Investigation of Lithosphere Structure of Northwestern Anatolia with long-period magnetotelluric: Part 1. acquisition data by using remotely controlled system and comparison to previously collected broadband magnetotelluric data

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SUMMARY

In our previous study, we collected magnetotelluric (MT) data in broadband period ranges (T=0.0031s to 2000s) on 2006-2011 to reveal the crustal structure of North-Western Anatolia. Due to the low resistivity structure of the study area, the relationship between the crustal structure and the lithosphere could not be clearly defined in our previous project. Therefore, long period (T=0.00001s to 10000s) MT measurements are planned in order to reveal the relationship of deep earthquakes in the area with the lithospheric mantle and to complete the deficiencies in 3-D interpretation due to profile intervals. For this purpose, Long Period MT measurements were collected with a station spacing of approximately 15 km along four South-North profile. The data collected by new generation MT measurement system developed by Phoenix (MTU-5C) that enable us to remotely control the data during measurements. This part of the study describes and discusses the effectiveness of remotely controlled measurement system by using MT data collected in North-Western Anatolia. During the MT data collection phase, real-time data transfer was made with the help of a modem using a cellular network, which has recently been used in our country and in the world. Due to the very low signal amplitudes of long-term MT measurements, it is difficult to collect, especially in noisy area where settlements are located at frequent intervals. Thanks to remotely controlled measurement innovation, data quality is controlled during data collection. If the data quality is not good because of the unpredictable noise sources, the station location can be changed or precautions can be taken. In this study, real-time analysis of data and initial data processing results of measured data during long-period MT data collection will be presented. We also compare the broadband data collected from the same stations between the years 2008 to 2011.

Keywords: Long Period, Magnetotelluric, Remotely controlled, Lithosphere, North-Western Anatolia

INTRODUCTION

Magnetotelluric method is one of the most preferred geophysical electromagnetic methods in examining the deep resistivity structure of the earth (between 0.1 km and 40 km depth). There are many studies conducted in the last 15 years in the investigation of the upper crust-lower crust boundary and the tectonic structures, suture belts and fault zones in the crust using the magnetotelluric method (eg Becken et al. 2011; Zeng et al. 2015). Similarly, tectonic studies have been carried out in our country to examine the features of the North Anatolian Fault Zone, which is in the crust (first 20-30 km), especially in Western Anatolia (Tank et al. 2005; Ulugergerli et al. 2007; Kaya et al. 2009, 2013; Tank, 2012). Again, the studies on the upper-lower crust relationship, the suture belts and the fault zones in North-West Anatolia were carried out within the scope of our previous TÜBİTAK projects (Candansayar et al. 2008, 2010, 2012; Kaya 2010).

In recent years, many international projects have been carried out to investigate the relationship between the lithosphere and the crust. Studies carried out in the Tibet-Himalayan belt within the scope of the INDEPTH project have investigated continent-continent collision and crustal melting in the lithosphere (Unsworth 2010; Xie 2016). Similarly, the study on lithosphere research in northern Europe was carried out within the scope of the BEAR (Baltic Electromagnetic Array Research) project (Korja 2007).

In our country, there is only one study conducted in the Arab-European collision zone to investigate the lithosphere (Türkoğlu et al. 2015). In Western Anatolia, there is no study on the examination of the lithosphere. Within the scope of this study, long period Magnetotelluric measurements were taken for the first time in order to examine the lithosphere structure up to the first 100 km depth of the area surrounded by the provinces of Zonguldak, Kocaeli, Uşak and Konya in Northwest Anatolia. During the measurement, the data was transferred to a server computer via the cellular network in real time. In this context, in long-term MT data collection, a work flow chart for remote data management and real-time data analysis of these data and measured data in the workspace will be presented.

METHOD

In the MT method, two components of the electric field (Ex and Ey) and three components of the magnetic field (Hx, Hy, Hz) are measured as a function of time. By taking the Fourier transforms of these measured E and H fields, the impedance tensor and tipper tensor are estimated in the frequency domain. In classical magnetotelluric measurement systems, the measured electric and magnetic field components are recorded on an SD card (internal memory) located in the receiver unit (Figure 1a). In this study, during the MT data collection, the MT measurement system is connected to a modem with a cellular network (GSM operator) and the measurements are transferred to the computer used as server in the office via the cellular network with a 10 minute packages. Data quality is controlled by performing basic data processing of these transferred data in real time. Thus, during data collection phase, the data quality can be examined continuously, the negative effects on each component of the electric or magnetic field measurements can be intervened, shutdown of the instrument due to overheating can be overseen and instant information can be obtained.

In Long-Period magnetotelluric measurements, the measurement time at a station in the field takes 10-20 days to reach the desired period (T>10000 sec). For this reason, a box arrangement has been designed to ensure the safety of the Long-period MT measurement system in the field and to be affected by adverse weather conditions as little as possible. The assembly in question includes the Phoenix MTU-5C MT receiver system, the power supply (battery) and a modem for continuous transmission of measurements via the cellular network connection (Figure 2).

MAGNETOTELLURIC DATA ACQUISITION PHASE

Long-period magnetotelluric measurements were collected along four parallel directions from which broadband MT measurements were taken within the scope of our previous TÜBİTAK project number 105G145. Thanks to the simultaneous monitoring of the data, the measurement times at each Long Period MT station varied between 10-20 days to reach the targeted data quality. Based on the analysis of the broadband MT data measured in the previous project, station positions with low cultural noise were selected for the long-period MT data acquisition phase. Thus, measurements that have to be repeated and data losses were minimized. During the 15 years after the project, the changes in the residential area and energy transmission lines were taken into consideration and the site selections were made interactively in the light of all this information. A comparison of previously measured broadband MT and long-period MT measured in 2020 is presented in Figure 3. In this comparison, it is seen that the apparent resistivity and phases obtained from the non-diagonal elements of the impedance are almost same in the same period intervals. However, the apparent resistivity and phase obtained from the diagonal elements of the impedance are not very similar due to the fact that these components amplitude are very small amplitude and affected by noise and some unforeseen deficiencies in the data processing algorithm used before. Similarly, when comparing Tipper amplitudes and phases, it is seen that broadband data is scattered and long-period data has a less scattered character. The most important reason for this effect is that the coil used in the measurement of the vertical magnetic field cannot be fully buried due to the fact that it was too long in the previous equipment and so project.

CONCLUSIONS

In this study, for the first time, MT data covering broad and long period bands (0.0001 sec < T < 20.000 sec) were collected by real-time data transfer and data control. The main advantage of this type of measurement is that the time series data transferred to the host computer in packages within 10 minutes from the station installation can be analyzed. Thus, installation errors can be seen in the station setup and the error can be corrected. On the other hand, while collecting data, especially if the electric field is measured, rodents break the cables or for any reason, the problem in the cable connections can be observed and this problem can be resolved. The waiting time for long-period MT data acquisitionf15 takes an average of 10-20 days. In classical measurement systems, interruptions in cables, battery depletion, etc. situations occur frequently from the first day to the end. These sources of problems could have been noticed when going to the study area after 20 days. However, with this new system, it can be intervened as soon as a problem occurs.

On the other hand, the other experience gained in this study is that the changes in the signal amplitude according to the solar storms can affect the measurements and cause an increase or decrease in the noise content among the MT data measured at the same station after about 15 years. In this study, it was concluded that the data measured at the same station with an interval of 15 years were generally in harmony in accordance with the resistivity structure of the environment. Again, in this study, it was observed that the low amplitude components of the impedance (Zxx and Zyy) were greatly affected by the noise, and therefore these components were not in good agreement when the data measured at 15-year intervals were compared.

The same problem was observed in tipper amplitude and phase components. Therefore, in 3D inversion, care should be taken to include the main diagonal components of the impedance and the tipper components in the inversion according to the noise content.

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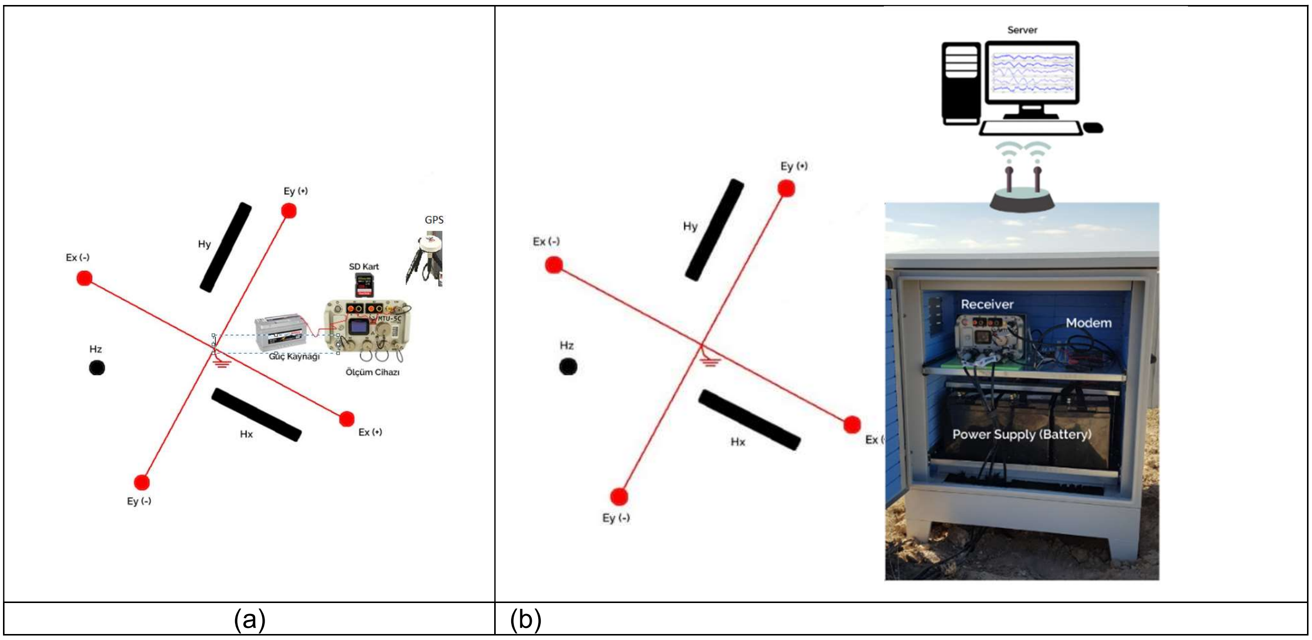

(a) (b)

Figure 1. a) Classical measurement system, (b) Remotely controlled measurement system

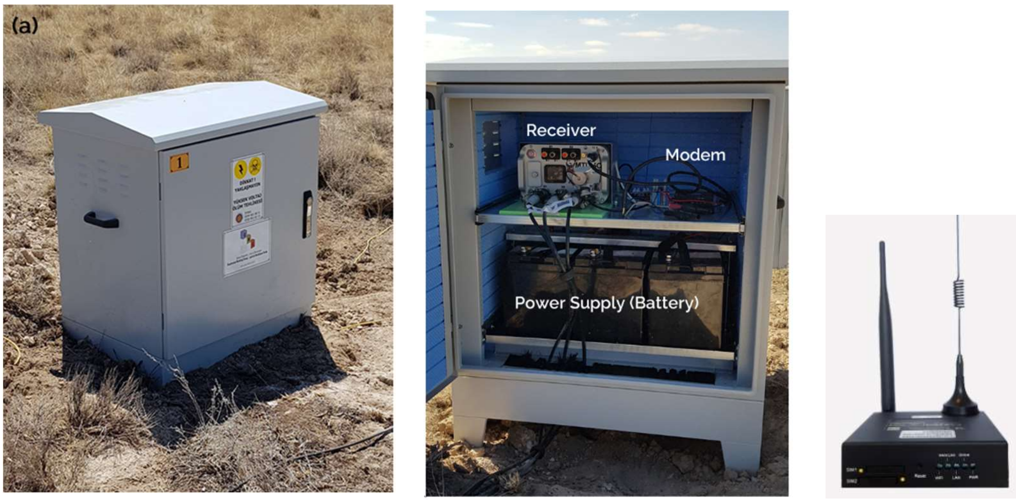

Figure 2. **a**) MT measurement system box designed in accordance with the field conditions, **b**) the layout of the system inside and **c**) the modem used.

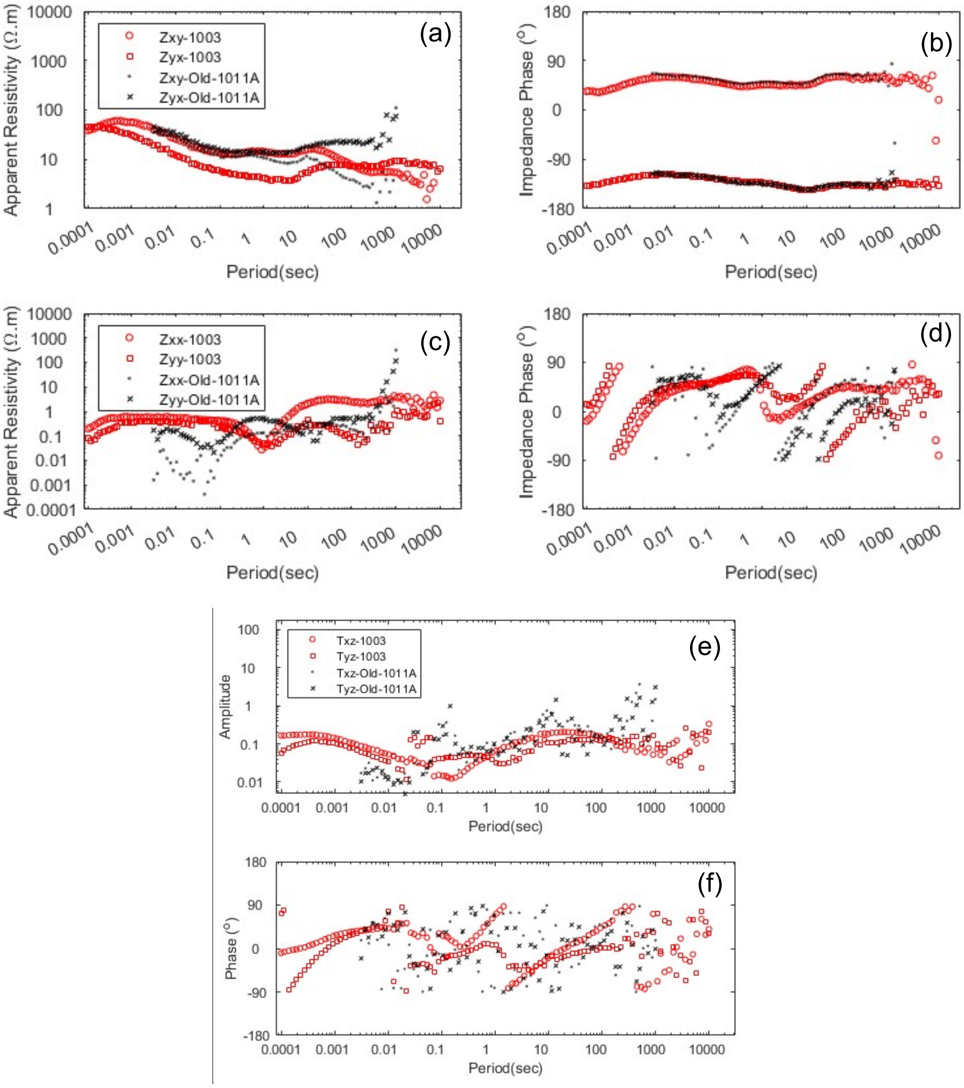

Figure 3. Presentation of Long Period MT (station 1003) measured in 2020 and broadband MT (old 1011A) measured in 2007 at the same point: (a) xy and yx component Apparent Resistivity curves, (b) xy and yx component Impedance Phase curves, (c) xx and yy component Apparent Resistivity curves, (d) xx and yy component Impedance Phase curves, (e) Txz and Tyz tipper amplitudes, (e) Txz and Tyz tipper phases. Red "circle and square" symbols indicate long period MT data, black "+ and x" symbols indicate broadband MT measurements.