Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

STT056-01 Room:101 Time:May 26 14:15-14:30

New radiography method for small scale structure using soft component of air shower

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Air shower consists of hard component and soft component. Hard component is mainly consists of muon, and soft components is consists of electron, positron and photon. Hard component has strong penetration power, so radiography using hard component has been performed in several volcanoes and seismic faults. However, because of its penetration power, hard component is not suitable for small scale structure thinner than 1 kg/cm2 equivalent to 10m thick water, like buildings, bridges and small hills.

Soft component is suitable for small scale structure, but it requires particle identification. Here, particles identification means distinguishing hard component and soft component. Particle identification can be done very easily by using strong magnet and dense detectors, but it is very hard to use that kind of detector for radiography because of their weight and cost.

There are two kinds of detector for muon radiography, one is comprised of plastic scintillators and the other is comprised of emulsion films. If we can use one of them, we will be able to do radiography thinner structure than 1 kg/cm2 using same detector.

Recently, we found we can measure the lateral distribution of air shower by using current detector for muon radiography comprised of plastic scintillators, and lateral distribution can be used for radiography. Here, lateral distribution means the distance of two particles passed through detector simultaneously. The lateral distribution of soft component is steeper than that of hard component, and the lateral distribution of random component is flat. Also, lateral distribution of hard component will not change after thin structure because hard component has strong penetration power and muons including multi-particle event has much more energy than individual muons. By using these information, distinguishing the soft component, hard component and random component became possible statistically.

To evaluate this newly developed technique, we measured the lateral distribution under the free sky, 0.1m thick concrete, 2m thick concrete and 2.1m thick concrete. We could reproduce the lateral distribution of free sky by simulation completely, and succeeded to reproduce 2m thick concrete and 2.1m thick concrete using their lateral distribution and that under 0.1m thick concrete.

We will report this newly developed radiography method using soft component for small scale structure in detail and the result of measurement. Further improvement and possible application are also discussed.

Keywords: muon, radiography, air shower

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Slingram EM surveys for the delineation ofseasonal change in the near-surface resistivity around a river levee

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We conducted resistivity mapping surveys around a river levee for tracking the seasonal change in the near-surface ground water condition. A Slingram-type horizontal-loop electromagnetic induction tool was adopted for the surveys. Slingram method is effective to map large area or profile the near-surface resistivity anomaly. The survey area was set in and around Aino-shima District, Suzaka City, Nagano Prefecture. A total of 6,000 point data were measured over a 1 km by 3 km area around a levee using a commercially available Slingram system GEM2 in rainy and dry seasons in 2009.

The data were processed to reconstruct the near-surface resistivity maps using a 1-D inversion technique proposed by Mitsuhata et al. (2006). It was characteristic that river side of the levee showed relatively high resistivity (low conductivity). In contrast, low resistivity zones were concordantly delineated along the interpreted paleo-channels at the land side. Accordingly, the maps demonstrate that Slingram EM method is helpful to map 2D near-surface resistivity structure that affects ground water flow across a levee system.

Keywords: Slingram EM survey, resistivity, river levee, seasonal change

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Development of a magnetic exploration system for seabed resources using AUV and deep-tow system: tests in the Bayonnaise

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Seabed resources like seafloor hydrothermal deposits have recently attracted much attention. It is, however, difficult to estimate accurate abundance of those resources. Conventional marine (sea-surface) geophysical explorations do not have enough resolution, and an exploratory drilling needs much time and money. Thus, new technology of geophysical exploration near the seafloor is required in order to discover and estimate the resources precisely. From such a standpoint, we have been developing electrical and magnetic exploration systems by using AUV (Autonomous Underwater Vehicle), ROV (Remotely Operated Vehicle), and a deep-tow system in order to estimate structures of the seafloor in detail. Since this study started in 2008, we have made each device of magnetic and electrical exploration systems on an experimental basis. In this presentation, we will report the current situation of the development of the magnetic exploration system, especially about the tests in Bayonnaise knoll area. The magnetic exploration system was tested in the Kumano Basin using AUV "Urashima" and towing vehicle "Yokosuka Deep-Tow" during the R/V Yokosuka cruise in 2009. In this test, we examined the performance of the system through an artificial magnetic target set on the seafloor. In 2010, it was tested more practically in the Bayonnaise knoll area both using a titanium towing frame during the R/V Bosei-maru cruise and using AUV "Urashima" during the R/V Yokosuka cruise. The purpose of these tests was to evaluate the magnetic exploration system in an actual seafloor hydrothermal deposit area for practical applications of that. From these tests, we have succeeded in measuring three components and total intensity of the geomagnetic field using the AUV and total intensity of that using the deep-tow system. The obtained data will contribute to develop the magnetic exploration system for seabed resources, to study magnetic structures of the Hakurei deposit area, the seafloor hydrothermal deposit area, in the Bayonnaise knoll caldera. We will also improve the accuracy of the magnetic measurement, the measurement of three components of the geomagnetic field using the deep-tow system, positioning of the deep-tow system, etc. in order to construct practical magnetic exploration system. Note that this study has been supported by MEXT.

Keywords: seabed resources, sea-floor hydrothermal deposits, geophysical exploration, magnetic, development of instruments

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A particle method for modeling seismic ground motion

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A particle-based continuum model for the simulation of seismic wave propagation is presented. Accurate simulation of seismic ground motion for arbitrary topography is a key issue for not only scientific interest but also disaster prediction and mitigation. In the present study, moving particle semi-implicit (MPS) method is applied to seismological simulation. MPS method has some advantages comparing to traditional continuous and discontinuous methods ; first, the introduction of traction-free boundary conditions is easier than finite difference methods (FDM), second, data structure in MPS method is simpler than that in finite element methods (FEM) because we do not need the connectivity between nodes and elements to discretize the analysis object, third, we do not need material parameter calibrations and can use arbitrary material constants unlike distinct element method (DEM) with a hexagonal arrangement. We first introduce moment-tensor earthquake source description to MPS method. Next, we demonstrate that a strong ground motion due to the surface basin structure can be reproduced by MPS method. Finally, we calculate surface wave propagation in the model with arbitrary surface topography. It is found that the method can reproduce the strong ground motion produced by earthquakes with satisfactory accuracy.

Keywords: particle method, seismic wave propagation, numerical simulation

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The Investigation of the Active Fault in the Beijing, China, Using Microtremor Survey Method

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The Investigation of the Active Fault in the Beijing, China, Using Microtremor Survey Method

Keywords: the microtremor survey method, array observation, apparent S velocity, active fault

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Determination of S-Wave structure beneath Istanbul, by using Love wave and by Joint Inversion of Rayleigh Wave and H/V

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On August 17, 1999, a devastating earthquake with a moment magnitude of Mw=7.4 struck the Kocaeli and Sakarya (Adapazari) provinces, and part of suburbs of Istanbul in the northwestern of Turkey, a very densely populated region in the industrial heartland of Turkey. This earthquake is considered to be the largest event to have devastated a modern, industrialized area since the 1923 Great Kanto earthquake. This earthquake caused about 30.000 losses of life and collapsed thousands of buildings. Thus, total loss figure amounted to about US$ 16 Billion. Following the losses during this large earthquake, there has been a broad recognition among Turkey governmental, non-governmental and academic organizations of the need for extensive response planning based on detailed risk analysis of likely seismic hazard, microzonation studies and ground-motion researches in Turkey, in general and, Istanbul particular. In this frame, we have been performing a project on the determination of S-wave velocity structure beneath the European side of Istanbul, Turkey. One of the aims of the project is to improve the knowledge about the influence of local geology in the city on the expected earthquake ground motion. In this project , we conducted both array measurements and single station microtremor measurements at 30 sites. We applied SPAC method for the inversion, and used both Love and Rayleigh waves, and H/V technique, as well, to determine the S-wave velocity structure. Furthermore, we compared S-wave velocity-depth model obtained from the inversion of Love wave dispersion curve with that obtained by joint inversion of Rayleigh wave dispersion curve and H/V curve. As a conclusion, we have found that Love waves are more sensitive to shallower parts than Rayleigh waves, since penetration depth of Love waves are shallower than Rayleigh waves. Contrarily, deeper parts are modelled more presizely by the joint inversion of Rayleigh waves and H/V curves.

Keywords: Microtremor, SPAC, Love waves, Rayleigh wave, H/V technique, Istanbul

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Quantitative Evaluation of Rock Mass Classification by Using Sonic Logging Data

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Keywords: Rock Mass Classification, Rock Mass Properties, Sonic Logging

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Fast calculation of formation factors of 3-D pore-scale images of geo-materials by renormalization

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The formation factor, the dimensionless electric resistivity of porous rock/sediment saturated with conductive fluid, is an important quantity in geophysical exploration for petroleum reservoirs and groundwater aquifers. In the rock physics related to such exploration, there is a need to calculate formation factors from large three-dimensional (3-D) images of porous rocks/sediments obtained by X-ray microtomography. In the present study, we applied a renormalization technique to quickly estimate the formation factors for various pore-scale image sets of real geo-materials (sandstones, pumice, lava, and sandy sediments). In this method, the effective formation factor is first calculated using Ohm's law and Kirchhoff's law for small subsystems of 2x2x2 = 8 voxels, and this is then upscaled based on the arrangement of voxels in the 3-D image. This method is several orders of magnitude faster than the conventional method because the time-consuming iterative algorithm for solving the 3-D large-scale Laplace equation is not employed. Application of this technique to microtomographic images of real porous rocks/sediments revealed that its accuracy increases with increasing porosity and pore elongation along the direction of the applied electric field and with decreasing pore/grain size. Most importantly, a high degree of elongation of the pore structure along the applied field ensures good accuracy even if the porosity is low and the pore/grain size is large. Taking these effects into consideration, the method can be used to produce a rough but quick estimate of the formation factors for large pore-scale images of geo-materials. Because steady-state thermal and material diffusion obeys the same Laplace equation, the renormalization technique presented here can also be applied to estimate thermal/material diffusivity for natural geo-materials and industrial composite materials, particularly for those having strong prolate structural anisotropy parallel to the applied field gradient.

Ref: Nakashima, Y. and Nakano, T. (2011) J. Appl. Geophys. (in review)

Keywords: resistivity, large-scale simulation, super computing, Laplace equation, X-ray microtomography, Diffusion coefficient