Overburden Effect Examination Of Cubical Anomaly Using Geometry Normalized Electromagnetic System (GNES) Equipment

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Abstract—The objective of this study is to examine an instrument of Geometry Normalized Electromagnetic System (GNES) with various size of physical model (n=100) of aluminum overburden and cubical anomalies for the master curves. The GNES instrument is relatively not sensitive to geometrical factors (geometry normalized), i.e., the distance, height differences, and angle between transmitter and receiver coils. Simultaneous transmissions of two electromagnetic waves with different frequencies will induce an eddy current in cubical anomaly. This current in turn will produce secondary electromagnetic fields which are measured by the receiver together with the primary fields. Measurement of percent change of vertical component of the field will give the percent response caused by the cubical. As a result that the master curves of the cubical anomalies is similar to a square (overburden) master curve pattern. The contrasts of anomaly are low for cubical anomaly and cubical with overburden anomaly but high in overburden anomaly.

Keywords-GNES; physical model; master curve; eddy current; overburden

I. INTRODUCTION

Electromagnetic inductions were originally mainly used in the search for conductive sulphide mineralization but are now being increasingly used for area mapping and depth sounding [1]. The electromagnetic responses of a large variety of geologic models were obtained by physical scale modeling as an important technique. Measurements are made using miniaturized loops or electrode arrays. Early model studies were confined to measurements of the response of metal sheets placed in air at one or, at most, a few frequencies [2].

A comparison of numerical modeling results and physical scale modeling measurements for a conducting cube in free space and in a conducting host has been conducted [3]. The numerical results were computed using a new implementation of the electric-field volume integral equation, one in which the electric field is approximated using bilinear edge-element basis functions and in which the normal component of the electric field between cells is related explicitly to the contrast in conductivity. The scale-model measurements were made using an apparatus designed to investigate the behavior of EM exploration systems over conductive features residing in a conductive host.

The physical model data plot has been utilized as the master curve of the single frequency system of horizontal loop method for field data interpretation [4]. Moreover, a thin plate model with aluminum plate target has also been studied in laboratory scale by many researchers [5].

Geometrical error (i.e. the high difference, misorientation and the distance between transmitter and receiver coil) is one of the causes of the data error. The error often be faced in the exploration field and creates the data that obtained does not indicate the precise anomaly. Mathematical calculations of the errors and its geometrical shape have been completely reported [6]. Geometry normalized electromagnetic system (GNES) equipment is an instrument that not sensitive to the geometrical factors (geometry normalized) [7].

The GNES equipment also generated a master curve for the overburden thickness by vertical coil orientation. The master curves are for half-covering-coil, all-covering-coil, and un-covering-coil systems. The overburdens are presented by amplitude inversion in out-of-phase component. The GNES equipment has data automation and tested by several aluminums plate with overburden thickness [8].

The mathematical simulation circuit of the GNES equipment had been developed [9]. The circuit works based on logarithmic and antilogarithmic functions from bipolar transistors. The logarithmic characteristic is produced by bipolar transistor from the plotted characteristic base-emitter voltage toward collector current.

II. METHODOLOGY

A. The Equipment System

Fig. 1 shows the GNES equipment system without the coil system. The GNES equipment was used in this work, the hollow aluminums cubical (type A, type B, and type C), and aluminum sheets (type P, type Q, and type R) (Table 1).

B. Physical Modeling

The scale factor n is important for interpreting the field data using the physical model data. In this physical modeling ($n=100$), the anomaly target and the overburden were a cubical aluminum and an aluminum plate respectively. It is assumed that the environment was non conductive. In the free-air condition which has zero conductivity is become representative for this environment. In the zero conductivity, the secondary field from the medium is not presence. In this condition, there are no phase differences between transmitted electromagnetic fields and that was received by receiver.
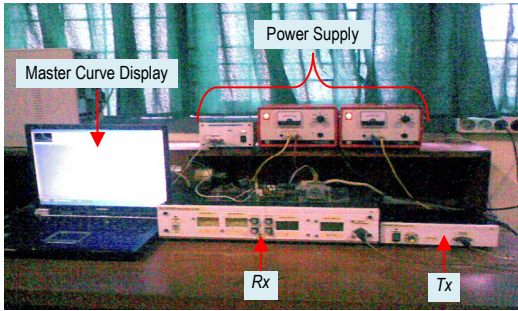

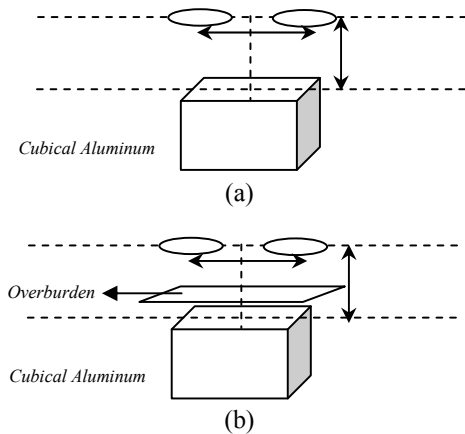Figure 1. The equipment system description without the coil system.

Figure 2. Equipment examination scheme of the cubical aluminum target: (a) without overburden (b) with overburden.

It was observed that aluminum cubical response without overburden was observed as described in Fig. 2a, while that with presence of overburden is presented in Fig. 2b. The cubical types were type A, type B, and type C. The measurement was perpendicular to cubical strike.

TABLE I. THE EQUIPMENT SYSTEM COMPONENTS

The Equipment	Total
GNES Equipment	1 unit
The hollow aluminum cubical Type A (20cm x 20cm x 20cm)	1 unit
The hollow aluminum cubical Type B (36cm x 36cm x 36cm)	1 unit
The hollow aluminum cubical Type C (50cm x 50cm x 50cm)	1 unit
Aluminum sheet type P (20cm x 20cm)	1 unit
Aluminum sheet type Q (36cm x 36cm)	1 unit
Aluminum sheet type R (50cm x 50cm)	1 unit

III. RESULTS

A. The Calibration and Examination of Transmitter-Receiver System

In ideal condition measurement of geometry normalized method, the transmitter and receiver coil condition should have a constant distance, a same plane, and parallel axis.

The effect of the coil distance variation, the correction angle between the coils orientation and the high deference between transmitter and receiver coil to the data validity has been examined.

If the transmitter coil assumed as a dipole laid on above land surface and so the receiver with a certain distance, the measured vertical electromagnetic field inversely to the coil interval power three [10].

The examination of the characteristic of the equipment was performed. The characteristic was indicated by deference between laboratory measurement and theoretical results. The examination was performed by measurements and plotting of the amplitude response and coil separation. By the data the correlation coefficient value between theory and observation were determined. The coefficient value has been coming close to one in which indicated the transmitter and receiver has been well performed (Fig. 3).

The examination was observing whether the transmitter-receiver system transmitted and received the electromagnetic wave as required. The source frequencies of transmitter were 112.5, 337.5, 1012.5, and 3037.5Hz whereas the reference frequencies were 337.5 and 1012.5Hz. It was found that the wave shapes and electromagnetic phase differences between all of the pair of source-reference signals. The reference-source signal pairs were 112.5 and 337.5Hz, 112.5 and 1012.5Hz, 112.5 and 3037.5Hz, 337.5 and 1012.5Hz, 337.5 and 3037.5Hz respectively. The response amplitude as vertical field that measured is proportional to the receiver-transmitter coil interval to the power of minus three as described in Fig. 3.

B. Overburden Response

Measurement and data processing were performed using a computer through Delphi program. The overburden response had inverted the percent value of maximum negative response then there were three maximum response

amplitude peaks. The diagonal cross section point as the overburden center was the maximum value of inverting value of the highest minimum response amplitude named C point.

The measurement graphic in the computer screen with overburden type P is displayed in Fig. 4. We had the center position for overburden type P was 50 cm. For overburden type Q and type R we had the center positions were 52cm and 46cm respectively. We had the overburden width for overburden type P by subtracted C point and A point positions we found 19 cm. For the overburden type Q and type R we had the overburden width were 40cm and 50cm respectively. We had the overburden position accurately for type P and we had error 2cm and 4cm for the overburden type Q and type R respectively. The overburden width had error approximately 1cm for overburden type P and we had the overburden width accurately for the other overburden type.

The master curve had a high anomaly contrast. There were two positive anomaly peaks. The anomaly position (B) was between two of negative anomaly peaks (A and C) (Fig. 4).

C. Cubical Response Without Overburden

The measurements are using cubical type A, type B, and type C. We had 51cm in the center position for cubical type A (Fig. 5). For the cubical type B and type C we had the center positions were 49cm and 55cm respectively. We had 22cm in the cubical width of type A cubical by subtracting C point and A point position. For the cubical type B and type C we had the cubical widths were 40cm and 50cm respectively.

We had the cubical position error 1cm for type A and found accurate for measurement of cubical type B and cubical type C. The master curve had a low anomaly contrast compared with overburden response caused by anomaly position had no much differences amplitude between anomaly negative peak inverting (B) and two positive anomaly peaks. There were three positive anomaly peaks. The anomaly position (B) as anomaly negative peak inverting is between two of negative anomaly peaks (A and C) (Fig. 5).

D. Cubical Response with Overburden

The measurements were using cubical type A with overburden type P, type Q, and type R. We had the center position for overburden type P and cubical type A was 52 cm (Fig. 6). For the cubical type A with overburden type Q and type R we had the center position were 44cm and 49cm respectively. We had the overburden position error 2cm, 6cm, and 1cm for overburden type P, type Q, and type R respectively. The master curve had a low anomaly contrast caused by two positive anomaly peaks were not in the same amplitude. Besides two anomalies negative peaks (A and C) also were not in the same amplitude. The master curve was liked an anomaly of thin plate. There were two positive anomaly peaks, one of the inverting of negative anomaly peak as position of anomaly (B) and two of negative anomaly peaks (A and C) (Fig. 6).

The presence of overburden made a significant error in cubical position determination especially if the surface wide area of the overburden and the cubical surface wide area had no much difference.
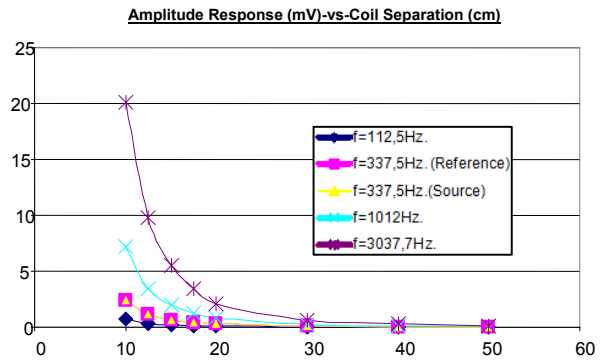

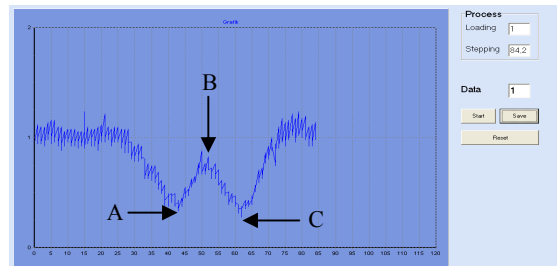Figure 3.   Amplitude response versus coil separation.
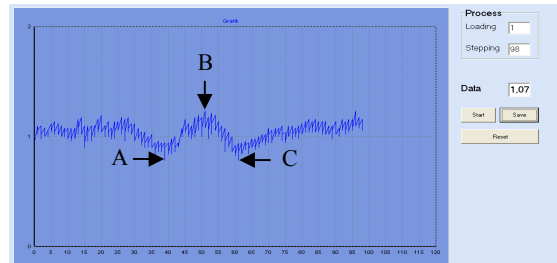

Figure 4.   Overburden response (type P).

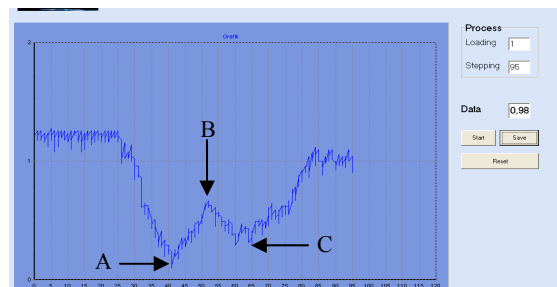

Figure 5.   Cubical response (type A).

Figure 6.   Cubical type A response with overburden type P.

IV. CONCLUSION

B point described cubical anomaly or cover position when A point and C point were described the ends of cubical anomaly or overburden. The anomaly contrast increased with increasing differences between two positive anomaly response peaks and B point.

The anomaly contrast was low for cubical anomaly and cubical anomaly with overburden but high for overburden anomaly. The higher of anomaly contrast the more accurate of anomaly position determination. The inverting value of negative peak anomaly was tending to the same in amplitude for cubical anomaly with overburden if the cubical anomaly was wider in width area comparing with the overburden. The cubical anomaly tends to had behavior liked an overburden.

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