APPLYING AVERAGING METHOD TO SOLVE UNREALISTIC TDEM DATA RESULT FOR STATIC SHIFT CORRECTION IN MT DATA

Agus Sulistyo[1,2], Fikri Fahmi[1,2], Diajeng Liati[1], Fitrianita[1], Wambra Aswo Nuqramadha[1], Yunus Daud[2]

[1]PT NewQuest Geotechnology, Pesona Khayangan Estate, DC12, Depok
[2]Master Program in Geothermal Exploration, Graduate Program of Physical Science, Universitas Indonesia
agus.sulistyo@newquest-geotechnology.com

ABSTRACT

Static shift effect is one of the problems that usually occur in Magenetotelluric (MT) data. It is caused by the existence of near surface inhomogeneity, topography and vertical contact. Due to galvanic distortion arising from near surface structures, the measured electric fields for the whole frequency range are affected by a constant shift on a log scale. The effect produces apparent resistivity curves with the correct shape but it is shifted to the upward and downward on the vertical logarithmic axes. In this decade, Time Domain Electromagnetic (TDEM) is commonly used for correcting static shift in MT measurements. It has been shown that magnetic fields are relatively unaffected by near surface structures that cause static shift in MT measurements. Jointly inverting TDEM and MT measurements has been found to be an effective way to deal with the static shift. However, sometimes TDEM curve has different trend with MT curve which causes both curves are not coincided smoothly in the high frequency. Consequently, the resulting MT curve from the static shift correction could give a less rational interpretation result. Therefore, one of the alternatives to conduct static shift correction when MT and TDEM curves has a different trend is using Averaging Method. The averaging method is a geostatistical method that uses the average value from all referenced MT stations to correct the station which affected by the static shift effect. The result from the averaging method represents a subsurface regional condition. Combination of TDEM and averaging method is effective enough for performing static shift correction and can produce realistic subsurface model. Comparison between 3-D MT inversion result and well data confirm that the static shift correction is important and should be conducted properly in MT data.

INTRODUCTION

The magnetotelluric method is the most reliable method in geothermal exploration. MT method can be used to delineate reservoir geometry, cap rock and basement layer or plutonic body. The characteristics of geothermal area in Indonesia is located in the complex volcanic structure as well as rugged topography. This condition related to near surface inhomogeneity, topography effect and vertical contact often leads to static shift problem in MT data. The study of static shift effect has been much explained in (Jiracek, 1990; Sulistyo, 2015; Liati, et al., 2018). Static shift effect should be reduced, otherwise, it can influence the processing result and modelling of MT data, which finally affects the interpretation result and drilling recommendation. Therefore, the application of MT technology in geothermal exploration should be done properly.

MT method usually conducted jointly with TDEM method, where the TDEM method is only measured the magnetic fields which relatively unaffected by near surface structure. So, it can be used to correct the MT measurement. However, in several cases, TDEM result can not solve all the static shift problem which causing incompatibility with MT data. Accordingly, new approach is needed to be developed to reduce the static shift effect. A geostatictical method such as cokriging and averaging could become the other solutions to answer this problem. The previous study about cokriging and averaging methods has been done in (Sulistyo, 2015).

Furthermore, this paper focused on the application of TDEM and averaging methods to remove static shift effect of MT data. The averaging method is used when the TDEM data produce unrealistic result. Both methods are then applied in the real data. Moreover, the results are then compared in form of 3-D MT inversion and then confirmed by well.

STATIC SHIFT EFFECT ON MT DATA

Static shifts are defined as vertical displacements of the apparent resistivity sounding curves, between adjacent sites or between two curves at one site, without any other difference in either the shape of the curves or the phase (Xiao, 2004). As already explained previously, static shift effect is usually caused by near surface inhomogeneity, topography effect and vertical contact. Sulistyo, (2015) has perfomed several simulations of static shift effect phenomena in MT data through MT 2D Forward Modeling as shown in Figure 1. The modeling process is conducted by using MT2DFor-X software that is developed by PT. NewQuest Geotechnology.

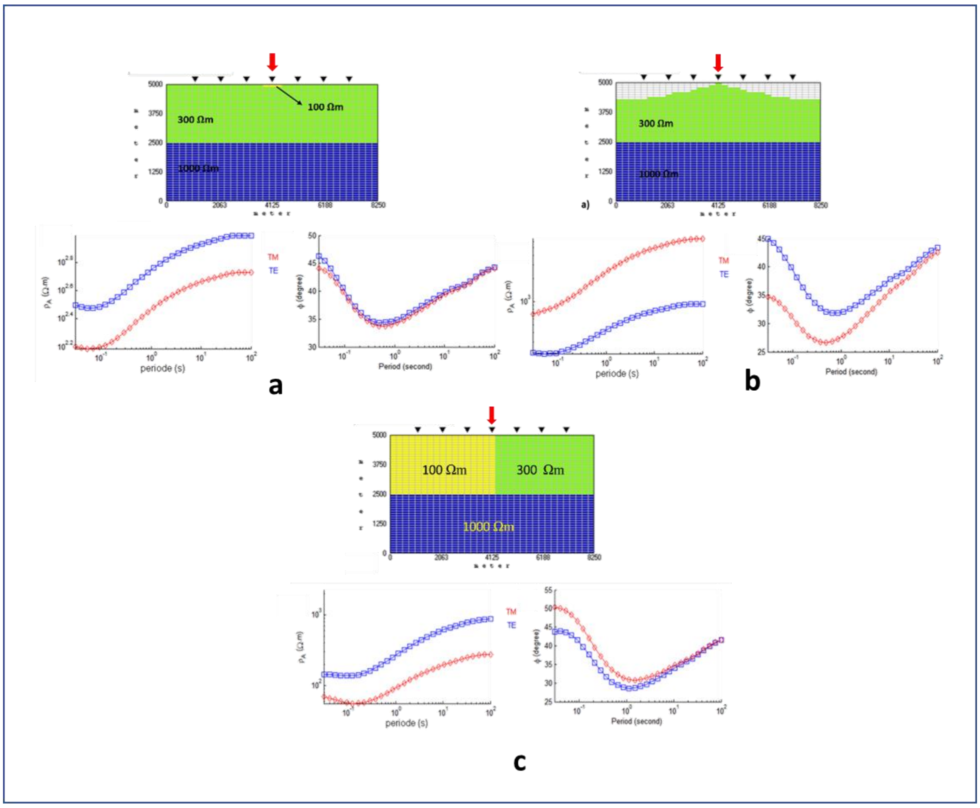

Figure 1. Forward modeling of static shift phenomena a) near surface inhomogeneity b) topography effect c) vertical contact (modified after Sulistyo , 2015)

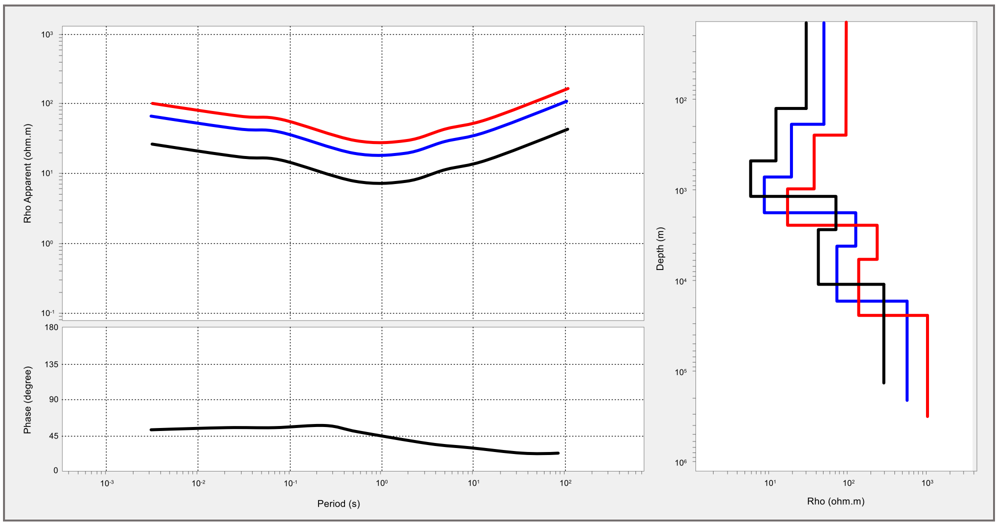

Figure 2. Static shift effect in MT interpretation

The forward modeling shows that the static shifts can severely distort the MT data. The static shift effect causes the MT curve shifted to upwards/downward, so that the curve doesn't describe the real condition of the subsurface. If the static shift effect is not handled properly, it can lead to misinterpretation of resistivity and depth values as shown Figure 2. Furthermore, it will influence the processing and modelling of MT data and guide to a wrong drilling recommendation.

TIME DOMAIN ELECTROMAGNETIC (TDEM)

Time Domain Electromagnetic (TDEM) is an active geophysical method using electromagnetic (EM) induction to determine shallow subsurface structure. It is commonly used for static shift correction.

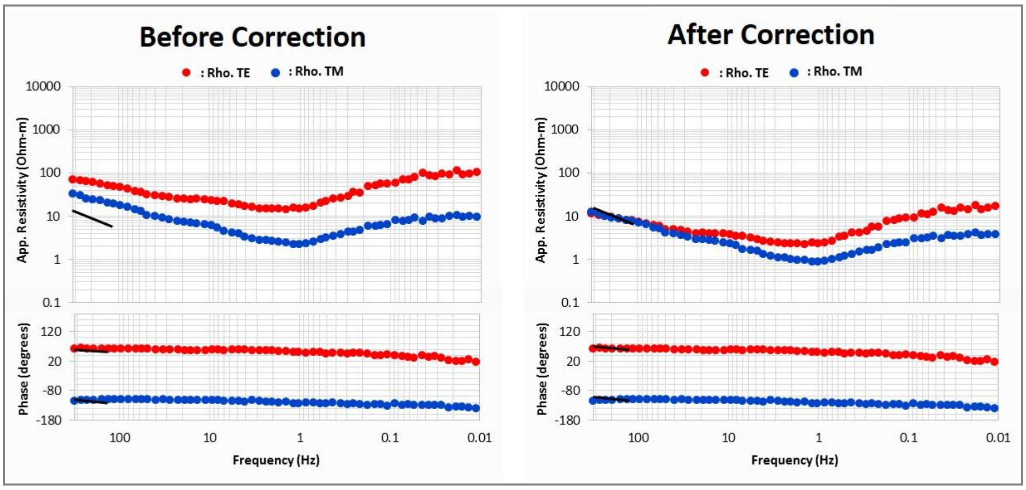

Figure 3. TDEM in MT data Correction

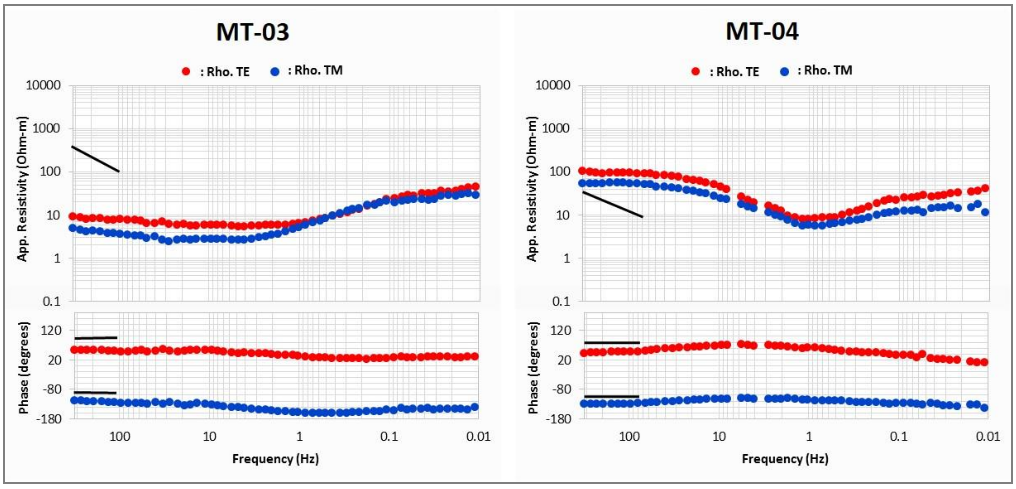

Figure 4. Mismatch between MT and TDEM data

TDEM data that passed field quality control check was processed and modeled to generate 1D inversion model. This data was converted to MT apparent resistivity curve. TDEM resistivity curve will be presented at the high frequency part of the MT curve. It will be used to correct the MT static effect (Irfan, et al., 2010). Static shift correction process in MT data by using TDEM is shown in Figure 3.

However, the used of TDEM for removing static shift effect often encounters a problem such as mismatch between TDEM dan MT data. The example of mismatch which is usually found is different trend curves of both data. Another problem is TDEM generates very different resistivity value with MT data as shown in Figure 4.

AVERAGING METHOD

Averaging method is done by using undisturbed MT data as references for calculating the average resistivity statistically in the high frequency range (associated with shallow depth) as shown in Figure 5. Appplication of averaging method has been clearly demonstrated in the Baikal Region (Berdhichesvsky & Dmitriev, 2008). They are close to the normal curve characterizing the regional background. By using the averaging method, it is assumed that the regional effect representing the subsurface condition will actually emerge after averaging.

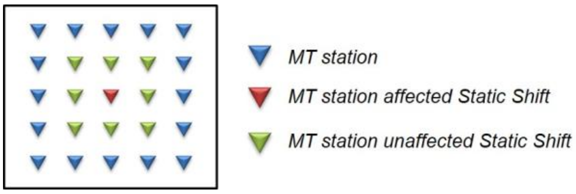

Figure 5. Averaging method in static shift correction

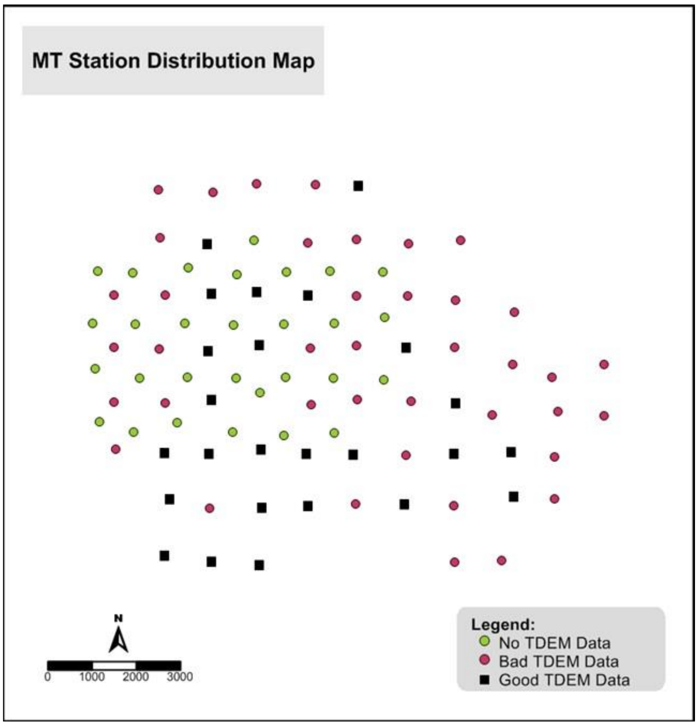

Figure 6. Distribution of MT data

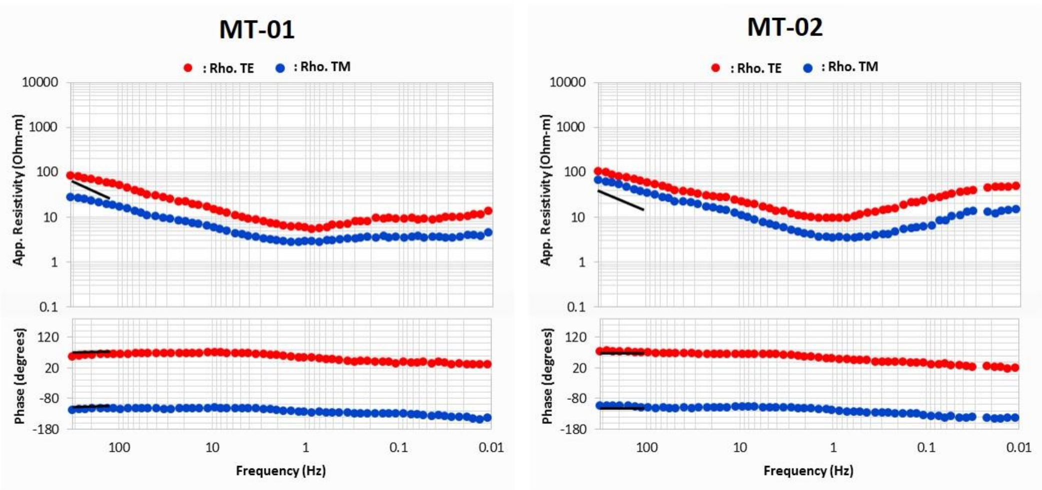

Figure 7. Good correlation between TDEM and MT data

APPLICATION TO REAL DATA

TDEM and averaging methods are applied for correcting MT real data acquired in geothermal area. The total of 94 MT data are distributed as shown in Figure 6. From 94 MT data, 27 data are not provided with TDEM data. The other 67 data consist of 25 good TDEM data and 42 bad TDEM data. Figure 7 shows the example of good correlation between TDEM and MT data. However, 42 bad TDEM data still have to be solved. To accomplish this unrealistic TDEM result, averaging method was applied. Furthermore, to find out the ability of averaging metod in eliminating the static shift effect, the corrected data were than conducted using 3D inversion. The 3-D inversion was carried out by MT3Dinv-X software developed by PT. NewQuest Geotechnology. Then the 3D MT inversion result of corrected data was compared with the other MT data which is not corrected from the static shift effect as shown in Figure 8. Both results show very different image of subsurface condition.

The 3-D inversion of MT data without static shift correction shows shallower and thinner low resistivity zone which is identified from the shallow depth of BOC (Base of Conductor) while 3D inversion result of corrected MT data shows deeper and thicker low resistivity zone.

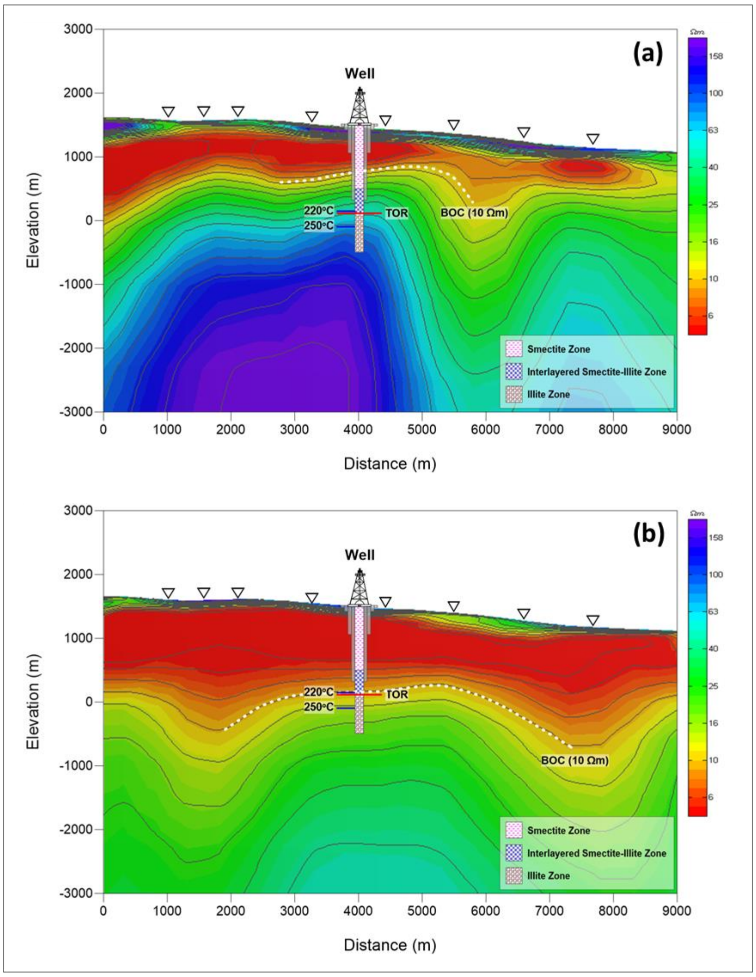

Figure 8. 3-D Inversion results : (a) without static shift correction and (b) with static shift correction.

Besides, 3D uncorrected data inversion result shows that the the posisition of the updome-shape which is interpreted as the heat source is located more to the left of the position of 3D corrected data inversion. Moreover, after confirmed by well, the 3-D inversion results have a good correlation with temperature and lithology of the well. It shows that static shift correction is one of the most important parts of MT data processing that could affect the interpretation result. Incorrect handling in static shift problem can lead to the wrong drilling recommendation as shown in Figure 8 (b).

DISCUSSIONS

Study to remove static shift effect has been attemped using TDEM and averaging method. Both correction has good ability but also has a limitation. Averaging method highly dependent on the MT data distribution of the influenced data by static shift effect and also the present of clean data. If there is no clean MT data which is unaffected by static shift effect, the Averaging method could not be applied since clean MT data is needed as references in correcting the influenced MT data. However, based on the results, Averaging method has been proven in eliminating the effect of static shift and give a good result in imaging the subsurface condition. Averaging method can be one good solution to overcome the absence of TDEM data as well as the unrealistic TDEM curve.

CONCLUSIONS

MT is one of the powerful method in geothermal exploration. Therefore, a proper way in applying this method must be well noticed in order to avoid mislead in delineating subsurface condition. Static shift effect plays important role in MT data processing. If it is not treated properly, it could affect further interpretation and also cause misleading in well targeting.

In delineating subusurface structure through 3-D inversion, there is a big difference between MT data which are corrected from static shift effect (using Averaging method) and uncorrected MT data. The 3D inversion result of uncorrected MT data could not recognize the real condition of geothermal system in this area. It is confirmed by the result which is not in accordance with the location of well. Otherwise, 3D inversion result of MT data which is corrected using Averaging method shows a good agreement with location of well.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge management PT. NewQuest Geotechnology for supporting this research by providing the data, software and also for helpful discussions on this study.

REFERENCES

Berdhichesvsky, M. & Dmitriev, V., 2008. *Model and method magnetotellturic.* Berlin: Springer.

Irfan, R., Kamah, Y., Gaffar, E. & Ts.Winarso, 2010. *Magnetotelluric Static Shift Correction Using Time Domain Electromagnetics Case Study: Indonesian Geothermal Rough Fields.* Bali, World Geothermal Congress.

Jiracek, G. R., 1990. Near surface and electromagnetic distortion in electromagnetic induction. Dalam: *Surveys In Geophysics.* Netherland: Kluwer Academic Publisher, pp. 163-203.

Liati, D., Sulistyo, A., Nuqramadha, W. A. & Daud, Y., 2018. *Study of static shift correction for magnetotelluric (mt) data using averaging and cokriging methods upon 3-dimensional forward model of geothermal field.* Bandung, IIGW.

Sulistyo, A., 2015. *Koreksi Pergeseran Statik Data Magnetotellurik (MT) Menggunakan Metode Geostatistik Cokriging dan Averaging dibandingkan dengan data Time Domain Electromagnetic.* Jakarta, IIGCE.

Xiao, W., 2004. *Magnetotelluric exploration in the Rocky Mountain foothills, Alberta,* Edmonton: Universitas Alberta.