ELECTROMAGNETIC SIMULATIONS OF BOREHOLE RADAR FOR METAL ORE DETECTION

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1. INTRODUCTION

Conventionally, electromagnetic geophysical methods, such as TEM, CSATM, are used in metal ores survey extensively, together with DC electric survey and magnetic survey. These methods meet some problems as the prospecting depth become deep, one is the investigation depth, and the other is the resolution. Borehole radar has the advantages of farther detection range and higher resolution over conventional borehole geophysical tools for metal ore detection. Conventional well logging tool is only sensitive to the meters of range near borehole. Borehole radar can detect nearly 100m in crystalline rocks, and 20-30m in conductive rocks (200-300Ω.m). These advantages make it is possible for borehole radar to find blind deposits during late prospecting and development stage.

South Africa located the golden vein [1] using borehole radar. As the shallow reserve using up, South Africa began to dig the deep ores. There are many engineering geological problems such as small faults, ancient terraces, which expect borehole radar technology. Fullgar etc. [2] introduced and compared the application of Borehole radar and radio imaging (RIM) system in nickel sulfide deposit. They tried to map the McConnell massive Ni-Cu deposit in Sudbury, Ontario and got good results.

However, Borehole radar is mainly used in engineering and environmental issues by now, not in ore prospecting. We use Finite difference time domain (FDTD) [3] in this paper for Borehole Radar forward modeling in metal ores detection. Through numerous numerical modeling for various metal ore bodies, including spherical, planar, and a practical ore body, we got many numerical results. It is found that single-hole reflection measurement has good effect for these kinds of ore bodies, not only the positions of the ores can be detected, but also the shape of the ore bodies can be deduced.

2. SIMULATED RESULTS AND ANALYSIS

We simulated borehole radar response to spherical, planar, and cylindrical ore bodies which are all ideal ore models. In order to consider the more practical situation, we simulated a field Ni-Cu-Pt ore body [4] which is a magmatic deposit located in Sudbury, Canada. The origin of the Sudburg structure is still poorly understood.

The structure includes overburden, ore zone, iron formation peridotite, granite-gneiss, and sediments as shown in Fig. 1. The relative dielectric constants and resitivity are (4.5, 1000 Ω .m), (25, 10 Ω .m), (10, 100 Ω .m), (5.5, 3000 Ω .m), (4, 5000 Ω .m), (5, 10000 Ω .m) for overburden, ore zone, iron formation peridotite, granite-gneiss, sediments, respectively. All these physical parameters are selected by our experience. We designed three boreholes located in the left, middle, and the right side. The single reflection mode is adapted here. The simulated results are shown in Fig. 2(a-c) for the left, the middle, and the right borehole measurement. The antenna central frequency is 50 MHz with 1m separation between two antennas.

We analyze the radar profile for the left borehole as shown in Fig. 2(a), the left irregular and continuous curve after the direct wave is the interface between sediment and gneiss. The signal is weak because the dielectric difference is not so large. Then, the reflection from the interface between ore zone and sediment appears. The signal is strong because the dielectric difference is large on the interface. The ore zone can be delineated and located clearly. Because the electromagnetic absorption in the ore zone, the wave becomes weak and we cannot see other interface.

Fig. 2(b) shows the radar profile obtained in the middle borehole. The reflection from the sediment-gneiss interface appears in the up-left corner. Form the depth of 50m and 65m, there are two strong reflection events upward and downward respectively. Upward signals correspond to the interface between ore zone and sediment and the downward one correspond to the interface between iron formation and sediment. At the depth range from 50 to 65m, antennas pass ore zone and iron formation, absorption is very strong, direct wave disconnects.

Fig. 2(c) shows the result form the right borehole. There is only a clear reflection event which comes from the interface between the iron formation and the sediment. Since the strong absorption in the iron formation, we cannot see other reflection events

By combining the signals from three boreholes, we can deduce the structure of the ores and other formations.

3. CONCLUSIONS

The application of borehole radar for metal ore detection is a new area, the practical examples are rare. We use FDTD to simulate the single-hole reflection mode detection for metal ore model based on a practical deposit. The initiative study shows that borehole radar has good effect for ore detection. Through synthetic interpretation of multi-borehole, the ore can be delineated. It is noticed that low-resitivity bodies have strong absorption which prevent far detection in certain cases.

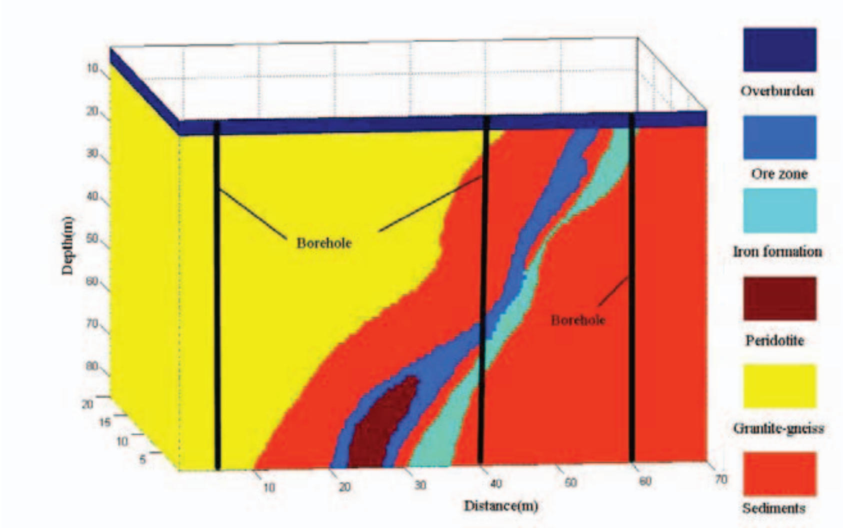
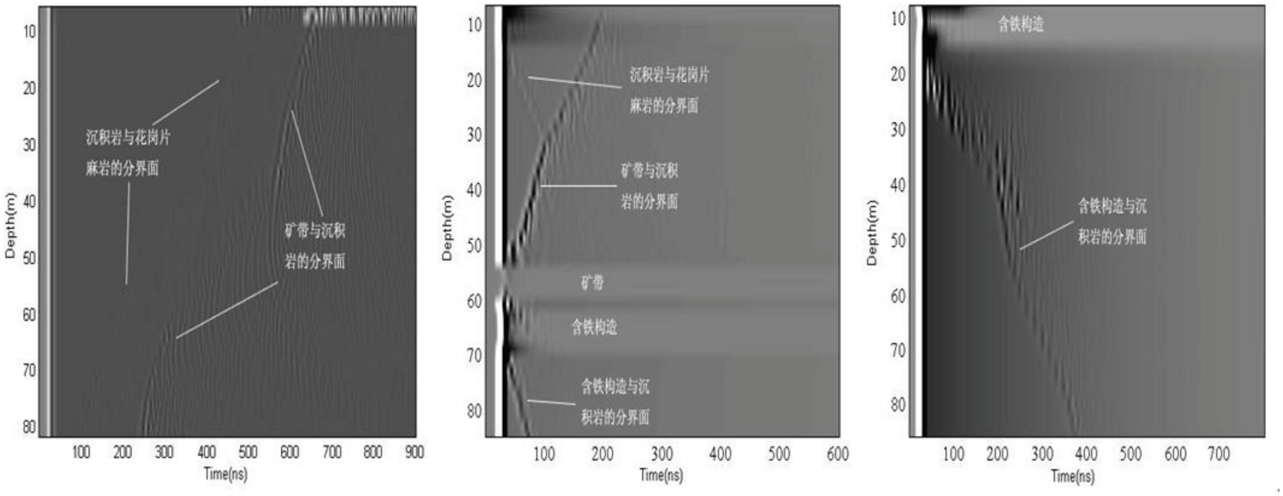


Fig. 1 Geologic model of a Nickel-cupper deposit in CANADA



(a) (b) (c)

Fig.2 Simulated results

4. ACKNOWLEDGEMENT

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5. REFERENCES

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