Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

STT07-P01 Room:Poster Time:April 29 18:15-19:30

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

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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 intensity data of gravity and magnetic fields could be acquired in much quicker and simpler ways than the other geophysical or geological surveys. The inversion of such 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 equations 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. Adding the simple FCM clustering scheme, we introduced the smoothness constraint to a weight for membership to each clusters, instead of the conventional smoothness constraint to model parameters. Numerical studies using synthetic data indicate the effectiveness of FCM clustering in the joint inversion: the joint inversion results using gravity and magnetic data sets show higher accuracy and resolution than the individual ones.

As the field example, we focus on submarine volcanoes located at Mozambique Channel, because the world-class gas fields were discovered around that area and it is necessitated to estimate structure of submarine volcanoes near gas fields. We apply our inversion method to the real field gravity and magnetic data of the submarine volcanoes at Mozambique Channel. We conclude that our joint inversion method gives the reliable and detailed density/magnetization structures inside the submarine volcanoes in term s of the gravity and magnetic anomalies.

Keywords: joint inversion, gravity, magnetic, submarine volcano

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Stress field and fracture propagation due to the change of injection pressure

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Hydraulic fracturing is an indispensable scheme to stimulate fluid production in hydrocarbon reservoir development in conjunction with various well testing methods such as drill stem, buildup tests, etc. In recent years, it is also well known that hydraulic fracturing plays a major role in the development of shale oil or gas reservoirs.

The extension length and the orientation of fractures induced by hydraulic fracturing are strongly influenced by the crustal stress field under which any reservoirs are located. Therefore the propagation of fractures is controlled by the regional stress field. It is, in general, necessary to get some understanding of regional stress field before the application of hydraulic fracturing as well as acquiring the rock physical properties of reservoir formations.

However, hydraulically induced fractures may not be created as planned and could cause some environmental issues such as pollution, induced seismicity, etc. It is, we think, very important to estimate how fractures are induced under various crustal conditions to cope with unexpected behavior of fracture propagation.

We focused the effects of the in-situ stress on the stress field around the pre-existing fracture and the fracture propagation with both steady and non-steady hydraulic pressure conditions. To simulate failures in crustal materials under the complicated stress field, we use an extended finite element method (X-FEM) in this study, which can retrieve the stress distribution affected by fractures effectively and estimate the fracture propagation based on linear elastic fracture mechanics (LEFM). Numerical simulations are conducted for a 2D elastic medium having a borehole and a pre-existing fracture. We put the pre-existing fracture around the borehole initially and simulate the propagation of this fracture by applying the hydraulic pressure. The velocity of fracture propagation and the interval of the stress recovery from the stress drop caused by the propagation are set uniformly for the kinetic simulation.

We first simulate the fracture propagation around the borehole under different steady hydraulic pressures with regional stress field. Then we try to see how the fracture could propagate with the non-steady hydraulic pressure during the propagation.

We confirmed that the orientation of the fracture propagation converges to that of the principal stress. Moreover, the convergence speed could be inversely related to the hydraulic pressure. We also found the time delay of the influence of the hydraulic pressure change to the fracture propagation with non-steady hydraulic pressure condition.

From the results of our numerical simulations, we would like to have two conclusions. First, the curvature of the fracture trace depends on hydraulic pressure, but no matter how the fluid pressure is, the orientation of fracture propagation converges to that of principal stress. Second, the transition of the stress field involves the time delay, which leads to the delayed response of the fracture propagation in the non-steady hydraulic pressure condition.

When we develop a hydrocarbon reservoir using hydraulic fracturing, the orientation of maximum in-situ principal stress and the fluid pressure for fracturing should be quantitatively taken into account for the environmental safety and for the stimulation efficiency. It might be also necessary to consider the time delay of the transition of the stress due to the non-steady hydraulic pressure.

Keywords: Hydraulic fracturing, Fracture propagation, X-FEM, Stress field

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Estimation of the Dispersion Curve for Soil Layers with Lateral Heterogeneity Using Continuous Wavelet Transform

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The MASW method is the normal method regarding surface wave testing, but it requires 12 or more receivers to measure the phase velocity for statistical redundancy. Therefore, the SASW method has potential for use because only two receivers are required. A time-frequency domain analysis is used to extract a dispersion image of Rayleigh waves and select a dispersion curve from the seismic signals of two receivers during surface wave testing. The signals are transformed by continuous wavelet transform, and the products of the transformed signals of the two receivers are summed at the same slowness over the intercept time to construct a dispersion image. This method is unnecessary empirical judgment in the unwrapping of phases and a significant number of receivers. To examine the applicability of the method on evaluating the dispersion curve for soil layers with lateral heterogeneity, three synthetic examples and an experience example of surface wave testing are discussed. The method is applicable for extracting a dispersion image for lateral heterogeneity soil layers. A high-resolution dispersion image is generated in this study by increasing the interval of the receivers. The result of the experience example was in accordance with that of the borehole data.

Keywords: Dispersion curve, Continuous wavelet transform, Lateral heterogeneity

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Issues and Countermeasures for the Geophysics Investigation of Contaminated with Chlorinated Hydrocarbon

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Environmental geophysics survey has the advantages of survey rapidly, high resolution result and less affected by the surface topography and objects. It is suitable to either a wide range of general survey or a small-scale precise survey. Recently, non-invaded technologies such as geophysical technology have been introduced to provide the plane and space information of pollution in subsurface by integrating few bore-hole dates. The most common used geophysical technologies are ground-penetrating radar method (GPR) and electrical resistivity tomography (ERT). The electrical resistivity tomography (ERT) is one of the most widely used geophysical methods in geological, hydro-geological, and geo-environmental investigations.This study would first discuss how DNAPL and its soluble-phase components invade into the low permeable layer based on the field observation. Then, the importance of geophysical technology is introduced with comparing to the limitations of bore-hole investigation. Last, the case studies on using geophysical technologies including geophysical well logging are introduced to snapshot the complex profile of DNAPL distribution for improving future application.

Keywords: Geophysical survey, Electrical Resistivity Tomography, Borehole Radar