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CONTINUOUS MAGNETOTELLURIC MEASUREMENTS AT THE NORTH ANATOLIAN FAULT ZONE : FIRST RESULTS

Introduction

In the frame of the European Programme of Climatology and Hazards a new system for long-term magnetotelluric measurements (MT) has been developed at the Geophysical Institute of the University of Kiel (IfG-Kiel) in order to investigate the usefulness of continuous MT measurements in earthquake prediction research. The main objective was the attempt to detect "Seismic Electrical Signals" preceding earthquakes like they have been reported by Varotsos et. al. (1991). The reliability of these effects in connection to earthquakes is still in discussion. Especially most of their published data are not corrected for the well known induction effect due to magnetic variations. In this work special emphasize has been given to reduce the measured electric variations by the magnetic induced effects. This method has successfully been carried out for a time interval of five weeks at two stations in Greece (Chouliaras and Rasmussen, 1988). It works under the consideration of a constant magnetotelluric transfer functions. In contrast, Müller et. al. (1994) attempt to resolve temporal variations of the magnetotelluric transfer functions.

The measuring system

The system has been developed in 1992 at the Geophysical Institute of the University of Kiel (IfG-Kiel). It contains a data-logger (heslog08/20; IfG-Kiel in close cooperation with Heinrich Seifert Heslab GmbH), a three axis flux gate magnetometer (Bartington; Dr. Beblo of Geomag. Obs. FFB), Cu-$CuSO_4$-probes (IfG-Kiel), a solar-power station (AEG/Hoppecke) and a DCF-time-signal-clock (Hopf). It records up to 100 MB data in 7 galvanicaly separated channels with a resolution of 20 bit and a digitizing rate up to 20 sample/sec. It has an extremely low power consumption. Digital-offset-compensation of the signal is possible. Fig.1 shows the componentes of the datalogger. More detailed information about the technical specification is given at an additional page.

The measuring sites

The localizations for the long-term measurements have been chosen according to previous magnetotelluric prospection results. Special emphasize has been given to a low noise-level at the testsites. Finally, two MT-stations have been installed in Kuzuluk and in Gökören in the area of the Turkish-German Earthquake Research Project at the western end of the North Anatolan Fault Zone (NAFZ) (Fig.2). Other stations have been installed in Greece at Volos and at Lutraki and on the island Milos.

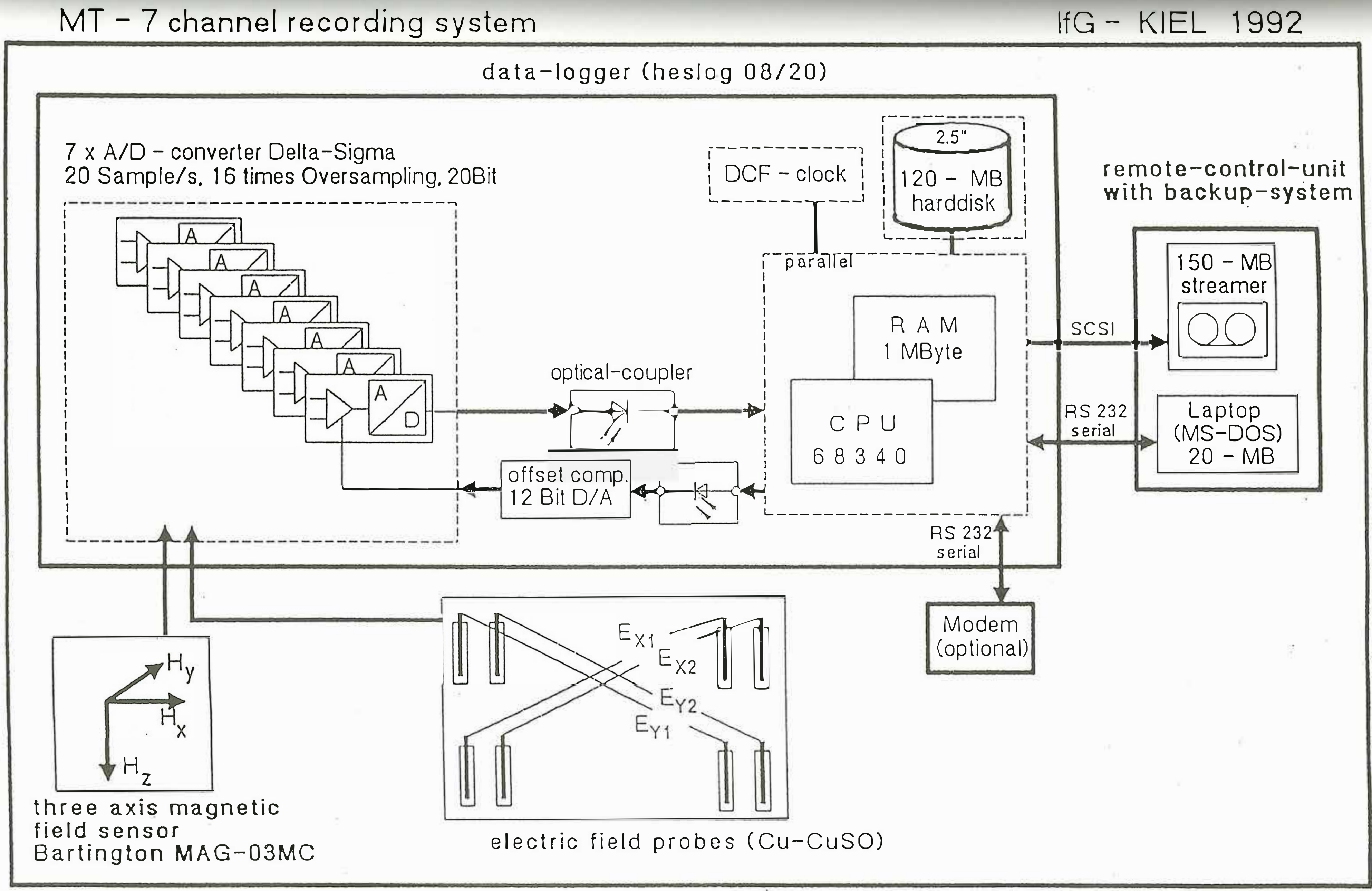


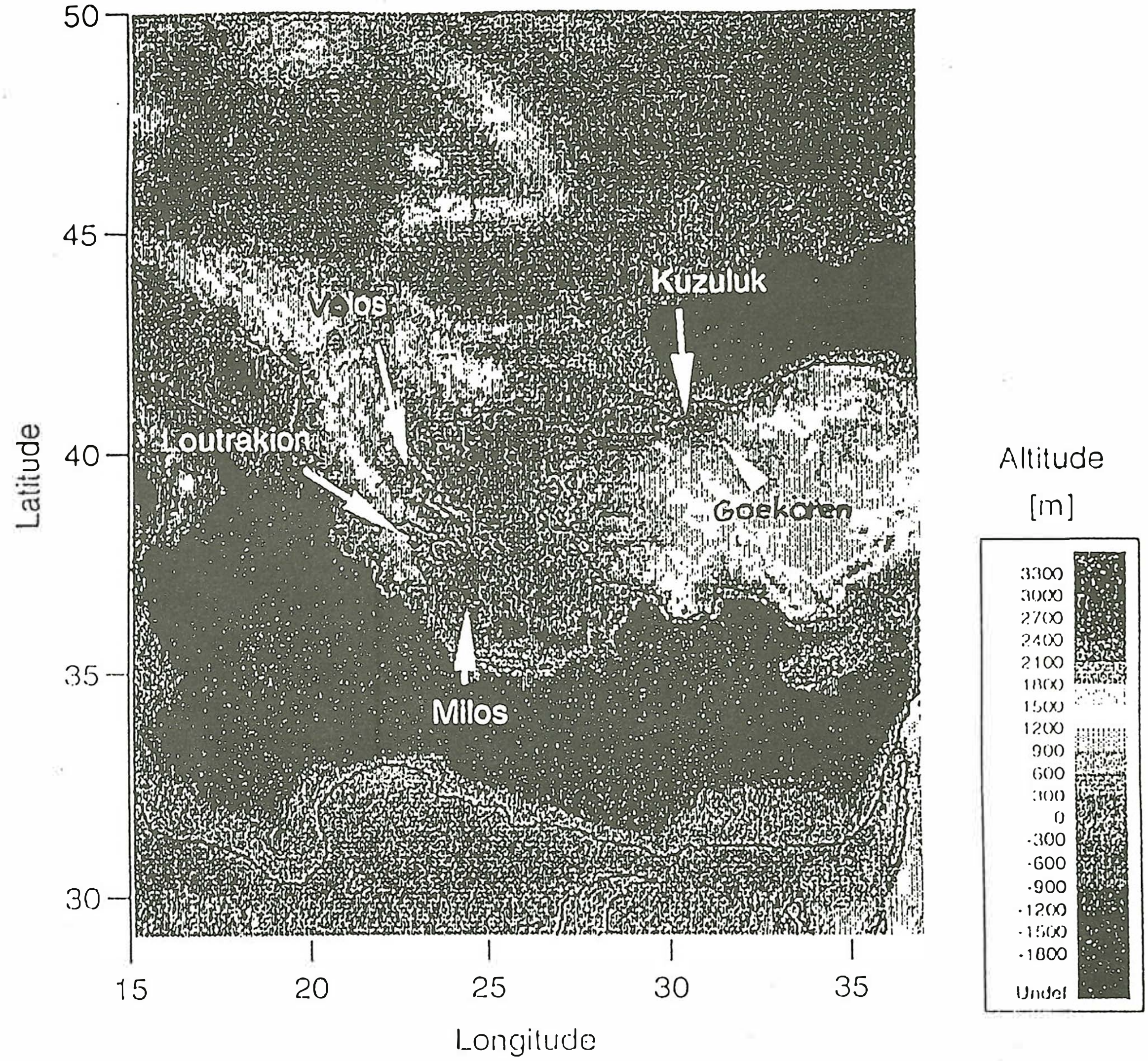
Fig. 1 The new developed MT - recording system

Specifications of the data-logger

Size	420 X 240 X 210mm
Box	aluminum-box water-resistant (IP 65)
Weight	10kg
Power	12Volt/ normal 6 - 8Watt, peak 10 - 12Watt
Sampling rate	0.1Hz - 20Hz adjustable by software oversampling technique and digital filter
Channels	7 X CMOS-Delta—Sigma-Converter and preamplifier, each channel galvanically insulated
Preamplifier	gain-setting (10, 100, 1000) adjustable by jumper for each channel
ADC	Resolution: 20 bit
ABC	Active Background Calibration for compensation of temperature drift
CPU	68340, 16/32 bit, 2MB (possible to enlarge) static-Ram, 128kByte Programme Rom, RTC, Watchdog
Mass-Storage	2.5"-hard disk with IDE-interface, 120MByte (shock up to 60g off line)
Interfaces	SCSI for tape streamer, RS-232C for remote-control, RS-232C for DCF-clock, RS-232C optional for modem
Power supply	input: 220 Volt, 45 - 60 Hz and/or 12V DC (9 - 18 Volt) output: +/-12 Volt, max. 200 mA for magnetic device
Software	communication-programme via RS-232, parameter controlled data acquisition - sample rate - max. number of data - number of channels - offset compensation - setting of date and time - process controlling programme - harddisk management - data transfer to harddisk - upload to backup-medium (tape-cartridge) via parallel port (SCSI) - self-test - storage of actual parameters and protocolled automatical restart after failure - on-line data display

Remote-Control-Unit with Backup-System
(tape-streamer with 150MByte, Teac-System), 3.5" harddisk with 150MByte, 3.5" floppy-driver with 1.44 MByte, communication- and upload-programme for data-logger, LC-display B/W, with 640 X 480 pixels, keyboard, operation system MS-Dos 5.0, processor 80C286, in vibration-dampened case.

Location of the MT-Stations



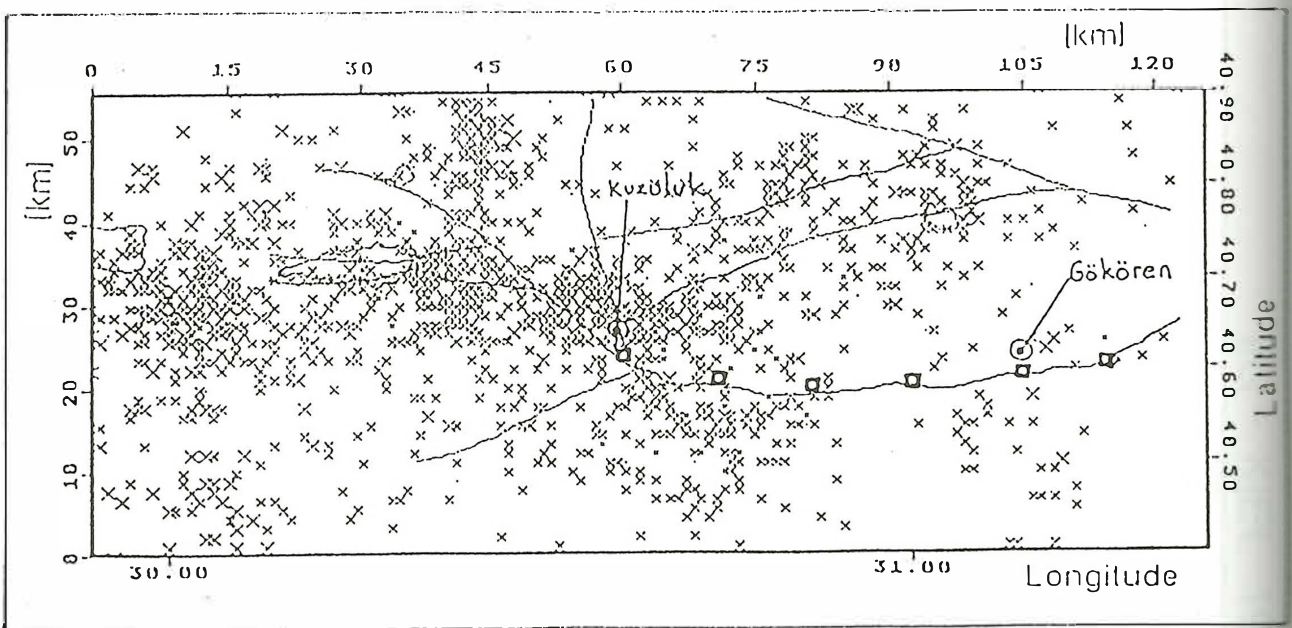


Fig. 2 **Seismicity of the work area in Turkey and the location of the recording stations**

X earthquake **M<4** ◉ Magnetotelluric Station ☐ Multiparameter Station

Magnetotelluric Transfer-Functions (Amplitudes and Phases)

Fig.3 and Fig.4 show amplitudes and phases of the magnetotelluric transferfunctions derived from 1-minute averages from a data set 19.03 to 23.03.93. The magnetic and electric signals are recorded with a rate of 2 Hz. In order to reduce the effects of the discontinuities on the computed spectra the time series are multiplied with a cosinus-window-function and the linear-trends are removed. Subsequently the daily-variations (sq) are subtracted. The resulting variations of the components are plotted relatively in a graphic window. The error-bars are calculated from the multiple-squared-coherency and the number of the degrees of freedom for a 95% confidence-limit. The lowest frequency-band and the highest frequency-band show relatively large error-bars for the following reasons : the low frequency-band is not so well determined because it contains only a few full oscillations. Furthermore, the power in the low frequency band of the telluric-signal is low. The power in the highest frequency of the magnetic-signal-band is also low. The spectrum-curves of the magnetotelluric-tensor are quite smooth within the scope of accuracy. With increasing frequency the transmission increases according to the induction law. The Zxy and Zyy-components of the impedance tensor in the spectrum-bands higher than 100 cpd contain the smallest error-bars and the highest amplitude values. This would not be expected from a lateral-homogenous subsoil. It indicates conductivity distortions.

First Results from the Station Gökören

Fig.5 shows minute-averages of MT-data from 19.03 to 23.03.93 at the station in Gökören. (Ex,th) and (Ey,th) are calculated electrical variations from the impedance-tensor and the magnetic data. (Ex,res) and (Ey,res) are the electric variations after reduction of the magnetic induction effects from the measured electric data. The resulting variations of the components are plotted relatively. The arrows indicating disturbances observed approximately every 24 hours in the whole dataset. The frequency is around 0.1 Hz, therefore it is damped for minute-values. The daily recurrence indicates artificial noise. The disturbances give an example for the improved facility to detect anomalies in the residual electric field due to the method of correction for induction effects.

Fig.6 shows 1-minute-averages from 11.04.93 - 4.06.94 . The data are highpass-filtered with a corner frequency of 5 cpd. Comparing time sections of high electric variations with the residuals it appears that there is a small remaining inductive part left in the residual variations. A low energy level remains due to the limited accuracy of the magnetometers for higher frequencies.

Due to the well determined transfer-function it was possible to reduce the magnetic induction effects in the electric time series drastically. The remaining variations in the reduced electric (Ex,res and Ey,res) time series are:

- low frequency parts due to sq-variations and weakly determined transfer-functions.
- high frequency parts according to errors in the transfer-functions.

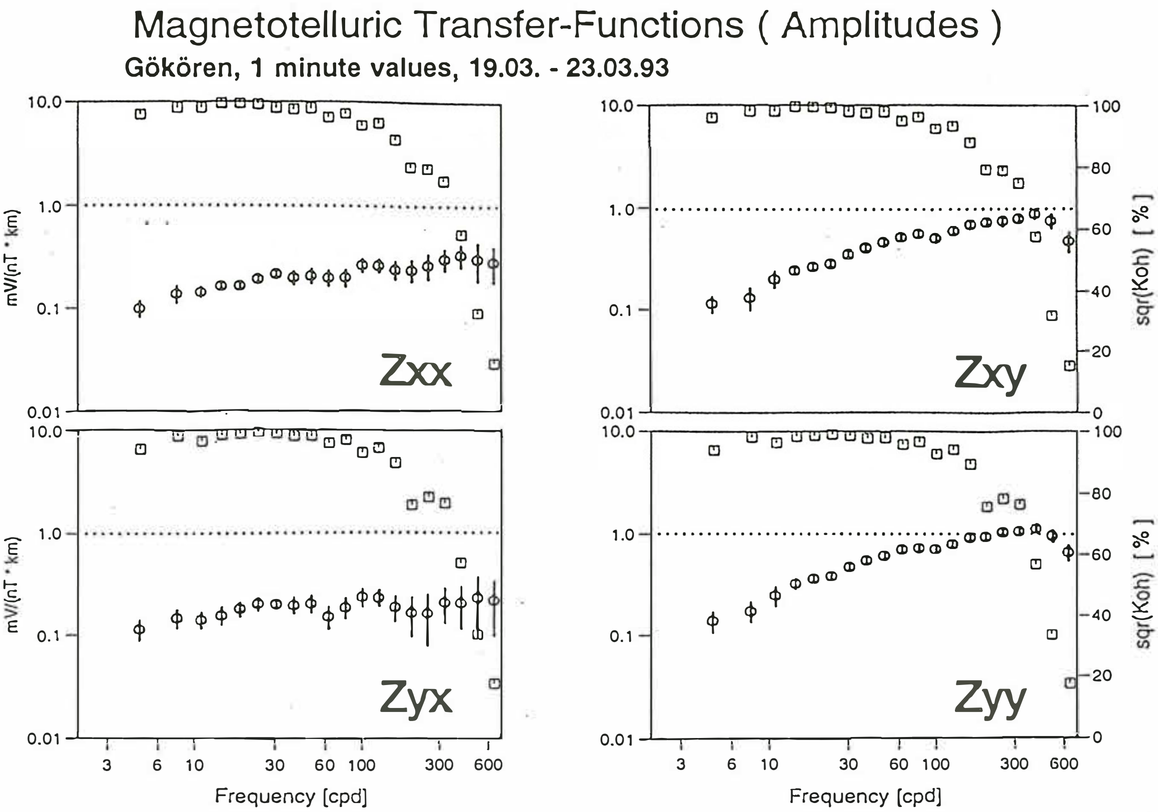


Fig.3 Amplitudes of the impedance tensor elements
The squares show the multiple squared coherency (scaling right).

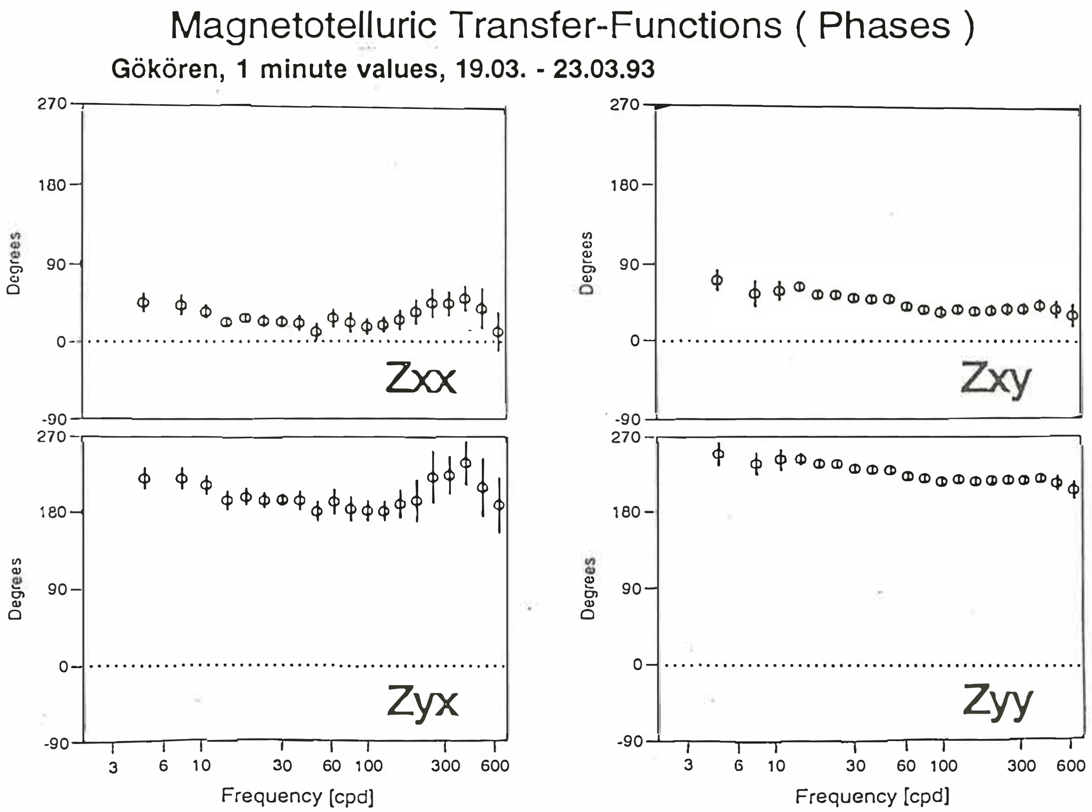


Fig.4 Phases of the impedance tensor elements

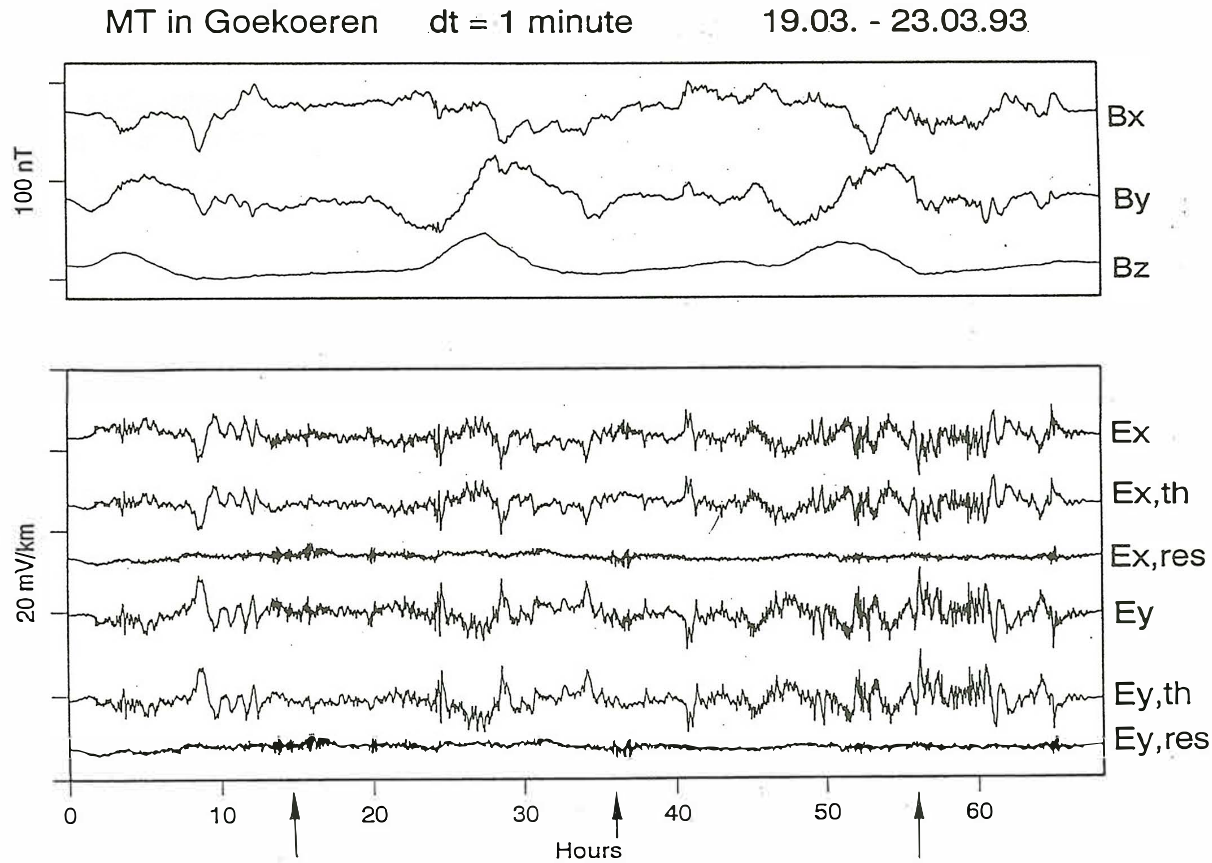


Fig.5 Plot of analysed magnetic (B) and electric (E) variations from Gökören.
Components : (x)-North-South, (y)-East-West, (z)-Vertical
(th)-theoretical induced electric variations
(res) - residual electric variations
Just relative values are shown. Offsets are arbitrary.

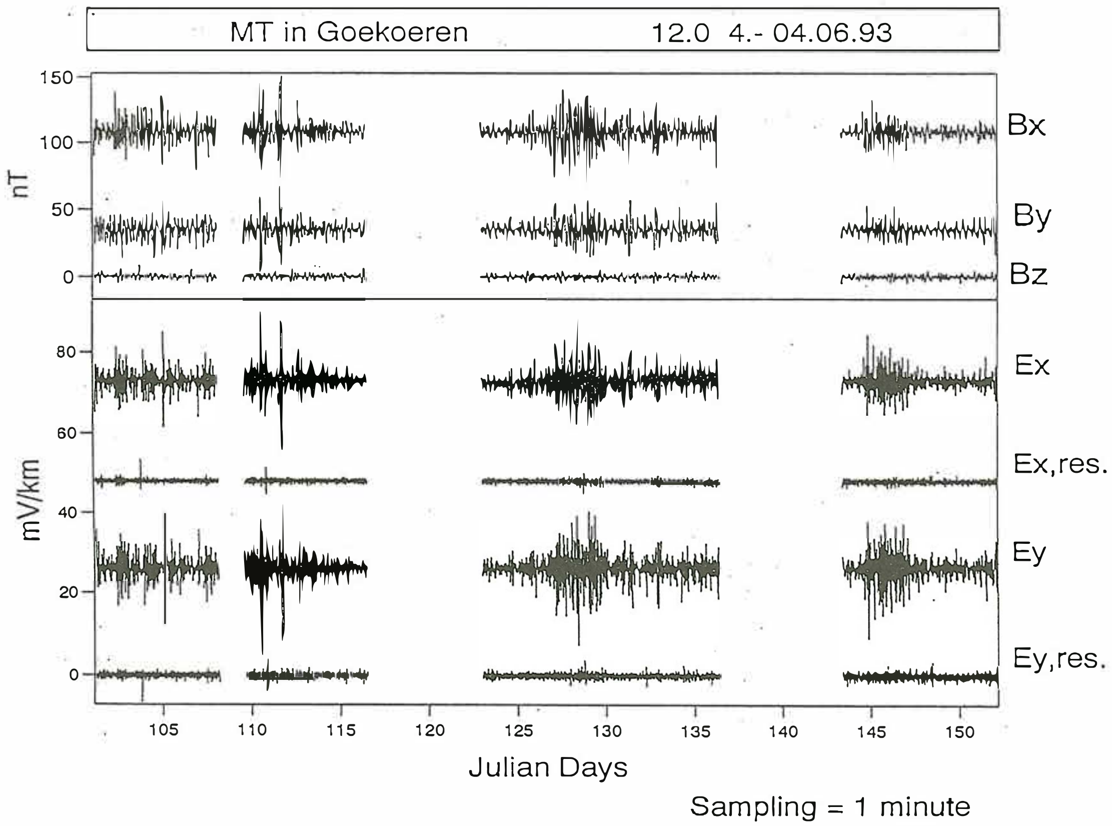


Fig.6 Plot of analysed magnetic (B) and electric (E) variations from Gökören.
Components : (x)-North-South, (y)-East-West, (z)-Vertical
(res) - residual electric variations

- other high frequency disturbances with so far unknown origin. Due to the effectiveness of the reduction it was possible to see distortions with periods lower than 1 min and durations of 2-3 hours per day in the electric time series. The reason of this distortions is not yet clear. It may represent a technical noise in this area.

Conclusion and Outlook

Within a period of about one year the MT-measurements have shown that our MT-System is appropriate for long-term-recording. The method of calculating theoretical electric variations from the MT-transfer function and the magnetic variations made it possible to reduce electrical time series by the magnetically induced effects. Now we can compare the reduced time series with meteorological variations and other measured parameters at the multiparameter stations of the Turkish-German-Earthquake- Research-Project, and especially try to correlate them with seismic activity. Up to now no "SES-like" signals have been detected in the analysed blocks of data. However, since the start of the measurements no strong earthquake has occurred in the vicinity of the MT-stations in Turkey.

In the future it is planed :

- to continue the MT-data-recording, -analysis and -interpretation in close cooperation with the participants.
- to compare the results of the MT-interpretation with parameters recorded at the multiparameter-stations in the test-area of the Turkish-German-Earthquake-Prediction-Research-Project.
- to study the possibility of on-line analysis of the data in the field in order to reduce the amount of data and allow on-line transfer of the most important parameters such as transfer functions and other quantities.

References

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