Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P01 Room:Convention Hall Time:May 21 18:15-19:30

Estimation of S-wave impedance in ground surface layer due to vertical load excitation

Nobuaki Tanaka[1*], Hiroyuki Goto[2], Sumio Sawada[2]

[1]Kyoto univ., [2]DPRI

Estimation of S-wave impedance in ground surface layer due to vertical load excitation

Dynamic response of structures during earthquakes depends on physical parameters in the ground due to the dynamic soil-structure interaction. The influence is complicated, but it is known that elastic impedance of ground layer associates with the radiation damping.

Normalized Energy Density (NED; Goto et al., 2011a) is a physical quantity related to wave propagation in multi-layered ground, and it becomes a constant value through each layer independent of how layer structure is. That is, S-wave impedance is an important physical parameter to decide dynamic ground response.

We develop a method to estimate S-wave impedance in half space, and in the most upper surface layers based on numerical experiments.

Hiroyuki Goto, Sumio Sawada and Toshiyuki Hirai: Conserved quantity of elastic waves in multi-layered media: 2D SH case -Normalized Energy Density-, Wave Motion, 48, pp.602-612, 2011.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P02 Room:Convention Hall Time:May 21 18:15-19:30

Q factor of elastic wave propagating in poroelastic medium

Kazuki Ishikura[1*], Hitoshi Mikada[1], Tada-nori Goto[1], Junichi Takekawa[1]

[1]Kyoto University

Sonic logging has been widely used for many years to understand physical properties of hydrocarbon reservoirs. For understanding the reservoir characteristic, quality factor based on the Biot's equation is often used. Although the Biot theory considers viscous attenuation induced at the interface between rocks and pore fluids, intrinsic attenuation caused by internal friction in the matrix is ignored. In the present study, we first hypothesized that the effect of the intrinsic attenuation could influence the evaluation of pore fluid properties, i.e., reservoir properties, based on the quality factor. We employ a 2D finite-difference scheme to simulate seismic wave propagation in a poroelastic medium for the confirmation of the hypothesis. The intrinsic attenuation is included in our model by using the filter of frequency-independent quality factor (constant-Q). We compare the results with and without the intrinsic attenuation in our numerical simulations. Our results clearly show that the amplitude and phase of the waveforms are strongly influenced by the intrinsic attenuation, and the calculated quality factors could be seen shifted to show different value from the real value derived from the Biot theory. We conclude that the evaluations of hydrocarbon reservoir based on the quality factor might require the inclusion of the intrinsic attenuation as well as the viscous attenuation.

Keywords: quality factor, poroelastic medium, constant-Q, intrinsic attenuation, viscous attenuation

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P03 Room:Convention Hall Time:May 21 18:15-19:30

Numerical electromagnetic simulation for high resolution eddy-current testing method

Takuya Saito[1*], Hitoshi Mikada[1], Tada-nori Goto[1], Junichi Takekawa[1]

[1]Graduate School of Engineering , Kyoto University

The applicability and feasibility of eddy current detection method for the measurement of wall thinning and surface crack of steel structure have been practically confirmed by field and laboratory experiments. Recently, we could roughly understand the location and size of defects by this method. But the estimated size and shape are qualitative ones. For more accurate inspections, there has been a demand to quantitatively evaluate the defects. Therefore, we developed a numerical simulator to consider whether we could refine the high accuracy eddy current method.

In the eddy current method, we use the information of excitation and induced magnetic field.In order to calculate the induced magnetic field, we used 2.5 dimensional finite-difference frequency domain technique (2.5D-FDFD) to solve Maxwell's equations numerically. In this technique, we assumed the two-dimensional structure and the three-dimensional electromagnetic field. We used two-layer structure consisting of seawater and steel plate containing defects. To estimate characteristic of the induced magnetic field, we simulated for various defects and compared what effects appear.

As a result, we could confirm the effect of surface defects of steel plate on receiving magnetic field intensity. The induced magnetic field intensity increases near the edge of the defects and decays above the defects. The larger the defects length and width are, the more attenuation the magnetic field intensity becomes. Our simulation results indicated that we could calculate the response of magnetic field intensity whose detectable scale of defects is no smaller than mm order.

Keywords: Eddy current, Maxwell's equation, NDE, 2.5D-FDFD, Magnetic field

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P04 Room:Convention Hall Time:May 21 18:15-19:30

Removable of galvanic distortion on 3-D MT inversion.

Masanori Tani[1*], Hitoshi Mikada[1], Tada-nori Goto[1], Junichi Takekawa[1], weerachai siripunvaraporn[2]

[1]Department of Civil and Earth Resources Engineering, Graduate School of Engineering, Kyoto Univ., [2]Department of Physics, Faculty of Science, Mahidol University. Thailand

The galvanic distortion is caused by localized resistivity anomalies near the surface and creates artificial false images in the inversion of MT data. Although the effects of galvanic distortion should be imaged locally, they tend to appear as gradual resistivity changes at deeper part of survey area, that is in general close to the target depth for hydrocarbon resource exploration of several kilometers, due to the smoothness constraint. Therefore, the galvanic distortion has to be removed to improve 3-D MT inversion results. In our study, we refine the smoothness function to image local anomaly on the surface layer in the inversion to cope with the effects of galvanic distortion. In the refinement, we modify a model covariance matrix in 3-D MT inversion algorithm, WSINV3DMT. We applied WSINV3DMT to several synthetic datasets to evaluate how local anomalies on the surface influences the result of 3-D MT inversion. The synthetic resistivity models used in this experiments have low resistivity anomalies in the subsurface with and without the surface local heterogeneities, respectively. The thickness of surface blocks is 10m. We estimated synthetic MT response functions from these two models for 7 periods; 0.01s,0.05s,0.1s,0.5s,1s,5s,10s. Then we applied WSINV3DMT to those synthetic datasets. For the removable of the effect of galvanic distortion, we applied a modified model covariance matrix to MT response functions calculated from the model with local anomalies on the surface. Finally, we first confirm that the effects of galvanic distortion would generate false resistivity anomalies in the inversion, in particular in the deeper part. This problem would not be negligible in the imaging of realistic resistivity structure in the subsurface. The results from the modified model covariance matrix we have introduced show more reliable results than those from the original model covariance matrix. Since a thin surface layer is an analogue of the galvanic distortion, we could deal with the galvanic distortions by thin layers placed at each observation site.

Keywords: Magnetotelluric, Inversion, Distortion

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P05 Room:Convention Hall Time:May 21 18:15-19:30

Visualization of subsurface resistivity anomalies in VLF-EM method

Daisuke Hyodo[1*], Hitoshi Mikada[1]

[1]Graduate school of Kyoto University

Electromagnetic waves of narrow-band frequencies generated by VLF transmitters induce electrical currents in the subsurface due to localized electrical conductivity anomalies. Secondary induced components of magnetic field would be observed above the surface due to the induced electrical currents. Therefore, the secondary induced magnetic field could be used to detect the induced currents in the subsurface. This method, so-called VLF-EM, has been recognized as a powerful tool for mapping subsurface conductivity anomalies because of its low cost and short survey terms. Conductivity anomalies are in general mapped on the surface but have not been estimated as a vertical pseudo-resistivity section nor in a 3D cube. We hypothesized that both the apparent resistivity and the depth of conductive anomalies could be estimated using the measured magnetic components with a single frequency. In this study, the Normalized Full Gradient (NFG) method, generally used for the downward continuation of the potential filed data, is applied to the observed magnetic data on the surface in order to estimate the 3D distribution of conductivity anomalies in the subsurface. A synthetic VLF-EM data set was created numerically to test our hypothesis. The cross section of NFG values derived from the horizontal component of magnetic field clearly peaks at the edges of a low resistivity anomaly zone buried below the surface, while the value of the NFG from the vertical component at the centre of the anomaly. Finally, we estimate a pseudo-section of apparent resistivity from the VLF-EM data weighted with the NFG values at each depth. We confirm that the weighted apparent resistivity values are lower in the vicinity of low resistivity anomaly than in the surrounding area, although the estimated value is a little higher than the original value. We conclude that our simple technique gives approximate subsurface resistivity structures quickly, which is useful for geological interpretations and also for building an initial model of three-dimensional inversion.

Keywords: VLF-EM, downwardcontinuation, NFG, apparent resistivity

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P06 Room:Convention Hall Time:May 21 18:15-19:30

Electromagnetic survey around the seafloor massive sulfide using autonomous underwater vehicle

Tada-nori Goto[1*], Takafumi Kasaya[2], Naoto Imamura[1], Hitoshi Mikada[1], Junichi Takekawa[1], Keizo Sayanagi[3]

[1]Graduate School of Engineering, Kyoto University, [2]JAMSTEC, [3]Institute of Oceanic Research and Development, Tokai University

The recent growth of world-wide requirement of metals demands advanced explorations for finding metal mine and deposits. The feasibility studies demonstrated that the electromagnetic responses are very sensitive to the conductive layer simulating the submarine massive sulfide (SMS) deposits, which is buried at the depth of several tens meters. On the basis of the results, we developed instruments for the marine controlled-source electromagnetic (CSEM) survey with autonomous underwater vehicle (AUV), on which a transmitter was attached. For the real field test, R/V Yokosuka and AUV Urashima were used. The target region is a real deep-sea mine in a caldera structure called Bayonnaise, located in the Izu-Bonin island arc, south of Japan. We succeeded in the test experiment along four survey lines with current shooting from AUV. Six ocean-bottom receivers (OBEM) simultaneously recorded those signals. The maximum source-receiver distance, in which we can detect the artificial current signals, exceeds to about 500m. Therefore, the inferred maximum sounding depth will be 150m or more below the seafloor. For evaluating the anomalous attenuation or amplification of received electric field at OBEMs, the three-dimensional forward modeling including the real bathymetry and a simple subsurface structure having an uniform resistivity (1 Ohm-m) was employed. Comparison between the observed and synthesized received field gives us a three-dimensional pseudo-section of anomalous received field, which can visualize heterogeneity of sub seafloor structure qualitatively. On the basis of the preliminary result of our AUV-CSEM survey around the SMS, high conductive features are observed not only in the SMS exposed area, but also the surrounding area of SMS. It would reflect both the mineral deposits in and around the SMS and highly conductive pore water below the surface due to warm temperature by hydrothermal activities below the SMS. We conclude that our new technology imaging the near sub-seafloor structures will be useful for discussion about the geological background of SMS, and also be a powerful tool for the SMS detection and developments.

Keywords: CSEM, AUV, seafloor massive sulfide, OBEM

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P07 Room:Convention Hall Time:May 21 18:15-19:30

Three-dimensional joint inversion of gravity and magnetic anomalies using fuzzy c-means clustering

Yosuke Teranishi[1*], Hitoshi Mikada[1], Tada-nori Goto[1], Junichi Takekawa[1]

[1]Kyoto University

The gravity and magnetic surveys have been widely carried out over the years, especially for the exploration of metallic mineral deposits and geothermal resources. These field intensity data could be acquired in much quicker and simpler way than the other geophysical or geological data. The inversion of potential field data, however, has been known as a non-uniqueness problem expressed in the Green's equivalent layer theory. Because of this problem, gravity and magnetic data have no inherent resolution in depth. We, therefore, would like to develop a way to make use of high exploration efficiency that takes the advantages of the convenience to conduct gravity and magnetic surveys.

We present a 3D joint inversion method to estimate two physical parameters, density and magnetization of subsurface materials. In the method, we introduce the fuzzy c-means (FCM) clustering technique in our joint inversion algorithm to consider the petrophysical relation between density and magnetization of subsurface materials. The fuzzy c-means clustering technique we introduce does not necessitate any empirical equation but deals with a linear combination of the influence from multiple clusters given a piece of data to belong to plural clusters in the parameter space formed by the petrophysical parameters.

In this study, we focus on natural resources such as submarine massive sulphides (SMS), which are attractive material due to the recent rapid growth of global economical activities, but their deposit locations below deep seafloor restricts the access. This necessitates detailed exploration using potential field data. We test our inversion method using synthetic numerical experiments for SMS. The joint inversion results using gravity and magnetic data sets show higher accuracy and resolution than the individual ones, and especially have improved horizontal resolution. We conclude that our joint inversion method demonstrates the accuracy of our method in the estimation of SMS in terms of the gravity and magnetic anomalies.

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P08 Room:Convention Hall Time:May 21 18:15-19:30

Lattice Boltzmann simulation for flux change under oscillating boundary condition

Ryuta Ueda[1*], Hitoshi Mikada[1], Tada-nori Goto[1], Junichi Takekawa[1]

[1]Graduate school of Engineering, Kyoto University

The amount of oil production in the world is decreasing recently and it is of importance to seek the technological development for enhanced oil recovery (EOR) in place in the subsurface. Seismic stimulation is known as one of the methods of EOR. Recently, many laboratory experiments and field tests have been performed such as water, gas, chemical, or thermal injections to attempt the enhancement of oil production. Numerous observations show that seismic stimulation of oil reservoir may improve oil production. To use seismic EOR efficiently, we need to understand the mechanisms of macroscopic phenomena: flux increment, pore-water pressure increment and relative permeability improvement, in particular in terms of seismic frequency and amplitude, to improve oil production. In this study, we attempt to demonstrate the flux change in viscous laminar flow under oscillating boundary condition with various frequencies and amplitudes for the simulation of interstitial flow. We discuss five characteristics: amplitude, frequency, angle, aspect ratio of pore length to pore width, and scale. All characteristics are largely related with the amount of flux change. The flux increases under cases with large amplitude, high frequency, large angle of incident to the wall, large aspect ratio or large scale. The angle is one of the most important characteristics for the flux change. So, vertically oscillating wall has smaller effect even if the other characteristics satisfy the condition to cause the flux increment. Our numerical results imply: i) the flow resistance increases by the velocity difference between the wall and the center of flow, ii) fluid extrusion is generated by partial pressure gradient near the wall, and iii) the oscillating boundary may cause pressure loss. We then discuss the possibility of flux change in terms of pore scales or shapes under the oscillating boundary condition with LBM. Finally, we try to enhance our simulations to include two-phase flow. We confirm that the oscillating boundary conditions could generate the reduction of interfacial tension to improve the relative permeability of oil droplets.

Keywords: seismic EOR, Lattice Boltzmann method, Computational Fluid Dynamics

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P09 Room:Convention Hall Time:May 21 18:15-19:30

Estimation of 2D shear wave velocity profile of soil layers using surface wave seismic tests

Pei-hsun Tsai[1*], Zheng-yi Feng[2]

[1]Department of Construction Engineering, Chaoyang University of Technology, Taichung, 413, Taiwan, [2]Department of Soil and Water Conservation, National Chung Hsing University, Taichung, 402, Taiwan

The 2D shear wave velocity profile of strata is estimated using the active and passive surface wave seismic tests. The experimental dispersion curves were obtained after the recorded signals were transformed by the slant stack procedure. The phase velocity in the relatively high frequency range can be obtained using the dispersion curves deduced from the active tests. On the other side, dispersion curves obtained from the passive tests can be used to estimate the phase velocity in the relatively low frequency range. From the higher frequency portion of the dispersion curves that stand for the fundamental mode, we obtained the phase velocities about 190 m/s for the sandy surface fill. Theoretical dispersion curves can be constructed by the thin-layer-stiffness-matrix method. For theoretical dispersion curves, the soil layers of the test site were modeled as the sandy surface fill overlying a half space soil layer. A real-parameter genetic algorithm was programmed to minimize the difference between the theoretical and experimental dispersion curves. We prove that the real-parameter genetic algorithm is capable to reduce the error between experimental and theoretical dispersion curves. The estimated 2D geometry of the sandy surface fill using the active and passive surface wave seismic tests was verified with the borehole data.

Keywords: Slant stack, shear wave velocity, genetic algorithm, dispersion curve

Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

STT11-P10 Room:Convention Hall Time:May 21 18:15-19:30

Application of Geophysical Methods to investigate the Polluted Site and river bottom mud.

HsinChang Liu[1*], S. N. Cheng[1]

[1]Chien Hsin University of Science and Technology

Investigation of many polluted sites indicates that DNAPL plume in the subsurface is able to penetrate a low permeable layer such as clay or silt-caly layer. These DNAPL plume within the low permeable Layer will gradually diffuse to the high permeable layer to affect the accuracy of investigation and remedial design. As to the deeper zone affected by the penetration of DNAPL, the investigating technique of conventional bore-hole sampling design is always limited to the first unconfined aquifer, it is no longer suitable for DNAPL detecting underneath. Precisely define the boundary and the distribution of high and low permeable layer is the key to conduct a successful DNAPL detecting.

Point information derived from the conventional bore-hole sampling is difficult to be used for locating the DNAPL pollution due to the uncertainty of DNAPL migration and the soluble-phase distribution of the DNAPL partitioned into ground water between the low and high permeable layer. Recently, non-invaded technologies such as geophysical technology have been introduced to provide The plane and space information of pollution in subsurface by referring a few bore-hole dates. The most common used geophysical technologies are ground-penetrating radar method (GPR) and electrical resistivity tomography (ERT). Both methods have their limitations when its survey is affected by the existence of surface objects such as building structure or heavy pavement. This drawback can be overcome by using geophysical well logging. The information of multi-wells logging could be used to interpret the permeability of subsurface, the dominate flow path and the hot-spot for evaluating the distribution of pollution and the efficiency of remediation in different time sequences.

This study would first discuss how the DNAPL and its soluble-phase components invade into the low permeable layer based on the field observation. Then, the geophysical technologies are being introduced and compare to the bore-hole investigation alone. Finally, a case study using various geophysical technologies including geophysical well logging are introduced to snapshot the complex profile of subsurface DNAPL distribution for improving future application.

Geophysical Techniques for Near-Surface Hydrological Investigations:

Traditionally, the location and geometrical characterization of fractures and/or fracture zones are recognized by outcrop observations, knowledge of the geological setting and extrapolation from geological data sets etc... Most geophysical methods, such as electrical resistivity mapping, are able to detect variations in the subsurface that could possibly be due to fracturing, such as increased moisture content but only provide a proxy indicator of true fracture orientation, structure and density. At some point in the last few decades, almost every conceivable geophysical technique has been applied to the problem of locating subsurface, groundwater and pollutant flow though these porous and fractured media. Of the available methods, GPR, ERT and EM techniques are deemed the most appropriate. With EM conductivity (e.g., EM 31) considered but discounted due to the presence of surface metallic structures (e.g., steel pathway stabilizing rods, handrail anchors, etc) and a lack of suitable survey space in the investigation areas.

Keywords: Electrical Resistivity Tomography, Ground Penetrating Radar, Horizontal Loop Electromagnetic Method