Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

STT56-P01 Room:Convention Hall Time:May 20 15:30-15:45

Modeling Real Structure with FDM using In-equally Spaced Grids - Effects of Seafloor Topography on Tsunami Propagation-

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When we use numerical simulation to understand geophysical phenomena, topography often affects those phenomena. It is necessary for understanding them to explain those phenomena in realistic structure models. In this study, we consider to use the Finite Difference Method (FDM) with in-equally spaced grids as a method for modeling realistic structures. We apply our method to tsunami disaster mitigation, considering the effects of the seafloor topography on the tsunami propagation.

Tsunami simulations are widely used to predict tsunami behavior occurred by an earthquake. The simulated tsunami, however, does not show good agreement with the observed one so often, especially in later phases. In this study, we make a hypothesis; the simulation of tsunami propagation including the effects of the seafloor topography can solve the difficulty of prediction of tsunami in later phases. We simulated tsunami propagation by solving three dimensional Navier-Stokes equations and by using FDM with in-equally spaced grids for realistic seafloor topography model. Comparing tsunami propagation in our method with that based on the conventional long wave theory, we discuss the effects of seafloor topography on tsunami propagation. We find that the tsunami propagation is influenced by two effects; effects of real changes in water depths and those of nonlinear terms in N-S equations. As a result, we conclude that our method, considering realistic seafloor topography on tsunami propagation, leads to the prediction of tsunami including later phases with much higher accuracy than the present.

Keywords: simulation of tsunami propagation, seafloor topography, modeling, in-equally spaced grids, later phases of tsunami, The Tohoku earthquake

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The application of the fullwave inversion techniques to Ocean Acoustic Tomography

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The problem of Ocean Acoustic Tomography (OAT) is to estimate the state of ocean in temperature, salinity, etc. that are related to sound velocity structure from the travel-time or other properties in acoustic wave propagation. The ocean is nearly transparent for low frequency acoustic waves so that the acoustic wave could propagate for thousands of kms. OAT was first introduced by Munk et al. (1995) and based on a ray theoretical approach. A travel-time inversion method has been developed using a ray-tracing scheme in the Munk's method. There is some similarity with seismic exploration both in theory and in data processing methods. However the waveform analysis is not common in OAT although its importance is widely recognized in seismic explorations. Actually there is hardly any precedent studies on waveform inversion in the application of OAT. In this study, a full-wave inversion technique is applied to OAT in the 2-D acoustic FDTD model in order to investigate the effectiveness of the method through the comparison of the results with that of the ray-tracing inversion approach. Then, as an application for a field data, the full-wave inversion technique is applied to the VCS experiment data in Lake Biwa. The result shows applicability of the full-wave inversion technique to OAT and also shows that full-wave inversion provides higher image construction than in travel-times inversions.

Keywords: Underwater acoustic, VSC, Full-wave inversion, Ocean Acoustic Tomography

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STT56-P03 Room:Convention Hall Time:May 20 15:30-15:45

Relationship between formation of parallel faults and stress fields in rock mass

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Some parallel cracks and faults, which are caused by earthquakes and crustal deformations, can be observed as various sizes from crustal scale to laboratory scale. The mechanism of formation of these parallel faults is not well investigated, and there still remains an important geophysical subject. If we find the relationship between the formation of parallel faults and stress field applied to rock mass, we could infer stress field loaded to the crust from the pattern of faults. For interpretation of these cracks behaviors, many attempts have been made using fracture mechanics theory. These attempts have successfully represented the propagation of predefined cracks. However, it is difficult to describe the initiation and the coalescence of cracks using this theory. Thus, in the recent years, numerical modeling has been applied to study crack behaviors in rocks. In this study, we conducted numerical simulations of rock mass failure under different conditions to investigate the nucleation conditions.

In this study, we use the Hamiltonian Particle Method (HPM), one of the particle methods. In the particle methods, a continuum is represented as a set of particles and a motion of the continuum is approximated as a movement of the particles. Therefore, the particle methods do not need the calculation grids or elements and can describe the failure at faults or cracks. We assumed that a rock mass with rectangular shape consists of basalt. The calculation model is based on a three dimensional elastic body. The failure of rock mass is assumed to obey the Mohr-Coulomb failure criterion and the tensile and compressive strength of rock elements distribute following the Weibull distribution. As stress fields in rock mass, we applied compressive, shear and bending forces to rock mass and changed the direction and magnitude of these forces. Results of the simulations suggest that the confining pressure would have dominant influence for the initiation of parallel faults in compressive conditions and that the shear force would provoke the propagation of parallel fractures along the shear direction.

Keywords: fault, particle method

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11 years long term monitoring of Seismic velocity near Nojima fault using ACROSS

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We have conducted a monitoring experiment of near fault seismic velocity for 11 years using an accurately controlled seismic signal system named ACROSS.

The aim of our study is to monitor the healing process of the fault after the rupture by the 1995 Kobe earthquake (M7.3) using ACROSS. The name ACROSS stands for Accurately Controlled and Routinely Operated Signal System, which continuously generate controlled seismic wave by centrifugal force from mass rotation. We deployed a couple of ACROSS sources in a source house just 300m away from the fault surface and the seismic signal generated by them is received by seismometers deployed at the bottom of 800m- and 1700m-deep boreholes just beneath the sources. The two sources are designed to generate same force of $2x10^5$N by different rotation frequency of 25Hz and 35Hz respectively.

In this study, the source operation was repeated intermittently for 11 years from 2000 to 2012. We monitored the following three elements of the signal.

1. Travel time and amplitude of P and S waves. The both waves advanced about 4 per mill in the 11 years.
2. Travel time of S-coda phases. The coda part showed velocity increase (travel time advance) for 1 per mill, smaller than that of body waves.
3. S-wave splitting. The difference of velocity has been 10 % between the two S waves in the orthogonal vibration directions through the measurement period. The difference did not change to the detectable level.

If we assume the cause of the travel time advance to be a reduction of the crack density, the value is calculated to be 0.004-0.01 assuming random coin-shape crack. Previous studies reported that the permeability around the 1700m-deep borehole decreased by 50 per cent from 2000 to 2007. The decrease of the crack density qualitatively explains the permeability change. However, the permeability changed drastically while the change of the crack density is very small. This suggests that just disconnection or sealing of the water channels occurs without large change of crack density.

Keywords: ACROSS, Nojima Fault, Fault-zone Probe, Seismic velocity, Monitoring

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The measurement of soil water content of upper part of the cave using electromagnetic component of air shower

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We have developed a new radiographic method to measure the time variation of the water content of the soil with soft component of air shower.

Air shower produced by a primary cosmic ray consists of hard component and soft component. Hard component is mainly consists of muon, and soft components is consists of electron, positron and photon. The penetration power of soft component is weaker than that of hard component, so soft component is suitable for small scale structure thinner than 2 kg/cm2 equivalent to 20m thick water, like buildings and small hills. But it requires particle identification which means distinguishing hard component and soft component. Particle identification can be done with strong magnets and dense detectors, but it is very hard to use that kind of detector for radiography because of their weight and cost.

We established the cheap and effective method to distinguish soft component and hard component statistically. We also performed measurements in Arimura observation pit of Mt. Sakurajima, Japan. As a result of this observation, we found there is an anti-correlation between soft component flux and rainfall. If the water content of the soil became larger, the amount of absorption increases. So this result can be interpreted as detecting the increase of the water content by soft component flux.

This method can be applied for the quantitive compensation of the measurement data like absolute gravitymeter data and tiltmeter data which is easy to receive turbulence by rain. It is also expected that the quantitive compensation leads to the improvement in accuracy of diastrophism measurement and the improvement in presumed accuracy of magma movement inside a volcano.

Keywords: soil water content, cosmic ray, radiography

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Analysis of electromagnetic data by using MT frequency response function, application of geophysical exploration

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Electromagnetic inductive response, produced by electromagnetic variation in ionosphere or magnetosphere, is mainly included in observed electromagnetic data in the earth surface. The inductive response is used for the estimation of resistivity structure such as a MT method. The inductive effect is made by solar activity which varies widely cyclic or irregularly, and the observed electromagnetic data also vary widely. Therefore, the inductive response becomes obstructive factor in analyzing water injection or CO2 storage experiment in the real field. Recently, we attempt to remove the inductive effect on time-series electromagnetic data by using MT frequency response function. This method is able to estimate inductive effect on time-series electric data from magnetic data, or magnetic data from electric data. If the inductive effect on observed electromagnetic data can be removed by the method, the target signal should be clearly picked out. We will present the results of the analysis of observed MT time-series data.

Keywords: MT method, frequency response function, geophysical exploration, analysis of time-domain data

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Improvement of prospecting accuracy of subsurface structure by GPR using polarization and transmitted waves

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Visualization techniques of the subsurface structure using the electromagnetic waves have been used widely in many fields such as detecting underground pipe, existences of underground cave and fractures that can cause subsidence, excavation of archeological site, estimating geological structure, and natural resource exploration. Estimating subsurface physical properties such as dielectricity, electric conductivity, and magnetic permeability is indispensable to improve the prospecting accuracy, which can contribute to identify the subsurface materials in addition to geometrical properties of material boundaries. However, it is difficult to estimate such subsurface properties at the present because of strong heterogeneity concerning physical properties distribution and shape of stratum boundary.

For this problem, we developed a prototype system of Ground Penetrating Radar (GPR), termed POGRA (POlarimetry Ground penetration RAdar system) which separates transmission and receiving antennas. The merit of POGRA is that it can measure two types of microwaves: transmitted waves and two or more polarization waves by the arrangement of antennas. Transmission-type GPR (T-GPR) can receive the input signals more strongly than the traditional reflection-type GPR by reducing the travel distance of microwaves by half. Capability of the T-GPR was tested for a structure with caves under the water table: the T-GPR could detect the caves correctly. For a horizontal layer structure, geological box model was produced using many small boxes filled with sands whose dielectricity values were set as large, middle, and small by changing the water content. Polarization-type GPR (P-GPR) was applied to three layers structure, and dielectricity values of each layer were calculated. It was clarified that the dielectricity values could be obtained correctly for the structure in which the dielectricity increased with the depth.

Keywords: Dielectricity, Fresnel equations, Reflection coefficient, Transmittance, Geological model