SUBSURFACE GEOLOGICAL CONDITION OF SEVERAL LAND COASTAL ZONE IN INDONESIA BASED ON THE GSSI GROUND PROBING RADAR (GPR) RECORD INTERPRETATION

By :

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ABSTRACT

The GSSI Ground Penetrating radar have been used to profile the shallow depth of subsurface geology of several area of Land Coastal zone in Indonesia

Analysis of a large data base of GPR profile from natural subsurface geological condition along the land coast line have allowed identification of reflection configuration that characterize this type of sub surface geological environment.

In many contamination problem, the geological information of coastal area is sparse and drill-core description only gives a limited picture of the geometry of inhomogeneties. The Ground-Probing Radar (GPR) method is a promising tool for resolving changes of physical properties in subsurface geological condition at the scale of natural inhomogeneties arising from changing lithology composition.

The objective of present work are to examine whether and to what extent the characteristic lithofacies of subsurface lithology can be recognised as mapable reflection pattern on ground probing radar (GPR) reflection profiles in order to gain information about the subsurface geometry of subsurface geology in coastal area.

Key word: Subsurface geology, coastal zone, Ground Probing Radar

SARI

Ground probing radar produksi GSSI telah dipergunakan untuk membuat penampang geologi bawah permukaan dangkal di beberapa kawasan pantai Indonesia.

Analisa data dasar penampang GPR dari geologi bawah permukaan di kawasan pantai dapat memperlihatkan konfigurasi reflector yang mencerminkan jenis lingkungan geologi bawah permukaan.

Dalam masalah kontaminasi, informasi geologi di daerah pantai yang dihasilkan dari pemboran inti hanya dapat memperlihatkan gambaran yang sederhana tentang geometri ketidakseragaman. Metoda ground probing radar merupakan alat bantu yang menjanjikan untuk menanggulangi masalah sifat fisik kondisi geologi bawah permukaan pada skala ketidak seragaman yang sebenarnya dari perubahan komposisi litologi.

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Tujuan utama dari penelitian ini adalah untuk menguji sampai sejauh mana karakteristik litofasies dari litologi bawah permukaan dapat dilihat sebagai pola refleksi yang dapat dipetakan dalam penampang GPR dengan maksud untuk mendapatkan informasi geometri geologi bawah permukaan di daerah pantai.

Kata kunci: Geologi bawah permukaan, zona pantai, "Ground probing radar"

INTRODUCTION

Ground-penetrating radar (GPR) is used for various applications such as aquifer and soil studies, civil enginnering, maining, archeology, waste disposal and geology,etc.

GPR survey was carried out at several coast area such, Tambelan isles in Riau Isles Province, Cirebon coast in West Java Province and Moumere coast in Flores Island.

The objectives of the GPR survey were to investigate the coastal geo resources, coastal geohazard and coastal geotechnique.

METHOD AND DESCRIPTION OF GPR SYSTEM

The method uses antennas placed near or in contact with the surface of the ground to probe the shallow subsurface

The technique is known as Electromagnetic Subsurface Profiling (ESP) and is the electrical analog of seismic sub-bottom profiling technique used in marine geology.

The techniques are also based on the principle that high-frequency electromagnetic waves may be reflected at boundaries separating heterogeneous regions of the subsurface. They are best suited for high-resolution geophysical and subsurface Quartenary geological investigation. The system is capable of detecting and graphically displaying subsurface interface to depth of as much as 50 m.

Most georadar surveys are conducted with the transmitter and receiver antennas very close together, practically at zero offset. An important feature of georadar antennas with beam apertures of 30^0 to 60^0, broadband, time-limited pulses of electromagnetic energy are continuously radiated into the earth from a special antenna moving along the surface.

Ground-penetrating radar (GPR) reflections often occur at boundaries between insimilar or sediment units where the conductivity and dielectric constant changes. In many geological setting, GPR is an effective method for imaging near surface boundaries because variations in stratigraphy and in electrical properties are closely correlated in space.

The system is also capable of identifying subsurface materials by analyzing the reflected pulses. The shapes of these pulses depend only on the effective dielectric constant and conductivity of the material. Ranges of values of dielectric constant and conductivity for different materials are taken from the literature. By using these values, and by assuming an incident pulse with Gaussian distribution in time and space, one can calculate the reflected pulse shape and hence identify the material within broad limits.

A reflection may also be generated by a gradual change in dielectric constant caused by variable moisture content within a soil unit. Capillary force produce a continuos change is moisture content over a thin depth interval for sands and gravels but over a broad interval in fine-grained soils such as clays and silts.

If the two types of reflectors-one a transition zone and the other a layer boundary are closely spaced, then their reflections may be superimposed in a radar section. Neither feature will be easily recognized, and interpretation would be difficult.

The system receives reflections of these pulses from interfaces between materials that have different electrical properties. This data is

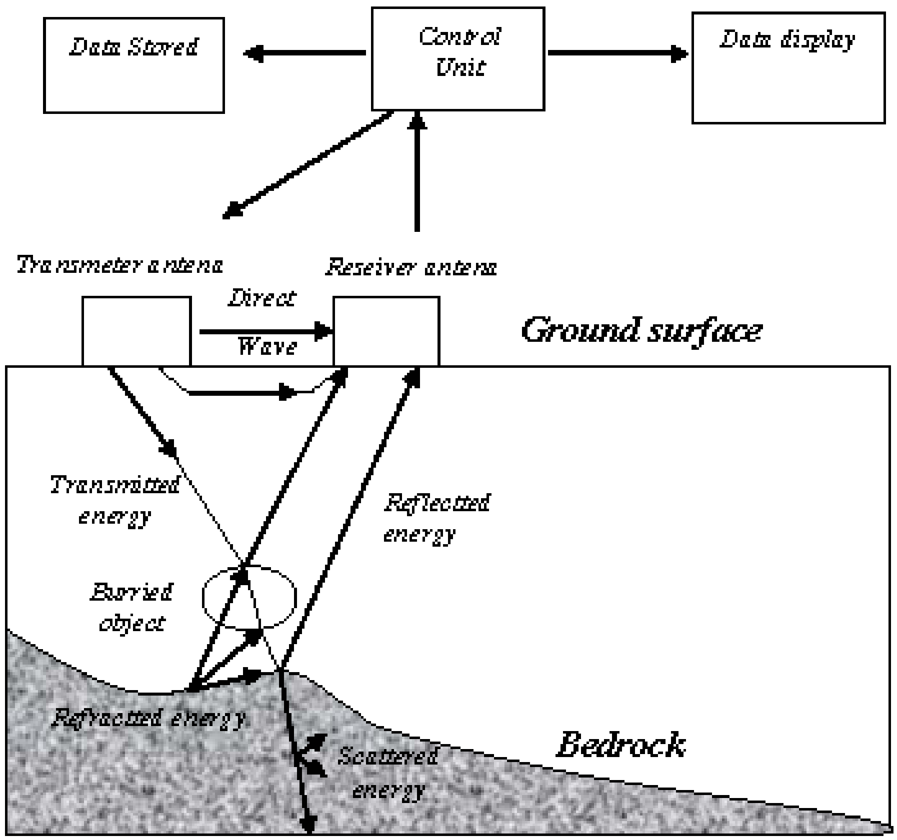

Figure 1. The principle work of GPR method

stored on magnetic tape and is printed out graphically after area has been scanned.

This section describes the principle, the operating procedures of the GPR system. The GPR system is composed of video pulse transmitter, a receiver and an antenna and graphic recorder.

Once an area for subsurface investigation has been established, the lightweight antenna unit is towed over the ground by hand. Every three inches of travel the antenna transmits a radar pulse into the ground.

A portion of the radar signals that have been reflected from the interface of surface and subsurface lithology is received by the antenna.

Radar reflections from the interface are governed by the differential in the dielectric constant and conductivity of the materials.

The radar pulses are diplayed in real time on a screen and are recorded on graphic recorder. By recording a signal return every three inches a continues profile is developed.

The subsurface strata are shown the lithology in detail profile, Quarternary sediments and the pra Quartenary sediments

The graphic presentation of a vertical section of the earth is called a profile. The profile has been produce by printing high signal levels black and no signal white, intermediate signals are in gray range. The surface of the ground is the top of horizontal line.

Individual GPR records can be interpreted in terms of parameters such as reflection configuration, continuity, amplitude, spacing (frequency), interval velocity and external form (Heteron et al.,1998)

MEASUREMENT OF VELOCITY OF PROPAGATION

In order to convert the two-way travel time of the echo from a detectable subsurface interface to a depth scale, one must know the velocity of propagation of the EM pulse within the intervening medium. Knowing the effective propagation velocity, the depth can be derived from the relation :

$$D = Vm \frac{Td}{2}$$

Where :

D = depth to reflecting interface

Vm = effective velocity of propagation

Td = elapsed time between transmitted and received pulse

In general, however, the dielectric constant is not known and the velocity of propagation must be measured insitu.

The method explained here for determining the velocity of propagation requires the use of two antennas. One antenna operates in the standard vertical sounding mode (transmit and receive) and the other antenna in the receive only mode as depicted in Shermatic for Dual Receive Mode. The antennas are separated a fixed distance apart and scanned as a unit over the ground. The effective propagation velocity in the medium is given by

$$Vm = \frac{X}{\sqrt{t_x^2 - t_d^2}}$$

Where :

X = horizontal distance between the transmitting antenna and receive only antenna

t_d = Two way vertical travel time to the reflecting interface

t_x = arrival time of the reflection from the same interface at X antenna separation

Based on the velocity analysis that was done in the study area, the range of velocity of the subsurface lithology are 0.07 – 0.1 m/ns and the depth of penetration of GPR are 10–15 m.

FIELD DATA AND INTERPRETATION

In this section, we interpret reflection within GPR profile from several transect containing common conditions associated with clay, silt ,sand., gravel and boulder

The result of GPR survey and core drilling description can be summarised as follow:

Tambelan Isles, Riau Isles Province

In order to know the depth of potential sand iron around the coast of Tambelan Isles, the GPR survey was carried out in prospect area. The result of GPR survey can be explained as follow :

Soil, sand and gravel wich contain iron is the upper most layer which is can be found at 0–2m depth and occasionally until 3 m and distribute un homogeneous. Below 3 m depth the GPR profile is characterized by quartz and coral sand.

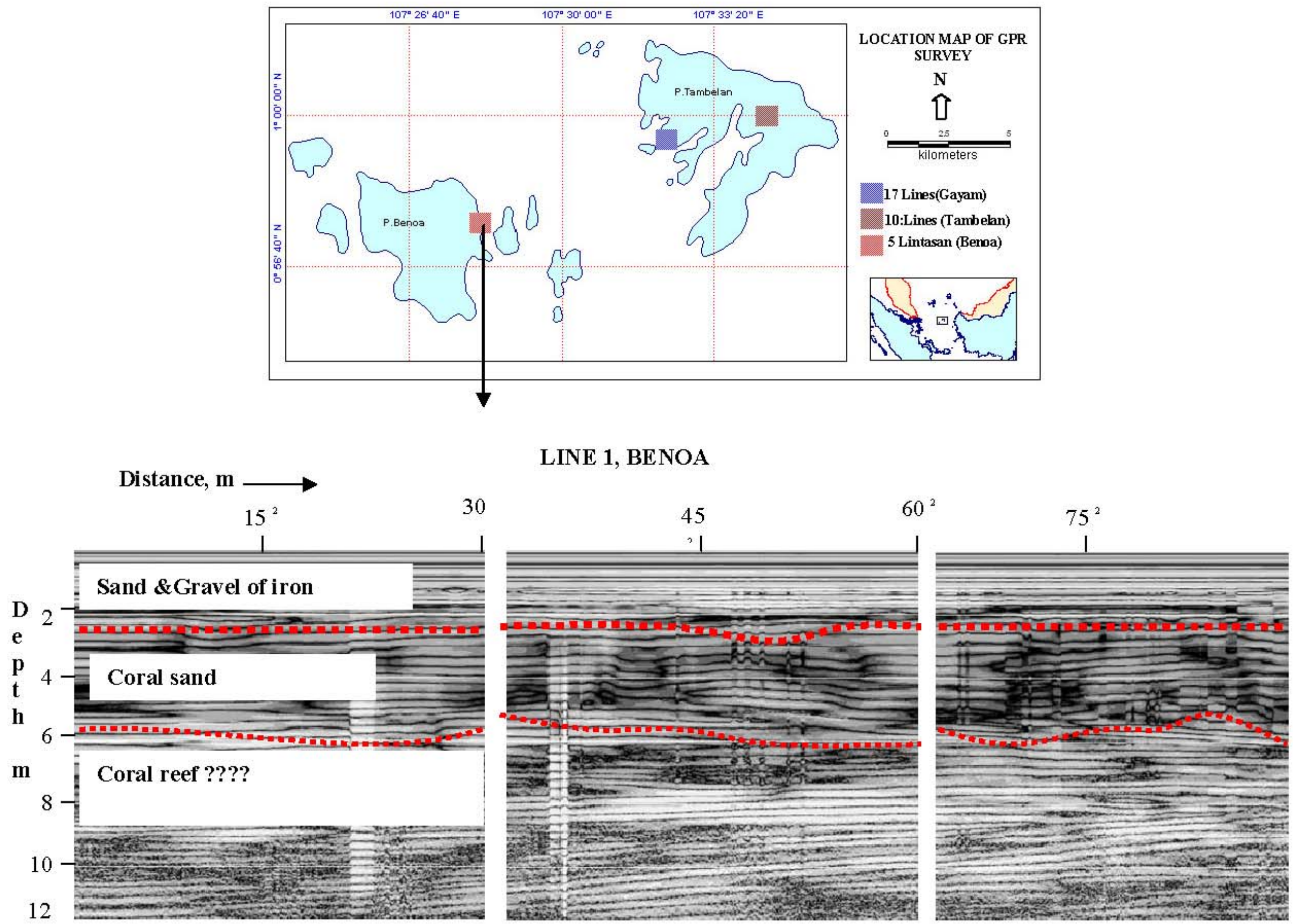

Figure 2. The GPR profile at Benoa, Tambelan Isles

Below 4 m until 12 m the subsurface lithology is dominataed by coral reef and weathered of Granite (Figure 2).

Based on the core sample, in general iron sand is dominated by fine to coarse grained sand and occasionally consists of gravel size of ore iron.

Megascopically, the percentage of iron and all of sand and gravel sedimen is about 50 – 60%.

Cirebon coast, West Java Province

The GPR survey was carried out around the Cirebon coast in order to profile the subsurface lithology for engineering purposes (Figure 3).

The GPR records was correlated with core drilling result and can be summarized as follow:

The upper most layer is characterized by clay, the most reflector show as parallel ,continous, and strong reflector. Based on the description of core sample, the physical properties of clay is moist in place, high plasticity, and have N blow 5 – 10 of Standart Penetration Test.

Below the clay soil can be found clayeysand, moist to wet inplace, medium consolidated with Standart Penetration Test about 15 – 25 N blow. The configuration of reflector is dominated by subparallel, medium and continous reflector (Figure 3).

The lowermost layer is characterized by subparallel and convergence reflector and shows as dipping layer of sediment. Based on the core samples the lithology consists of gravelly sand, medium to coarse grained and well consolidated. The number blow of SPT is 25 – 35 N blows (Figure 3).

Maumere coast, Flores Island

The GPR profile from most of transect show that the upper layer are characterized by strong reflector, high conductivity configuration, parallel and continous reflector configuration. Borehole data describes that the upper most layer are dominated by soft to stiff silt and clay and very saturated (Figure 4).

Bellow the parallel reflector configuration it is found the scatered sub parallel reflector configuration, weak to medium and countinous reflector. Based on the bore hole data this configuration are characterized by fine to medium sand and very saturated. The lowermost layer is characterized of scattered parallel and hyperbolic reflector con figuration, strong, high conductivity and continuous reflector. The bore hore data show that this configuration is dominated by sand and gravel and is influenced by the groundwater.

Figure 4 shows that the evidence of post liquefaction can be identified clearly.

DISCUSSION AND CONCLUSIONS

The feasibility of using GPR for investigation of coastal geology is demonstrated. The data show structures of the expected scales and spatial relationship. Correlation of GPR data record with borehole data is seen on the scale of the main subsurface lithology boundaries.

GPR data can be used to analyse the dynamics of coastal processes and resulting barrier response and it is frequently possible to distinguish beach sediments formed by progradation, aggradation and longshore accretion.

The subsurface lithology condition such as sedimentary structure, the groundwater level and the condition after liquefaction can also be detected by using GPR.

In view of the limitation in present data with regard to scales of Quartenary and Pra Quartenary stratigraphic features, it will be useful to do additional data acquisition both at finer sampling intervals and over larger areas.

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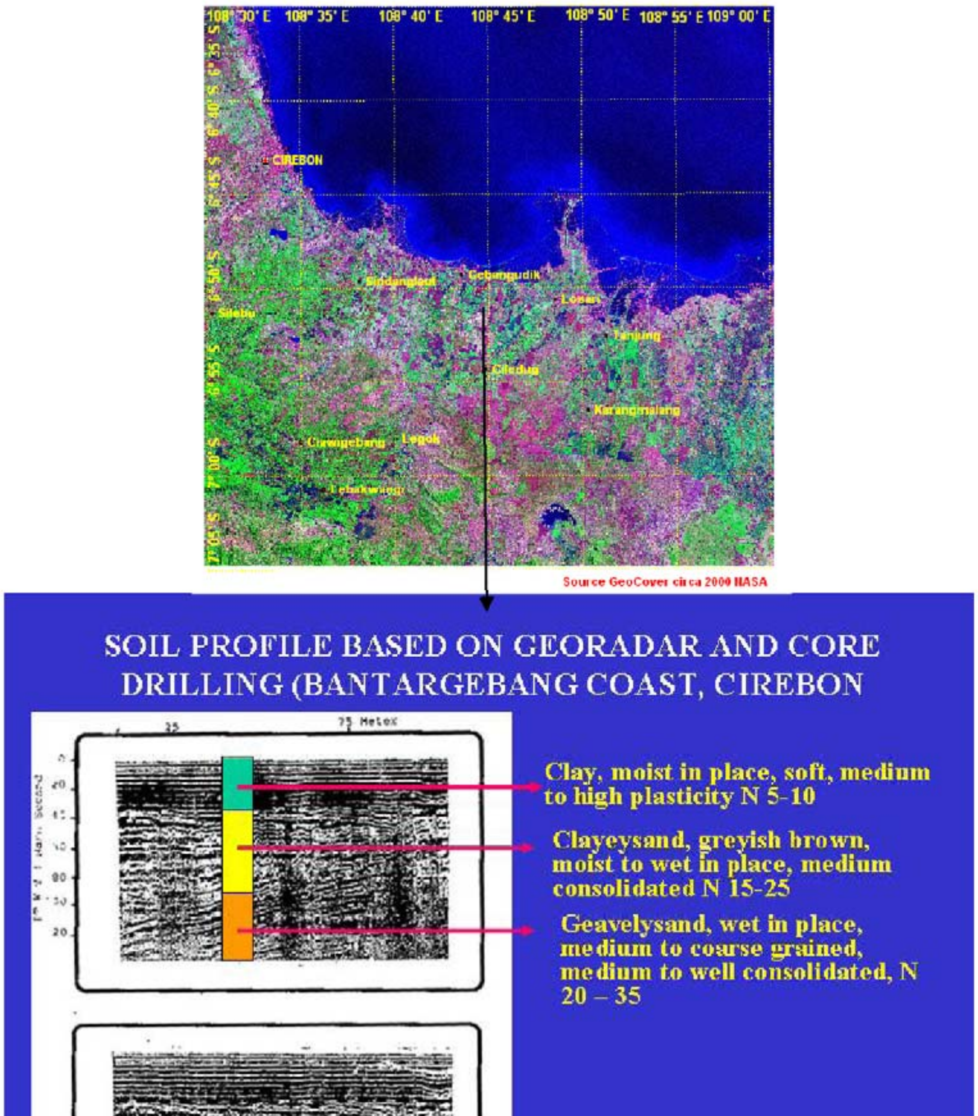

Figure 3. GPR profile of Bantargebang, Cirebon Coast

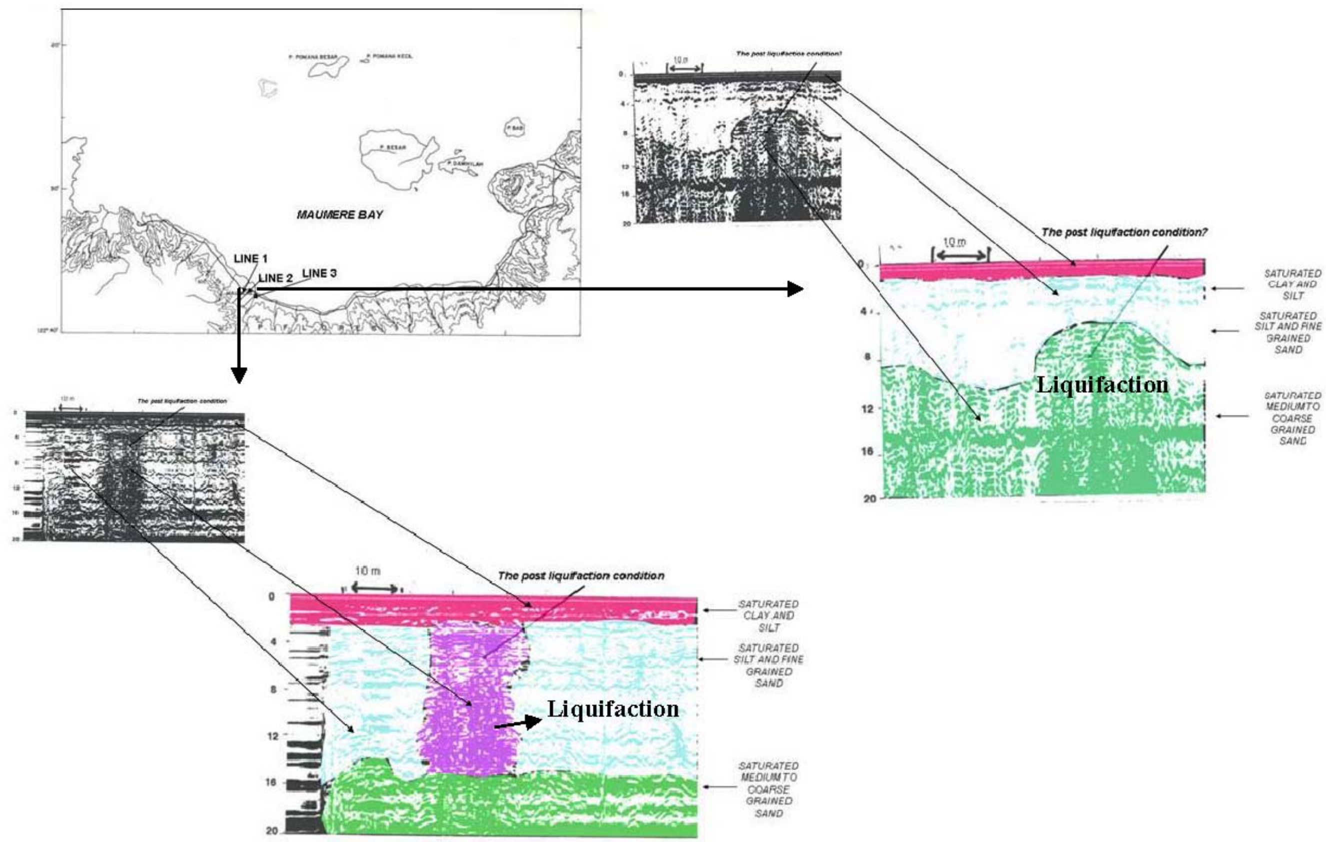

Figure 4. GPR profile of Moumere Coast, for Liquifaction detection

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