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Effect of new audio magnetolluric equipment for groundwater investigation in water barren area

Yang Lunkai[1], Liu Hong[1,2], He Zhanxiang[2]
[1]BGP, China National Petroleum Corporation, [2]Chengdu University of Technology

Abstract: This paper deals with the recent achievements in AMT data acquisition and processing, which have improved the quality of the collected data,. Comparing AMT with VES, IP and logging data, it is concluded through some case histories that qualified results can be achieved in probing the karst water with AMT technique.

1. Introduction

The survey site is located at the dividing ridge of intermontane hills. The topographic relief in this area is considerable. The ground level ranges from 215m to 500m, and the terrain reveals dipping southwards and northwards respectively. Archaean group (Ar), which mainly comprises plagiogneiss, schist and marble, outcroping in the west of the area, and in the east part there exits Lower Ordovician (O_1), which prominently consists of nodular dolomite and dolomitic limestone, stratigraphically dipping westwards. The catchment condition is poor, and the total area of collecting surface water is relatively small and therefore this area is water barren. The investigation target of this project is the water in fratured karst. The replenishment of karst water is mainly dependent on the percolation of the meteoric water in limestone outcropping area.And the replenishments of river and lateral disappearing stream are not considerable.

Some suevey work were conducted in this area. Two holes were drilled and did not encounter any water-bearing formatiom. Later on , natural field selectable frequency measurement, Wenner sounding and induced polarization (IP) measurement were performed. The employed frequencies in the field selectable frequency technique are 15.7Hz, 23.6Hz, 71.8Hz, 129Hz and 320Hz. The polar spacing is 20m, and the point spacing is 10m. Eight lines with total length of 6,670m have been conducted . $AB/2_{max}$=560m, $AB/2_{min}$=1m, and AB/MN=10 are deployed in Wenner sounding technique. And six lines with 86 points are completed. $AB/2_{max}$=320m, $AB/2_{min}$=10m, and AB/MN=3 are configured in IP measurement, and seven points have been surveyed. A normal fault trending eastwards was discovered. In adition, IP data reveal significant water abundance at the fault, but to the east of the fault, the water abundace is relatively poor.

Based on the VES and IP achievements, two AMT survey lines which are coincident with Wener lines, are laid out in the profitable area. The point spacing is 30m, and 18 points are covered. It is concluded that there exists a series of conductive strata, which are considered as raptured karst development belt with favorable water abundance.

2. New advances of AMT and data acquisition

AMT has been advancing significantly since the early 1970s. Modern 24-bit, GPS synchronization AMT acquisition systems, new sensor designs and robust time series processing algorithms have been developed over the last decade, which ensures that high quality AMT response can be routinely acquired from 10-10,000Hz with less than an hour' s recording time . And moreover, we have obtained great advances in 2-D AMT inversion program. The main advances include the joint inversion of AMT apparent resistivity and phase in TE and TM modes, and the numerically calculation of the response treated as a kind of information of a near surface

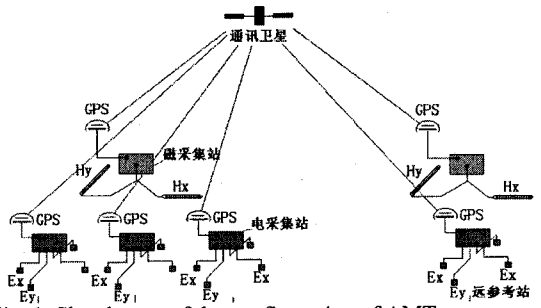

Fig. 1. Sketch map of the configuration of AMT survey.

inhomogeneous feature.This has effectively diminished the impact of the static displacement and improved the inversion accuracy.

AMT acquire four horizontal components of magnetotelluric field: Ex, Ey, Hx, Hy with observation frequency range of 10000Hz~10Hz. It is synchronized by GPS among multi-acquisition units to realize remote reference acquisition to improve quality of acquired data. Figure 1 shows sketch map of the configuration of AMT survey.

3. Data analysis

VES and IP data analysis

The inversion result of line 8 (Figure 2) is showed as a VES resistivity contour section, whose characteristics are as follows: the west and east portion of the line are of resistivity high, the rest presents gentle and low resistivity between 100~420 Ω m in deep segment. It grows gradually from its lower to upper. Figure 3 shows plane contour of AB/2=180m, whose characteristics are as follows: the west portion presents relatively high resistivity and dense contour, which is probably caused by different lithology of its two sides due to faults.

Figure 4 shows compound index with IP method, which is characterized by gentle Zs curves with maximum value of 2. We infer that there exists a formation weakly enriched in water, regarded as fracture water containing in karst.

In general, only fault position is confirmed according to VES data, but belt where karst is richly developed is not clearly reflected, this is probably caused by deep burial and small scale and low resolution in vertical direction for VES.

AMT data analysis

2D inversion section of line 8 presents low resistivity at the depth of upper 40~60m, which is referred as Quaternary and weathered zone of basement. It presents a suite of low resistivity at the depth of 200~300m, which is referred as cavern, fracture, and weathered crust containing water at the top of limestone, because it is impossible that variation of resistivity on large scale is caused by variation of lithology or mineral components within limestone er. Drilling hole located at site 370 of line 8 indicates that the segment at the depth of 21~63.5m are severely weathered with richly developed fractures and karsts, which is filled with arenaceous rock; while segment at the depth of 208~308.6m develops karst and fracture with water enrichment. The rest presents no karst and fracture. Log data indicates that water is mainly produced at the segment of depth of 255~273m. All above evidences show that AMT 2D inversion results are consistent with real data and AMT is sensitive to underlying formation with low resistivity beneath high resistivity.

4. Conclusions

Due to poor topography with criss-cross ridge and gouge in work area, the quality and reliability of VES data are affected. Moreover, exploration depth of VES is limited because of AB/2max=560m. But AMT is sensitive to conductive underlying bed beneath poor conductive bed, and characterized by high resolution whthin exploration depth of 1000m. So AMT is an effective means to detect water contained in karsts and in fractures for karst area.

References

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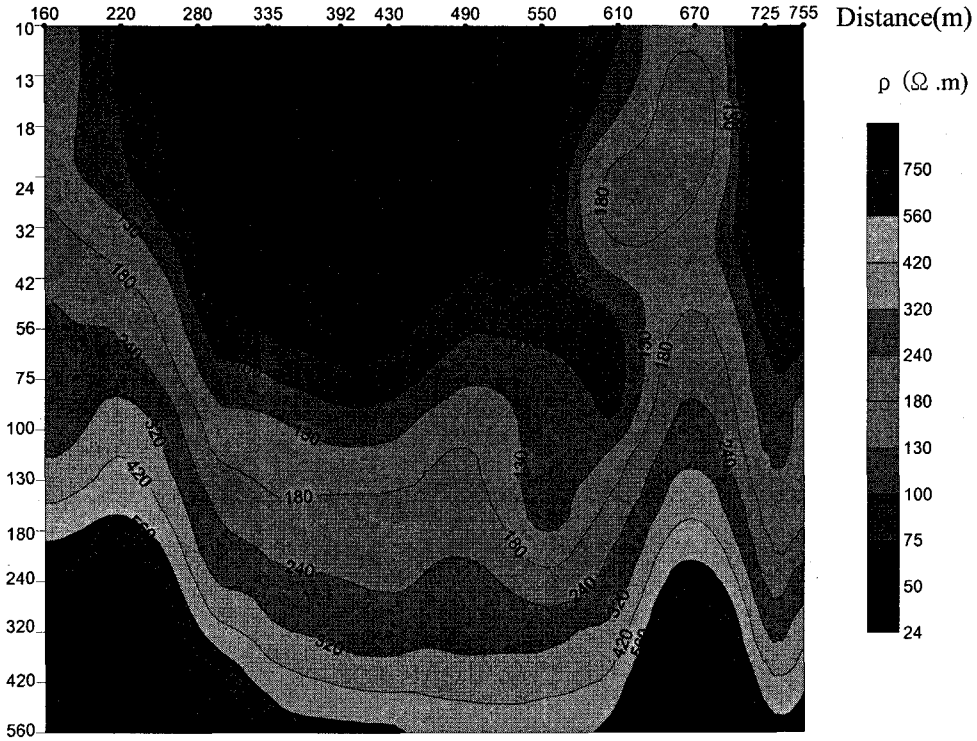

Fig. 2. VES apparent resistivity section of line 8.

Fig. 3. contour plane of apparent resistivity with AB/2=180m.

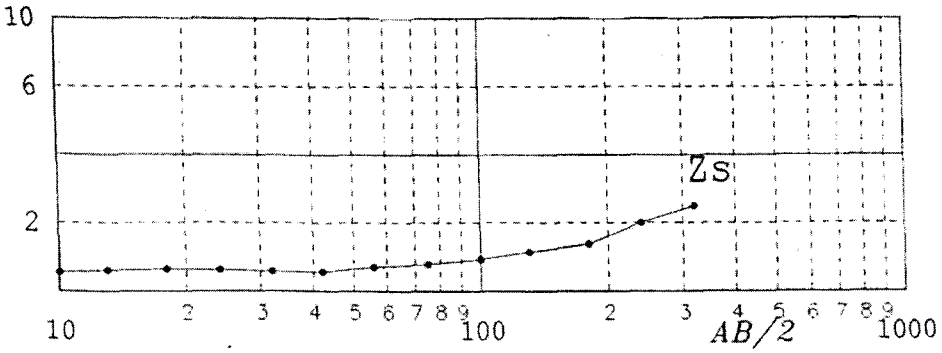

Fig. 4. IP sounding curve.

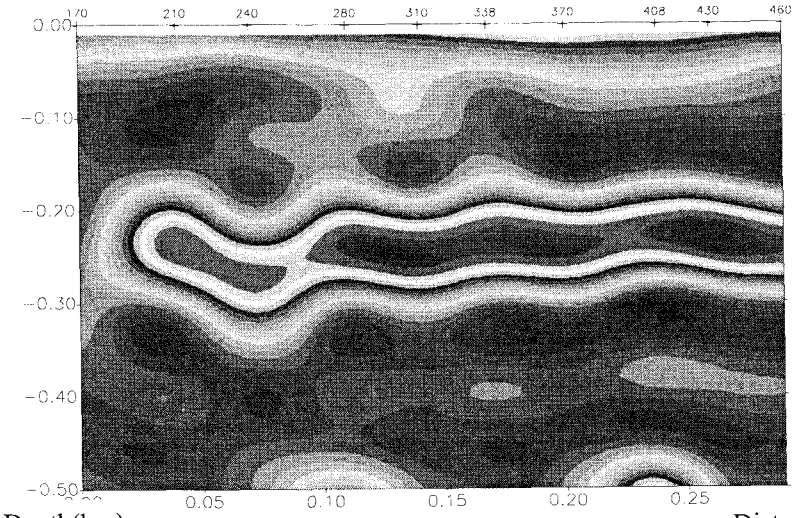

Fig. 5. 2-D inversion model for line 8.