SCG61-01 Room:102B Time:May 27 11:00-11:15

Triggering of earthquake swarms following the 2011 Tohoku megathrust earthquake

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Earthquake swarms, often interpreted to result from fluids invading the brittle seismogenic zone, have seismicity patterns that are significantly different from an aftershock sequence. Following the Mw 9.0 Tohoku-Oki earthquake, an unusual, shallow normal-faulting swarm sequence occurred near the Pacific coast in the southeastern Tohoku district. An integrated approach combining geophysical and geochemical methods was utilized to establish the presence of aqueous fluids around the seismic source region and their derivation. Magnetotelluric inversion defined an anomalous conductor with a width of 20 km and clearly visible to depths of more than 20 km, extending to the base of the crust. Independent geophysical observations, including seismic, strongly support the suggestion that fluid-filled porous materials and fluids associated with slab dehydration are present in the convergent plate boundary. In order to provide geochemical constraints on the source of the fluids triggering the swarm activity, new helium isotope data were acquired from gas and water samples around the seismic source region. The observed 3He/4He ratios in these samples are significantly lower than the atmospheric value of 1.4x10-6, indicating that the mantle helium contribution is less than 10% of the total helium. Plausible sources of the fluids can be attributed to waters produced by dehydration of accreted deep-sea sediments and/or seawater-altered volcanic rocks, rather than dehydration reactions in the subducted oceanic crust and/or hydrated mantle below the fore-arc mantle wedge. The swarm sequence would have been triggered by stress changes associated with the Tohoku-Oki earthquake, enhanced by vertical metamorphic fluid expulsion from the reaction zone.

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SCG61-02 Room:102B Time:May 27 11:15-11:30

Underground Structure of Wushanding Mud Volcanoes in Southwest Taiwan by Electromagnetic Exploration

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As it is expected that the mud volcanism causes natural disasters, it is important to evaluate the activity of a mud volcano when choosing the underground facilities such as high level radioactive geological disposal facility. Active inland mud volcanoes are distributed in Southwest Taiwan, locating along the axis of anticlines and faults. We carried out the geophysical exploration by CSAMT method around the Wushanding mud volcanoes distributed along the Chishan fault in Taiwan to identify the underground structure and flow path of fluid from deep underground based on the resistivity distribution.

As a result, the low resistivity zone is distributed along the Chisan fault at the depth of 100-500m. Also, the low resistivity zone is distributed under the Wushanding mud volcano from 100m to 300m deep. The fluid erupted at the mud volcano ascends along the Chishan fault and some of them are erupted at the fault and others migrate to the anticline axis, being trapped once under the impermeable cap rock and ascend again to the ground surface, forming mud volcanoes.

Keywords: mud volcano, Taiwan, CSAMT method, underground structure, fluid

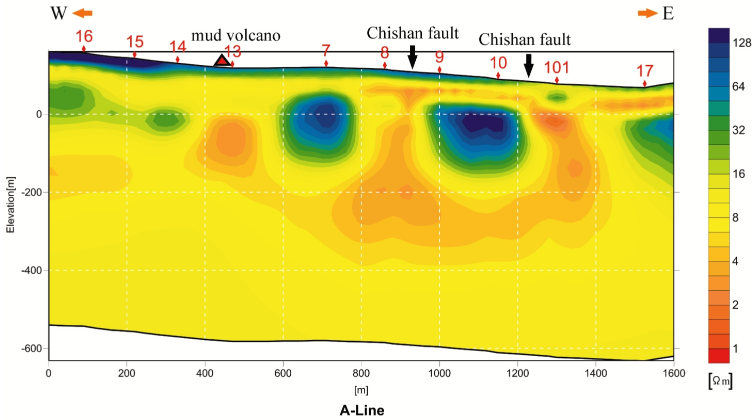

Fig.1 Resistivity profile analyzed by 2D inversion of the CSAMT survey

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SCG61-03 Room:102B Time:May 27 11:30-11:45

Dehydration from hydrated minerals and its relation to the chemical and isotopic compositions of mud volcanic fluids

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Mud volcanoes found in the tips of subduction zones are thought to be related to fluids which subducted with descending slab in the form of pore water and hydrous minerals. Fluids in subduction zones and mode of their circulations are closely related to dynamic processes such as seismicity, island volcanism, and geochemical cycles. Thus, fluid chemistry of mud volcano is one of the most important topics in order to understand the fluid cycle and earthquake generation mechanism in subduction zones. The major origins of mud volcano fluids are considered to be pore water in the subducting sediments squeezed by tectonic compaction, dehydration from minerals, decomposition of gas hydrate, meteoric water and seawater. In shallow subduction zones, smectite is a major mineral which dehydrates between about 60－ 160 ℃. This study aims to quantify the chemical and isotopic compositions of fluids from dehydration of hydrous minerals using the chemical and isotopic data of fluids from mud volcanoes. In this study, a three-component mixing model using Cl concentration, oxygen and hydrogen isotope compositions of mud volcano fluids, are used for constraining the oxygen and hydrogen isotope compositions of mineral dehydration fluids. Rayleigh fractionation equation was also used to constrain the isotopic compositions, because the isotopic fractionation factor during smectite dehydration are reported to be temperature-dependent. As a result of Rayleigh fractionation equation, δ^{18}O=+ 9.5 ‰, δD=-17.7 ‰ are obtained as the isotopic composition of smectite dehydration fluids at 160 ℃. Three-component mixing model could explain chemical compositions of most of mud volcano fluids in Taiwan which are distributed on land, and those off Costa Rica. However, mud volcano fluids off Tanegashima Island and East Mediterranean, in addition to CKF group mud volcanoes in Taiwan would not be well explained by three-component mixing model. For these mud volcanoes, another component such as deep sheeted brine, like an Arima-type brine are considered as the fourth end member. This four-component mixing model could explain these mud volcanoes better than the three-component mixing model. Reported fluctuation of chemical and isotopic composition in CKF mud volcanoes can also be well explained as the change in contribution ratio of Arima-type brine. This result supports that deep sheeted brine like an Arima-type brine would contribute to the fluid circulation in shallow subduction zone.

SCG61-04 Room:102B Time:May 27 11:45-12:00

Investigation on the fluid migration associated with the Chi-Chi aftershock sequence and Ontake eruption events

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Our previous studies in attenuation, noted as 1/ Qs, for the 1999 Chi-Chi earthquake suggest that the fracture zone associated with fault zone could be considered as a fluid reservoir, which possibly yield to some observations/detections of phenomena associated with pre-, co- or post-seismic of a larger earthquake. The sudden changes in attenuation co-seismically with decay following a diffusion process indicated possible high pore-fluid saturation within fractured fault zone from fully to partial saturation, especially in the dilatational region. The migration of the fluid in the dilatational region might have the association of the aftershock sequences. Aftershock sequence following a mainshock often considered to be related to regional tectonic stress and stress triggering of a mainshock. For stress triggering, it is often considered to be in the stress increase region with some lapse time (>one month) for the static stress triggering. In this study, we tried to deviate the possible fluid associated aftershocks by focusing on the region with dilatation stress (stress decrease) and one-month aftershock sequence to understand their possible association. The 2014 Ontake eruption had been considered as an eruption associated with fluid/gas within the magma chamber. We investigate the possible passage of fluid flux within the magma chamber from the observed seismicity and waveforms. The recorded waveforms near Ontake show several different types. Some waveforms exhibit the possible detection of the trap-waves from magma chamber. The simulation of the waveform might give the hints on the structure (geometry and velocity) of the magma chamber and the mechanism of the earthquake associated with 2014 Ontake eruption.

SCG61-05 Room:102B Time:May 27 12:00-12:15

Groundwater pressure changes at the Ohtaki observatory before and after the 2007 and 2014 eruptions of Mt.Ontake

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[1]Geological Survey of Japan, AIST

Geological Survey of Japan, AIST started groundwater observation at the Ohtaki observatory (GOT) in 1998. GOT is about 10km southeast of the top of Mt.Ontake. At GOT we measure groundwater pressure in a sealed well. Since the groundwater pressure at GOT has tidal changes caused by the earth tides, we estimated the volumetric strain sensitivity of the groundwater pressure, which is 1-3 mm/nstrain, where the groundwater pressure is expressed as water head and "nstrain" means 10^{-9} strain. Since the resolution of the pressure gage at GOT is about 2 mm, that of the volumetric strain converted from the groundwater pressure is about 1 nstrain. The altitude of the well is about 1040m and the depth of the screen is 645-663 m. It means that we can observe the volumetric strain at the depth of about 650 m or at the altitude of about 390 m by measuring the groundwater pressure.

After 1998 there were two eruptions at Mt.Ontake. One is the 2007 eruption, which occurred in March, 2007. The other is the 2014 eruption, which occurred in September 2014. A few months before the 2007 eruption, a relatively large crustal deformation, which was the gradual increase in the length of the baseline crossing Mt Ontake, was observed although no such crustal deformation was observed in the 2014 eruption. At the 2007 eruption the groundwater pressure at GOT dropped 20 cm during almost the same period when the length of the baseline gradually increased. However no such groundwater pressure change was observed in the 2014 eruption. Taking the volumetric strain sensitivity into account, the 20 cm drop in the groundwater pressure means about 100 nstrain increase in the volumetric strain at GOT. The precursory gradual increase in the length of the baseline is converted into about 300 nstrain increase in the linear strain along the baseline. These two values are well-matched.

In the presentation we will report the details of those groundwater pressure changes and the crustal deformation.

Keywords: Mt.Ontake, eruption, groundwater, crustal deformaiton

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SCG61-06 Room:102B Time:May 27 12:15-12:30

Observation of co- and post-seismic fluid migration in and around Kamishiro Fault, Naganoken-Hokubu earthquake

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[1]Hidemi Tanaka

On November 28, An M 6.7 earthquake occurred at northern part of Nagano Prefecture, Central Japan. The Kamishiro Fault, which has been well known as to be a part of Itoigawa-Shizuoka Tectonic Line, was activated by the earthquake and surface rupture with about 9 km in length was appeared along it's trace.

Right before and after the earthquake, pre-, co- and post-seismic fluid migration was observed at around the Kamishiro Fault. Our team has been observing and monitoring the flow amount and chemical characteristics of the fluid from one week after the earthquake to present and still continue observation.

In this presentation, we consider the driving mechanism for fluid flow and hydrological characteristics of the fracture zone of the Kamishiro Fault.

Keywords: Naganoken-Hokubu earthquake, Kamishiro Fault, Fluid, Hot spring, Fracture zone, hydrological characteristics

SCG61-07 Room:102B Time:May 27 14:15-14:30

Poroelastic behavior of bedrocks around Tono Research Institute of Earthquake Science

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[1]Tono Rearch Institute of Earthquake Science ADEP

Tono Research Institute of Earthquake Science (TRIES) has set up multi-component borehole instrument at 15 deep boreholes around 10km square area. In the boreholes water level meter have also installed. Japan Atomic Energy Agency (JAEA) has constructed deep boreholes with diameters of 6.5m and 4.5m and studied flow of ground water. Depth of the boreholes reached to 500 m. The boreholes are 40m apart and connected by horizontal tunnels at every 100m. We also have set up stress meters, water pressure meters and tilt meters in the horizontal tunnels. By this kind of observations we have recorded the following variations.

1. Variation by spring water and draining water.
2. Variation by seismic wave.
3. Variation by pumping water performed in a borehole
4. Variation by atmospheric pressure change.
5. Variation by boring work in boreholes.

By analyzing these variations we could clarify poroelastic characteristics of bedrocks around TRIES.
The main results obtained are as follows:

1.Construction of poroelastic model.
2. Difference between elastic variation caused by pore pressure variation
and pore pressure variation caused by elastic variation.
3. Form and distribution of pore.
4. Variation difference at both side of fault.

We will report the details about these.

Keywords: Multi-component borehole instrument, stress,strain,tilt,waterlevel, poroelasticitic behavior, stress and strain seismograms, movement of fault

SCG61-08 Room:102B Time:May 27 14:30-14:45

Water flux model around TRIES/MIU to explain the gravity change

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[1]TRIES, [2]JAEA

The absolute gravity measurement by FG-5 has been operated in and around the Tono Research Institute of Earthquake Science (TRIES) since 2003. During this period, two types of ground water level change was observed. One is the water level decrease more than 70 m in 12 years, which along the drilling of the 500 m deep shafts of the Mizunami Underground Research Laboratory (MIU). The other is the coseismic water level increase in many events. Generally, the gravity value increases if the water level just beneath increases, and vice versa. Nevertheless, the gravity values in 3 stations show the same trend; show no decrease along with water level decrease in 12 years and the gravity decrease along the coseismic water level increase. The distinct coseismic gravity change was observed only in two cases. One is in the 2004 off Kii Peninsula Earthquake (Tanaka et al., 2006, G3), and the other is in the 2011 off the Pacific coast of Tohoku Earthquake. We introduce the model of the groundwater flow, which is explicable for both gravity and ground water level.

The interspaces of these stations are 1 to 2 km. The coseismic gravity decrease in these stations were about 10 micro gals which suggest that the mass moved away from these three stations equivalently. Based on former researches of geology and hydraulic geology, which clarified the permeable and impermeable layers well, we reached the model as follows for the coseismic case. 1) The subsurface structure is constructed by three permeable and two impermeable layers 2) The seismic wave or stress propagation causes the high permeable path through the deeper impermeable layer. 2) The water reserved in the middle reservoir flows down to the bottom reservoir driven by gravity force. Geologic fault plays an impermeable role for a lateral flow, however, the high permeable region are generated by the seismic event, along fault plane.

Keywords: Gravity, Ground water, Ground water flux

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SCG61-09 Room:102B Time:May 27 14:45-15:00

In-situ measurement of permeability of fault zones by hydraulic tests and continuous groundwater-level observation

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[1]GSJ, AIST

GSJ, AIST constructed an integrated groundwater observatory at Matsusaka-Iitaka as a part of the groundwater and crustal deformation observation network for the prediction research of the Nankai and Tonankai earthquakes (Shigematsu et al., 2012; Koizumi, 2013). Hole 1 (total depth 600m) was penetrated the Median Tectonic Line (MTL) at a depth of 473.9m. Total depth of Hole 2 is 208m. We obtained core samples and well logging data and conducted hydraulic tests in these wells. Screened depth of Hole 1 is 547.6 - 558.5 m and is located in the lower fracture zone of the MTL fault zone developed in the Sanbagawa metamorphic rocks. Screened depth of Hole 2 is 145.5-156.4 m and is located at a branch fault in the Ryoke Granitolds (Shigematsu et al., 2012).

The results of the hydraulic tests and continuous groundwater observation show 1.8 - 8.5 x 10^{-16} and 1.8 x 10^{-15} m^2 in Hole 1 and Hole 2, respectively. These permeabilities are consistent with laboratory permeability measurement of MTL fault rocks (Wibberley and Shimamoto, 2003).

Keywords: permeability, fault zone, hydraulic test, groundwater level