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SCG010-01 会場:203 時間:5 月 25 日 14:15-14:35

Near-Surface 3D Imaging of Buried Metallic Objects Using Real-Time Data Fusion of GPR and IGPS

Near-Surface 3D Imaging of Buried Metallic Objects Using Real-Time Data Fusion of GPR and IGPS

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ABSTRACT

The 3-Dimentional GPR image allowed the generation of time/depth slices images that effectively illustrate the geometry of the near surface structures. Moreover, crossline image resolution in the order of centimeters is needed for detecting small targets. Therefore, a new 3D GPR system has been developed to measure the position with millimeter accuracy. In this system, positions data is obtained by iGPS, which provides millimeter accuracy x, y, and z coordinates simultaneously from a small detectors attached to moving GPR antennas. For a heterogeneous subsurface, minimum grid spacing of GPR measurements is required and has to be an eighth of a wavelength or less in all directions for correct grid-point assignment. This clear image could not be achieved with the conventional GPR which includes a few centimeter position errors.

A 500 MHz commercial GPR system and rotary laser positioning system (RLPS) have been used at two pre-designed test sites belong to Osaka Gas Company. These two sites have quiet complicated buried pipes at different depths and with different diameters. The data was acquired along survey having 5cm inline and 2.5cm crossline spacing. Both iGPS and GPR data is stored independently and later regularized, fused and re-arranged on rectangular grid. A 3D-fk migration of the three dimensional fused data on the basis of a constant velocity (7.5 cm/ns) is performed. The 3D migrated depth slice data has been used for picking the buried objectives only by extracting the positive and negative high amplitudes in each individual slice. Such high amplitudes picks have been displayed in a 3D cube for better visualization.

キーワード: IGPS, GPR, Data fusion, 3D-fk migration, 3D imaging, Buried objectives
Keywords: IGPS, GPR, Data fusion, 3D-fk migration, 3D imaging, Buried objectives

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Characterizing subsurface fractures based on forward molding of EM scattering from synthesized fractal fractures

Characterizing subsurface fractures based on forward molding of EM scattering from synthesized fractal fractures

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We developed a new full polarimetry subsurface borehole radar measuring system which can be applied for several applications one of them is subsurface fractures characterization. But, In order to understand the scattering behavior of electromagnetic waves from subsurface fractures, we utilize FDTD numerical simulation for synthesized fracture models. In this approach we use single fracture model as it represents the nucleus for whole fracture set and from it we realize the interaction of electromagnetic wave fractures. These synthetic fractures have isotropic surfaces and were created by a spectral method based on fractional Brownian motion. Thus the fractal surface is created by the inverse Fourier transform of the spectrum components with random phase that are given according to the scaling law of the surface height. On the other hand, the upper fracture surface is created by introducing spectrum components for the lower surface with the same amplitude as that of the upper surface but with a different relative phase from the lower surface. For simplification, we maintained a constant fracture aperture which can be considered as normal fracture case with full water saturated type for examination the fracture roughness parameter. In FDTD model, we use plane wave as electromagnetic source and frequency ranges between 1 MHz up to 200 MHz. Firstly, We observe the electromagnetic scattering for one fractal rough fracture aperture and examine the electromagnetic scattering properties from various fracture rough surfaces with 3 cm fracture aperture width and we concluded that the cross polarization (HV and VH) is a significant component for characterizing subsurface fractures where its mean power scatting matrix values are increasing with roughness of fracture models parameter for normal incidence plane wave case. Entropy and Alpha distribution are well known parameters for characterizing the scattering mechanism in SAR remote sensing; we proposed the same configuration in our forward modeling for EM scattering from fracture model by 2D observation plane which can be represented as SAR image. 2D observation plane is located regularly in X and Y directions close to the fracture model with a fixed separation in both directions to recover the scattering from certain illuminated zone from fracture surface. Analyzing the Entropy and Alpha distribution parameters at each single frequency from synthesized fractal fracture we notice variability of the results due to fracture roughness parameter as Entropy-Alpha distribution values increasing especially at 60 MHz and 80 MHz with RMS fracture roughness. Furthermore, we characterize the fracture aperture content when it has water, air and hydrocarbon filled materials and we figure out that Entropy parameters is the high for water filled fracture aperture as the scattering complexity is the largest in this case.

キーワード: subsurface fracture characterization, FDTD modeling, full polarimetry borehole radar, power scatting matrix, Entropy and Alpha distribution
Keywords: subsurface fracture characterization, FDTD modeling, full polarimetry borehole radar, power scatting matrix, Entropy and Alpha distribution

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PSO vs. GA vs. VFSA: A comparison of performance, accuracy and resolution with respect to inversion of SP data.

PSO vs. GA vs. VFSA: A comparison of performance, accuracy and resolution with respect to inversion of SP data.

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Introduction

The process of geophysical inversion is pivotal to data interpretation. It aims to find the closest fitting relationship between the observed and computed data obtained henceforth. The target of finding the best model among viable alternates that produces the least deviation from the observed data is known as optimization. This paper aims to compare three global optimization methods namely Genetic Algorithm (GA), Very Fast Simulated Annealing (VFSA) and Particle Swarm Optimization (PSO) in reference to inverting Self Potential (SP) data.

Algorithms

Genetic Algorithm (GA) is a global optimization algorithm that mimics the process of biological evolution to find the best solution. It operates by meta-heuristic way which generates solution to optimization problems using techniques inspired by natural evolution such as inheritance, mutation, selection and crossover. Solutions are represented generally in strings of real numbers. Unlike GA, Particle Swarm Optimization (PSO) is a population based stochastic optimization technique which works on principle inspired by social behavior of bird flocking. Convergence to obtain optimum solution is carried out by calculating fitness value at each iteration and correcting those using local and global best in the neighborhood. On the other hand, Very Fast Simulated Annealing (VFSA), a variant of Simulated Annealing simulates the physical process of annealing which cools a heated object very slowly to minimize the randomness in the system and hence the energy. Here the error function is the analogous equivalent of energy that is optimized to reach a global minima.

Forward Equation

$K[(x-x_0)\cos(a)+(z)\sin(a)]/[(x-x_0)^2+z^2]^q$

Data and Models

Self-Potential (SP) anomalies in general are used for mineral and ground water exploration. The SP anomaly due simple geometric bodies is given by a simple equation which forms the forward problem in this inversion scheme and gives the position(x_0), depth(z), dipole moment(K),shape(q) and angle of polarization(a) of the source body. The algorithms were tested on the basis of their performance, accuracy and flexibility. Mean Square Error was taken as the objective function in all the cases. Both synthetic and field data were used to evaluate the algorithms. Among synthetic data there were both noise free and noise corrupted data sets generated by bodies of spherical and cylindrical shapes. To increase the complexity, a combination of two sources in the same profile was also implemented with after adding 20% random noise. Additionally, a resolution test was performed which outlined the ability of an algorithm to resolve two closely placed bodies exhibiting SP anomalies. The distance between the two sources was initially kept at 10m with 10m increments in the subsequent data sets. Finally, two field datasets from Balangir, India and Vilarelho da Raia region, Portugal were inverted and the results were compared. While the former field dataset was a single source anomaly, the latter was a two source anomaly. The comparative plots of the field anomalies are shown in Fig. 1b and Fig. 1c while those of a two source anomaly and one of the resolution tests are shown in Fig. 1a and Fig. 1d respectively.

Conclusions

All the three algorithm were coded in FORTRAN77. The results obtained by three algorithms were comparable. However, the resolution capability of VFSA was the best followed by PSO and VFSA. PSO obtained the optimum results quicker than the other two. The variable probabilistic parameters were the least and very well established in the case of PSO. As a result fine gained control over the algorithm was quite easy. However, with GA and VFSA there were more probabilistic parameters which made fine tuning quite an effort.

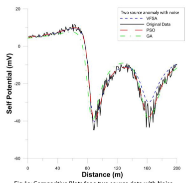

Fig 1a: Comparitive Plots for a two source data with Noise

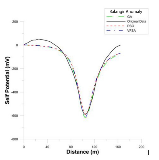

Fig1b: Comparitive Plots for Balangir Anomaly

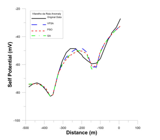

Fig 1c: Comparitive Plots for Vilarelho da Raia Anomaly

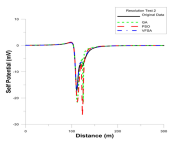

Fig 1d: Comparitive Plots for Resolution Test

キーワード: Self Potential, Inversion, Optimization, Particle Swarm Optimization, Very Fast Simulated Annealing, Genetic Algorithm
Keywords: Self Potential, Inversion, Optimization, Particle Swarm Optimization, Very Fast Simulated Annealing, Genetic Algorithm

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孔井間地中レーダデータと岩石物理学的関係に基づく不飽和帯溶質移動の定量的評価
Quantitative estimation for solute movement in vadose zone beased on crosshole radar data and petrophysical relationship

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One of the best ways to solve problems with nitrate contamination of groundwater in agricultural areas is to improve fertilization and farming methods to reduce the leaching rate and impacts of nitrate to the groundwater. Recently, we can find some successful examples of the effort of farmers that maintain low input farming to overcome this problem. On the contrary, we can find cases in which the improvement of farming and the reduction of the amount of fertilizer applied have little effect for improving the quality of groundwater.

In order to maintain sustainable efforts in agriculture for environmental conservation, contamination and purification processes must be clarified. However, it is difficult to explain all the processes because they are subsurface phenomena and cannot be observed directly. This uncertainty and opacity are major obstacles to the improvement of water quality in watersheds contaminated by non-point sources. A technique to clarify the contamination process and to assess the effects of nitrate leaching rate, rain infiltration ratio and other principal factors affecting groundwater quality should be established.

Clarification and quantitative estimation of hydrological phenomena in the deep vadose zone are essential and necessary in environmental science and engineering. However, it is difficult to explain these phenomena because of a lack of proper measurement methods. We propose a method to monitor soil water and solute dynamics quantitatively in the vadose zone. This approach is based on time-lapse cross-borehole ground-penetrating radar (GPR) measurements in the vadose zone and petrophysical relationship between electromagnetic property of soil and soil solution.

The objective of this research is to develop a method to clarify the dynamics of soil water and solute quantitatively in the vadose zone, which is a zone of unsaturated soil from soil surface to groundwater. The proposed method was tested in Makinohara Plateau in Shizuoka Prefecture to evaluate the applicability.

キーワード: 地中レーダ, 孔井間物理探査, 繰り返し探査, 不飽和帯水文学, 土壌環境, 溶質移動
Keywords: Ground Penetrating Radar (GPR), Cross-hole geophyisics, Time-lapse, Vadose zone hydro-geophysics, Soil environment, Solute movement

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2010 ARCHAEOGEOPHYSICAL STUDIES CONDUCTED AT HARSENA PALACE OF FORTRESS OF THE MAIDENS

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The province of Amasya is located inland of the Central Black Sea Region. The province is between 34.57- 36.31 east longitude and 41.04 - 40.16 north latitude. The sea level of the province is 1,150 m and its provincial center is 411.69 m above sea level. Amasya (Amaseia) is an important city in the history of Anatolia. The city was given the name Hakmis/Hakpis according to Hittite sources. The Amasya Fortress was founded on Mount Harsena as the most convenient place to defend the city. From the Early Bronze Age (3200 BC) to the end of the Ottoman period, it was used for defense purposes. The first settlement at Amasya commenced around 5500 BC and continued without interruption under the Hittites, Phrygians, Kimmers, Scythians, Lydians, Persians, Hellenes, (Pontuians), Romans, Byzantines, Danismends, Seljuks, Ilkhanids and Ottoman periods. The fortress standing at the northern end of Amasya consists of three sections known as the Inner Town (Hatuniye Neighborhood), the Palace of Maidens and the Upper Fortress (Har?ena).

During the Hellenistic Age, the Tombs of the Pontic Kings in Amasya, as the capital of the Pontic kings between 333 BC and 26 AD, were carved from calcareous rocks in the southern foothills of Mount Harsena. The Fortress has four gates named: Belkis, Saray, Maydonos and Meydan, a water well named Cilanbolu, as well as a cistern and prisons. Seventy meters below the fortress is an underground stairway dating back to 3 BC that stretches to the Kizilirmak River and the Tombs of the Kings as well as the remains of a bastion and a mosque.

On the southern skirts of the fortress, the remains of the Palace of the Maidens used by the Ottomans as well as a 20-25 meter straight wall rising from the mountain skirts that is carved from calcareous rocks and that includes 18 large and small stone cemeteries dating from 3 BC can be found.

The Palace of the Maidens is below the caves which are located above the inner fortress. When the niece of governor Isfendiyar Bey, Dograk Hatun arrived at Amasya and not being able to enter the Seljuk Palace, the Palace of the Maidens was built. The Palace of the Maidens housed Ottoman princes, ladies and governors for over 150 years and was used continuously until 1852. Today it stands in ruins.

In terms of topographic location, Amasya exists today without having changed for centuries. Founded on the skirts of the valley where the Kizilirmak (Iris) River flows through, for reasons of settlement, security and defense, it was built among the rising foothills north of the Kizilirmak River among a hill surrounded by a fortress and expanded from the slopes to the floor of valley as security was made available.

The Fortress of Amasya consists of three main sections of Lower City that declines from the top to the lower end; the fortress terrace (basilica) known as the Palace of the Maidens and the Upper Fortress known as the Harsena Fortress. The section known as the Palace of the Maidens of Amasya Fortress is on a terrace that is against the mountain behind it.

Using geophysical techniques in archaeological site is rather important in terms of both saving time and reducing the cost. For these reasons, in order to research foundation structure of Amasya Fortress and to determine the locations in which excavations will be executed in the 2011 excavation season, GPR and magnetometer methods were used in Amasya. After taken magnetic and GPR measurements, it was clear that the magnetic maps and GPR radargrams indicated regular anomalies in the foundation of structure. In the light of these data, it was decided that trenches will be executed at these locations during the 2011 excavation season.

キーワード: Amasya- Harsena Castle, Archaeogeophysics, Magnetic Survey, GPR
Keywords: Amasya- Harsena Castle, Archaeogeophysics, Magnetic Survey, GPR