Photo 1) Leyte Convention Center – an evacuation facility where strong winds caused the roof to collapse.

Survey carried out after the disaster in the Philippines.

The ferocious Typhoon No. 30 (Typhoon Haiyan, meaning "storm Petrel" in Chinese) that crossed the Philippines on November 6 to 9, 2013, caused great devastation in various regions due in particular to high waves and a storm surge centered on Leyte and Samar Islands. As of January 14, 2014, the number of confirmed casualties stood at 6,201 dead, 28,626 injured, and 1,785 missing.

Soon after this unprecedented disaster, the International Research Institute of Disaster Science of Tohoku University organized a "Philippine typhoon disaster task force team" under the direction of Arata Hirakawa, Director, and lead by Fumihiko Imamura, Deputy Director. The team gathered information including quick estimation of the extent of flooding (Figure 1) and damage to buildings using satellite information. They also surveyed the medical situation on the ground and made an assessment of the risk of infectious disease outbreaks. Numerical simulation of the large waves and storm surge were also performed. Together with this initial analysis, an emergency primary survey was carried out (to gather information and build cooperative relationships) in the Philippine capital, Manila, from December 3 to 7, 2013, and secondary on-site surveys were done on Leyte and Samar Islands from January 16 to 24, 2014. The survey task force included a "coastal damage estimation team" from the Hazard and Risk Evaluation Research Division of IRIDeS, and a "disaster medical treatment survey team" from the Disaster Medical Science Division.

Transfer of disaster mitigation strategies from disaster-prone Japan to implement sustainable development abroad

The following summarizes knowledge gained in the mudslide disaster survey after the Akita/Iwate torrential rain, together with lessons learned and issues remaining.

(1) Why was the scale of the damage so large? – Population concentration along the coastal regions.

Reasons for the scale of the damage include the fact that many poor people live in these areas not only because of convenience for daily living and for those involved in the fishing industry, but also because paying land rent can be avoided by building homes on government owned land along the coast. Furthermore, this was the largest typhoon in recorded history, and it took the worst possible path, bringing very high winds and storm surges to densely populated areas.

(2) Why did the residents not evacuate? – Societal problems (poverty) and lack of understanding of the term storm surge.

The Philippine Meteorological Service PAGASA issued a storm surge and high wave warning, but many adult males did not evacuate due to worries that their homes would be broken into while unoccupied. Also, it is thought that evacuation behavior was affected by the term storm surge not being properly understood.

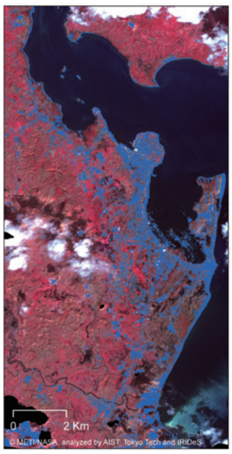
(3) What was the reason for the damage at places of evacuation? – Inadequate and vulnerable evacuation facilities.

In many cases the evacuation locations themselves were in flooded areas or in inappropriate locations. Some were vulnerable to strong winds, with roofs being blown off (Photo 1). If robust evacuation facilities had been provided the casualties would probably have been lower.

(4) What caused the large disparities among the evacuation locations? – Poor hygienic conditions in evacuation locations, disaster-related infectious diseases, and disaster-related stress.

While some disaster victims have begun living in temporary housing under the direction of the Philippine Department of Public Works and Highways (DPWH), others are still living in very poor conditions (Photo 2). Relief supplies have not reached all those in need, nor has information on how to obtain aid, and as the period of evacuation becomes long, the risks to health increase. Extensive humanitarian aid and support is required, including assistance to hospitals.

The Philippines is a country that has confronted many natural disasters, including earthquakes, volcanoes, typhoons, floods, and landslides. For reconstruction and restoration to be implemented at the earliest possible stage after the current disaster, and in preparation for future disasters, the International Research Institute of Disaster Science has an important part to play. The Institute will continue with its efforts to encourage sustainable development in the Philippines and to provide a bright future for the children of that country.



(Figure 1: The area inundated by a storm surge around the City of Tacloban is evident from analysis of satellite images. (Images provided by: Shunichi Koshimura, Erick Mas, Bruno Adriano and Hideomi Gokon (International Research Institute of Disaster Science), Masashi Matsuoka and Liu Wen (Tokyo Institute of Technology)).

(Photo 2): Inside a tent for disaster victims in the coastal region, set up by UNHCR (Office of the United Nations High Commissioner for Refugees). The tent has no floor and only a ground sheet is provided.

"Practical Disaster Mitigation" aiming at a society resilient against disaster and flexible in recovering from adversity

We spoke to Professor Takeshi Sato about forming and systematizing Practical Disaster Mitigation

▶(Photo 1) The "Ishinomaki City Support Project", Disaster Reconstruction Implementation, Disaster Information Management and Public Collaboration Division, has organized a design team of researchers specializing in disaster mitigation for civil engineering works, buildings and towns. The team provides advice to government and consultant firms regarding reconstruction plan revision proposals and solution strategies for tackling difficult problems. The photo shows an explanatory meeting for residents of Ogatsu town. (Photo provided by Associate Professor Katsuya Hirano)

Practical Disaster Mitigation: Applying what has been learned from the disaster to society and daily living

The Tohoku Pacific Earthquake and accompanying huge tsunami were disasters that inspired a sense of awe at the power of nature. The natural world, which constantly provides us with blessings, can be an unpredictable threat that human society must confront.

The International Research Institute of Disaster Science (IRIDeS), which is now approaching the third anniversary of its foundation, refers to a "disaster cycle" comprising the sequence: advance preparation, disaster occurrence, spread of damage, emergency response, recovery and reconstruction, and future disaster reduction measures. IRIDeS is investigating and carrying out research on phenomena associated with each stage in this cycle. By applying the knowledge thus accumulated to society and daily living, we believe it possible to respond rapidly and wisely to complicated disaster cycles and to provide strength to overcome hardships.

Based on this, IRIDeS has the goal of systematizing "Practical Disaster Mitigation", a new field for building a societal system resilient against disaster and flexible in recovering from adversity.

For problems difficult to solve within single academic fields, we must combine theory, technology and action, transcending conventional frameworks.

In building this "Practical Disaster Mitigation", the following 3 keywords are important:

(1) Practical Implementation

The towns damaged in the Great East Japan Earthquake all possess their own cultures and histories, environments, and industrial establishments, and town reconstruction requires creativity to reflect this background. Ideally, time should be taken in carrying out surveys and forming plans, but in disaster reconstruction, urgency is essential.

For on-site reconstruction, IRIDeS researchers, with knowledge of urban development and practical experience prior to the disaster, can carry out constructive discussions with various stakeholders (individuals and organizations directly or indirectly affected) and implement sustainable reconstruction plans (See Photo 1).

(2) Interdisciplinary Research

Through observation and analysis, basic research into earthquake and tsunami generation mechanisms has indicated the regularity of such phenomena even though they are not artificial events. Since natural phenomena affect or may affect people and their daily lives, disaster risk reduction and mitigation are essential.

In Practical Disaster Mitigation it is anticipated that new knowledge will be created by combining the theories, technologies and actions of researchers with individual specialties in the natural sciences, medicine and sociology. For research domains in which solutions are difficult within single academic fields, IRIDeS is promoting studies in Practical Disaster Mitigation through interdisciplinary research integrating multiple fields.

(3) Collaboration

Research and practice are being actively performed through collaboration within the institute, among universities, across international borders, and in industry-government-academia groups, in addition to the interdisciplinary research described above. Embracing views and knowledge from multiple standpoints is essential in building and systematizing Practical Disaster Mitigation.

On pages 3 and 4 below, specific projects linking industry, government and academia (and in some cases, the private sector) are introduced.

The Disaster Information Management and Public Collaboration Division has the role of connecting the research divisions of IRIDeS with disaster areas. As part of reconstruction education and disaster mitigation education for children, Professor Sato is presently involved in the development of material for learning about the natural environment as well as the history and climate of their home region, based on interdisciplinary practical research. This is a first step in teaching that disaster mitigation is not someone else's problem but one's own. It is hoped that this will lead to lifelong learning for adults also.

Assistance and cooperation provided by Professor Takeshi Sato (International Research Institute of Disaster Science, Tohoku University)

みちのく震録伝
東北大学アーカイブプロジェクト

Leaving a secure record of disaster memories. Connecting past experience to the future as human wisdom.

- Great East Japan Earthquake Archive Project: *Michinoku-Shinrokuden* -

(Photo 1): On January 11, an international symposium with the theme of earthquake disaster archives was co-hosted with the National Diet Library. International and national case studies were reported, and discussions held on themes concerning regional memory for building the future. The photo shows Associate Professor Shibayama on the podium.

Collaboration among over 120 organizations from industry, government, academia and the private sector. Documenting images of the earthquake disaster as it happened.

Three years have passed since the Great East Japan Earthquake. The situation of the disaster region as reported by newspapers and TV cannot be given in a short description of the present state of reconstruction. While there is progress in some regions in community and local economic recovery and in rebuilding residents' daily lives, other places are still searching for hope and a vision of the future. The fading of memory as time passes is beginning to affect disaster regions under construction. Continuing interest in the disaster is of great importance in learning lessons from what happened and nurturing disaster risk reduction awareness.

The International Research Institute of Disaster Science (IRIDeS) of Tohoku University is collaborating with over 120 organizations from industry, government, the private sector, and academia (including Harvard University) to collect and share both nationally and internationally various types of memories, records, case studies and knowledge related to the Great East Japan Earthquake, and to develop *Michinoku-Shinrokuden*, an archive of the Great East Japan Earthquake as a link to the future. Using records collected from various viewpoints, from historical disasters up to the Great East Japan Earthquake, its aim is to develop cross-disciplinary research, clarifying the actual state of the Great East Japan Earthquake and accumulating knowledge in order to contribute to reconstruction. Consideration is also being given to developing countermeasure management studies for rare but large disasters with a view to application for the predicted Tokai, Tonankai and Nankai earthquakes.

Publishing collected records on the Web – an important information resource in disaster mitigation.

The Michinoku-Shinrokuden archive was begun three months after the Great East Japan Earthquake and now, three years since the quake, about 350,000 disaster records have been archived. The cornerstone of the collection activities is the "Reporting team of *Michinoku* now" that was formed in February, 2012. Their main activities are to employ local residents of 15 municipalities along the Miyagi coastline, and with the cooperation of industrial and private sectors, to investigate and record the present situation in the disaster-affected areas and to gather information to be conveyed to future generations. Photographic records collected by the "Reporting team of *Michinoku* now" include approximately 100,000 items, and valuable records of the earthquake have been gathered from over 3000 people. The members of the team along with IRIDeS researchers have collected not only earthquake records of information provided by residents and disaster victims, but also earthquake records from experts.

In order that the earthquake records do not remain just a collection of data but are widely utilized by those with interest or concern, approximately 100,000 items for which copyright issues have been resolved have been made public on a website. Access and feedback from many people with interest in the Great East Japan Earthquake has become a driving force for the activities of the "Reporting team of *Michinoku* now". In addition, a discussion symposium, *Katari-tsugi*, has been convened as a forum for collecting and sharing words and feelings about disaster reduction activities. The actress Keiko Takeshita has contributed by appearing in-person at symposia.

From 2013 a disaster experience and documentation transmission project of Tagajo City, Miyagi Prefecture, called "Tagajo Information Recollection", has been supported. Several tens of thousands of earthquake records of the city, comprising records of disaster risk reduction activities from before the disaster to records of reconstruction activities after the disaster, have been collected and made public on the website of the city.

The recorded information is a first step in disaster research, but forms a cornerstone for disaster reduction measures. *Michinoku-Shinrokuden* is providing a record of the disaster region as it transforms with each passing moment.

Michinoku-Shinrokuden: http://shinrokuden.irides.tohoku.ac.jp/

Text and photos provided by Akihiro Shibayama (Associate Professor, Disaster Digital Archive, Disaster Information Management and Public Collaboration Division)

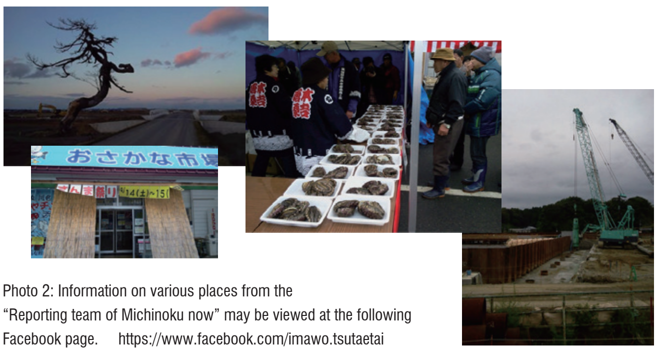


Photo 2: Information on various places from the "Reporting team of Michinoku now" may be viewed at the following Facebook page. https://www.facebook.com/imawo.tsutaetai

Strength for living with disaster makes Japan resilient

- *Strength for Living* Citizens' Movement Project -

Photo 1: A view of the first Strength for Living Citizens' Movement Project Symposium in Tokyo on March 7, 2013. The second symposium was held in Osaka on December 6 of the same year, with "disaster education" as the theme (co-host: Kansai University) and a third symposium is scheduled for February 28, 2014, in Tokyo. The symposia enable exchanges of opinions on improving regional disaster resilience.

Japan is one of the most disaster-prone countries in the world. Japanese people have long lived with various types of disasters and this situation is not going to change. We must be able *to face disaster*, and *to have the right type of fear of disaster*. We must possess the wisdom, energy, resilience and communicative ability to be able to make correct decisions and actions in order to survive when the worst happens. The International Research Institute of Disaster Science (IRIDeS) defines these abilities as *the strength for living with disaster*, and undertakes practical activities for increasing this strength.

As part of its work in the *Strength for Living* Citizens' Movement Project (leader: Fumihiko Imamura) which commenced in January 2013, IRIDeS has produced a compact "Disaster Safety Guidebook" summarizing information such as what type of everyday preparations you should make, and how you should act in order to protect yourself in a disaster. The booklet will be distributed to approximately 25,000 households in Tagajo City, Miyagi Prefecture, and several other municipalities around Japan are also considering doing likewise. Symposia regarding *Strength for Living* are regularly held in order to gather various types of opinions about society and to promote further discussion (Photo 1). By holding the symposia outside of Sendai, it is planned to stimulate networking and communication of the lessons learned from the disaster-affected regions to the whole country.

This project was selected in a "New Tohoku Leadership Model Initiative" promoted by the Reconstruction Agency, and a program is being advanced for developing and improving practical disaster risk reduction aimed as individual residents, with Tagajo City as a model. Following on from the "Disaster Safety Guidebook", IRIDeS is collaborating with the board of education of Tagajo City in developing a practical disaster risk reduction training tool (disaster reduction education tool) called "My Disaster Safety Guidebook" (provisional title) directed at elementary/middle school and high school pupils. A study has also been commenced on disaster risk reduction awareness and a disaster information service system making use of information communication technology. IRIDeS is committing its knowledge and technology in order to cultivate next generation leaders possessing this *Strength for Living*.

***Strength for Living* Citizens' Movement Project**
http://irides.tohoku.ac.jp/organization/infosociety/ikiru.html

"Disaster Safety Guidebook"
(Cabinet Office, Public Relations, Disaster Management)
http://www.bousai.go.jp/kohou/kouhoubousai/h25/72/special_02.html

Text and photo courtesy of Shosuke Sato (Assistant Professor, Disaster Digital Archive, Disaster Information Management and Public Collaboration Division).

Kakeagare! Japan (Get Going! Japan)

Protecting life and locality: practical action for tsunami risk reduction

Photo 2: Elementary school pupils wearing protective hoods rush to the school building of Tamaura Middle School (Tsunami evacuation drill, Iwanuma City, 2012)

Kakeagare! Japan is a project that aims to habitualize evacuation behavior in preparation for a tsunami while tackling regional problems based on the lessons learned from the Great East Japan Earthquake. Tsunami evacuation drill programs are being planned and implemented in collaboration with industry, government and academia, including the International Research Institute of Disaster Science (IRIDeS).

A tsunami drill to practice evacuation to higher elevations was carried out in Iwanuma City, Miyagi Prefecture, in September 2012, making use of artificially built elevated structures such as evacuation towers provided in schools on the coastal plain and along the Sendai East Highway (Expressway) (Photo 2). Many people participated, and after the drill, events were held so that the participants could learn in an enjoyable way about reducing disaster risk.

In Yamamoto town, Miyagi Prefecture, a tsunami evacuation drill using automobiles for the whole town was held in August 2013. Cars were used because high ground and evacuation locations are far away, making it difficult to evacuate on foot. In addition there were many people working on-site in reconstruction projects close to the coastline. Consideration was also given to the fact that when tsunami warnings were issued in the past, traffic jams occurred in many places in the town. Appropriate evacuation routes were investigated in advance, and various strategies used, such as car sharing.

IRIDeS is involved in validation operations for tsunami evacuation drills through cooperation with cities and towns in the planning of drills, in carrying out questionnaires among participants, and in investigating evacuation scenarios. The results are being put to use in regional disaster risk reduction planning.

The *Kakeagare! Japan* project was selected in the "New Tohoku Leadership Model Initiative" promoted by the Reconstruction Agency. With the slogan "tsunami risk reduction to protect lives and localities", and with Kahoku Shimpo, IRIDeS, Dentsu, and Dentsu East Japan as core members, the aim is to provide an effective and practical evacuation drill method as an initiative originating in Tohoku. A detailed list of items for drills along with implementation methods are being set out, giving consideration to local issues and situations, such as terrain and regional characteristics, whether daytime or nighttime, seasonal differences, and methods of support for those who need assistance in evacuating. In this way, various types of tsunami evacuation drill programs can be proposed, with methods selected in accordance with regional goals. Cooperation with municipalities and local residents is important for practical implementation.

Kakeagare! Japan http://kakeagare.jp/

Text and photo courtesy of Yoshi Abe (Research Associate, Earthquake Induced Tsunami Risk Evaluation (Tokio Marine), Endowed Research Division).

Disasters have no borders. Our task is to share the advanced expertise and technology of IRIDeS with the international community.

- Foreign research scientists at IRIDeS: round-table talk -

The Great East Japan Earthquake: The feelings of disaster victims mingle with the views of researchers

Anawat We have here today a group of foreign researchers who are working in the International Research Institute of Disaster Science (IRIDeS). Three years have passed since the Great East Japan Earthquake. In today's group, only myself and Haorile were here in Sendai when the quake struck.

Haorile There are no earthquakes in Inner Mongolia where I come from, so my first experience of how frightening it is when the ground moves was after I arrived in Japan. In contrast I saw how Japanese people living in this earthquake-prone country have become used to quakes. But the earthquake of March 11 2011 was for everyone a terrible event, with confusion even in medical centers where patients could not get adequate treatment and medical supplies were insufficient.

Anawat Three days after the disaster when I visited areas devastated by the tsunami I felt a mixture of emotions – the grief of the victims along with the perspective of a research scientist. Roeber, at that time I believe you were at the University of Hawaii.

Roeber The Hawaiian archipelago, as you know, is located in the center of the Pacific Ocean and is under the constant threat of huge intra-plate earthquakes and tsunamis. Hawaii was the first American state to introduce a tsunami warning system and hazard maps. The Pacific Tsunami Warning Center (PTWC), located on the island of Oahu, monitors earthquakes and tsunamis in the Pacific area. Immediately after the Tohoku Pacific Ocean Earthquake, the PTWC issued a tsunami advisory for the State of Hawaii. At about 10pm on March 10 (5pm on March 11, Japan time), this was raised to alert level and a tsunami warning siren sounded. The following morning before dawn the tsunami arrived, causing much damage to resorts on the west coast of the island of Hawaii (Big Island), as well as harbors, docks and ships on the different islands. Fortunately there were no human casualties.

The significance of carrying out research at IRIDeS, a pioneer in disaster science.

Anawat I would like to ask everyone about their work in IRIDeS.

Kim My field is originally traffic engineering, and my research concerns support for efficient highway and road planning. Since arriving at IRIDeS, my work has dealt with traffic evacuation simulation, that is, predicting what will happen when people evacuate by car during a time of disaster. After the Great East Japan Earthquake there was a lot of debate concerning evacuation methods. Prior to the quake the rules regarding means of transportation recommended not using a car for evacuation. However, when the earthquake struck, many people used cars for reasons such as being unable to escape on foot or the place of refuge being far away. Based on this and on regional circumstances, transportation rules have been revised to accept evacuation by car where unavoidable, while maintaining the general rule recommending evacuation on foot. This has required a new outlook on disaster risk reduction measures. What I am attempting to do is to create a scenario giving consideration to road networks for different areas and car-based evacuation behavior, together with building a simulation system for transportation evacuation. This will provide a rationale when local government is drafting disaster risk reduction plans.

Erick Peru, where I come from, is located on the circum-Pacific seismic belt, and like Japan is an earthquake- and tsunami-prone country. I had an interest in tsunamis and wished to carry out research overseas, so I chose Japan which is at the forefront of world-class research. Coincidentally, my high school was a Japanese Nikkei school, so I was familiar with Japanese culture and mentality. I was fortunate to be able to study at Tohoku University, and after the Chile earthquake and tsunami of 2010 I joined the Japan survey team carrying out on-site investigations. I was happy to contribute even in a small

way to disaster research in my native country. At present I am developing a new evacuation model that integrates numerical simulation of tsunami damage evaluation.

Roeber My study field is ocean engineering, specializing in developing flooding models for hurricanes, high tides and tsunamis, and numerical models for flooding hazards. These are evaluated for suitability to hazards, and are useful when drafting plans for disaster risk reduction and mitigation. The best way to carry out disaster research is to be in the place where an actual disaster occurs. In my native country of Germany, there are no tsunamis. On the other hand, many types of natural disasters occur in Japan, and within Japan, Sendai is a hotspot. By working at IRIDeS with its large amount of accumulated data, I hope to further advance my research.

Haorile After a calamity, infectious disease is a concern as a secondary disaster. Infectious diseases that have existed since ancient times are becoming less of a threat nowadays with the progress of medicine and health science, but with disasters causing environments to change rapidly, the risks are rising sharply. And, it must be added, infectious diseases are still among the top causes of death in developing countries. In order to prevent the spread of such diseases, it is necessary to quickly identify disease type, provide treatment, and then take effective measures to prevent the spread of infection. However, in a disaster situation, available resources are limited. I am carrying out research on a rapid diagnosis system combining various types of information with biomarkers that enable diagnosis of disaster-related infectious diseases.

Anawat I originally studied civil engineering and specialized in flooding. I moved to tsunami research after the Indian Ocean tsunami of December 2004. I decided to study at Tohoku University where tsunami research is being undertaken with an engineering approach, and I was able to come to Japan in October 2007. After joining IRIDeS, in addition to previous research, it was necessary to build a human network both within Japan and overseas. In order for our research to be utilized in ↗

Anawat Suppasri
Earthquake induced Tsunami Risk Evaluation (Tokio Marine) Endowed Research Division
Associate Professor
Thailand

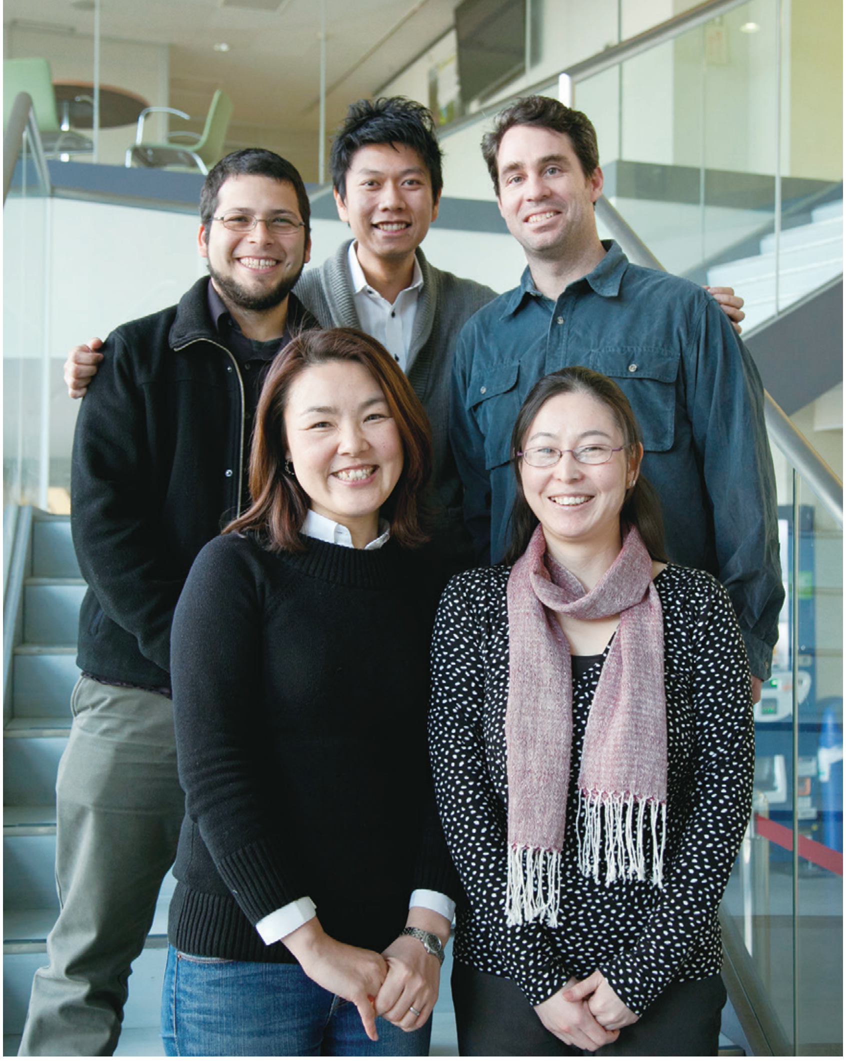
Erick Mas
Remote Sensing and Geoinformatics for Disaster Management, Hazard and Risk Evaluation Research Division
Assistant Professor
Peru

Jinyoung Kim
Affected Area Supportology
Human and Social Response Research Division
Assistant Professor
Republic of Korea

Haorile Chagan-Yasutan
Disaster-related Infectious Disease
Disaster Medical Science Division
Assistant Professor
Inner Mongolia

Volker Roeber
Technology for Global Disaster Risk
Hazard and Risk Evaluation Research Division
Assistant Professor
Germany

➚ disaster risk reduction strategies for daily life and for society, collaboration with other universities, local governments, enterprises, and other researchers is essential. In the same way, IRIDeS is promoting inter-disciplinary research, crossing over specialist boundaries. How do you feel about this point?



Foreign Researchers can form a bridge between IRIDeS and the world

Erick Up to how I have carried out research from an engineering perspective, but in modeling complicated human behavior during an evacuation, it is necessary to consider sociological and psychological aspects also. Discussions with researchers in different disciplines in IRIDeS have been very useful concerning perceptions and behavioral science regarding why people do not evacuate, why they evacuate on foot, or why they use cars.

Kim My work makes reference to previous research and expertise from different disciplines, such as travel data obtained from cars, prediction data of flood depth and flow speed for tsunamis, etc. I have had discussions with Erick. Even with the same goal of mitigating human casualties, it is of great interest to have different approaches.

Anawat Advocating practical disaster risk reduction, IRIDeS is aiming to open up to the world the expertise learned from the Great East Japan Earthquake as shared wisdom for humanity. I would like to ask each of you about your goals as a researcher.

Haorile While the risk of infectious disease is fortunately low in Japan, there is an opinion that infectious disease could spread due to future climate change or the increased movement of people accompanying globalization. Meanwhile in many developing countries public health is still a major problem. If technology enabling rapid diagnosis of disaster-related infectious disease could be established it would be of great use not only in times of disaster, but also more generally in countries and regions where infectious disease is endemic. I feel this is my mission and my duty as a researcher.

Kim As I mentioned earlier, I am working on research for modeling of driver decision-making and behavior at times of evacuation, in addition to studying traffic evacuation simulation for individual towns and villages. This effort is a very subtle matter not seen in other countries and regions. When communicating unique Japanese viewpoints and ideas on such matters to the world, I believe that the intuition, culture and of course language abilities of foreign researchers are very useful.

Erick Whenever a disaster occurs, the transportation network is cut and vital support cannot reach the places where it is needed. I envisage combining satellite and airplane image observation with spatial information processing technology and numerical simulation to realize technology for comprehending damage on a wide scale, so as to enable appropriate deployment of relief aid and supplies. There are many regions in Japan where the risk of an earthquake is high, and similarly there are many countries and regions in the world where a huge disaster may strike. Since disasters don't have borders, we must create a mechanism to enable sharing of this technology among the international community.

Roeber At present we are in the process of gathering and analyzing data to fully comprehend the damage suffered by the Philippines when typhoon Haiyan (typhoon no. 30) struck last November. Based on this, we hope to make progress in clarifying the relationship between structural damage and human casualties. In recent years, advanced computer technology has enabled simulation to be undertaken for many disasters throughout the world. In this regard, in order to advance research that is truly useful and practical, we must leverage the interdisciplinary collaboration which is one of the strong points of IRIDeS.

Anawat Last December was the 9th anniversary of the Indian Ocean tsunami. By surveying the present state of various disaster regions in Thailand, Indonesia and Sri Lanka, and focusing on certain reconstruction problems, I believe we can gain knowledge that is useful for regions struck by the Great east Japan Earthquake where reconstruction is underway. In expanding its international network, IRIDeS is strengthening collaboration with the University of London and the University of Hawaii. As Erick said, disasters have no borders. In building a disaster-resilient international community, foreign researchers like us in IRIDeS have a very important role to play.

Front Line Research 01

Professor Shimada is involved in the revision of a regional disaster plan for Kami-machi, Miyagi Prefecture. The photo shows a meeting with the administrative district chief.

Akio Shimada

Professor; Deputy Director of Public Law and Policy (School of Public Policy), Graduate School of Law; and Disaster Legislation, Human and Social Response Research Division, International Research Institute of Disaster Science (Concurrent), Tohoku University.

Akio Shimada graduated from the Department of Economics, Faculty of Economics, the University of Tokyo. He was employed as a senior government official in the Ministry of Construction (currently the Ministry of Land, Infrastructure, Transport and Tourism). His work concerned drafting public law and policy for the National Land Agency, the Ministry of Foreign Affairs (as First Secretary, Embassy of Japan in the UK), the Cabinet Office, and the Ministry of Land, Infrastructure, Transport and Tourism. He was conferred with a doctoral degree (engineering) in 2006 from the University of Tokyo. After serving as visiting professor at the Graduate Schools for Law and Politics, Faculty of Law, University of Tokyo in 2007, and the National Graduate Institute for Policy Studies in 2008, he served as professor at the Graduate School of Law, Tohoku University, in 2010. He was appointed to his current position in 2012.

Professor Shimada's empirical research is detailed in the following jointly authored publications: "Analyzing the Great East Japan Earthquake 2 – Disaster and people, towns, records" Akashi Shoten Publishers (in Japanese) (left side of photo); and "Living in the Present: From the Great East Japan Earthquake to tomorrow. Proposals for Reconstruction and Regeneration 3. Methods and Economy" Tohoku University Press (in Japanese) (right side of photo).

After seeing and hearing: thinking on the run. Field survey pushing into the disaster area.

"The human being is a thinking reed" (Pascal, French philosopher and mathematician). This quotation is said to mean that humans are feeble before nature but as thinking and intelligent beings we have infinite possibilities. The Great East Japan Earthquake was a disaster that exceeded previous human knowledge, but we learned much from the hardships, and the application of the acquired scientific knowledge and technology to building a resilient society is also human wisdom.

With the post-disaster slogan "Reconstruction and recovery are local issues; the ideas come from us", we have been fully engaged with state agencies such as the Disaster Prevention Bureau of the Cabinet Office and the Tohoku Regional Bureau of the Ministry of Land, Infrastructure and Transport, in addition to carrying out surveys and hearings on the actual situation among the disaster-affected municipalities and disaster victims. Our objective is to find out whether the Japanese legal system for disaster reduction is appropriate to the present disaster. We also investigate where the problems are and which issues should be tackled. Project studies having the title "Empirical research on issues regarding Japan's disaster policy legal system focusing on the Great East Japan Earthquake" have changed with time to respond to the immediate situation, from Initial response: emergency relief period in 2011, and From disaster relief to disaster reconstruction in 2012, to Recovery period and disaster reduction measures in 2013. The annually complied reports include the direction of necessary law revisions regarding urban development, housing, and industry and employment, with recommendations being made concerning policies with a high probability of implementation.

Urgent need for development legislation reflecting the real situation. A desire to continue to contribute to society from an academic standpoint.

The law concerning disaster measures is represented by the "Disaster Countermeasure Basic Act" enacted after the Isewan Typhoon in 1959. This legislation outlines the obligations of municipalities regarding the initial response to a disaster, such as the evacuation of residents and assessment of the magnitude of the disaster. After the Great East Japan Earthquake, however, many municipalities along the coast were dysfunctional. In view of this reality, the law was partly amended*1. The role of the state and prefectures in a large scale disaster over a broad area has been strengthened, sot that relief supplies can be dispatched without waiting for requests from municipalities, people can be accepted into evacuation centers and aid personnel can be deployed outside of municipal frameworks. While lessons learned from the Great East Japan Earthquake have been implemented, many problems still remain, such as consolidation of the framework for reconstruction and disaster victim support.

We are paying particular attention to housing, which is the foundation of resettlement. In the present disaster relief law, the loan period of (emergency) temporary housing is from the day of completion up to 2 years, but by removing this provision and building semi-permanent housing with improved durability, operations related to public housing have become possible in the third year or later. Since assistance in principle is provided in-kind, when privately rented housing is deemed temporary housing, complicated procedures are required by the municipalities, but by introducing a voucher system*2 the burden on the municipality is reduced. We are proposing the enactment of a "temporary housing law" (provisional name).

In the Great East Japan Earthquake it was realized that there is a limit to support from only the state. In measures directed towards earthquakes that may strike the Tokai, Tonankai, Nankai areas, or directly beneath Tokyo, further development of legal systems is required, and we are continuing to work on proposals regarding legal amendments through our independent empirical research.

*1 "Law partly amending Disaster Countermeasure Basic Act" published and put into effect June 21, 2013

*2 Voucher system: A system in which the state or municipalities provide individuals with assistance payment (primarily coupons) for restricted purposes.

Problems are treated on a local scale. We propose pragmatic policies, based on the actual circumstances of the Great East Japan Earthquake.

Experiments and analysis based on true state of nuclear accident. Evaluation of γ-ray shielding, using high-concentration radioactively contaminated soil from the site. High-density concrete trials.

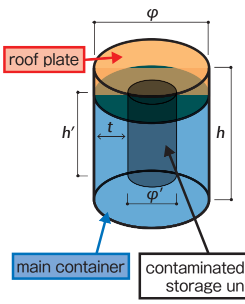
(Photo 1) Experiment performed under direction of senior radiation protection supervisor.

γ-rays emitted from radioactively contaminated material can be contained by concrete

The nuclear accident at the Tokyo Electric Power Fukushima Dai-ichi Nuclear Power Plant of March 2011 was a serious disaster resulting in radioactive emissions caused by core meltdown. As most people are aware, there are at present numerous causes for concern, including the issue of how to deal with contaminated water. One problem that urgently requires a solution is how to deal with high-concentration radioactively contaminated materials. Shielding is required against high level radiation (principally γ-rays) emitted from contaminated material that has accumulated during decontamination by high pressure washers, and the effects of the contaminated material on the environment must be minimized. It is known that a thick wall of lead, iron or concrete is almost impenetrable to these γ-rays. In a cost-effect comparison, concrete in particular excels as a shielding material.

It is known that in general, with a shield such as concrete, the greater the density, the better the performance at shutting out γ-rays. Previous research of radiation-shielding concrete involving trials of high density concrete (4〜5 g/cm^3, as compared with about 2.3 g/cm3 for normal concrete) have shown that concrete with a water/cement ratio (W/C*1) of about 50% is relatively expensive as high density concrete. Assuming that contaminated material from the nuclear accident is to be stored in a concrete container over a long period, this W/C ratio must be reduced and high durability ensured.

In trials to evaluate concrete shielding performance, cobalt-60 (an γ-ray source used in medicine and industry), which is a radionuclide that is easy to handle, has been used conventionally, but no research reports could be found (at the time our research group began this project) where modeling was performed of damage by radiation from material contaminated by radioactive cesium (cesium 134, cesium 137) which was actually dispersed by the nuclear accident.



dimension (mm)	high density concrete shielding container	normal concrete shielding container
t	100	200
φ	500	700
h	600	800
φ′	300	
h′	400	

●weight
high density concrete shielding container：about 420 kg
normal concrete shielding container：about 600 kg

(Fig. 1) The shielding container has a cylindrical shape, with a main unit and a roof plate. The jointing section is made uneven to prevent γ-ray leakage, with the central portion providing space for containing contaminated soil.

Evaluation of shielding performance of high density concrete, using radiation-contaminated soil from Fukushima

Our research group developed and fabricated high density concrete using iron granules instead of ordinary aggregate. Since this provided a density (4.57 g/cm^3) double that of normal concrete, the water cement ratio W/C was reduced to about 25%. Generally, when the W/C value is reduced, concrete pouring deteriorates, but a material mixture was configured that facilitated formwork. Trial containers of cylindrical shape were made using this high density concrete and normal concrete (Fig. 1) and γ-ray shielding performance was evaluated.

The high-concentration radioactively contaminated soil used as a radiation source in the experiment came from 4 locations in Fukushima Prefecture that were actually affected by the nuclear accident (^{134}Cs: 31.4±4.0 Bq/g; ^{137}Cs: 48.0 ±6.2 Bq/g). From the shielding test results, it was shown that a high density concrete container with wall thickness of 100mm reduced the quantity of γ-rays emitted from contaminated soil by over 90%. This is a shielding performance greater than a normal concrete container with double the wall thickness, pointing to the possibility of designing more compact shielding containers. Furthermore, the results of the shielding analysis showed the possibility of simulating the shielding trial results with high accuracy by giving appropriate consideration to the effect of background (air) radiation.

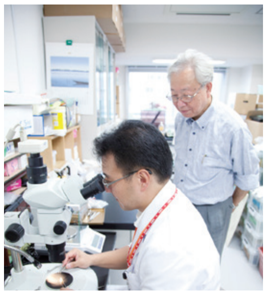
A great deal of knowledge and technology is required in moving towards a resolution of the Fukushima Dai-ichi Nuclear Power Plant accident. To play a role in this effort, we continue with our research.

*1 The water/cement ratio W/C is an indicator of concrete strength, expressing water/cement as a percentage. By reducing the water/cement ratio to some extent, concrete durability and water-tightness can be improved, but workability generally deteriorates. The water/cement ratio for architectural concrete is 55〜65%

Yusuke Suzuki
(Assistant Professor)
Hazard and Risk Evaluation Research Division, Technology for Optimum Mitigation, International Research Institute of Disaster Science, Tohoku University

IRIDeS Initiative on Nuclear Accident (2)

Radioactive substances from the atmosphere accumulate in teeth. Through analysis and evaluation of internal exposure to radiation using human teeth, basic data is collected for clarifying the effects of radiation on the human body.



(Photo 1) The analysis of various types of records left in teeth has been enthusiastically embraced as a research theme since before the Fukushima Dai-ichi Nuclear Power Plant disaster. The accumulated results have been leveraged in the present project. The photo shows Associate Professor Suzuki in the foreground, with Professor Emeritus Shinoda behind.

Teeth as time capsules and indicators of past internal exposure to radiation

Teeth have the property of accumulating chemical substances taken into the body during their period of formation. Since human teeth do not metabolize, we can comprehend the environment they experienced in the past and what substances they absorbed by analyzing substances contained in tooth tissue. Teeth may be said to form time capsules that record our personal history.

Among materials that accumulate in teeth, we have focused on strontium 90 (referred to below as 90Sr), a beta-ray emitting radionuclide. 90Sr closely resembles calcium in its chemical properties, and when absorbed by the body it follows an absorption path similar to calcium and accumulates in bones and teeth. Since teeth are lost (particularly baby teeth) or extracted, they can be used as specimens for investigating the occurrence and extent of internal exposure to radiation (through orally consumed food and water, or through air inhaled via the respiratory tract). In this way teeth may be indicators for evaluating internal radiation dosage and history.

Previous work involving surveys tracking internal radiation exposure using teeth has been done abroad. From 1945 when the first nuclear tests were performed, there have been over 500 nuclear tests carried out in the atmosphere. Research analyzing 90Sr in teeth has already reported notably high values measured in the 1960s when nuclear tests were frequently performed on land, in the sea and in the air. This provides one piece of scientific evidence of the effect of radioactive fallout in the atmosphere. However, although there is unease concerning the effect of internal exposure to radiation on the human body, the causal relationship has yet to be clarified.

When their functional role is over, deciduous teeth (baby teeth) are useful for research. The understanding and cooperation of donors is essential.

In the two year period following the disaster at the Fukushima Dai-ichi Nuclear Power Plant, we have undertaken an analysis of internal radiation exposure dose and history using the teeth of animals from the disaster-affected area, in order to investigate and establish effective and specific methods and technology ("Project on Comprehensive Estimation of Radioactivity in Affected Animals", Ministry of Education, Culture, Sports, Science and Technology). This is an interdisciplinary initiative based in the Institute of Development, Aging and Cancer, Tohoku University, with the collaboration of the Graduate School of Science, and the Graduate School of Agricultural Science.

Up to now there has been no technology for stable and quantitative 90Sr extraction using human deciduous teeth, which are limited in number, as specimens. As a result of performing a comparative investigation of various methods, we have clarified that a chemical assay method is the most stable and accurate method. Using about 50 deciduous teeth from humans, it was possible to extract radioactive strontium and perform a group radioactive dose evaluation. However, in group evaluation, since multiple teeth are collectively analyzed, it is not possible to track internal radiation exposure history (of individual people). Therefore, we established a method of screening for the existence and strength of radioactive substances in individual teeth by a physico-chemical method using imaging plates (showing two dimensional photographic density distribution of incident radiation).

For our research project it is indispensable to have human deciduous teeth as specimens. Collection of deciduous teeth whose functional role in the mouth is complete has already begun with the collaboration of national networks of researchers, dentists and dental clinics. The consent of donors is, of course, a prerequisite. Henceforth, by continuing this analysis and evaluation of internal radiation exposure history using human teeth in the long term, we aim to gather basic data in order to comprehend the effect of radioactive substances on the human body. The Fukushima nuclear accident was a tragic event, but by accumulating research results from an objective and scientific viewpoint, we can provide knowledge and wisdom to share with humanity. We look forward to continuing our work with the understanding and cooperation of all involved.

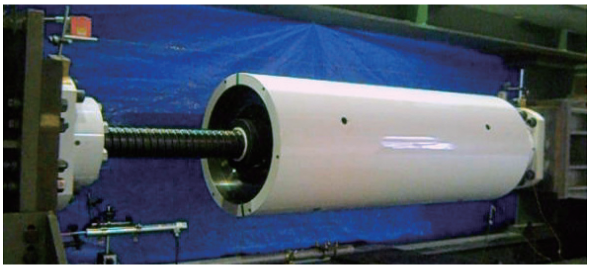
This research was selected as a 2013 Special Research Project of the International Research Institute of Disaster Science.
A-11 Analysis of Internal Radiation Exposure History in Humans using Teeth -- Radiation Dose Evaluation using deciduous teeth lost by children resident in Fukushima and Miyagi Prefectures (continuing)
Principal Investigator: Toshihiko Suzuki (Disaster Medical Science Division, Disaster Stomatology)
[Intramural Collaborating Researcher] Ken Osaka (as above)、
[Extramural Collaborating Researchers] Jun Aida (Tohoku University Graduate School of Dentistry), Mirei Chiba (Tohoku University Graduate School of Dentistry), Yoshinaka Shimizu (Tohoku University Graduate School of Dentistry), Atsushi Takahashi (Tohoku University Hospital), Hisashi Shinoda (Professor Emeritus, Tohoku University), Manabu Fukumoto (Institute of Development, Aging and Cancer, Tohoku University)

Toshihiko Suzuki
(Associate Professor)
Tohoku University Graduate School of Dentistry, Dental and Digital Forensics / Environmental Dentistry Center;
International Research Institute of Disaster Science, Disaster Stomatology (concurrent);
The Center for Academic Resources and Archives, University Museum (concurrent)

NEW TECHNOLOGY from IRIDeS

New seismic isolation control technology

Development of technology for effective seismic vibration control by amplifying the mass of a small weight



The idea of a "mass damper" to suppress the vibration of a shaking object by adding a weight has been around for a long time. A damper or shock-absorber is a device that absorbs and weakens vibration and impact. It has also been known for a long time that it is possible to amplify the apparent weight (mass) of a weight used as a "mass damper" by the principle of leverage, and various types of mechanisms have been proposed. Among them, the most suitable for implementing a "mass damper" for a building is currently considered to be a ball screw mechanism. When a nut is rotated on a screw, the nut advances on the screw shaft, and similarly, when a ball screw is pushed on, the ball nut rotates at high speed as the screw shaft advances. At this time, a small resistance force in the rotational direction of the weight is amplified into a large resistance force in the axial direction of the screw shaft. That is, the ball screw mechanism acts as a lever arm.

The Technology for Optimum Mitigation Laboratory of the Hazard and Risk Evaluation Research Division in The International Research Institute of Disaster Science is proceeding with development of a "mass damper" that can amplify by a factor of several hundred the apparent weight (mass) of a cylindrical flywheel using a ball screw for leverage. Through joint development with manufacturing partners that can produce a highly accurate ball screw mechanism, a damper has been successfully developed with an apparent mass of 1250t, while having a compactness of approximately 2m in overall length and approximately 60cm in diameter.

By installing this newly developed device in a seismically isolated building, it is possible to increase the apparent weight of the building by a factor of between 1.5 and 2, and to realize a seismically isolated building that does not shake easily. However, since the building weight does not actuality increase by a factor of 1.5 to 2, loading on the foundation does not increase nor does the seismic force. When the building is subjected to strong ground motions, the apparent weight increases considerably and resistance (inertia) to the shaking becomes large, so that the shaking is suppressed.

Professor Koju Ikago (Technology for Optimum Mitigation Laboratory, Hazard and Risk Evaluation Research Division)

One year to go to the Sendai hosting of the United Nations World Conference on Disaster Risk Reduction. Publication of Preliminary Report outlining problems and calling for discussion.

- Analysis and Observations based on Hyogo Framework for Action (HFA) -

Yokohama 1994, Kobe 2005, and next, Sendai 2015, where the 3rd World Conference on Disaster Risk Reduction (WCDRR) will be hosted in March of next year. Member countries of the United Nations will gather in Sendai with the goal of deciding on disaster risk reduction policies worldwide, providing the Tohoku region a valuable opportunity to communicate to the world the experiences and lessons learned in the aftermath of the 2011 earthquake and tsunami that followed it. As a university and research organization in the disaster area, Tohoku University responded quickly to the disaster by setting up the International Research Institute of Disaster Science to undertake the systemization of practical disaster risk reduction, combining the humanities and the sciences, and sharing research results and expertise.

The 2005 conference adopted the "Hyogo Framework for Action (HFA) 2005-2015: building disaster-resilient countries and regions". Comprehensive disaster risk reduction guidelines were compiled for implementation by the international community over a period of 10 years. In the 3rd conference in Sendai, an evaluation of HFA and a successor framework will be discussed, and decisions will be made concerning an international disaster risk reduction road map from 2015 onwards.

The HFA includes the following 5 priority actions. (1) Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation. (2) Identify, assess and monitor disaster risks and enhance early warning. (3) Use knowledge, innovation and education to build a culture of safety and resilience at all levels. (4) Reduce the underlying risk factors. (5) Strengthen disaster preparedness for effective response at all levels. In anticipation of the conference hosting next year, the International Research Institute of Disaster Science issued a preliminary report in October of last year. Focusing on the Great East Japan Earthquake and tsunami of 2011, knowledge and expertise based on the abovementioned 5 priority actions are discussed from a researcher or specialist viewpoint. Methods and actions learned from the history of disasters in Japan and from the Great East Japan Earthquake are covered, in addition to examples recommended for implementation. The report also outlines problems and calls for discussion in view of the forthcoming United Nations World Conference on Disaster Risk Reduction.

01

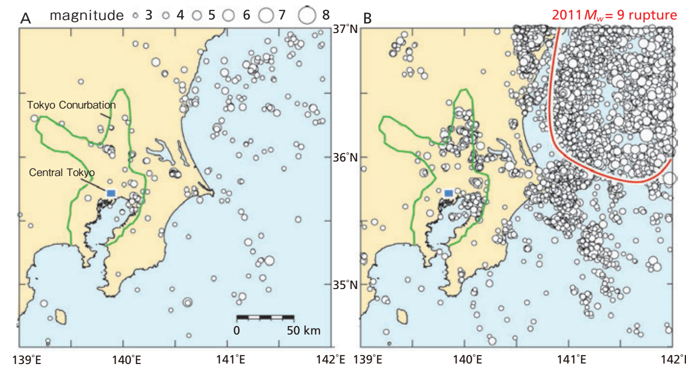
Seismic activity stimulated by a massive earthquake

~ Likely increased probability of large earthquakes beneath Santiago and Tokyo ~

According to a research report in the US academic journal Science by Professor Shinji Toda (Disaster Science Division, Natural Disaster Research, International Research Institute of Disaster Science) and Dr. Ross Stein (US Geological Survey), the Chile earthquake of 2010 and the Tohoku-oki earthquake of 2011 triggered seismic activity in Santiago (the capital of Chile) and Tokyo, respectively, each being about 100 km distant from the respective earthquake faults. The report was featured in the Perspective section of the journal, which publishes advanced research.

Santiago is located about 400 km from the epicenter of the Chile earthquake of 2010 and about 100 km from the earthquake fault, and Tokyo is located about 400 km from the epicenter of the Tohoku-oki Earthquake of 2011 and about 100 km from the fault. This same distance weakened the effect of the earthquake motion, but micro-earthquakes directly beneath Santiago and Tokyo have been occurring more frequently than before the massive quakes (for Tokyo this was up to three times the previous rate: see map on right). Seismic activity is caused by stress transferred from a massive earthquake, so in a wider sense it may be said to comprise aftershocks. Professor Toda points out that while increases in the number of small quakes are not necessarily linked to a large earthquake, since there is no change in the quake size distribution (proportion of large to small quakes) before and after a massive earthquake, the situation is one where a large earthquake can easily occur.

Both Santiago and Tokyo have been established as large cities for over 400 years and each have experienced catastrophic damage from historical earthquakes twice (1647 and 1730 in Santiago; the Ansei-Edo earthquake of 1855 and the great Kanto earthquake of 1923 in Tokyo). In modern times also, destructive earthquakes have regularly occurred within Japan and Chile, leading to continual revisions and strengthening of building codes. As a result these cities are among the world's most resilient cities (that is, cities that can recover rapidly and flexibly).



One year before Tohoku-oki earthquake   One year after Tohoku-oki earthquake

Paper title: Megacity Megaquakes - Two Near Misses
Authors: Stein, R. S., and S. Toda
Journal：Science
Publication Date: August 2013 Vol. 341
The complete paper is available at:
http://www.sciencemag.org/content/341/6148/850 (Login required)

As host for the Olympics and Paralympics in 2020, Tokyo is now proceeding with the construction of new facilities and development of its transportation network. The 7 years to come will provide a good opportunity for progress in building a city that is truly robust in the face of earthquakes. With world class knowledge and technology accumulated through being a "land of earthquakes", there is an urgent need to build a disaster mitigation system fusing both infrastructure and strategic aspects. Professor Toda concludes by pointing out the possibilities for high-level preparedness for disasters and for developing disaster countermeasures in large cities throughout the world where there is a risk of a magnitude-8 massive earthquake.

02

Geological Survey points to regional bias in frequency and scale of massive earthquakes and tsunamis in the Ryukyu Trench

In formulating disaster reduction strategies it is important to comprehend the scale and periodicity of past tsunamis. Associate Professor Kazuhisa Goto's team (Hazard and Risk Evaluation Research Division, Science and Technology for low-frequency Risk Evaluation) has carried out a geological survey of 10 islands, including the Amami Islands, the Okinawa Islands, the Sakishima Islands (Miyako-Yaeyama Islands) along the Ryukyu Trench, and found evidence of damage due to a huge tsunami only in the Sakishima Islands. These results were published in the November edition of the US academic journal *Geology*.

There is very little historical information concerning past massive earthquakes and tsunamis along the Ryukyu Trench, with the only available description of damage being that of the Great Meiwa Tsunami of 1771. The Meiwa Tsunami is supposed to have been caused by an earthquake of magnitude larger than 8.0 with an estimated epicenter in waters to the south-east of Ishigaki Island, and by a submarine landslide accompanying the quake. Although records of large damage exist for Miyako-Yaeyama Islands, there are no such records for the Okinama Islands and Yonagumi Island. Thus it is considered that the damage was limited to some of the Sakishima Islands.

A survey of tsunami deposits is usually effective in estimating the history and size of tsunamis in a time scale of several hundred to a thousand years. However, this method is not suitable in the Ryukyu Islands due to the shortage of soil suitable for a deposit survey (using sand grains as specimens).

Associate Professor Goto's research team focused on groups of boulders along the shore. Boulders detached mostly from coral reefs are scattered on the reef by high waves from typhoons as well as tsunamis. The team discovered that the distance these boulders have been carried inland varies according to differences in the hydrological period of tsunamis and high waves. That is, it has been clarified that boulders (of diameter greater than 1m) due to high waves in typhoons have not been carried more than 300m from the edge of the coral reef, and similar boulders currently distributed along the coral reefs of the entire Ryukyu archipelago are due to high waves in typhoons that have repeatedly occurred from over 2300 years ago. On the other hand, it is reasonable to consider massive boulders of coral up to 9m in diameter cast onto the seashore (up to 1.5km from the reef edge) to be "tsunami boulders" carried by the force of tsunamis. Based on the distribution of the tsunami boulders, there is no evidence of the massive tsunamis that struck the Sakishima Islands hitting the Amami and Okinawa Islands for at least 2300 years. Associate Professor Goto's group has shown a large regional bias in the frequency and scale of massive earthquakes and tsunamis that do not occur often along the Ryukyu Trench. Future research will further investigate the occurrence mechanism of these events.

Beach coral tsunami boulder, known as "bari rock" at Ibaruma, Ishigaki Island (national monument of Japan). Dating estimates indicate that this rock was cast here by the Great Meiwa Tsunami (1771). This is the world's largest tsunami boulder consisting of a single coral reef aggregation.

Paper title: Localized tsunamigenic earthquakes inferred from preferential distribution of coastal boulders on the Ryukyu Islands, Japan
Authors: Kazuhisa Goto, Kunimasa Miyagi and Fumihiko Imamura
Journal：Geology
Publication Date: November 2013 Vol. 41, No. 11, pp. 1139-1142
An abstract is available at:
http://geology.gsapubs.org/content/41/11/1139.abstract

03 Breakthrough research results, questioning conventional scientific understanding. - Tohoku-Oki Earthquake epicenter area probed by deep-sea drilling vessel *Chikyu* -

In the Tohoku-Oki earthquake, a large slip occurred along the shallow portion of the plate boundary fault near the Japan Trench not previously considered vulnerable to earthquakes, causing a massive quake and tsunami that stunned researchers and specialists throughout the world. The deep-sea drilling vessel Chikyu set out to explore the quake generation mechanism. The rock samples and data recovered from the deep sub-seafloor borehole forced earth scientists to reconsider conventional and widely accepted concepts regarding the behavior of earthquake generating faults. Three research papers covering the research results were published in the December 2013 edition of the US scientific magazine Science, with Professor Ryota Hino (Marine Geodesy Research, Disaster Science Division, International Research Institute of Disaster Science) providing a large contribution to two of the papers.

These research results have shown that nature behaves quite differently than conventionally expected by scientists. Why did the slip propagate through the shallowest part of the fault, where seismic slip had not been known to occur? After the Tohoku-Oki earthquake, the Japan Agency for Marine-Earth Science and Technology organized a survey and research expedition*1 by the deep-sea drilling vessel Chikyu, as part of IODP*2. In addition to collecting geological specimens from a shallow plate boundary fault of the slip region, the research team carried out direct measurement of residual frictional heat generated by the fault slippage during the earthquake. In a plate boundary fault yielding giant earthquakes, carrying out temperature measurements and collecting geological specimens at an early stage after the quake is technically very difficult, and this drilling survey has brought about a major breakthrough in seismology.

As a result of temperature data analysis and mechanical tests of the recovered rock samples, it was concluded that the fault is abundant in smectite (pelagic clay of low strength and permeability) lowering frictional resistance. It also turned out that the pressure of interstitial water (water in voids of the plate boundary fault material) increased due to frictional heat, causing slip to occur easily along the fault during the earthquake. The interplay of these two factors contributed to making the amount of fault slip large enough to cause an extraordinarily large tsunami.

The present research shows that if the shear strength (frictional resistance) in a fault at the time of a quake is low, slip on the fault can reach the ocean trench axis, causing seismic slip and resulting in a destructive giant tsunami. Further investigative research is required to evaluate the potential of earthquake/tsunami generation in subduction zones taking this new viewpoint into account, in addition to numerical simulation of earthquake generation. Additional survey research may also be necessary for understanding the diversity of fault characteristics in different ocean areas. It is hoped that the present findings will be utilized in disaster mitigation in all countries and regions subject to ocean trench-type giant earthquakes and tsunamis.

*1 Tohoku-Oki Earthquake Survey Drilling: April 1 to May 24, and July 5 to 19, 2012.

*2 IODP: The Integrated Ocean Drilling Program is an international marine scientific drilling program led by Japan and the US, with the goal of explaining global environment changes, the earth's inner structure, and the biosphere within the earth's crust. In 2013, the program became the "International Ocean Discovery Program".

Papers (1) – (3) were published in Science Vol. 342, no. 6163

Professor Hino is a co-author of papers (2) and (3).

(1) Paper title: Structure and composition of the plate-boundary slip zone for the 2011 Tohoku-Oki earthquake
Authors: Chester et al.
The complete paper is available at (login required): http://www.sciencemag.org/content/342/6163/1208.full

(2) Paper title: Low coseismic shear stress on the Tohoku-Oki megathrust determined from laboratory experiments
Authors: Ujiie et al.
The complete paper is available at (login required): http:// www.sciencemag.org/content/342/6163/1211.full

(3) Paper title: Low coseismic friction on the Tohoku-Oki fault determined from temperature measurements
Authors: Fulton et al.
The complete paper is available at (login required): http://www.sciencemag.org/content/342/6163/1214.full

04 Discovery of new pathology marker (indicator) for dengue fever infection. Role of Galectin-9 as a danger signal biomarker indicating disease severity.

Dengue Virus (DENV) infection*3 is an endemic disease in over 110 countries. With 100 million people infected worldwide every year, it has become a major public health issue. It is known as a mosquito-borne, disaster-related infection with outbreaks being caused by mosquito epidemics that accompany flood disasters. For many infected people, the disease is a temporary febrile condition, but on occasions it may develop into dengue hemorrhagic fever that can be life-threatening. Professor Toshio Hattori and Assistant Professor Haorile Chagan-Yasutan's group (Disaster-related Infectious Disease, Disaster Medical Science Division, International Research Institute of Disaster Science; and Department of Emerging Infectious Diseases, Tohoku University Graduate School of Medicine (concurrent)) have discovered a novel biomarker for dengue virus infections. The importance of this research lies in the fact that this is the first time it has been shown that Galectin-9 (Gal-9) levels are significantly higher in dengue virus infected patients in correlation with the progressive severity of their infections. The results have been published in the Journal of Clinical Virology (online edition) of October 2013.

In conventional research the state pathology of acute dengue virus infection has been estimated from a "soluble inflammatory factor". Professor Hattori and Assistant Professor Chagan-Yasutan's group used a system with world-class sensitivity to measure Gal-9 (a soluble β-galactoside-binding lectin*4); and thereby to measure plasma Gal-9 and 29 types of cytokine/chemokine*5 in 65 patients infected with dengue virus in the Philippines in 2010.

During the critical phase, Gal-9 levels were significantly higher in dengue hemorrhagic fever (DHF) patients (2464pg/ml) and dengue fever (DF) patients (1407pg/ml), compared to healthy people (196pg/ml) or those with non-dengue febrile illness (616pg/ml). In the recovery phase, Gal-9 levels declined rapidly. It was established by multivariate analysis that Gal-9 levels correlate with IL-1, IL-8, IP-10 and growth factor VEGF values, which are known to correlate with pathological condition in dengue virus infected patients. Further discriminant analyses showed that eotaxin, Gal-9, IFN-α2, and MCP-1 could enable detection of 92% of DHF and 79.3% of DF cases. These results indicate higher plasma Gal-9 as a biomarker for DENV, and it is hypothesized that this provides a danger signal marker at the time of virus infection. This research was collaboratively performed with San Lazaro Hospital (Philippines), Kagawa University, the University of Hawaii (USA), and Nagasaki University.

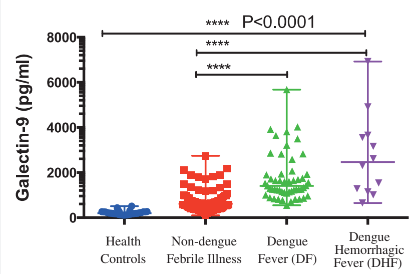


Figure 1: Plasma Galectin-9 values are shown. Significantly higher values are indicated for dengue fever and dengue hemorrhagic fever patients, compared to health controls and non-dengue febrile patients.

*3 Also known as dengue fever. Patients exhibit symptoms including fever, headaches, severe myalgia, arthralgia, and rashes resembling measles. The disease is borne by striped mosquitos.

*4 Lectins are a generic name for carbohydrate-binding proteins. Galectin shows galactose specificity.

*5 Cytokine/chemokines are proteins released from cells, forming intercellular communication elements. Many of them function by immunological/inflammatory response, propagating and attracting leukocytes. IL-1, IL-8, IP-10, eotaxin, IFN-α2, and MCP-1, etc.

Paper title: Galectin-9 Plasma Levels Reflect Adverse Hamatological and Immunological Features in Acute Dengue Virus Infection

Authors: Haorile Chagan-Yasutan, Lishomwa C. Ndhlovu, Talitha Lea Lacuesta, Toru Kubo, Prisca Susan A. Leano, Toshiro Niki, Shigeru Oguma, Kouichi Morita, Glen. M. Chew, Jason D. Barbour, Elizabeth Freda O. Telan, Mitsuomi Hirashima, Toshio Hattori, Efren M. Dimaano

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