Reliability of Surface Electromagnetic Prospecting (SEP) system-A case study in Dongguashan copper mine

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***Abstract*—The Surface Electromagnetic Prospecting system developed by Institute of Geology and Geophysics, Chinese Academy of Sciences was introduced through a CSAMT case study in Dongguashan copper mine in east of Tonglin, Anhui province. Strong electromagnetic noise generated by mineral industries and nearby downtown both challenges the electromagnetic field work and benefits the anti-interference test of the system. Measured data were however of good quality, which demonstrates that our system has the ability to stay reliable in complicate environment and can be employed in geophysical exploration practice.**

Keywords—component; formatting; style; styling; insert (key words)

I. INTRODUCTION

The Development of Surface Electromagnetic Prospecting (SEP) system program leading by Institute of Geology and Geophysics, Chinese Academy of Sciences was started in 2010. It's one of the major research programs in the Sino-Probe Research Project supported by the Ministry of Land and Resources of China. The main objective of the program is to develop a Surface Electromagnetic Prospecting system with fully independent intellectual property, which can be used for MT, AMT, and CSAMT exploration. The goals have been achieved and many good results have been obtained [1]. Many field trial were conducted to test the new developed equipment in Gu'an, Zhangjiakou in Hebei province, Xin'cheng in Liaoning Province, and Jin'chang in Gansu Province, based on which, a lot of improvements have been made. During the field trial at Xin'he Neimenggu Province in 2013, a comparison experiment between our equipment and many leading foreign equipment include those from Zonge and Phoenix Company was made, and our system had showed very perfect behaviors [2-3].

To investigate into the system's reliability in complicate environment furtherly, a cooperative exploration project was performed at Dongguashan copper deposit between Institute of Geology and Geophysics and Institute of Geochemistry, Chinese Academy of Sciences in 2014. Anti-interference experiment was carried out for v8 receiver from Phoenix Company, GDP32 receiver from Zonge Company, improved V8 [4], and our equipment. Data of high quality can only be acquired by improved V8 and our equipment, which shows that the SEP system does have a strong anti-interference ability

II. EM BACKGROUND OF DONGGUASHAN SURVEY

Survey line BD-1 lay across the deposit, about 2.5km in length. The site number are 77.5-125.5, with a offset of 50m between every two nearest sites. The survey line was showed in Fig. 1[5]. Besides, some near surface electromagnetic noise sources are also demonstrated in Fig.1, which include power substations, signal tower, power lines, highways, railways, and pipe lines.

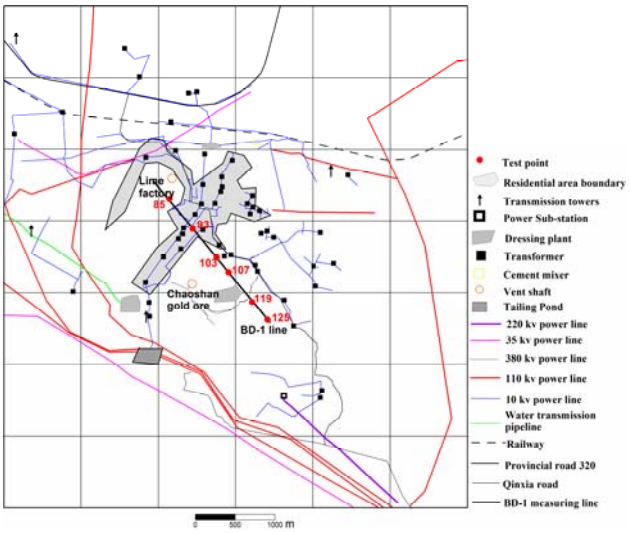

Fig. 1. Location of interference source in Dongguashan copper mine area

There are a power line of 220 kV, four power line of 110kV, and another one of 35kv which circle our survey area and limit the survey line into a area of about 1-2km. what's more, the civil power lines of 220V are distributed densely in that area. Three major power substations, including the Zhucun power substation, the largest power substation in East China are

located there. Additionally, about 52 power voltage transformer of 10kv are distributed in the survey area, with 8 of which have a distance of less than 200m to the nearest sites.

Qingxia Road, the main way from Zhucun town to Tonglin, was about 200m to the north of survey line BD-1, which has a very heavy traffic vehicle. There is also a drilling gallery 200m to the southwest of the BD-1 line with the depth of 800-1000m. Electronic facilities such as powerful donkey and winding engines and railways working in the gallery are operated 24h a day and contribute to a very heavy electromagnetic noise to the survey.

III. Geology of Dongguashan survey

Dongguasha copper deposit is a strata bounded skarn type copper deposit strictly controlled by the master strata. Metallic minerals contained are mainly pyrrhotite, pyrite, chalcopyrite and magnetite. The deposit has a very complex ore type, containing mainly copper pyrrhotite ore, followed by copper skarns, and copper pyrite ore. The main ore body lies in shaft portion and two wings of Qingshan anticline, strictly controlled by the Carboniferous, Huanglong to Chuanshan group. The top boundary of it usually lies in the contact zone between the uplifts portion of the anticline and the ore body, and up to the Permian Qixia group.

The Permian strata in our survey area show high resistivity and low polarization characteristics. The average resistivity is above 1000Ω·m, and the average polarization rate is about 2-3%. While the Permian Dalong group and Gufeng group have a resistivity as low as tens to hundreds Ω·m, and polarization rate as large as 40%, which are considered as interference to our survey. Intrusive rocks in this area all have moderate resistivity about hundreds Ω·m, and polarization rate about 2-4%. The electromagnetic properties of the deposit vary with the extent of mineration, mostly shows a low resistivity and high polarization trends. Its resistivity is usually less than 100 Ω·m, and polarization rate greater than 60%.

IV. Field experiments

A. Equipment

During the experiment of anti-interference, the CSAMT original data acquired employing V8 receiver were processed by two different programs. The current E2 version data pre-processing program developed by Phoenix Company takes only the 50Hz noise into consideration, while neglects its high order harmonic waves. Qi and Da[6-7] have discussed the employing of Notch filter to filtering the high order harmonic waves, and made improvement to the E2 version data pre-processing program. Their notch filter can suppress the 1-20th order harmonic waves successfully.

The powerful transmitter of SEP system has taken advantage of the transmitter has an output power of 50kw, and could be extended to 100kw. The maximum emissive current is up to 50A. The receiver of the system has a very broad frequency band from DC to 10 kHz. With a 24 bites A/D convertor, it has a large dynamic range bigger than 120dB. The suppression for power frequency noise is more than 70dB.

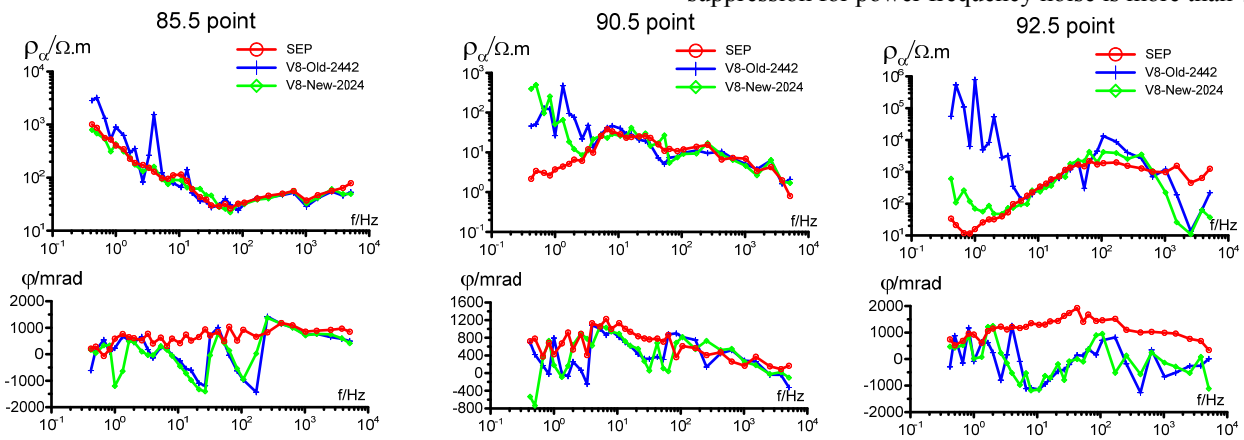

Fig. 2. the comparison between data acquired with V8 and SEP receivers

B. Data Acquisition

A broadside scalar observation configuration was employed for the CSAMT experiment. Ex and Hy components were recorded. Galvanic dipole source of 2300m parallel to the BD-1 line was injected into the earth. The offset was 8.1 km.

Ground resistivity for receiver electrodes was less than 2000 Ω through the usage of solid non polarizable electrodes. The length for electric field receiver dipole is 50 m, with a 50 m distance every two dipoles. Electromagnetic signal of 40 frequencies from 0.42Hz to 5120 Hz was emitted and received.

Two V8 receivers were employed for data acquisition, one with original software and one with modified software. They worked one after another at every site in line BD-1 sharing the same magnetic sensors and electrodes. After that, an array of six SEP receivers were put into practice.

C. Results

Survey line BD-1 run across some residential area with large population. A lot of power lines are distributed in that area. A lot of noise sources have already been shown in figure 2. Site 85.5 is located at a large quarry with a lot of facilities working day and night, which generated strong electromagnetic noise of a very broad band. As shown in Fig. 2, apparent resistivity and phase are serious biased by the noise at site 85.5,

especially for data acquired with V8 receiver. Data obtained with SEP system have a better performance. They are much smoother and have better resistance for noise. Sites 90.5 to sites 95.5 are located in the residential area and have a main drilling gallery beneath them. Strong electromagnetic background has a very bed influence on data acquired on those sites. Apparent resistivity and phase for Site 90.5 and 92.5 show that data acquired with V8 receiver are more likely to be biased by noise than SEP receiver.

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