Real Time Sea Bed Shallow Sounding for Resistive or Conductive Target Layer

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ABSTRACT

This paper presents a time domain controlled source electromagnetic (CSEM) exploration system for a real-time sea bed shallow sounding using a vertical wire source. Layer earth numerical modeling is applied to study the sensitivity and dynamic range of the electrical and magnetic field needed for a reduced size system in order to facilitate the marine operation.

INTRODUCTION

Marine controlled source electromagnetic (CSEM) survey has been applied for oil and gas exploration successfully. The ability to determine the resistivity of deep drilling targets from the seafloor may well make marine CSEM the most important geophysical technique to emerge since 3D reflection seismology (S, Srnka LJ. 2007). It is known that vertical transmitter has less effect from the sea water. Considering the marine operation, it is advantageous to keep the vertical wire transmitter and the separation between the transmitter and the receiver as short as possible while keeping a reasonable depth of investigation. Assuming a 1.5 meter long vertical wire transmitter, numerical modeling using layer earth is presented to investigate the sensitivity and dynamic range needed for a short separation between the transmitter and receiver, which would facilitate the marine operation.

A dragged vehicle mounted with a vertical transmitter and receiver is proposed for the field testing. The vertical potential field will be measured and interpreted in real time while the vehicle is towed toward the seashore. The vibration of the system is measured by the embedded tilt meter. The influence of the interpretation due to the vibration of the system will also be studied.

SENSITIVITY AND DYNAMIC RANGE ANALYSIS BY NUMERICAL MODELING

The layer earth modeling is applied to investigate the sensitivity and dynamic range needed for the system design. Fig. 1 represents the earth model and its Cartesian system. The vertical wire transmitter (Tx) is located on the sea bed. The electrical and magnetic field receivers (Rx) are also located on the sea bed. The separation between the Tx and Rx is kept at 2 meters. The resistivity of first layer below the sea bed is assumed to be 1 ohm-m while the thickness will be changing from 2, 5, 10, 20, 50 meters and infinity.

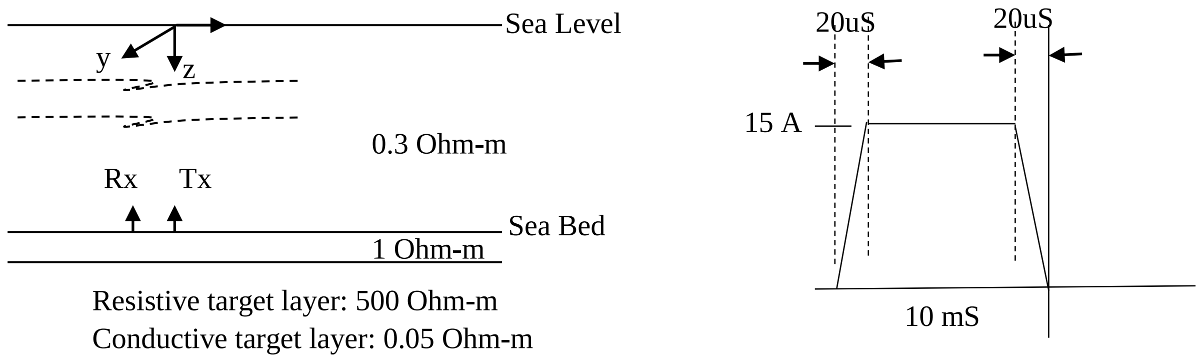


Fig. 1: The earth model with the Cartesian system and the transmitting current waveform used for the numerical modeling.

Fig. 2a and Fig. 2b represent the numerically calculated Ez and By field respectively for a resistive target layer of different depths. From Fig. 2a, in order to distinguish the resistive target at 50 meter deep, the resolution of 10^{-8} V/M and dynamic range of about 90 dB would be needed. From Fig. 2b, one pico Tesla resolution and dynamic range of 90 dB would be needed. Fig. 3a and Fig. 3b represent the numerical calculated Ez and By field respectively for a conductive target layer of different depths. From Fig. 3a, in order to distinguish the conductive target at 50 meter deep, the resolution of 10^{-8} V/M and dynamic range of about 90 dB would be needed. From Fig. 3b, one pico Tesla resolution and dynamic range of 90 dB would be needed. The sensitivity and dynamic range are achievable using nowadays electronic and sensor technologies.

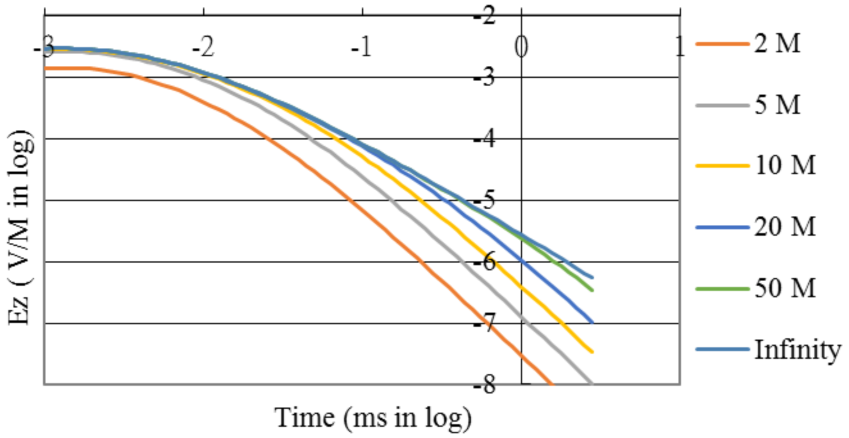


Fig. 2a: Calculated Ez field for a resistive target layer of different depth with the system configuration shown in Fig. 1.

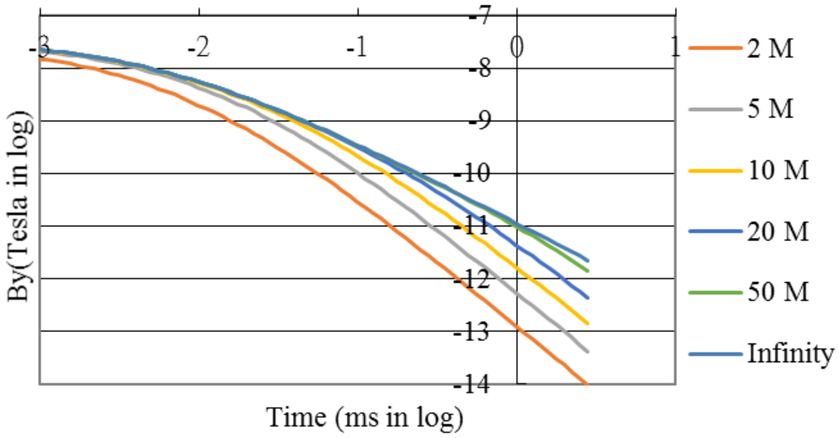


Fig. 2b: Calculated By field for a resistive target layer of different depth with the system configuration shown in Fig. 1.

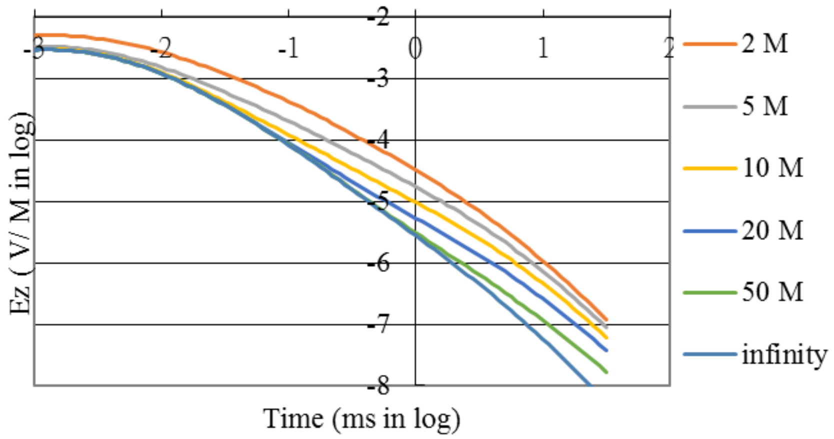


Fig. 3a: Calculated Ez field for a conductive target layer of different depth with the system configuration shown in Fig. 1.

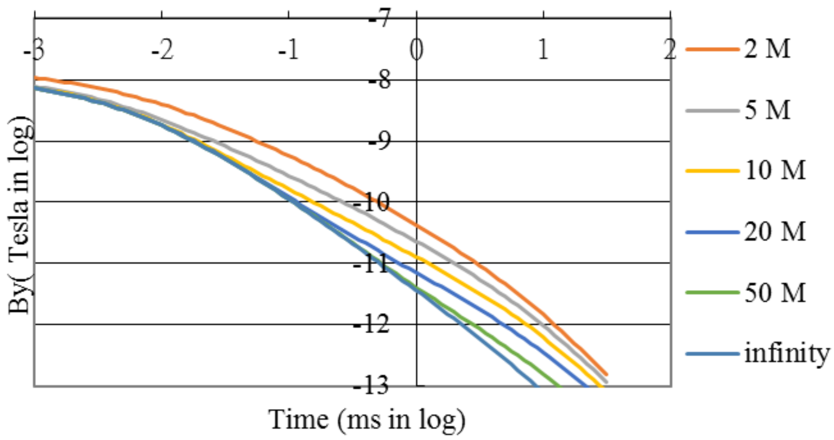


Fig. 3b: Calculated By field for a conductive target layer of different depth with the system configuration shown in Fig. 1.

PROPOSED DRAGGED VEHICLE FOR TEST SURVEY CLOSE TO THE SEASHORE

In order to carry out a test survey, a dragged vehicle mounted with vertical wire transmitter and potential electrodes as shown in Fig. 4 is designed. The system connected with armored cable will be sunk to the sea bottom after towed with buoy by a small boat to about 2,000 meters away from the seashore. The system is then towed with a winch located on the shore. The data stacked in one second will be sent continuously to the base station on the coast and inverse-interpreted in real time. The vibration and the orientation of the system will be recorded with a tilt meter. The influence of the interpreted earth model and the vibration of the system will be correlated.

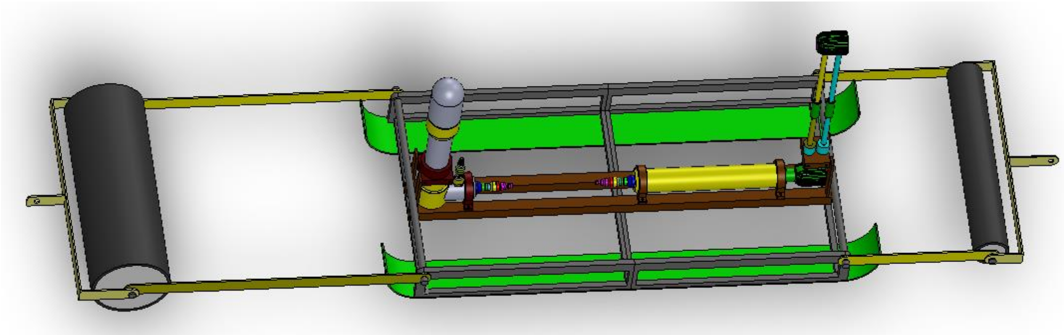


Fig. 4: A dragged vehicle of 4 meter long mounted with 1.5 meter vertical wire transmitter and a pair of potential electrodes at 1 meter apart

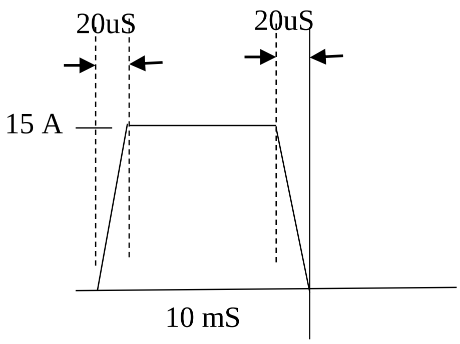
CONCLUSIONS

From numerical modeling, a system with the expected sensitivity and dynamic range of the electrical and magnetic field using a vertical wired transmitter could be designed with nowadays electronic and sensor technologies. Measuring the vertical electrical field and the y component of the magnetic field seem to yield the same resolution. Increasing the sensitivity and dynamic range of the receiver, the length of the vertical transmitter and the separation between the transmitter and receiver could be reduced. The field operation is therefore easy to be carried out. A pilot survey using a dragged vehicle towed toward the seashore should help the designing of a dragged or floated system towed by a vessel.

REFERENCES

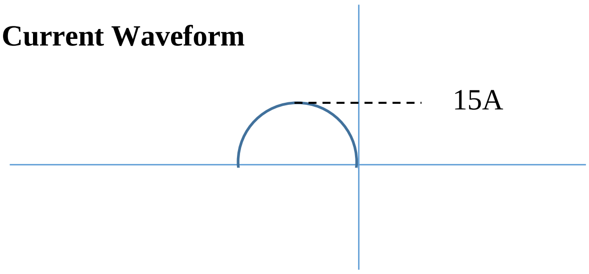
S, Srnka LJ. 2007. An introduction to marine controlled-source electromagnetic methods for hydrocarbon exploration. *Geophysics. 72:WA3-WA12.*

Step Function with 20 uS ramp time



For Fig. 2a, Fig. 2b, Fig. 3a and Fig. 3b.

Half Sinusoidal Current Waveform



10 mS half sinusoidal current waveform

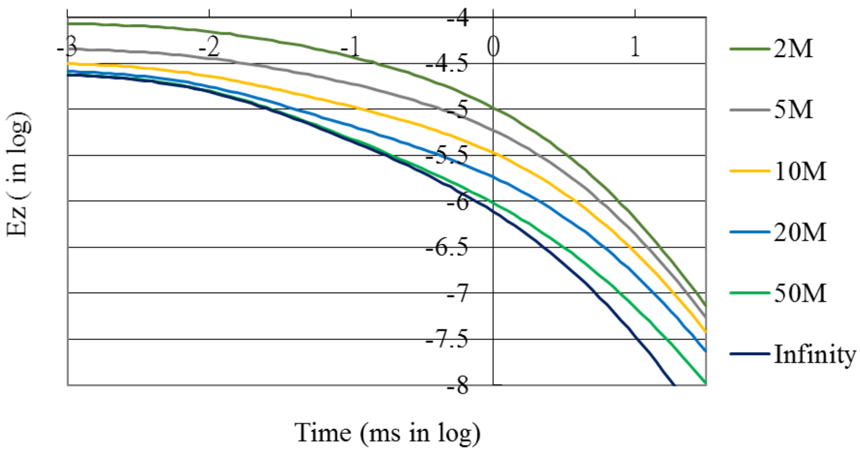


Fig. 4a: Calculated Ez field for a conductive target layer of different depth with the system configuration shown in Fig. 1 and a 10 mS half sinusoidal current waveform.

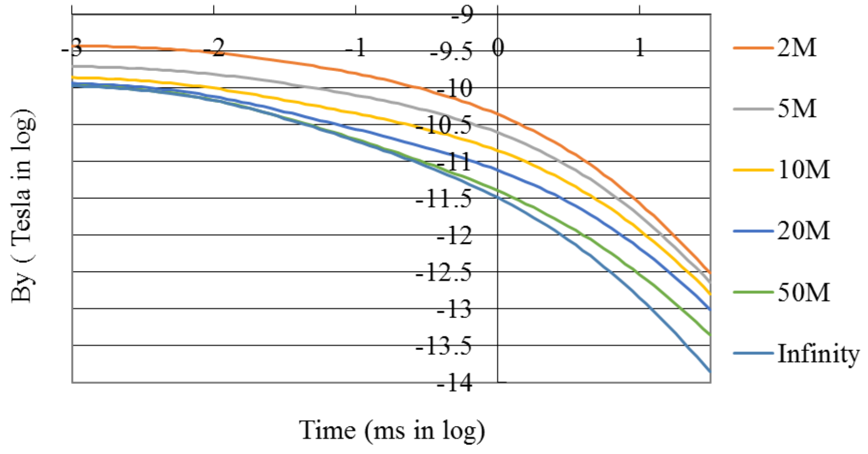


Fig. 4b: Calculated By field for a conductive target layer of different depth with the system configuration shown in Fig. 1 and a 10 mS half sinusoidal current waveform.

1 mS half sinusoidal current waveform

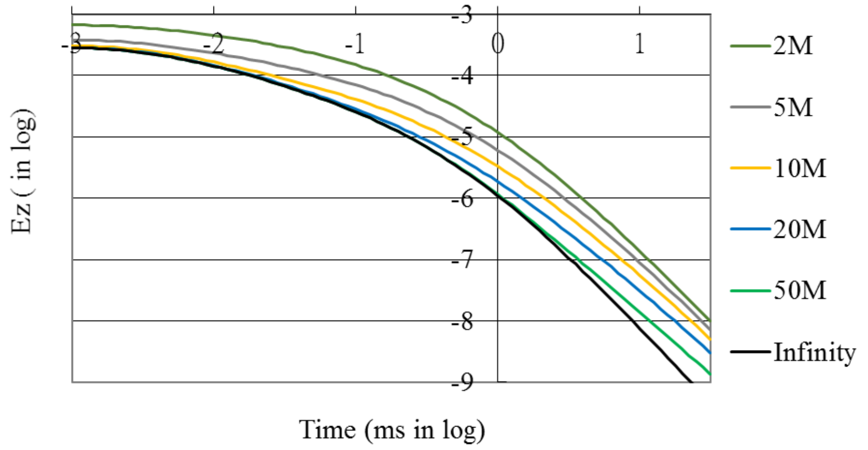


Fig. 5a: Calculated Ez field for a conductive target layer of different depth with the system configuration shown in Fig. 1 and a 1 mS half sinusoidal current waveform.

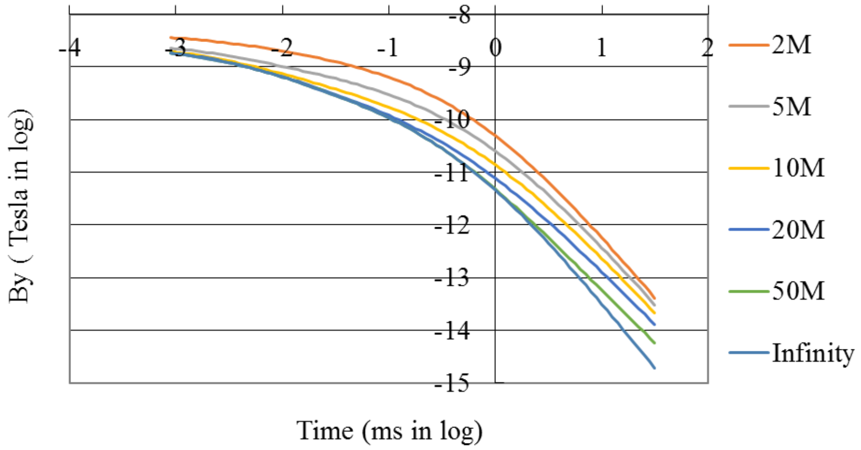


Fig. 5ba: Calculated By field for a conductive target layer of different depth with the system configuration shown in Fig. 1 and a 1 mS half sinusoidal current waveform.